A FACTORIAL STUDY OF PICTURE TESTS FOR YOUNG CHILDREN.

with special reference to the appearance of a Space Factor among boys.

BY

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CHAPTER I.

INTRODUCTION.

The following investigation was undertaken in the course of the construction of a Group Picture Intelligence Test for seven year olds. Many factorial studies have been performed with groups of adult subjects and older school children, but so far as the writer is aware no such work has been done with subjects as young as this. She considered, however, that it would be of considerable interest and value to find out whether a mixed battery of tests given to children of this age would be explicable in terms of one general factor and specifics only or whether it would show differentiation into the widely accepted group factors, verbal, number, space etc. For there has, as Professor G.H. Thomson[1] has pointed out, been a general tendency noticeable in experimental reports to the effect that batteries of tests do not permit of being explained by as small a number of factors in adults as in children.

The pioneer work on factor analysis was that of Professor Charles Spearman[2] early in the present century. He noticed the tendency for the intercorrelations of any battery of tests to fall into hierarchical order. This tendency he explained by his famous Theory of Two Factors, that is to say by/

by the hypothesis that all the correlations were due to the operation of one general factor ('g') only, present in varying quantities in all the tests, while each test had also a second factor specific to itself. Further experimentation however showed that the tendency to hierarchical order was not universal enough to permit all test scores to be explained in terms of 'g' and specifics. It was necessary to explain linkages between groups of tests in terms of group factors such as a verbal, a number, a spatial factor etc. These group factors seemed to be more in the nature of acquired abilities enabling a man to do well in certain tests, while 'g' was still generally thought of as his innate intelligence. If this were so, these group factors should make their appearance at varying ages as the effect of education and experience becomes noticeable, and the younger the children we test, the more nearly should we find one general factor only present in all the tests and no group factors. As has already been observed, such a tendency is noticeable in the reports of factorial experiments.

While the Spearman school continued to work on the theory of a general factor supplemented when necessary by group factors, other experimenters were evolving methods of multiple factor analysis by which a matrix of test correlations could be analysed directly into all its factors.

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The pioneer work here was done by Professor Thurstone[3] of Chicago. His centroid method of analysis will give the loadings of all the tests in as many common factors as are present in the battery. It can be used when only one common factor is present, as in this case the residual correlations after the first factor has been extracted will be small enough to be regarded as due to a chance error. Where more than one factor is taken out, however, about half the loadings in all the factors after the first are negative. In order to eliminate these negative loadings - and it is very difficult to see how any mental ability could actually interfere with the performance of a task, even one carried out chiefly by means of some other ability - the original reference axes must be rotated before a psychological interpretation can be given to the factors obtained. Professor Thurstone himself aims at rotating the axes to maximise the number of zero loadings. He has defined the factor pattern which will do this as "simple structure." One of the requirements of simple structure is that there should be at least as many zero loadings in each column of the factor matrix as there are factors. Thus the presence of any general factor such as the Spearman 'g' is by definition excluded. In his large scale experiment using 57 tests with adult subjects in Chicago University, Thurstone extracted

13 centroid factors, 9 of which were rotated to a simple structure, and to the first seven he gives psychological definitions as different "Primary Mental Abilities."[4] The axes when located so as to give this simple structure were not entirely orthogonal, but the departures from orthogonality were not greater than might be attributed to experimental error.

When slightly simplified versions of many of the same tests together with some newly constructed ones were later given to a group of Chicago 14 year old school children,[5] the same factors were identified. But in order to attain simple structure from the test configuration the rotated axes were more oblique than could be attributed to experimental error, so that there were significant correlations between the identified primary abilities. Thurstone then analysed the intercorrelations of the primary abilities themselves, and found that these could be explained in terms of one general factor. He believes that this points to the existence of a "second order" general intellective factor, operative in children, but less so in adults when further education and experience may be presumed to have caused clearer differentiations of the primary mental abilities.

Some workers, notably Professor Cyril Burt,[6] have attempted to give a psychological interpretation to the centroid/

centroid factors as they come out of the first analysis without rotation. Burt however was working chiefly with tests of temperament and personality where it is quite possible to visualise the activity of bi-polar factors, such as extroversion - introversion for instance. In order to give an interpretation to the negative loadings obtained in centroid analyses of cognitive tests, the loadings must be considered, as Burt has himself pointed out, not as absolute values, but relational measures about a mean. If this is done, there is no need to eliminate negative loadings by rotation of the axes, a process which, as Burt observes,* may sometimes obscure lines of classification among the tests that were clear before rotation. Interpretations of both rotated and unrotated factor matrices in the present investigation will be discussed in later chapters; the writer is however of the opinion that only by rotation of the axes obtained from a centroid analysis can we obtain not only a meaningful factor matrix, but one comparable to that obtained by other methods of analysis such as a Spearman or a Holzinger bi-factor analysis.

So far the writer has expressly avoided any discussion of the reality of the factors obtained by analysis, or whether they correspond to any underlying neural structure of the brain. She is herself of the opinion that the action of some/

* The Factors of the Mind, p. 316.

some kind of "bonds" as discussed by G.H. Thomson* is the best explanation that can be given, and that these bonds act in the early years in an entirely undifferentiated fashion, leading to the appearance of one general factor only when the intercorrelations of tests given to young children are analysed, while education and vocation impose in later years a structure which is absent in the young, leading to matrices of intercorrelations of tests which depart further and further from rank 1 as the subjects tested become older. That past investigations bear out the possibility of such a thesis has been previously noticed.

The present investigation was undertaken to find out whether with seven year old subjects any differentiation would be found. By this time of course the children have been in school for two years, and acquired the beginnings of both reading and number, so that it might be expected that the verbal and number factors would already have made some appearance, though possibly not very clearly. It would also be necessary to look for a space factor, which is probably to be identified with W.P. Alexander's[7] "F" factor of practical ability. Alexander claims that this factor can be estimated at 11 years old, and used as a valuable indication of the type of post-primary course which any child should follow. Patrick Slater[8] on the other hand has found it difficult to obtain a reliable estimate/

* Factorial Analysis of Human Ability pp.270-271.

estimate of any spatial factor at 11 years old, using tests which do provide such an estimate at older ages, and that still give a satisfactory score scatter for the younger subjects. In his latest experiment[9] in fact he finds that even at 13 years old a battery including intelligence, verbal and spatial tests is sufficient only to define a general and a verbal factor, with no trace of a spatial one. If this is so then there will almost certainly be no indication of such a factor separate from the general factor at the still younger age of seven, but if it is as clear at 11 years old as Alexander believes, then it might also be present at any younger age.

CHAPTER 2.

PREPARATION OF THE EXPERIMENT.

1. Construction of Test Battery.

The construction of the present test battery began with a request from Edinburgh Education Authority to make for them a test which would give as accurate a measure of intelligence for the seven year old age group as possible, this being the time when children leave the Infant Department and go up into the Primary Division of the school. Other requirements were that the test should not be dependent upon reading or other school knowledge, and that it should be a group test. For some years the Authority had been in the habit of giving an individual intelligence test at this stage, but the teachers were finding the burden of individual testing too heavy, and also the particular test used had proved unsatisfactory as it seemed to be measuring reading attainment almost more than intelligence, and failed to differentiate well at the lower levels of ability. It seemed that the requirements of the Authority would be best fulfilled by a picture test of the paper and pencil type in which instructions were given orally by the examiner.

The first experimental battery therefore was designed to include various types of test which had previously been used in tests claiming to measure general intelligence.

For/

For this purpose many previous picture tests were examined, and also verbal tests for types of item which could be expressed in picture or diagrammatic form. Fourteen types of test were eventually selected for inclusion in the battery.* These tests were:-

(1) Substitution: the task in this test is to put under six different drawings the correct symbol according to a key at the top of the page.

How was this test scored? See p. 51 + 77.

(2) Classification: in this test the child is required to pick out from among six drawings in each line two that are similar in some way to three sample ones given at the beginning of the line.

(3) Absurdities: here the child has to find the one drawing among six in a line that has something foolish or wrong about it.

(4) Memory Span: in this test the task is to mark from among all the drawings in a line those ones that are named by the examiner.

(5) Series: in this test rows of crosses and rings in various patterns are given and the child has to complete each row in the same pattern.

(6) Analogies: this is similar to verbal tests of the same type except that it is presented in picture form.

(7)/

* See specimen copies of M.H.T.(Pic.) 1, (Draft 1a)and (Draft 1b)

(7) Block Counting: here the child is presented with drawings of a number of different piles of bricks, and has to write under each one how many there are in it.

(8) Directions: the task here is to follow exactly the instructions given by the examiner, as for example, "Draw a line from the elephant's tail to the top of the woman's head", or "Put a cross above the one that we put milk in".

(9) Doesn't Belong: this test is rather similar to the classification one, except that this time the child has to pick out from among six drawings in the line the one that is different from the others.

(10) Always Has: the child here is asked to find in each line the two things that the first object given always has, as for instance a head and a leg for a man rather than a coat, an attaché case, a wife, or a pair of shoes.

(11) Completion: here a drawing with some part missing is given at the beginning of the line, and the child has to find the missing part in the rest of the line.

(12) Sequence: four or five drawings are here given in each line which, if arranged in the right order, would form an ordered sequence, but they are actually given in random order. The child is asked to think what the order should be, and then mark the first and the last.

(13) Reversed Similarities: the task here is to pick out

from/

from among a number of drawings the mirror image of the first one.

(14) Mazes: the correct path has to be found from a mouse in the middle of the first maze to a piece of cheese at the end of the last one. One point is given for each maze where the correct path is found regardless of entries into wrong passages.

Fifteen items of each of these types were put together in two booklets, 7 tests in each, in the same order as they have been mentioned above. Standard instructions for administration were also made.* In all the tests except Memory Span and Directions, in which instructions were given separately for each item, there were three sample items at the beginning which were done with the children by the examiner, and then they did the test items by themselves. Emphasis as well as wording was controlled as far as possible in the instructions by underlining key words. For some of the tests completely new instructions were made up, for others wording previously used in similar tests was adapted.

Items of all these types, either in verbal or picture form, had previously been used in tests claiming to give a single measure of general intelligence. But it seemed to the writer that the battery should be quite adequate to define as well as a general factor any space factor that is operative at/

* See Instructions for administration M.H.T.(Pic)1, Drafts 1a and 1b.

at this age. In order to define the verbal and the number factors if such are to be found it would have been necessary to include some verbal and some number tests in the battery. This however was not very feasible, as such tests can hardly be given to groups of seven year old children, and time would not allow of giving individual tests to the 500 or so children included in the experimental group. Records were however available for most of the children of performance in the Vernon[10] graded word-reading test and the Ballard[11] one minute addition and subtraction tests; and the teachers willingly gave the tests to the few children who had not had them previously, as such testing would in any case have had to be done later in the course of normal school routine. Neither test alone would define a verbal or a number factor but would help to do so were these factors present at all in the rest of the battery. The Vernon test of course, being concerned with the mechanics of reading and not in the least with understanding of the words read might not be dependent on what we commonly think of as a verbal factor at any age. Understanding of verbal instructions is involved slightly in all the picture tests, and especially in the Directions Test itself where no one could possibly know what to do without the instructions, and probably the Analogies Test, where the form of the instructions imposes a set towards verbalising the

problem/

problem. Number appears explicitly only in the block counting test, and possibly a little in series.

Fair confidence was thus felt that a space factor would show itself if operative in the subjects at all, and it was hoped that verbal and number factors might also have a chance to do so.

2. Subjects Tested.

The subjects tested consisted of some 500 children from six of the city Public Elementary Schools and the Demonstration School attached to the Teachers' Training College. Among them these schools formed a pretty representative sample of the city's population, ranging from the Demonstration School which takes selected children from any part of the city, and in which the average I.Q. is significantly above 100, to a school in a very poor district serving chiefly the families of dock workers and other unskilled labourers and in which the average I.Q. is well below 100.

The picture tests were given during May 1942, and the children tested were the complete age group from 6 yrs. 7 m. to 7 yrs. 6 m. inclusive as at 31st May 1942 in the four smaller schools, and half that group in the three larger ones. The final numbers that took both sets of picture tests and the reading and arithmetic tests were 414, 218 boys and 196 girls.

Tables/

Tables showing the number of children from each school and of each month of age will be found in the appendix.

3. Testing Procedure.

The reading and arithmetic tests were given individually by the Infant Mistress of each school at varying dates from nine months before to one month after the group testing. In order to eliminate differences in raw score due to these large differences in age at the time of testing, reading and arithmetic quotients were used in calculating correlations.

The picture tests had been put together in two booklets of 7 tests in each - M.H.T. (Pic.) 1, Draft 1a and Draft 1b - as has been described above. The children were tested in groups of not more than 25: in the schools with only two such groups all the testing was done by the writer with the assistance of the class teacher or a student; where there were three groups the writer tested one in the morning with the assistance of the Infant Mistress, and in the afternoon she took the second group while the writer took the third, each assisted by another teacher or student. All the children took Draft 1a first, followed by Draft 1b at intervals of from one to three weeks.

It was found that 25 was quite the largest group of such young children that could be tested at one time, and that it was essential always to have two adults present in the room.

The/

The examiner was thus free to concentrate entirely on the giving of instructions, eliciting answers to the sample items from the children, and timing the tests. The second adult made sure that the books were open at the right place, handed out new pencils when necessary and encouraged the children to keep steadily working. This last was particularly important as they tended to stop after doing only one item or at the end of the first page when the whole test consisted of two pages. As long as there were two adults, however, satisfactory results were obtained.

CHAPTER 3.

GENERAL RESULTS OF TESTS.

Tables showing the distribution of raw scores in all the picture tests, and of reading and arithmetic quotients will be found in the appendix. The mean scores in each test, boys and girls separately, are shown below:-

TABLE I.

Mean Scores in Tests

Test	Boys	Girls
Substitution	13.7	13.2
Classification	1.2	1.4
Absurdities	6.2	5.4
Memory Span	9.4	9.5
Series	5.6	6.0
Analogies	2.5	2.2
Block Counting	9.2	7.0
Directions	9.1	8.8
Doesn't Belong	6.1	5.8
Always Has	2.5	2.0
Completion	7.0	6.6
Sequence	4.1	4.1
Reversed Similarities	7.9	7.4
Mazes	8.5	3.6
Reading Quotient	103.2	106.5
Arithmetic Quotient	108.4	110.7

Test 2 was obviously far too difficult for the subjects, and therefore it was omitted altogether in the analysis. Except in Block Counting and Mazes there is almost no difference between the mean scores of boys and girls. In these two however there is a quite significant difference. The boys' and girls' results were therefore kept separate throughout the calculations. The mazes test in fact had to be abandoned altogether in the case of the girls, because although the mean score is no lower than that in some of the other tests, more than half of them (109 out of 196) gained no score at all.

The final battery for analysis was therefore, for the boys:

1. Substitution	2. Absurdities	3. Memory Span
4. Series	5. Analogies	6. Block Counting
7. Directions	8. Doesn't Belong	9. Always Has
10. Completion	11. Sequence	12. Reversed Similarities
13. Mazes	14. Reading	15. Arithmetic

For the girls the tests were just the same except for the omission of No.13, Mazes.

In order to facilitate the making of grids and calculation of correlations each child's results were transferred onto a postcard* showing name and number, school (by a code letter), sex, date of birth, date of testing, chronological/

* For specimen card see appendix.

Chronological age, school class, R.Q., A.Q., I.Q. (if this had been measured by any other test) and name of test used, and also the score on each of the picture tests separately, the total on each draft, and the grand total. These cards were then sorted into bundles for the making of the correlation grids, and the product-moment correlations between the different tests calculated from the grids by the diagonal adding method. The sums of squares were checked by calculating each from two different origins. A final check was applied by calculating both diagonal variances and making sure that $D_1 + D_2 = 2$ (Horizontal + Vertical variance)

The complete correlation matrices for both boys and girls are shown overleaf. Using Fisher's 'Z' technique (12) we find that to be significant at the 5 per cent point the correlations in the case of the boys must exceed .133 there being 218 cases, and for the girls, with 196 cases, must exceed .140.

The insignificant correlations in the boy's results are therefore:

Block Counting with Substitution and Memory Span.

Mazes with Memory Span, Reading, Arithmetic.

Substitution with Reading.

The rest are all positive and significant.

In the case of the girls, the insignificant correlations are:

TABLE II.

CORRELATION MATRIX. BOYS.

Test No in app. II		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1a	1. Substitution	-	3541	3125	3065	2081	0174	2465	2480	1390	2844	2475	2849	2322	-0124	1571
3a	2. Absurdities	3541	-	3932	3420	4513	1451	2556	4277	3248	3870	4197	4226	3412	1922	1401
4a	3. Memory Span	3125	3932	-	3131	2414	1029	2065	2989	1800	2433	2930	3205	0682	2053	1787
5a	4. Series	3065	3420	3131	-	3919	3972	2118	3877	3639	4293	4515	5033	3849	2600	2470
6a	5. Analogies	2081	4513	2414	3919	-	2005	1745	3852	3214	3447	3514	4525	3339	1728	1565
7a	6. Block Counting	0174	1451	1029	3972	2005	-	2326	2286	1485	3219	2449	3084	2974	2003	2123
1b	7. Directions	2465	2556	2065	2118	1745	2326	-	2750	2800	3559	2733	3582	3094	1903	2353
2b	8. Doesn't Belong	2480	4277	2989	3877	3852	2286	2750	-	3730	4086	5135	4276	2797	2218	1657
3b	9. Always Has	1390	3248	1800	3639	3214	1485	2800	3730	-	4966	3625	4412	2943	2152	2684
4b	10. Completion	2844	3870	2433	4293	3447	3219	3559	4086	4966	-	4067	5570	3945	2609	3015
5b	11. Sequence	2475	4197	2930	4515	3514	2449	2733	5135	3625	4067	-	5154	3042	2520	3134
6b	12. Reversed Similarities	2849	4226	3205	5033	4525	3084	3582	4276	4412	5570	5154	-	4508	2480	2072
7b	13. Mazes	2322	3412	0682	3849	3339	2974	3094	2797	2943	3945	3042	4508	-	1334	0989
	14. Vernon R.Q.	-0124	1922	2053	2600	1728	2003	1903	2218	2152	2609	2520	2480	1334	-	5412
	15. Ballard A.Q.	1571	1401	1787	2470	1565	2123	2353	1657	2684	3015	3134	2072	0989	5412	-
	Sum:	30258	45966	36575	49901	41861	30610	36049	46410	42088	51923	49490	54976	39230	30810	32233
		3.7936	5.2554	4.2893	5.6052	4.8522	3.7606	4.2955	5.3613	4.9145	5.7978	5.6448	6.0062	4.9230	3.9476	4.1244

N.B. All decimal points in the body of this table have been omitted.

see p 18a for numbering of tests in App. II, Score distributions.

TABLE III.

CORRELATION MATRIX. GIRLS.

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	14.	15.
1.	Substitution	-	2538	2054	1328	3181	0857	2418	1649	2457	2485	2039	2527	0175	1058
2.	Absurdities	2538	-	4057	3814	4400	2332	3403	4521	3784	4521	3810	3763	0632	0935
3.	Memory Span	2054	4057	-	3308	2826	1506	2333	3004	1781	3267	2623	2252	1567	1061
4.	Series	1328	3814	3308	-	3184	1400	4121	4669	3788	4615	4132	4702	1708	2195
5.	Analogies	3181	4400	2826	3184	-	1710	3333	4397	4279	4405	3841	4372	1974	1697
6.	Block Counting	0857	2332	1506	1400	1710	-	1125	2200	1664	2125	1875	1884	0092	1635
7.	Directions	2418	3403	2333	4121	3333	1125	-	2969	2748	3836	3097	4444	2772	2921
8.	Doesn't Belong	1649	4521	3004	4669	4397	2200	2969	-	4514	4298	5354	4239	2436	2048
Draft, b Test 3 → 9.	Always Has	2457	3784	1781	3788	4279	1664	2748	4514	-	3771	3450	4397	2055	0693
10.	Completion	2485	4521	3267	4615	4405	2125	3836	4298	3771	-	4020	4070	1633	1916
11.	Sequence	2039	3810	2623	4132	3841	1875	3097	5354	3450	4020	-	4707	1192	2451
12.	Reversed Similarities	2527	3763	2252	4702	4372	1884	4444	4239	4397	4070	4707	-	2099	1804
14.	Vernon R.Q.	0175	0632	1567	1708	1974	0092	2772	2436	2055	1633	1192	2099	-	5645
15.	Ballard A.Q.	1058	0935	1061	2195	1697	1635	2921	2048	0693	1916	2451	1804	5645	-
	Sum:	2.4766	42510	3.1639	4.2964	43599	20405	39520	46298	39381	44962	42591	45260	23980	26059

N.B. All decimal points in the body of this table have been omitted.

Block Counting with Substitution, Series, Directions, Reading.

Reading with Substitution, Absurdities, Sequence.

Arithmetic with Substitution, Absurdities, Memory Span, Always Has.

Substitution with Series.

The remaining correlations are all positive and significant.

The tests that had to be dropped out when Draft 2 of the Picture Test was made up were: Block Counting and Mazes because of the sex difference, Memory Span because it was too easy, Classification because it was too difficult and Substitution because its agreement with the test as a whole was too small. The following tests were therefore available for making up the second draft: 2. Absurdities; 4. Series: 5. Analogies; 7. Directions; 8. Doesn't Belong; 9. Always Has; 10. Completion; 11. Sequence; 12. Reversed Similarities.

The choice of these nine tests was governed in the first instance by the fact that they had proved themselves of equal difficulty for both sexes and of suitable difficulty for the age range to be tested. Before making up this draft however the factorial analysis was completed in order that we might have all available evidence regarding the suitability of these tests for a test of general intelligence. These nine did in fact prove themselves to be the ones of which the final version of the test was made, though by no means all their original items of course survived.

CHAPTER 4.

THE FACTORIAL ANALYSIS.

Thurstone's centroid method* with guessed communalities in the diagonal cells was used for the analysis. The boys' battery was analysed first, three factors being taken out. The first of these took out 4.74 of the total variance, the second .74 and the third .52. Only one test had a loading in the third factor above .3 and only two others above .25, so that it was considered unnecessary to carry the process any further. The loadings obtained are shown in Table IV below.

An inspection of these loadings as they stand shows fairly clearly that Factor I is some kind of general factor present in the whole battery, and that Factor II brings out a strong contrast between the scholastic tests (reading and arithmetic) along with possibly Series, Memory Span and Block Counting, and the rest of the picture tests. Factor III seems to be bringing out a division among the picture tests themselves, with Substitution, Absurdities and Memory at one end, and Series, Block Counting, Mazes, with possibly Completion and Reversed Similarities at the other. Discussion of the interpretation of these may be reserved to a later chapter.

* A fully worked example will be found in the appendix.

TABLE IV.

CENTROID FACTOR MATRIX

Complete Battery - Boys

Test	I	II	III	h^2
1. Substitution	.408	.155	.222	.240
2. Absurdities	.609	.217	.210	.463
3. Memory Span	.453	-.064	.295	.296
4. Series	.663	-.105	-.225	.502
5. Analogies	.560	.134	-.078	.338
6. Block Counting	.417	-.195	-.308	.307
7. Directions	.478	.053	.062	.236
8. Doesn't Belong	.622	.149	.127	.426
9. Always Has	.568	.123	-.096	.347
10. Completion	.694	.103	-.143	.513
11. Sequence	.660	.042	.107	.448
12. Reversed Similarities	.731	.174	-.148	.587
13. Mazes	.528	.220	-.261	.396
14. Reading	.437	-.506	.093	.456
15. Arithmetic	.455	-.461	.152	.442
Variance Taken Out:	4.737	.743	.515	5.995

Next the complete battery of girls' tests was analysed. Three factors were again taken out, the first accounting for 4.33 of the total variance, the second 1.00 and the third .34. The loadings obtained are shown in Table V below.

Tests 11 + 11 have exactly the same loadings - the h² should be the same. The correct value is .4339, not .411. I wonder whether the loadings in Test 4 are correct. MBz

TABLE V.

CENTROID FACTOR MATRIX.

Complete Battery - Girls.

Test	I	II	III	h^2
1. Substitution	.368	.083	-.199	.182
2. Absurdities	.619	.297	.095	.480
3. Memory Span	.470	.086	.160	.254
4. Series	.631	.139	.128	.411
5. Analogies	.632	.141	-.201	.460
6. Block Counting	.292	.080	.172	.121
7. Directions	.579	-.135	-.112	.366
8. Doesn't Belong	.680	.152	.132	.503
9. Always Has	.578	.198	-.262	.442
10. Completion	.652	.138	.042	.447
11. Sequence	.631	.139	.128	.434
12. Reversed Similarities	.658	.074	-.194	.476
14. Reading	.390	-.615	-.074	.535
15. Arithmetic	.417	-.606	.161	.567
Variance Taken Out:	4.330	1.002	.345	5.676

Again the centroid loadings show a general factor running through the whole battery, and a sharp division between the scholastic and picture tests in Factor II. In this case the only one of the picture tests to go along with reading and arithmetic/

arithmetic is No.7, Directions. Various attempts were made to change the signs of more of the picture tests before taking out the second factor but none was satisfactory: the only negative residual of any appreciable size left after changing the signs of 7 (Directions), 14 (Reading) and 15 (Arithmetic) was -.0979 in tests 1 and 4 - Substitution and Series. But changing the signs of Test 1 gave a negative total to that column, and even changing the signs of test 4 reduced the amount of variance taken out by the second factor. The analysis shown above was therefore accepted as the best obtainable. As for the boys, Factor III shows a division among the picture tests themselves, but quite a different division. Tests 1 (Substitution), 5 (Analogies), 9 (Always Has) and possibly 12 (Reversed Similarities) this time group together at one end, and the remainder fairly closely at the other. Whatever this factor might be, therefore, it was not the same as the third factor for the boys. All the loadings in this factor are actually very small, none reaching as much as .30, and the average residual after extracting two factors was only .0395. It was suspected, therefore, that the third factor in the girls' battery might not be significant.

Before testing this any further however an analysis was made of the picture tests alone, both for the boys and the girls. It was thought that in this way divisions among the picture/

picture tests might show up more clearly. Three factors were once more extracted in each case. For the boys these accounted for 4.43, .53 and .33 respectively of the total variance, while the corresponding figures for the girls were 4.14, .33 and .38.

The loadings obtained are shown in Table VI below. It is quite clear from these loadings that the second factor here is the same as the third factor in the complete battery. The dropping of the reading and arithmetic tests has simply caused the elimination of one dimension from the analysis. This is not surprising, since the second dimension in the complete analysis was almost entirely defined by these two tests.

More interesting is the observation that the new third factor here taken out from the picture tests for the boys is very similar to the factor appearing third in the complete battery of girls' tests and second in the picture tests.

TABLE VI.

CENTROID FACTOR MATRICES

Picture Tests Only.

	BOYS				GIRLS			
	I	II	III	h^2	I	II	III	h^2
1.Substitution	.433	.291	-.141	.292	.387	-.267	-.239	.278
2.Absurdities	.632	.226	-.142	.470	.658	.128	-.201	.490
3.Memory Span	.451	.356	.094	.339	.479	.217	-.255	.341
4.Series	.668	-.173	.257	.542	.633	.119	.296	.503
5.Analogies	.577	-.054	-.034	.337	.642	-.173	-.113	.455
6.Block Counting	.408	-.275	.271	.315	.304	.106	-.095	.113
7.Directions	.474	.043	-.128	.243	.554	-.145	.091	.336
8.Doesn't Belong	.639	.156	.130	.449	.683	.194	.145	.525
9.Always Has	.566	-.130	-.123	.352	.596	-.162	.080	.387
10.Completion	.695	-.169	-.139	.531	.666	.053	-.026	.447
11.Sequence	.656	.104	.171	.471	.641	.105	.159	.448
12.Reversed Similarities	.750	-.126	-.046	.581	.667	-.195	.218	.530
13.Mazes	.515	-.252	-.198	.368	-	-	-	-
14.Reading	-	-	-	-	-	-	-	-
15.Arithmetic	-	-	-	-	-	-	-	-
Variance Taken Out	4.430	.532	.327	5.290	4.144	.326	.381	4.852

These similarities can be made clearer by the Table to be found overleaf, showing the corresponding factors under one another. For the girls the dimension represented by the third factor in the boys' complete battery and second in the picture tests alone appears to have been dropped out. Reason had already been found to consider that three factors were as many as were worth taking out from the complete battery of boys's tests and to doubt the significance of the third factor in the girls' battery. If this were so the line of significance would come in every case between the factor corresponding to the third in the complete boys' battery and the third in the complete girls' battery, leaving three significant factors in the complete battery of boys' tests and two in the picture tests, two in the complete battery for the girls and only one in the picture tests.

It was decided therefore to fit one factor to the intercorrelations of the picture tests for the girls by Mr. D.N. Lawley's[13] method of "maximum likelihood". The advantage of this method is that it allows of a satisfactory mathematical determination of how many factors are necessary to explain the correlations obtained. The first factor* leadings as estimated by this method were: (1) .358, (2) .647, (3) .451, (4) .642, (5) .639, (6) .289, (7) .540, (8) .689, (9) .596, (10) .665, (11) .639, (12) .670.

To test whether this one factor was sufficient to account for the data the first step was to calculate the residual correlations/

* A completely worked example will be found in the Appendix. p. 67

TABLE VII.

CENTROID FACTOR LOADINGS

showing corresponding factors under one another.

1. COMPLETE BATTERY. BOYS.

	I	II	III		
1. Substitution	.408	.155	.222		
2. Absurdities	.609	.217	.210		
3. Memory Span	.453	-.064	.295		
4. Series	.663	-.105	-.225		
5. Analogies	.560	.134	-.078		
6. Block Counting	.417	-.195	-.308		
7. Directions	.478	.053	.062		
8. Doesn't Belong	.622	.149	.127		
9. Always Has	.568	.123	-.096		
10. Completion	.694	.103	-.143		
11. Sequence	.660	.042	.107		
12. Reversed Similarities	.731	.174	-.148		
13. Mazes	.528	.220	-.261		
14. Reading	.437	-.506	.093		
15. Arithmetic	.455	-.461	.152		

2. PICTURE TESTS. BOYS.

	I		II	III	
1.	.433		.291	-.141	
2.	.632		.226	-.142	
3.	.451		.356	.094	
4.	.668		-.173	.257	
5.	.577		-.054	-.034	
6.	.408		-.275	.271	
7.	.474		.043	-.128	
8.	.639		.156	.130	
9.	.566		-.130	-.123	
10.	.695		-.169	-.139	
11.	.656		.104	.171	
12.	.750		-.126	-.046	
13.	.515		-.252	-.198	

3. COMPLETE BATTERY. GIRLS.

	I	II		III	
1.	.368	.083		-.199	
2.	.619	.297		.095	
3.	.470	.086		.160	
4.	.631	.139		.128	
5.	.632	.141		-.201	
6.	.292	.080		.172	
7.	.579	-.135		-.112	
8.	.680	.152		.132	
9.	.578	.198		-.262	
10.	.652	.138		.042	
11.	.631	.139		.128	
12.	.658	.074		-.194	
13.	-	-		-	
14.	.390	-.615		-.074	
15.	.417	-.606		.161	

4. PICTURE TESTS. GIRLS.

	I			II	III
1.	.387			-.267	-.239
2.	.658			.128	-.201
3.	.479			.217	-.255
4.	.633			.119	.296
5.	.642			-.173	-.113
6.	.304			.106	-.095
7.	.554			-.145	.091
8.	.683			.194	.145
9.	.596			-.162	.080
10.	.666			.053	-.026
11.	.641			.105	.159
12.	.667			-.195	.218
13.	-			-	-

N.B. Factors to the left of the double line are those that have been shown to be significant, while those to the right are not significant.

correlations left after taking out the effect of the one factor. In the diagonal cells of the matrix of residuals was placed the specific variance for each test. In order to calculate the measure, denoted "w", by which the significance of the residuals is tested, each residual correlation is squared and then divided by the product of the specific variances of the two tests concerned. Altogether in the present instance there were 66 such terms, one for each residual correlation, and "w" is their sum multiplied by the number of the children in the sample, in this case 196. It came to 62.3868. To find whether this value is significant we first determine the number of degrees of freedom, which are $\frac{1}{2}\left\{(n-m)^2 - n - m\right\}$ when n = the number of tests and m = the number of factors assumed. In our case n = 12 and m = 1, so that d.f. = 54. We now use a table of χ^2 such as that given by Fisher and Yates.[4] Where n is greater than 30, the term $\sqrt{2\chi^2}$ may be treated as a normally distributed variable with unit variance and mean = $\sqrt{2n-1}$. This gives a value of χ^2 in our case at the 1 per cent point of 83.5 and at the 5 per cent point of 75.6. The obtained value of "w" however was 62.39 which does not reach even the 5 per cent significance level. Therefore, although we cannot state definitely that only one general factor is present in the picture test for the girls, we have no reason to assume more than one, or more than two in the complete battery.

This/

This result showed that not more than the three factors would be significant in the complete battery of boys' tests or two in the picture tests. But the possibility still remained that even the factor appearing third in the complete battery and second among the picture tests for the boys might not be significant. To test this a single factor was fitted by the same method to the boys' picture test correlations, and the loadings obtained were: (1) .411, (2) .614, (3) .428, (4) .656, (5) .576, (6) .396, (7) .450, (8) .627, (9) 569, (10) .689, (11) .658, (12) .762, (13) .545.

This time, with 218 children, 13 tests, and 1 factor, w = 115.65, d.f. = 65, and χ^2 at 1 per cent = 79.03. There is no doubt whatever therefore that a second factor is needed to explain the data. As the calculations already performed on the girls' data indicated that a third factor would not be significant for the boys, no attempt was made to fit two factors and test the significance of the residuals by this method.

We were left therefore, as we had at first suspected, with three significant factors in the complete battery of boys' tests, two in the girls' complete battery, two in the picture tests for the boys and one only in the picture tests for the girls.

CHAPTER 5.

ROTATION OF FACTORS.

The unrotated centroid loadings of the significant factors are given again below for ease of reference.

TABLE VIII.

Loadings of Significant Centroid Factors.

	BOYS					GIRLS		
	Complete Battery			Picture Tests		Complete Battery		Picture Tests
	I	II	III	I	II	I	II	I
1. Subst.	.408	.155	.222	.433	.291	.368	.083	.387
2. Absurd.	.609	.217	.210	.632	.226	.619	.297	.658
3. Memory	.453	-.064	.295	.451	.356	.470	.086	.479
4. Series	.663	-.105	-.225	.668	-.173	.631	.139	.633
5. Analog.	.560	.134	-.078	.577	-.054	.632	.141	.642
6. Blocks	.417	-.195	-.308	.408	-.275	.292	.080	.304
7. Direct.	.478	.053	.062	.474	.043	.579	-.135	.554
8. Doesn't Belong	.622	.149	.127	.639	.156	.680	.152	.683
9. Always Has	.568	.123	-.096	.566	-.130	.578	.198	.596
10. Compl.	.694	.103	-.143	.695	-.169	.652	.138	.666
11. Sequ.	.660	.042	.107	.656	.104	.631	.139	.641
12. Rev.Sim.	.731	.174	-.148	.750	-.126	.658	.074	.667
13. Mazes	.528	.220	-.261	.515	-.252	-	-	-
14. Reading	.437	-.506	.093	-	-	.390	-.615	-
15. Arith.	.455	-.461	.152	-	-	.417	-.606	-

The present writer believes that these factors as they stand are not psychologically meaningful and that rotation is necessary before they can be so.. Some discussion of possible interpretations of the unrotated factors will, however, be given later. But first we must discuss the attempts so to rotate them that a psychologically meaningful structure would appear.

For this purpose the complete battery of boys' tests was first considered. Diagrams were first made showing the positions of the various tests with regard to the centroid axes. From these diagrams it was clear that it would be impossible to eliminate completely a general factor and so attain simple structure, unless the axes were placed at an oblique angle. In this case the factors would be correlated with each other and, it seems to the writer, would lose much of their value in giving a simplified explanation of the test scores.

Looking at the diagram of Factors I_0 and II_0 (see fig. 1) we can see that Factor II_0 shows a marked antithesis between the scholastic tests (reading and arithmetic) along with possibly block counting, series and memory, and the remaining tests. It was therefore decided so to place the first axis that no significant negative loadings would appear in Factor II while at the same time there would be a maximum of zero loadings and the reading and arithmetic loadings would be as high as possible.

Fig. 1. Factors I_o & II_o Boys.
Complete Battery.

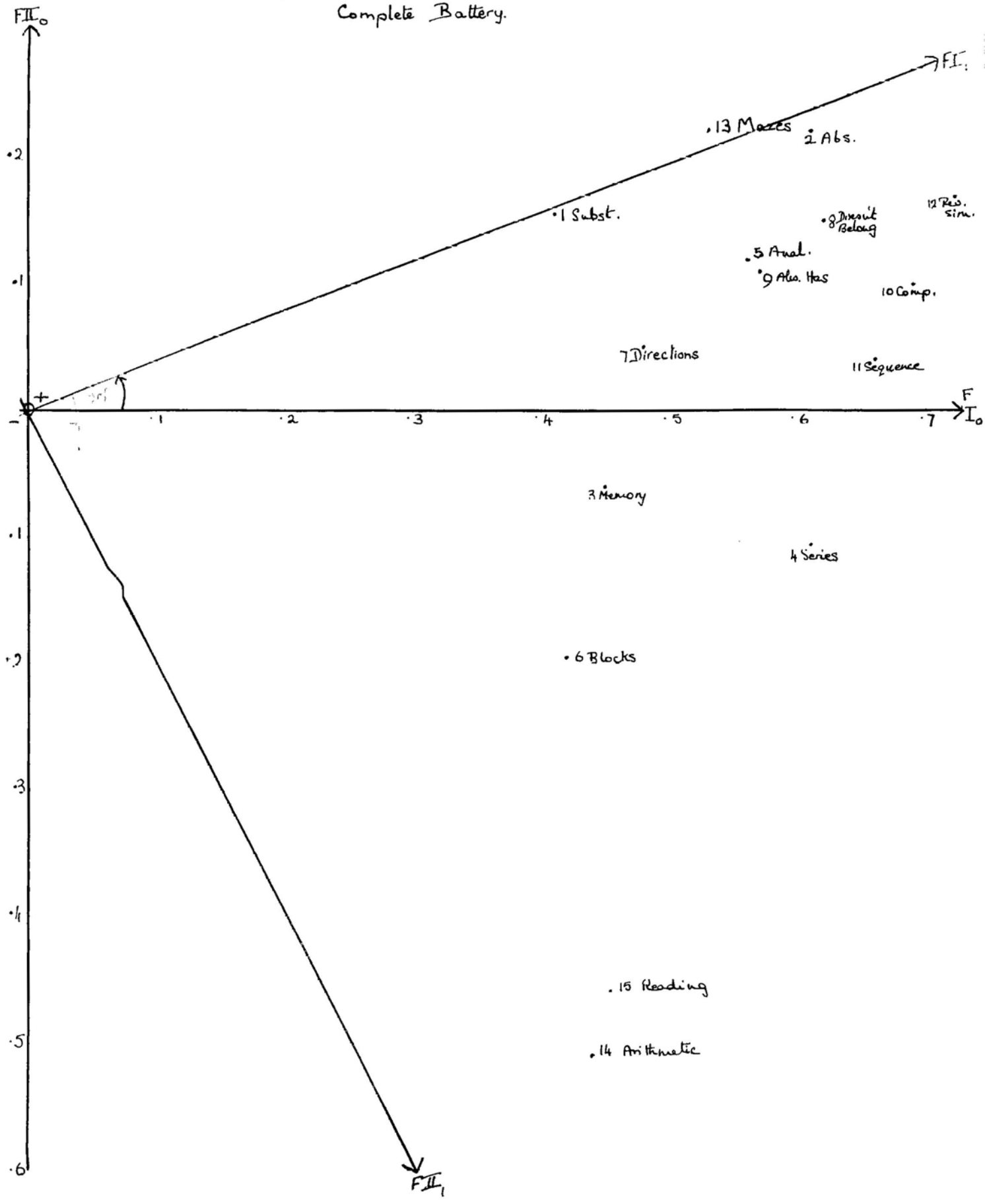
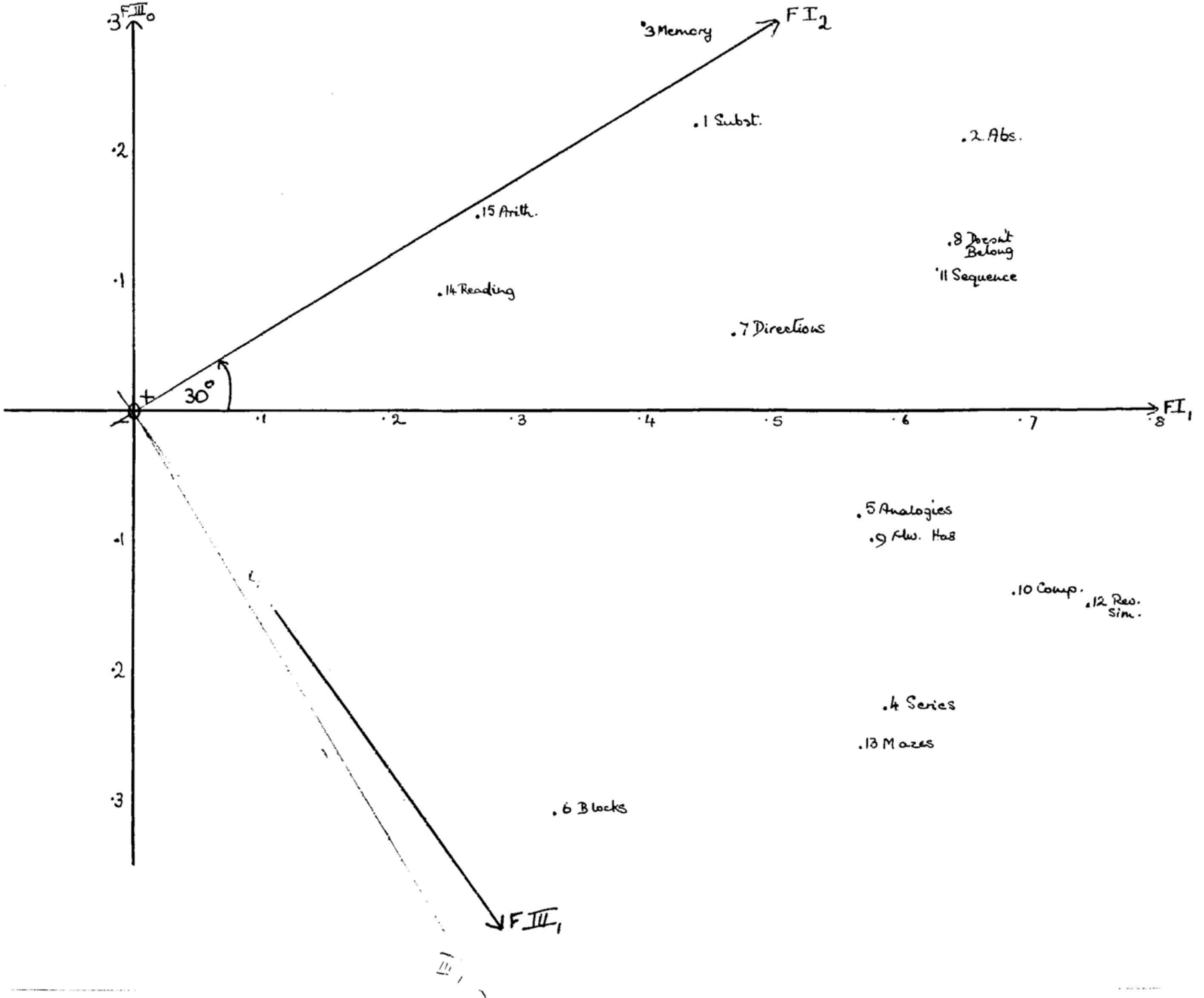


Fig. 2. Factors I_1 & III_0. Boys. Complete Battery.



A rotation of I_o and II_o through 20° in the positive direction achieved this, using the transformation matrix to find the new loadings:-

$$\begin{bmatrix} I_o & II_o \\ .93969 & .34202 \\ .34202 & -.93969 \end{bmatrix}$$

This gave loadings in Factor II of Reading .63, Arithmetic .59, Series and Block Counting each .33, and Memory .22. The rest were insignificant.

A diagram was then made of I_1 with III_o (see fig. 2). Here tests 1, 3, 14 and 15 (Substitution, Memory, Reading and Arithmetic) group together on the positive side. To eliminate these from the third factor requires a rotation of both I_1 and III_o through 30° in the positive direction, and gives high positive loadings in III_1 to tests 4, 6, 10, 12 and 13 (Series, Block Counting, Completion, Reversed Similarities and Mazes). From the presence of Block Counting, Reversed Similarities and Mazes in this group it looked as though it might be a space factor. This rotation was therefore adopted, the transformation matrix being:-

$$\begin{bmatrix} I_1 & III_o \\ .86603 & .5 \\ .5 & -.86603 \end{bmatrix}$$

The final rotated loadings thus obtained are shown in Table IX below.

TABLE IX.

ROTATED FACTOR MATRIX.

Complete Battery. Boys.

Test No.	Test	I_2	II_1	III_1	h^2
1.	Substitution	.488	-.007	.026	.240
2.	Absurdities	.665	.004	.142	.463
3.	Memory	.497	.215	-.054	.296
4.	Series	.396	.325	.489	.501
5.	Analogies	.456	.066	.354	.337
6.	Blocks	.128	.326	.429	.306
7.	Directions	.436	.114	.180	.236
8.	Doesn't Belong	.614	.073	.208	.426
9.	Always Has	.450	.079	.371	.347
10.	Completion	.524	.140	.468	.513
11.	Sequence	.603	.187	.224	.448
12.	Reversed Similarities	.573	.086	.502	.587
13.	Mazes	.364	-.026	.512	.396
14.	Reading	.253	.626	.038	.457
15.	Arithmetic	.309	.589	.003	.442

The complete battery of tests for the girls was next considered. A diagram of Factors I_0 and II_0 (see fig. 3) shows the same antithesis between the scholastic and picture tests as/

Fig. 3. Factors I_o & II_o. Girls.
Complete Battery.

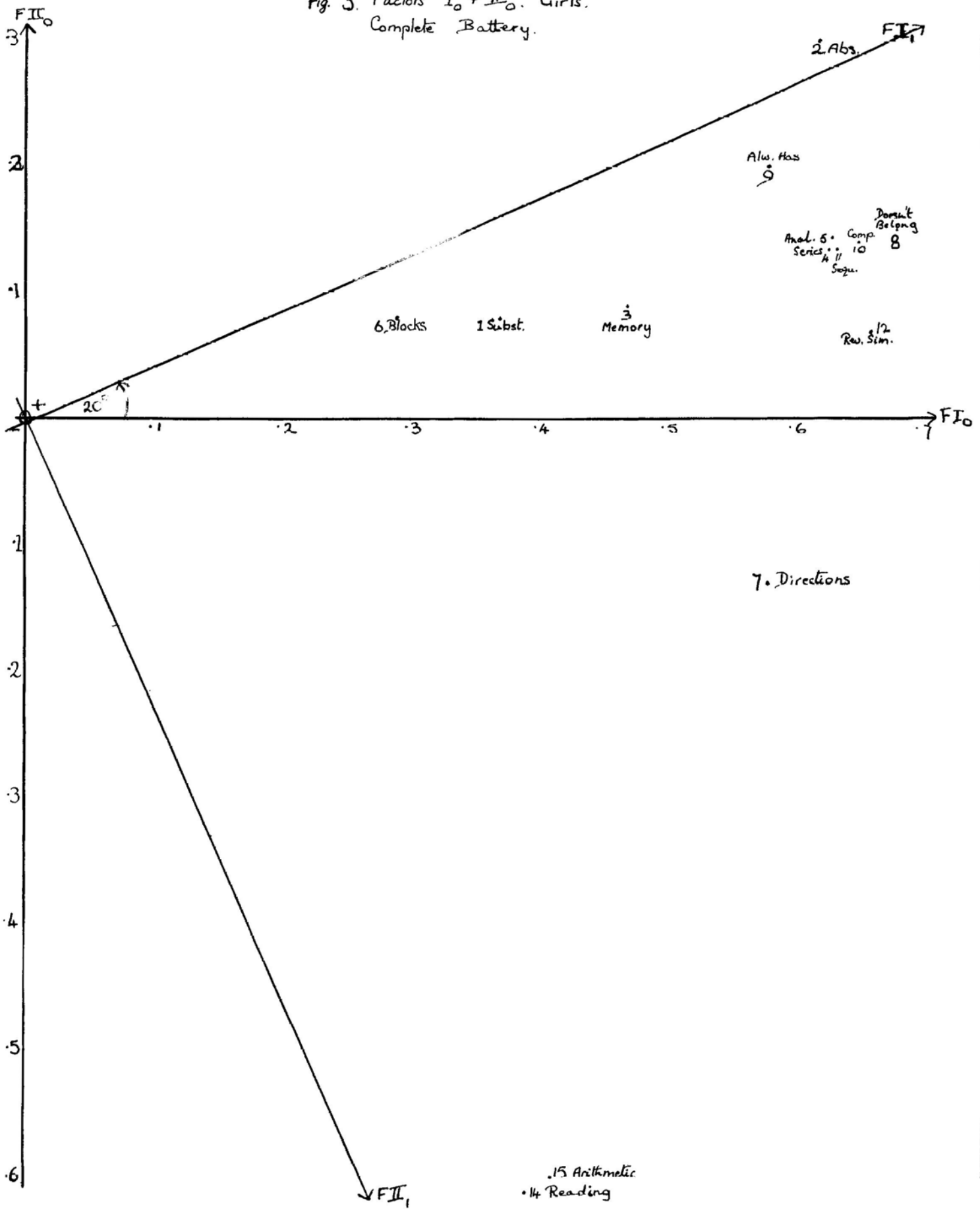


TABLE X.

ROTATED FACTOR MATRIX.

Complete Battery. Girls.

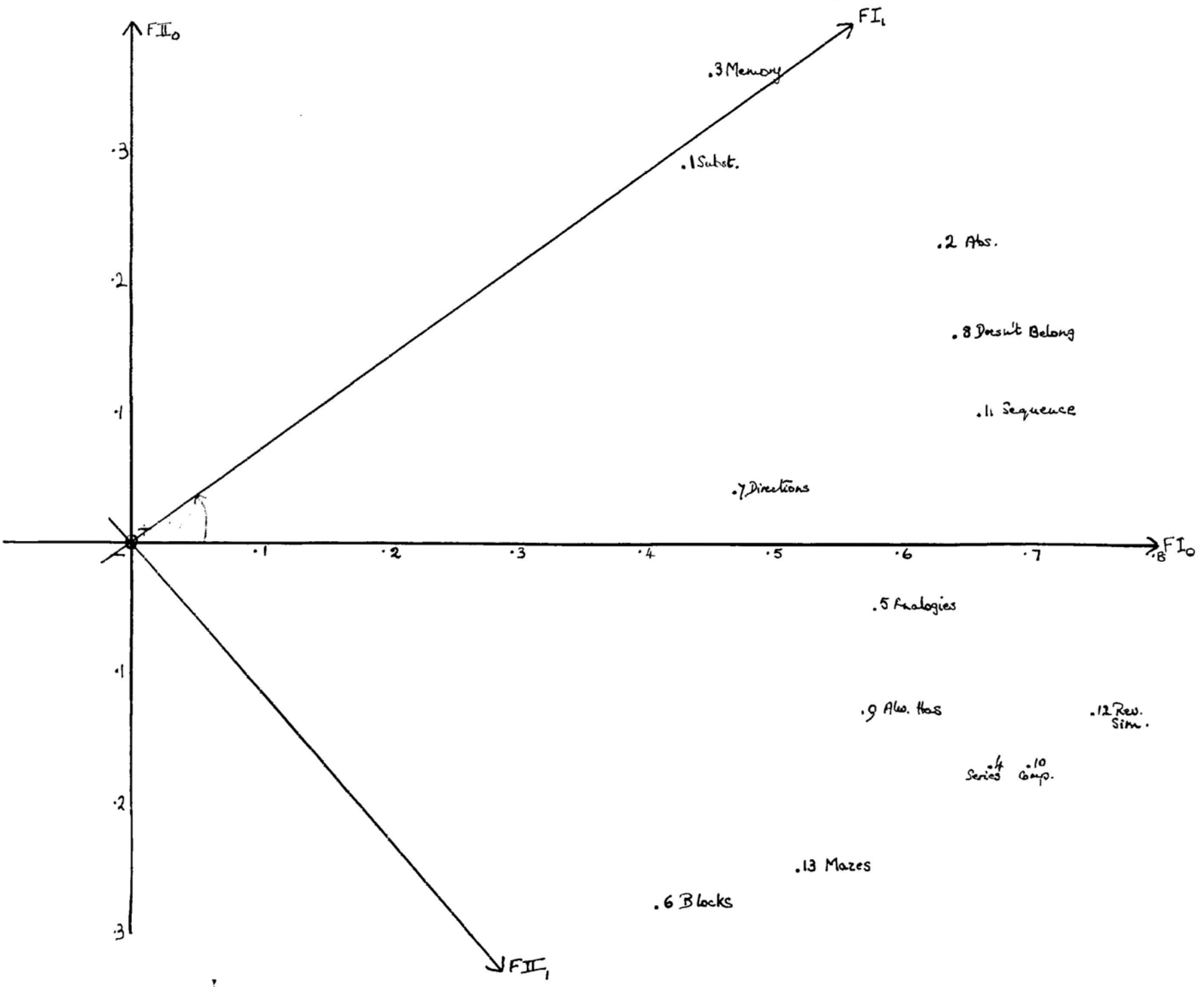
Test	I_1	II_1	h^2
1. Substitution	.374	.048	.142
2. Absurdities	.683	-.067	.471
3. Memory	.471	.080	.228
4. Series	.608	.163	.396
5. Analogies	.643	.081	.420
6. Blocks	.302	.025	.092
7. Directions	.498	.323	.352
8. Doesn't Belong	.691	.090	.477
9. Always Has	.611	.011	.373
10. Completion	.660	.093	.444
11. Sequence	.641	.085	.418
12. Reversed Similarities	.643	.155	.437
13. Mazes	-	-	-
14. Reading	.156	.711	.530
15. Arithmetic	.185	.712	.541

as for the boys, though the picture tests themselves as has before been mentioned were somewhat differently grouped. A rotation of I_o and II_o through 20^o in the positive direction was adopted as in the case of the boys. This gave loadings in Factor II, of .71 for each of reading and arithmetic, and .33 for Directions. The only other tests with loadings above even .1 were Series and Reversed Similarities.

Factor III in the girls' tests had already been shown to be insignificant; no further rotations were therefore necessary, and the final loadings are shown in Table X on the previous page.

The data for the picture tests alone were next examined. The boys' results were again taken first, and a diagram made of I_o with II_o (see fig. 4). It is clear from the centroid loadings that Factor II here is the same as Factor III in the complete battery. It was therefore desired so to rotate I_o and II_o that tests 1 and 3 (Substitution and Memory) would be eliminated from the second factor and tests 6, 12 and 13 (Block Counting, Reversed Similarities and Mazes) given as high loadings as possible.

Fig. 4. Factors I_o + II_o. Boys. Picture Tests Only.



This was achieved by rotating I_o and II_o 35° in the positive direction, the transformation matrix being:

$$\begin{bmatrix} I_o & II_o \\ .81915 & .57358 \\ .57358 & -.81915 \end{bmatrix}$$

As no further significant factors were found in the original analysis, no further rotations were necessary. The final rotated loadings are shown in Table XI below:

TABLE XI.

ROTATED FACTOR MATRIX.

Picture Tests Only. Boys.

Test	I_1	II_1	h^2
1. Substitution	.522	.011	.273
2. Absurdities	.647	.178	.450
3. Memory	.573	-.033	.329
4. Series	.448	.525	.476
5. Analogies	.442	.375	.336
6. Blocks	.176	.459	.242
7. Directions	.413	.237	.227
8. Doesn't Belong	.613	.238	.432
9. Always Has	.389	.431	.329
10. Completion	.472	.537	.511
11. Sequence	.597	.291	.441
12. Reversed Similarities	.542	.533	.578
13. Mazes	.277	.502	.329

In the picture tests for the girls only one significant factor was found, so that no rotations can be performed, and we can only accept the loadings as they stand as representing the saturations of the various tests in the one general factor present in the battery.

CHAPTER 6.

INTERPRETATION OF FACTORS.

It has been shown that the scores in the thirteen picture tests and reading and arithmetic can be adequately accounted for by three common factors for the boys and two for the girls, while those of the picture tests themselves are explained by two common factors for the boys and one only for the girls. The centroid and rotated loadings in these factors are shown in Table XII opposite.

Considering the first two factors in the complete battery, we find that the first is clearly a general factor involved in varying amounts in all the picture tests and at least slightly in the scholastic tests. The highest loading for the boys in the first centroid factor is in Reversed Similarities, .73, while Absurdities, Series, Doesn't Belong, Completion and Sequence follow not far behind, all being above .6. For the girls the same six tests along with Analogies all have loadings above .6, though Reversed Similarities comes second in the list instead of at the top. The smallest loadings for both boys and girls are in Substitution, Memory Span and Block Counting. Reading and Arithmetic are about equal to these three lowest of the picture tests.

This/

This seems as if the first centroid factor were much the same as what teachers and others mean by "general intelligence". The tests with the lowest loadings in it are those which had to be rejected after the first try-out. Of the remaining tests, Reversed Similarities, which has the highest loading in the first centroid factor for the boys and second highest for the girls, agreed better than any other single one of the picture tests with teachers' estimates of intelligence in the second try-out. But the term "general intelligence" does not necessarily denote a single unitary function. It may involve verbal and number ability, or speed, or some form of memory as well as pure "g". We cannot therefore equate the first centroid factor with "g" just because it agrees with teachers' estimates of intelligence. Indeed it is very likely that rotation with the other centroid factors is necessary before the first factor will show the "g" loadings of the tests.

The second centroid factor is defined chiefly by the reading and arithmetic tests with loadings of -.51 and -.46 respectively for the boys, and -.62 and -.61 for the girls. The tests that group most closely with these are Memory, Series and Block Counting for the boys, and Directions for the girls. All the loadings apart from the scholastic tests are however very small. The highest positive loadings are for/

TABLE XII.

Centroid and Rotated Loadings of all Significant Factors.

I. CENTROID.

	BOYS					GIRLS		
	Complete Tests			Picture Tests		Complete Tests		Picture Tests
Test	I	II	III	I	II	I	II	I
1. Substitution	41	16	22	43	29	37	08	39
2. Absurdities	61	22	21	63	23	62	30	66
3. Memory	45	-07	30	45	36	47	09	48
4. Series	66	-11	-23	67	-17	63	14	63
5. Analogies	56	13	-08	58	-05	63	14	64
6. Blocks	42	-20	-31	41	-28	29	08	30
7. Directions	48	05	06	47	04	58	-14	55
8. Doesn't Belong	62	15	13	64	16	68	15	68
9. Always Has	57	12	-10	57	-13	58	20	60
10. Completion	69	10	-14	70	-17	65	14	67
11. Sequence	66	04	11	66	10	63	14	64
12. Reversed Similarities	73	17	-15	75	-13	66	07	67
13. Mazes	53	22	-26	52	-25	-	-	-
14. Reading	44	-51	09	-	-	39	-62	-
15. Arithmetic	46	-46	15	-	-	42	-61	-

II. ROTATED.

	BOYS					GIRLS		
	Complete Tests			Picture Tests		Complete Tests		Picture Tests
	'g' I_2	Schol. II_1	Sp. III_1	'g' I_1	Sp. II_1	'g' I_1	Schol. II_1	'g' I_o
1. Substitution	49	-01	03	52	01	37	05	39
2. Absurdities	67	00	14	65	18	68	-07	66
3. Memory	50	22	-05	57	-03	47	08	48
4. Series	40	33	49	45	53	61	16	63
5. Analogies	46	07	35	44	38	64	08	64
6. Blocks	13	33	43	18	45	30	02	30
7. Directions	44	11	18	41	24	50	32	55
8. Doesn't Belong	61	07	21	61	24	69	09	68
9. Always Has	45	08	37	39	43	61	01	60
10. Completion	52	14	47	47:	54	66	09	67
11. Sequence	60	19	22	60	29	64	09	64
12. Reversed Similarities	57	09	50	54	53	64	16	67
13. Mazes	36	-03	51	28	50	-	-	-
14. Reading	25	63	04	-	-	16	71	-
15. Arithmetic	31	59	00	-	-	19	71	-

N.B. All decimal points in this table have been omitted.

for the boys in Absurdities and Mazes, for the girls Absurdities and Always Has. If we are to attempt to give an interpretation to this factor as it stands, it would be better to reverse its direction, giving positive signs to the two scholastic tests and negative to most of the picture tests. We then have the choice of attempting to find a bi-polar factor to fit the figures, with the reading and arithmetic tests at the one end, and Absurdities, along with Mazes for the boys and Always Has for the girls at the other, the ability involved in each group actually interfering with performance in the other; or of regarding the loadings not as absolute values but as variations about a mean at zero, the tests with the highest negative loadings involving least of this factor, while those with highest positive involve most. It is very difficult to think of any ability which could be highly involved in the performance of the word reading and mechanical arithmetic tests while at the same time interfering with Absurdities, Mazes and Always Has. If, however, we regard the loadings as relational measures, the interpretation will be almost the same as for the rotated factor, for the general effect of rotation is to make high loadings at the positive or negative end higher still, while zero loadings are brought up to a medium value, and high loadings at the other end made zero. Looking at the centroid and rotated/

rotated loadings of the second factor for the boys for instance, we find that reading and arithmetic, which have the highest loadings in the centroid factor, have higher still after rotation. The three other tests with the same sign as these two in the centroid factor are Memory, Series and Block Counting. These are the only other ones with significant positive loadings after rotation. Absurdities and Mazes, which are at the other end of the pole in the centroid factor, go out with zero loadings after rotation. And the effect of rotation is similar in the case of the girls.

It seems to the writer therefore that the rotated matrix offers a very much clearer picture for interpretation than the centroid matrix. The first factor for both boys and girls remains as a general factor present in all the picture tests and also slightly, at least for the boys, in the reading and arithmetic tests; the loadings of these two in the case of the girls are barely significant, both being under .2. We may probably say that it shows at least an approximation to the pure "g" loadings of the tests, though it may also involve some other factor or factors which the battery has proved itself inadequate to define, particularly in the case of the girls, where no other significant factor has appeared among the picture tests.

The second factor, defined largely by the reading and arithmetic tests, is clearly a school learning factor of some kind/

kind, possibly of a mixed verbal-number nature since it seems to appear equally in both tests, more probably something to do with the fact that both are concerned with something which has been actually taught in school, while the picture tests are not. The two picture tests with loadings above .3 in this factor for the boys are Series and Block Counting. Both these seem to have something in common with arithmetic, the counting of blocks, and probably counting the rings and crosses in the Series test. The only other significant loading is in the Memory test (.22) in which the children had to look at a row of pictures and then cross out the ones mentioned by the examiner; the number to be remembered at once increased gradually from two in the first item to nine in the last. The writer's own method of remembering disconnected lists such as this is to count how many items are to be reproduced, and then afterwards use auditory images of the actual words to reach the required number. Some such process as this may lead to a slight loading in this number-verbal factor for the Memory Span test, or it may be that memory is in itself in some way involved in the factor, for it certainly plays a large part in the early stages of reading and mechanical arithmetic.

In the case of the girls, the only one of the picture tests with a significant loading in the second factor is

Directions/

Directions (.32). Clearly, as for the boys, this is a school learning factor of some kind, the loadings in reading and arithmetic being high and equal. But whereas for the boys it seems from the presence of Series and Block Counting to be rather a number than a verbal factor, for the girls it seems to be rather verbal than number for Series and Block Counting are both absent, while the Directions test chiefly involves the comprehension and remembering of precise verbal instructions.

No further significant factors appeared in the girls' data, but for the boys a third factor in the complete battery and second among the picture tests was proved significant. This factor before rotation has its highest positive loadings in Substitution, Absurdities, Memory, and a barely significant loading in Arithmetic; its highest negative loadings are in Series, Block Counting, Mazes, and a very small one in Reversed Similarities. As in the case of the second factor, if the centroid loadings are considered as relational measures about a mean, the resulting interpretation will be much the same as if the factor is rotated to eliminate negative loadings. A possible bi-polar factor here might be one with tests depending on memory, learning and previous experience at the one end, while those dependent on a direct perception of the solution to the given material were at the other. This would/

would suppose however that a structure of mind favourable to quick learning and memorizing and reproduction of such learned material, at the same time actively hindered the imaginal visual manipulation of presented material, and vice-versa. This seems to the writer to be a possible but very improbable state of affairs. Moreover, if a bi-polar interpretation is given to this factor, it would be necessary to find such an interpretation also of the second factor, for both boys and girls, which we have already found it impossible to do.

Accepting then that rotation was necessary to give a clear interpretation of this factor the question arose whether the axis should be placed to give high loadings to the tests at the positive or those at the negative pole of the centroid factor. The highest positive loading is .30, the highest negative .31, so that there is nothing in this to show which is better. When the diagram of factor I_1 and III_0 was examined however it was found that the negative tests were so scattered that a negative rotation would eliminate only one test, Block Counting, from this factor, unless some significant negative loadings were allowed to remain.. A positive rotation would however eliminate four tests, Substitution, Memory, Reading and Arithmetic. Another point in favour of the positive rotation was that it would give high loadings to Block Counting and Mazes, the two tests in which the boys did better than the girls. It seemed reasonable/

reasonable to suppose that a factor found in the boys' results but not in the girls' should be largely concerned with these two tests.

Factor III therefore was found to have high loadings, in this order, in Mazes, Reversed Similarities, Series, Completion, Block Counting, Always Has and Analogies; low, but probably significant, loadings in Doesn't Belong and Sequence; and to be absent from Substitution, Memory, Reading and Arithmetic; and almost absent from Absurdities and Directions. This very definitely suggests that it is a space factor, involving ability to manipulate given material through visualisation, without any overt manipulation. Such an ability would have little to do with success in any of the tests not present in this factor, and would obviously be of great use in almost all those which have a significant positive loading. The most puzzling test present in the factor is Analogies, which involves not seeing something directly in the presented pictures, but a relationship between two of them, and moreover the instructions for the test are such that the child is encouraged always to verbalise the relationship. In spite of this however the writer is inclined to identify this factor as a space factor. This factor is the same as that which appears second in the analysis of the picture tests alone, and the interpretation of all the significant factors found/

found is therefore completed.

Perhaps the most interesting fact that emerges is that whereas two common factors, a general and a space factor, are needed in addition to specifics to explain the scores of the boys in the picture tests, one general factor alone, along with the specifics, is sufficient to account for the girls' scores. It seems as if the space factor is entirely lacking in girls at this age. One of the tests by which it is defined, Mazes, is missing from the girls' battery, but the remaining ones should have been sufficient to show it up had it been present, without allowing it to become absorbed in either the general factor or one of the specifics. In the Block Counting and Mazes tests the boys did significantly better than the girls, but in the Reversed Similarities and other tests with significant loadings in the space factor for the boys, there was no difference between the mean scores for boys and girls. This seems to indicate that the girls, even if lacking in the visual-manipulative ability possessed by the boys, can yet succeed in these tests by the exercise of their general intellectual ability. Indeed it seems clear that different individuals do perform the same task in different ways, and that the factorial composition of any test, while it must, if our analyses have any objective factual basis, remain invariant for the same or similar groups of subjects, might yet vary considerably with groups dissimilar in sex, age, or environment.

CHAPTER VII.

SUMMARY AND CONCLUSIONS.

A battery of 14 picture tests, a word reading test, and a mechanical arithmetic test was given to a group of 414 7 year old elementary school children, 218 boys and 196 girls. The intercorrelations of test scores, both of the complete battery and of the Picture Tests alone, were analysed by Thurstone's centroid method into three common factors and specifics, separately for boys and girls. Fitting one factor by the maximum likelihood method to the Picture Test results both for boys and girls showed that one general factor and specifics were sufficient to explain the girls' picture test scores and two common factors and specifics their scores in the complete battery, while for the boys two common factors and specifics were needed to explain the picture test scores, three common factors and specifics for the scores in the complete battery.

The centroid factor matrices were then rotated to eliminate negative loadings and as far as possible maximise zero loadings. Interpretations of both centroid and rotated factors were then discussed. It was not found possible to give a satisfactory interpretation of the centroid matrices in terms of bi-polar factors, and when the loadings were treated as relational measures about a mean at zero the interpretation was very similar to that of the rotated factor matrices. It

was/

was therefore considered preferable to deal with the rotated matrices for purposes of interpretation.

The first factor in every case was found to be a general factor present in all the picture tests, and slightly in the scholastic tests. It was impossible to eliminate this general factor without either allowing significant negative loadings in some factors, or else departing from the principle of orthogonal factors. The presence of a general factor was therefore accepted.

The second factor present in the complete battery but not present when the picture tests alone were analysed, was identified as a scholastic factor of a mixed number-verbal nature and possibly slightly influenced by memory. From the slight loadings of the picture tests in this factor it was suggested that it tended to be rather more number than verbal for the boys but rather more verbal for the girls.

The factor appearing third in the complete battery for the boys, second among the picture tests but not present at all in the girls' results, was identified as a space factor. In two of the tests with loadings in this factor, Block Counting and Mazes, the boys did better than the girls, but in the remaining ones there was no significant sex difference. It seemed therefore that the absence of a space factor in girls of this age prevented their being able to do these two tests as well as the boys; but the other tests involving a space factor for the boys were equally well performed by the girls by/

by means of their general intellectual ability.

No conclusions can be drawn as to whether girls are altogether lacking in the ability indicated by the space factor, or whether this ability is merely later in appearing for the girls than for the boys. It was however found in a large scale experiment with tests in an English County Borough prior to the Scottish Mental Survey[15] of 1932 that a block counting test was useless as a measure of general intelligence at 11 years old because of a significant sex difference in favour of the boys. There is also a general tendency noticeable for boys to do better than girls in tests of mechanical ability, which is probably very largely dependent on spatial judgment. It seems therefore that even if the space factor does appear among girls at a later age it is still in a less degree than for the boys.

Our general conclusions are therefore that at seven years old there is a general intellective factor operative in girls and boys; that there is already a scholastic factor, distinct from the general factor, and possibly resulting from two years' experience of school learning; and that a space factor distinct from both the above is already present among boys, but that there is no sign of such a factor among girls whether it may appear at a later age or not.

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APPENDIX I.

Table Showing Number of Subjects from Each School.

School	Boys	Girls	Total
A	40	28	68
B	26	19	45
C	40	29	69
D	34	36	70
E	14	22	36
F	35	30	65
G	29	32	61
	218	196	414

Table Showing Distribution of Ages.

Age	Boys	Girls	Total
6.7	8	12	20
8	11	8	19
9	13	11	24
10	27	25	52
11	30	21	51
7.0	31	21	52
1	24	22	46
2	17	27	44
3	18	16	34
4	18	18	36
5	11	8	19
6	10	7	17
	218	196	414

APPENDIX II.

Distributions of Raw Scores in Picture Tests and of Reading and Arithmetic Quotients.

Score	TEST 1a. SUBSTITUTION		2a. CLASSIFICATION	
	Boys	Girls	Boys	Girls
18	69	67		
17	11	5		
16	13	5		
15	21	17		
14	7	6		
13	12	12		
12	16	13		
11	18	15		
10	11	13	3	-
9	14	9	1	-
8	10	12	2	1
7	2	4	1	2
6	4	6	3	3
5	3	5	5	3
4	1	2	6	4
3	2	1	14	10
2	3	1	19	30
1	-	-	15	45
0	1	3	105	98

	2	TEST	3
	3a. ABSURDITIES		4a. MEMORY SPAN
Score	Boys	Girls	Boys	Girls
15	-	-	-	-
14	-	-	-	-
13	2	-	-	-
12	9	-	33	35
11	9	4	43	30
10	15	9	38	51
9	18	16	36	27
8	21	20	30	27
7	28	23	23	12
6	24	30	8	6
5	25	15	4	2
4	18	26	2	3
3	21	17	-	1
2	12	17	1	1
1	9	14	-	-
0	7	5	-	1

4 TEST 5

Score	5a. SERIES Boys	Girls	6a. ANALOGIES. Boys	Girls
15	-	-	-	-
14	-	-	-	-
13	-	2	-	-
12	1	1	-	-
11	5	3	2	-
10	7	9	2	2
9	8	12	2	1
8	27	18	3	2
7	41	40	4	4
6	29	36	7	3
5	34	36	15	14
4	24	13	27	29
3	11	7	40	23
2	10	7	25	27
1	10	4	33	37
0	11	8	50	54
Σ	1215	1180		
N	218	196		
Mean	5.587	6.020		

6 TEST 7

Score	7a. CUBE COUNTING Boys	Girls	1b. DIRECTIONS Boys	Girls
15	6	-	6	3
14	13	2	8	9
13	22	3	12	9
12	29	13	13	10
11	13	13	25	18
10	25	16	36	25
9	25	12	26	30
8	14	30	37	32
7	17	23	17	18
6	22	25	14	18
5	17	16	11	14
4	6	16	7	5
3	3	8	3	2
2	1	5	1	3
1	1	3	-	-
0	4	11	2	-
Σ	2008	1366		
N	218	196		
Mean	9.211 = 61.41	6.969 = 46.46		

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Score	2b. DOESN'T BELONG Boys	2b. DOESN'T BELONG Girls	TEST	3b. ALWAYS HAS Boys	3b. ALWAYS HAS Girls
15	-	-		-	-
14	-	-		-	-
13	3	2		-	-
12	3	5		1	-
11	7	5		1	-
10	20	12		4	1
9	18	17		1	2
8	29	12		1	3
7	28	31		7	4
6	27	25		8	8
5	16	24		16	13
4	19	17		22	10
3	12	10		38	25
2	12	21		27	25
1	12	5		28	48
0	12	10		64	62

Test 10 TEST Test 11.

Score	4b. COMPLETION Boys	Girls	5b. SEQUENCE Boys	Girls
15	-	-	-	-
14	-	-	1	-
13	4	-	-	-
12	8	1	1	-
11	9	10	3	3
10	20	16	7	5
9	22	15	7	10
8	35	28	12	8
7	24	33	16	11
6	40	29	29	18
5	16	22	17	27
4	16	21	21	26
3	12	13	30	28
2	2	3	18	18
1	4	3	19	18
0	6	2	35	24
$\Sigma(fx)$	1521	1288		
N	218	196		
Mean	6.977	6.571		

Note U-distribution

	12 TEST 13			
	6b. REVERSED SIMILARITIES		7b. MAZES	
Score	Boys	Girls	Boys	Girls
15	6	5	60	17
14	20	10	30	9
13	23	6	7	6
12	17	23	11	6
11	19	24	10	8
10	19	13	6	2
9	14	14	2	2
8	10	8	1	1
7	6	14	4	4
6	14	4	4	-
5	6	10	2	6
4	7	12	7	2
3	11	13	2	6
2	7	4	1	7
1	15	22	5	11
0	24	14	66	109
Σ	1724	1442	1842	774
N	218	196	318	196
Mean	7.908	7.357	5.850 = 56.3%	3.949 38.0%

14 TEST 15

Quotient	READING Boys	READING Girls	ARITHMETIC Boys	ARITHMETIC Girls
170-174	1	-	-	-
165-169	-	-	-	-
160-164	-	-	-	-
155-159	-	-	1	-
150-154	2	1	2	-
145-149	-	1	1	-
140-144	3	2	-	4
135-139	2	4	6	6
130-134	2	5	8	15
125-129	8	7	15	18
120-124	16	15	18	14
115-119	18	19	23	21
110-114	23	27	26	25
105-109	14	21	28	26
100-104	33	33	23	16
95- 99	22	20	30	22
90- 94	32	15	20	16
85- 89	18	13	10	8
80- 84	12	10	5	2
75- 79	9	2	-	2
70- 74	2	1	-	-
65- 69	1	-	-	-
60- 64	-	-	-	-
55- 59	-	-	-	-
50- 54	-	-	-	-
45- 49	-	-	-	-
40- 44	-	-	1	1
35- 39	-	-	1	-

APPENDIX III.

A. Centroid Analysis of Girls' Picture Test Data.

The correlation matrix with guessed communalities in the diagonal cells for the girls' picture tests is shown in Table I, omitting all decimal points from the body of the Table. All calculations were actually carried out to six decimal places, but are shown rounded off to three in order to save space. The column totals and grand total are also shown. The 1st factor loadings are then found by dividing the column totals by the square root of the grand total, or, more conveniently on the electric calculating machine, multiplying by the reciprocal of the square root. The resulting loadings are also shown in Table I. A check on the loadings is obtained in that their sum is equal to the square root of the grand total.

The next step is to take out the effect of the first factor and so find the first residuals. The first factor matrix is found by cross multiplying the loadings in the first factor, and to find the residuals this matrix is subtracted from the original correlation matrix. Both processes may be performed in one operation on the calculating machine and the residual matrix is shown in Table II, again omitting decimal points. Some of the residuals are positive, some negative, and a check is obtained on them in that each column total, taking account of signs, comes to zero, apart from any discrepancy in the last decimal place due to rounding off.

Obviously/

Obviously with column totals of zero no further factors could be extracted: to avoid this the signs of some of the tests are changed. It is desirable to account for as much as possible of the variance with each factor taken out; therefore we want the column totals to be as large as possible. We look for any large negative residuals, and change the signs of one or other of the two tests responsible for them. The process of sign changing is shown in Table III. The original signs, disregarding communalities, are set out in a square table, and all desirable changes marked. The negative residuals greater than .08 are found in the cells corresponding to Tests 1 and 4, 1 and 8, 3 and 9, 3 and 12, 4 and 5, 7 and 8. To change the signs of Tests 1, 5, 7, 9 and 12 makes all these positive without making any correspondingly large ones negative. This procedure was therefore adopted, as shown in Table III.

The residual matrix can now be rewritten with the new signs. To avoid errors due to having guessed the communality in the first place, instead of retaining the residual communality in the diagonal cells, we again estimate it at the highest figure to be found in the column regardless of sign, giving itself of course a positive sign.

Table IV shows the residual matrix at this stage, and the calculation of 2nd factor loadings, which is exactly like the calculation of the 1st loadings from the original correlations. In the original analysis a 3rd factor was extracted by exactly the same process, but as only the first factor finally proved significant,/

significant, no further calculations need be shown. In writing out the loadings the important point to remember is that as we changed the signs in the residual matrix of Tests 1, 5, 7, 9 and 12 the loadings obtained for these tests in the 2nd and any further factors will be negative.

The loadings in the first two factors are therefore:

Test	I	II	h^2
1	.387	-.267	.221
2	.658	.128	.449
3	.479	.217	.277
4	.633	.119	.415
5	.642	-.173	.442
6	.304	.106	.104
7	.554	-.145	.328
8	.683	.194	.504
9	.596	-.162	.381
10	.666	.053	.446
11	.641	.105	.422
12	.667	-.195	.483
Variance	4.14	.33	4.472

The variance accounted for by each factor is found by taking the sum of the squares of the loadings in that factor and the communality (h^2) of each test by summing the squares of that test's loadings in each factor. If desired these obtained communalities may be put in the diagonal cells of the/

the correlation matrix instead of the guessed communalities with which we began and the whole analysis done again. But so little extra accuracy is thus gained that it is very rarely worth doing.

TABLE I.

Correlation Matrix. Girls. Picture Tests Only.

		1	2	3	4	5	6	7	8	9	10	11	12
1.	Subst.	(318)	254	205	133	318	086	242	165	246	248	204	253
2.	Abs.	254	(452)	406	381	440	233	340	452	378	452	381	376
3.	Mem. Span	205	406	(406)	331	283	151	233	300	178	327	262	225
4.	Series	133	381	331	(470)	318	140	412	467	379	462	413	470
5.	Anal.	318	440	283	318	(441)	171	333	440	428	441	384	437
6.	Blocks	086	233	151	140	171	(233)	113	220	166	212	188	188
7.	Direct	242	340	233	412	333	113	(444)	297	275	384	310	444
8.	Doesn't Belong	165	452	300	467	440	220	297	(535)	451	430	535	424
9.	Alw. Has	246	378	178	379	428	166	275	451	(451)	377	345	440
10.	Compl..	248	452	327	462	441	212	384	430	377	(462)	402	407
11.	Sequ.	204	381	262	413	384	188	310	535	345	402	(535)	471
12.	Mazes	253	376	225	470	437	188	444	424	440	407	471	(471)
	Totals	2.672	4.545	3.307	4.376	4.434	2.101	3.827	4.716	4.114	4.604	4.430	4.606
	1st Loadings	.387	.658	.479	.633	.642	.304	.554	.683	.596	.666	.641	.667

Grand Total = 47.732 $\sqrt{\text{Grand Total}}$ = 6.9089 recip. = .1447

TABLE II.

Residual Matrix 1.

	1	2	3	4	5	6	7	8	9	10	11	12
1.	(+169)	-001	+020	-112	+070	-032	+028	-099	+015	-009	-044	-005
2.	-001	(+019)	+091	-035	+018	+033	-024	+003	-014	+014	-041	-062
3.	+020	+091	(+177)	+028	-025	+005	-032	-026	-107	+008	-045	-094
4.	-112	-035	+028	(+069)	-088	-053	+061	+034	+002	+039	+007	+048
5.	+070	+018	-025	-088	(+029)	-024	-022	+002	+046	+013	-027	+009
6.	-032	+033	+005	-053	-024	(+141)	-056	+012	-015	+010	-008	-014
7.	+028	-024	-032	+061	-022	-056	(+138)	-081	-055	+015	-046	+075
8.	-099	+003	-026	+034	+002	+012	-081	(+069)	+045	-025	+098	-031
9.	+015	-014	-107	+002	+046	-015	-055	+045	(+097)	-020	-037	+043
10.	-009	+014	+008	+039	+013	+010	+015	-025	-020	(+018)	-025	-037
11.	-044	-041	-045	+007	-027	-008	-046	+098	-037	-025	(+124)	+043
12.	-005	-062	-094	+048	+009	-014	+075	-031	+043	-037	+043	(+026)
Totals	000	+001	000	-001	+001	-001	+001	+001	000	+001	-001	+001

TABLE III

Sign Changing Residual Matrix 1.

(Change signs of Tests 1, 5, 7, 9, & 12.)

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
−	1.	·	+	⊕	+	⊕ +	+	⊕ +	+	⊕ +	+	+	⊕
	2.	+	·	+	−	⊕	+	+	+	+	+	−	+
	3.	⊕	+	·	+	+	+	+	−	+	+	−	+
	4.	+	−	+	·	+	−	⊕	+	⊕	+	+	⊕
−	5.	⊕ +	⊕	+	+	·	+	⊕	⊕	⊕ +	⊕	+	⊕ +
	6.	+	+	+	−	+	·	+	+	+	+	−	+
−	7.	⊕ +	+	+	⊕	⊕	+	·	+	⊕	⊕	+	⊕ +
	8.	+	+	−	+	⊕	+	+	·	⊕	−	+	+
−	9.	⊕ +	+	+	⊕	⊕ +	+	+	⊕	·	+	+	⊕ +
	10.	+	+	+	+	⊕	+	⊕	−	+	·	−	+
	11.	+	−	−	+	+	−	+	+	+	−	·	⊕
−	12.	⊕	+	+	⊕	⊕ +	+	⊕ +	+	⊕ +	+	⊕	·

TABLE IV.

Residual Matrix 1. Changed Signs and New Communalities.

	1	2	3	4	5	6	7	8	9	10	11	12
1.	(112)	+001	-020	+112	+070	+032	+028	+099	+015	+009	+044	-005
2.	+001	(091)	+091	-035	-018	+033	+024	+003	+014	+014	-041	+062
3.	-020	+091	(107)	+028	+025	+005	+032	-026	+107	+008	-045	+094
4.	+112	-035	+028	(112)	+088	-053	-061	+034	-002	+039	+007	-048
5.	+070	-018	+025	+088	(088)	+024	-022	-002	+046	-013	+027	+009
6.	+032	+033	+005	-053	+024	(056)	+056	+012	+015	+010	-008	+014
7.	+028	+024	+032	-061	-022	+056	(081)	+081	-055	-015	+046	+075
8.	+099	+003	-026	+034	-002	+012	+081	(099)	-045	-025	+098	+031
9.	+015	+014	+107	-002	+046	+015	-055	-045	(107)	+020	+037	+043
10.	+009	+014	+008	+039	-013	+010	-015	-025	+020	(039)	-025	+037
11.	+044	-041	-045	+007	+027	-008	+046	+098	+037	-025	(098)	-043
12.	-005	+062	+094	-048	+009	+014	+075	+031	+043	+037	-043	(094)
Totals	.497	.239	.406	.221	.322	.196	.270	.359	.302	.098	.195	.363
2nd Loadings	.267	.128	.217	.119	.173	.106	.145	.194	.162	.053	.105	.195

Grand Total = 3.468 $\sqrt{\text{Grand Total}}$ = 1.8628 recip. = .5368

B. Fitting one Factor to Girls' Picture Test Results by "Maximum Likelihood" Method.

This method of estimating factor loadings is one of successive approximations. Its chief advantage lies in the fact that it is possible to determine mathematically how many factors are needed to account for the correlations obtained. It was for this reason that it was undertaken in the present investigation, as reasons had been found to suspect that the correlations between the picture tests could be adequately explained for the girls by one factor whereas for the boys two seemed to be needed.

In the following example the whole process of fitting one factor and of calculating the significance of the residuals for the girls' data is shown. As the correlation matrix has already been shown in Table I of Part A of this appendix, it need not be printed again here. For our present purpose however we must consider the diagonal cells as filled not by the guessed communality but unities.

We begin the process of approximation by taking the loadings of the first centroid factor. The whole process of calculation is then shown in Table I overleaf.

Beneath the first trial loadings are written the corresponding approximations to the specific variances. Rows (a_1), (b_1) and (c_1) then show the calculations for obtaining second approximations. Row (a_1) is found by dividing the trial loadings by the corresponding specific variances. The figures in row (b_1) are then given by the inner products of row (a_1) with the successive rows of/

of the correlation matrix (with unities in the diagonal cells). Row (c_1) is obtained by subtracting from the figures in row (b_1) the corresponding trial loadings. The quantity h^2_1 is given by the inner product of rows a and c, and hence, taking the square root of the reciprocal of this quantity, we find $1/h_1$. Finally row (d_1) is obtained by multiplying the figures in row (c_1) by $1/h_1$, or .146338. The resulting numbers are then second approximations to the loadings of the tests in Factor I.

The whole process is now repeated, as shown in rows (a_2), (b_2) and (c_2). Row (d_2) shows the third approximations to the loadings, which differ from the second approximations only in the third decimal place. This is sufficiently accurate for our purposes, and in order to test our hypothesis that one factor is sufficient to explain the data we now calculate in the usual way the residual correlations left after taking out the effect of this factor.

These residuals are shown in Table II, omitting all decimal points from the body of the Table and with the specific variances in the diagonal cells. The row and column totals are also shown at the sides. The measure by which we test our hypothesis is now denoted 'w'. To find it we square each of the residual correlations and divide by the product of the numbers in the corresponding pairs of diagonal cells. Thus, for example, the residual correlation for Tests 5 and 9 would be squared and divided by the product of the 5th and 9th diagonal elements, giving/

giving the result

$$\frac{(.047)^2}{.592 \times .645} = .005785$$

There are altogether 66 such terms, one for each residual correlation and 'w' is obtained simply by forming the sum of these terms and multiplying it by 196, the number of children in the sample. It is found to be 62.387.

The use of the χ^2 test to determine whether or not this value is significant has already been described in the body of the present work (See page 27).

TABLE I.

Fitting 1 Factor to Girls' Picture Test Data by Maximum Likelihood Method.

	Test	1	2	3	4	5	6	7	8	9	10	11	12
Trial Loading	1	.39	.66	.48	.63	.64	.30	.55	.68	.60	.67	.64	.67
Specif. Variance		.848	.564	.770	.603	.590	.910	.698	.538	.640	.551	.590	.551
	(a_1)	.456	1.169	.624	1.045	1.084	.330	.789	1.265	.938	1.216	1.084	1.216
	(b_1)	2.853	5.105	3.580	5.000	5.012	2.281	4.247	5.369	4.672	5.222	5.002	5.243
	(c_1)	2.463	4.445	3.100	4.370	4.372	1.981	3.697	4.689	4.072	4.552	4.362	4.573
				h_1^2 = 46.6968		h_1 = 6.8335		$1/h_1$ = .1463					
2nd Approx.	(d_1)	.360	.651	.454	.640	.640	.290	.541	.686	.596	.666	.638	.669
Specif.Variance		.870	.577	.794	.591	.591	.916	.707	.529	.645	.556	.593	.552
	(a_2)	.414	1.128	.571	1.082	1.083	.317	.765	1.296	.924	1.197	1.077	1.212
	(b_2)	2.782	5.031	3.504	4.983	4.962	2.247	4.195	5.346	4.631	5.166	4.965	5.201
	(c_2)	2.422	4.381	3.051	4.344	4.322	1.957	3.654	4.660	4.036	4.500	4.327	4.532
				h_2^2 = 45.7895		h_2 = 6.7668		$1/h_2$ = .1478					
3rd Approx.	(d_2)	.358	.647	.451	.642	.639	.289	.540	.689	.596	.665	.639	.670
Specif.Variance		.872	.581	.797	.588	.592	.917	.708	.525	.645	.558	.592	.551

TABLE II.

1st Residuals.

Signs are omitted, as these quantities are all squared before being used.

	1	2	3	4	5	6	7	8	9	10	11	12
1	(872)	022	044	097	089	018	048	082	032	010	025	013
2	022	(581)	114	034	027	046	009	006	007	022	032	057
3	044	114	(797)	041	006	020	010	010	091	027	026	077
4	097	034	041	(588)	092	045	065	027	002	037	005	042
5	089	027	006	092	(592)	014	012	001	047	016	024	009
6	018	046	020	045	014	(916)	044	021	006	020	003	005
7	048	009	010	065	012	044	(708)	075	047	024	035	083
8	082	006	010	027	001	021	075	(525)	041	028	095	038
9	032	007	091	002	047	006	047	041	(645)	019	036	040
10	010	022	027	037	016	020	024	028	019	(558)	023	039
11	025	032	026	005	024	003	035	095	036	023	(592)	043
12	013	057	077	042	009	005	083	038	040	039	043	(551)

C. Rotation of Factors. Girls' Complete Battery.

The girls' complete battery had two significant factors, which required to be rotated to eliminate the negative loadings in the second factor before a psychological interpretation could be given to the factors.

The first step is to make a diagram with Factor I_o as its horizontal axis and Factor II_o as the vertical. Each test can then be represented by a point the co-ordinates of which are its loadings in these two factors. The cosines of the angles between the test vectors are then equal to the correlations between the tests in so far as they are accounted for by these two factors, and the cosines of the angles between the test vectors and the two axes are equal to the loadings of the tests in the two factors. Such a diagram for Factors I_o and II_o in the present instance is shown in Figure I overleaf.

Clearly the second factor shows a marked antithesis between the scholastic tests (Reading and Arithmetic) and the picture tests; it is in fact largely defined by the two scholastic tests. Our object in rotation then is to give as many zero loadings as possible to the picture tests in this second factor, making the reading and arithmetic loadings as high as possible, and at the same time leaving no significant negative loadings.

Tests 4, 5, 8, 10 and 11 all cluster very closely together, and/

and if the first axis were placed through that group they would certainly all be eliminated from the second factor. But this would leave Test 2 and probably Test 9 as well with a significant negative loading. The best plan therefore seems to be to place the first axis between Tests 2 and 9, thus eliminating Tests 2, 6, and 9 from the second factor and probably Tests 1 and 3 as well, while even the cluster of Tests 4, 5, 8, 10 and 11 may not have significant loadings. This involves a rotation of 20° reversing the direction of the second axis so that all the tests may come in the positive quadrant.

The loadings of the tests in the rotated factors are then equal to the cosines of the angles between the test vectors and the new axes, and are found for I_1 by taking $x \cos\theta + y \sin\theta$ and for II_1 by $x \sin\theta - y \cos\theta$ when x = the loading in I_o and y the loading in II_o. The process of calculation is shown in Table I below, and is checked by seeing that the communalities remain the same after as before rotation.

Figure 1

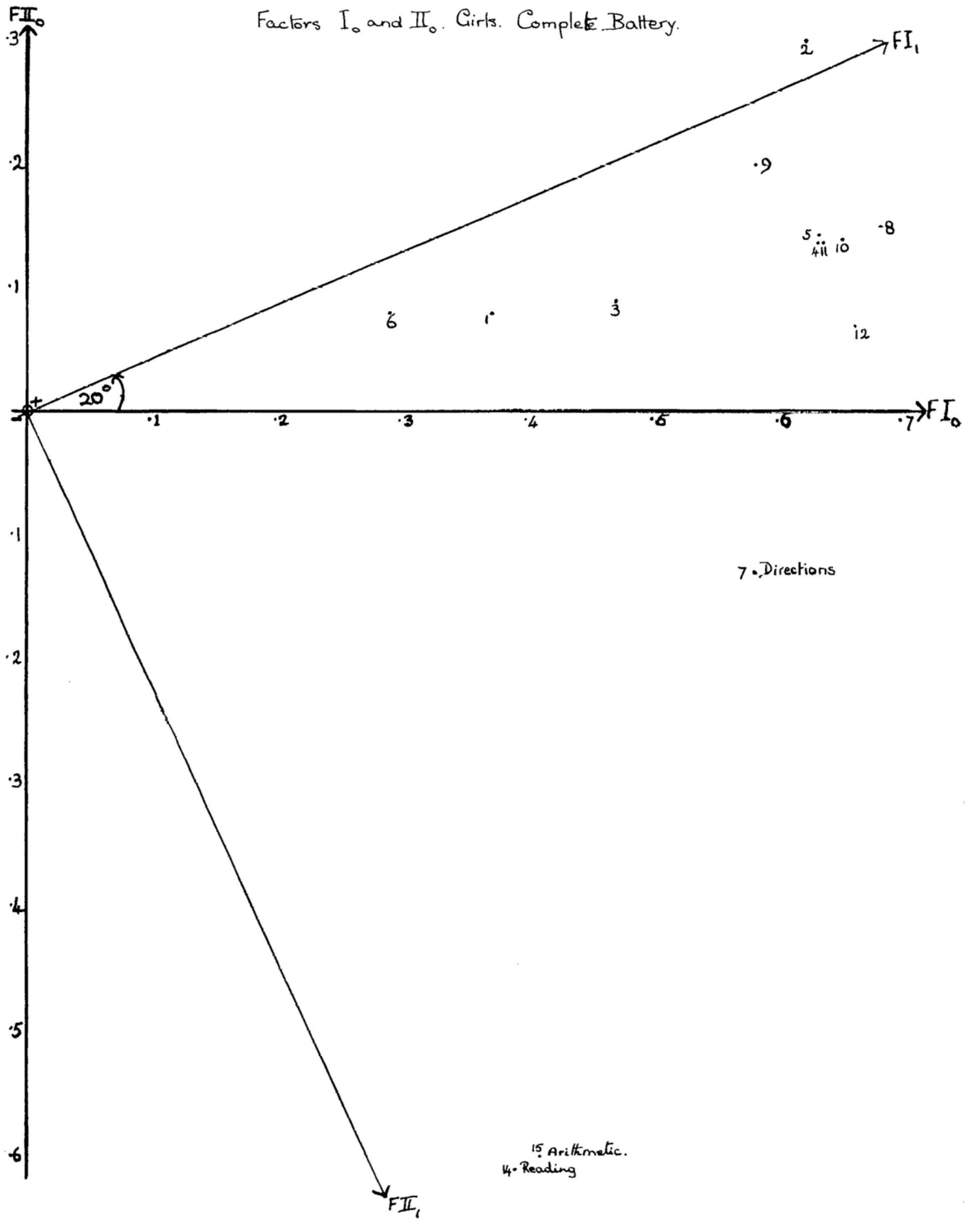

Factors I_o and II_o. Girls. Complete Battery.
FII_o
FI_1
FI_o
FII_1
20°
·1
·2
·3
·4
·5
·6
·7
·8
·9
1
2
3
4
5
6
7. Directions
8
9
10
11
12
15. Arithmetic.
14. Reading

TABLE I.

Rotation of I_o and II_o through 20°. ($\sin\theta = .34202$, $\cos\theta = .93969$).

Test	I_o	II_o	h^2	.93969 x I_o	.34202 x II_o	I_1	.34202 x I_o	-.93969 x II_o	II_1
1.	.368	.083	.142	.3456	.0284	.374	.1258	-.0779	.048
2.	.619	.297	.471	.5816	.1014	.683	.2117	-.2786	-.067
3.	.470	.086	.228	.4415	.0292	.471	.1607	-.0803	.080
4.	.631	.139	.396	.5895	.0189	.608	.2145	-.0520	.163
5.	.632	.141	.420	.5936	.0491	.643	.2161	-.1350	.081
6.	.292	.080	.092	.2746	.0272	.302	.0999	-.0747	.025
7.	.579	-.135	.352	.5437	-.0462	.498	.1979	.1270	.325
8.	.680	.152	.477	.6388	.0521	.691	.2325	-.1430	.090
9.	.578	.198	.373	.5429	.0678	.611	.1976	-.1863	.011
10.	.652	.138	.444	.6131	.0472	.660	.2231	-.1298	.093
11.	.631	.139	.418	.5929	.0476	.641	.2158	-.1308	.085
12.	.658	.071	.437	.6179	.0254	.643	.2249	-.0699	.155
14.	.390	-.615	.530	.3664	-.2102	.156	.1334	.5775	.711
15.	.417	-.606	.541	.3920	-.2072	.185	.1427	.5694	.712

APPENDIX IV.

Specimen Copies of Tests

A. M.H.T. (Pic) 1. (Draft 1a)

and

M.H.T. (Pic) 1. (Draft 1b)

B. Instructions for Administration
M.H.T. (Pic.) 1. (Drafts 1a and 1b)

C. Subject's Score Card

page 77

MORAY HOUSE EXPERIMENTAL

PICTURE TEST

Name..... Sex F

Date of Birth..... Date of Test..... Age 6 yrs 7 m.

School..... Class.....

TEST	SCORE
1.	
2.	
3.	4
4.	7
5.	3
6.	
7.	
TOTAL	9
Signature of Marker:	

NOTES

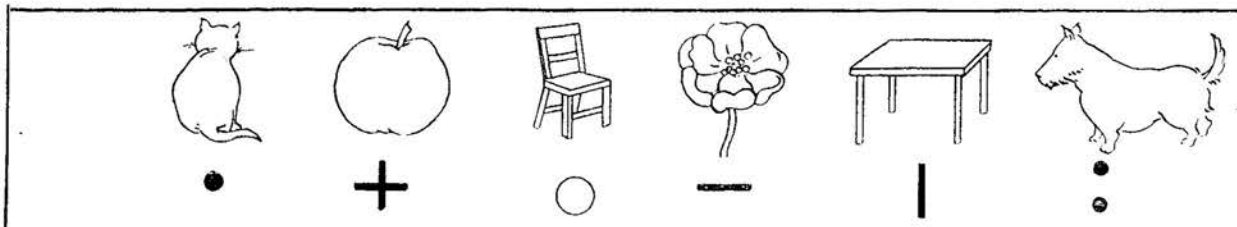
Binet I.Q. (if known)..... Date of Test.....

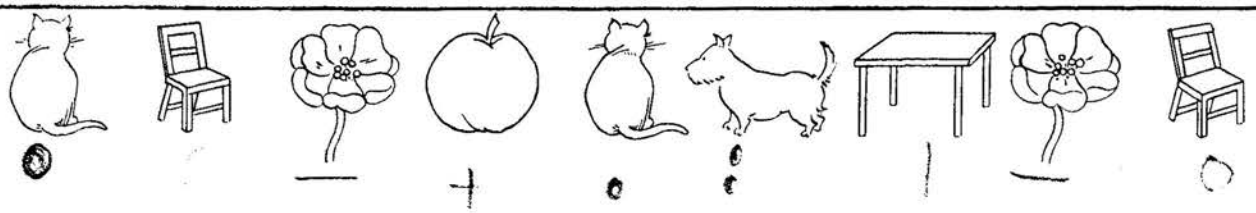
C.A. at date of Binet Test.....

M.A. at date of Binet Test.....

M.H.T.(Pic.) 1. (Draft 1a).

TEST 1. Substitution



a 

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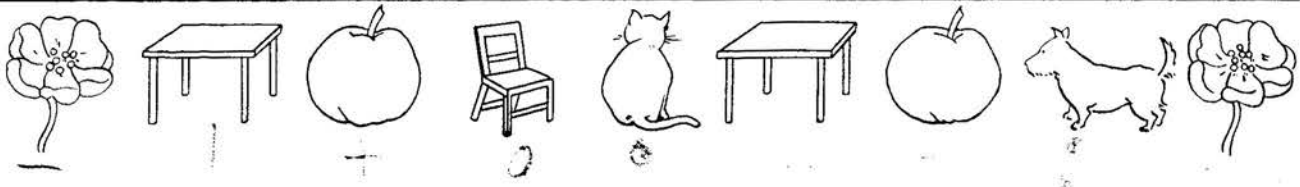
c

1 

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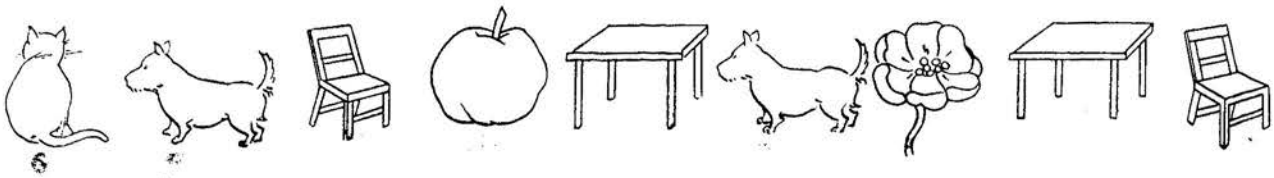
3 

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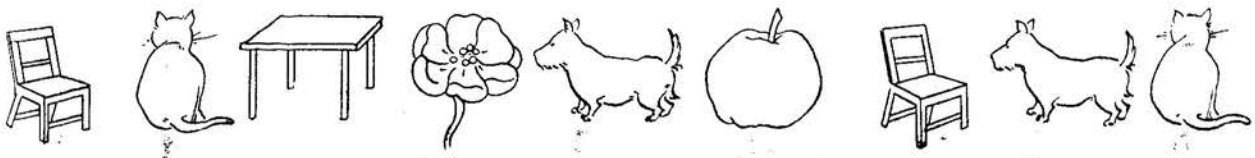
6 

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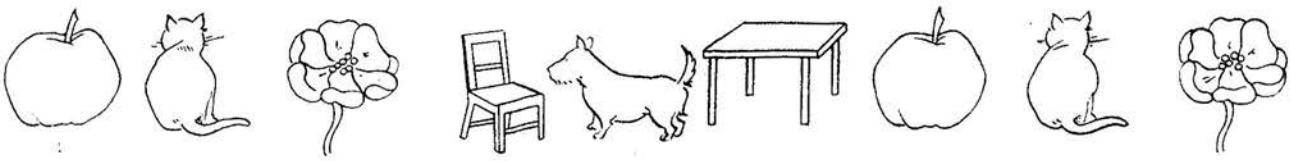
9 

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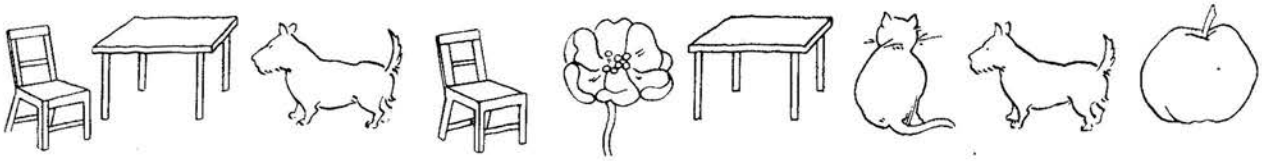
12 

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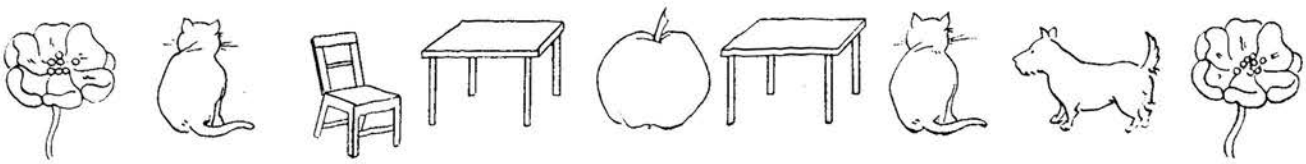
15 

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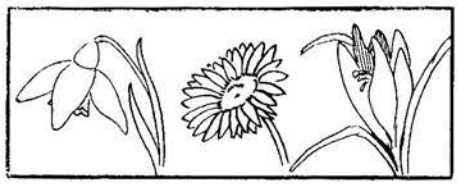
17

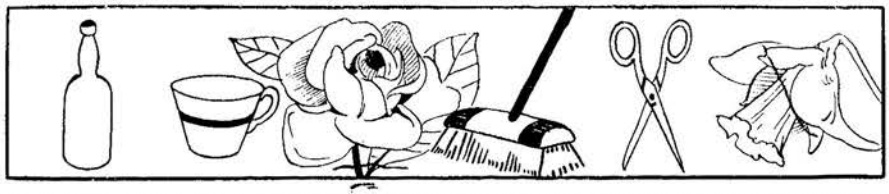
18

Score.....

TEST 2. Classification

a





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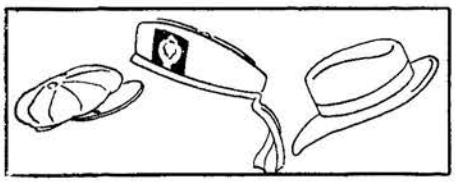

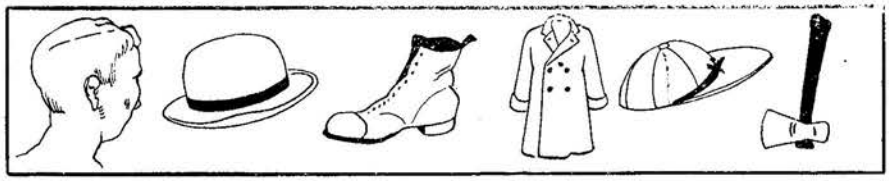

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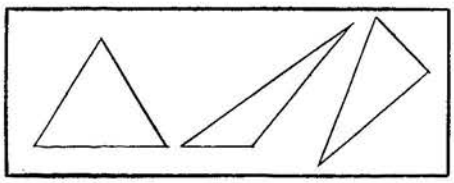

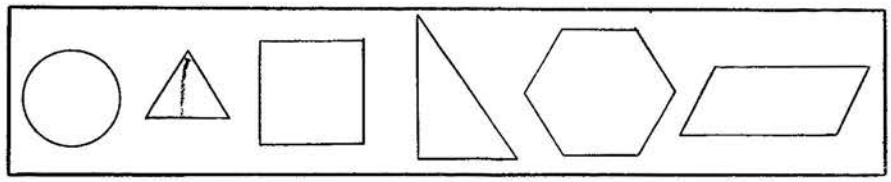

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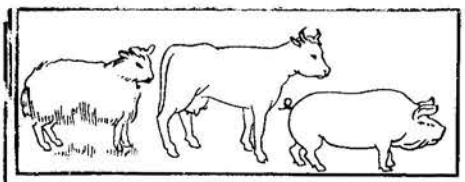

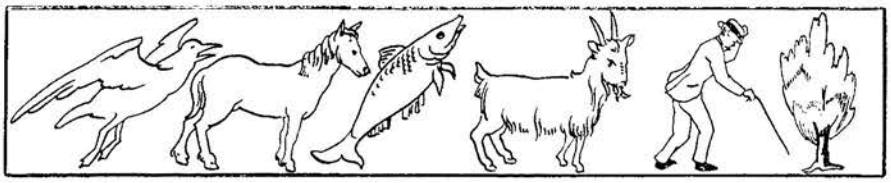

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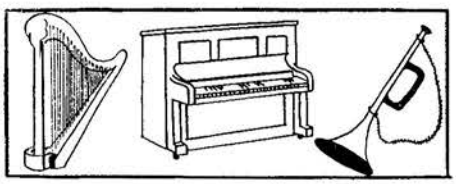

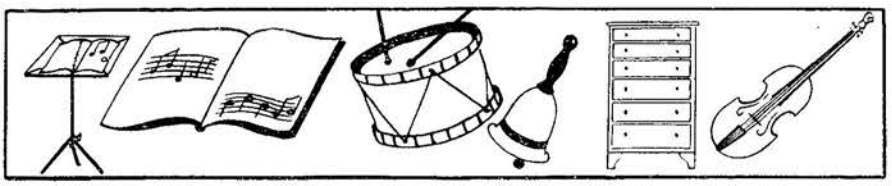

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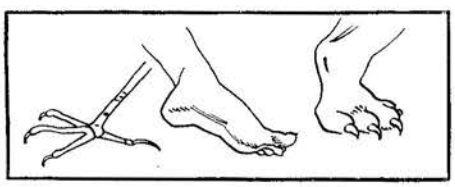

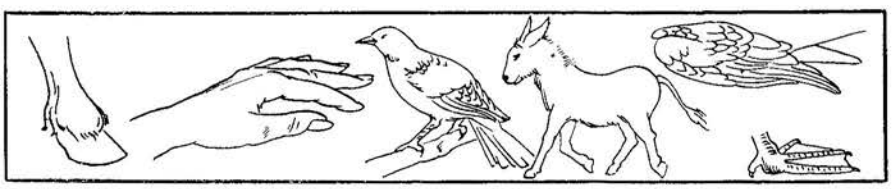

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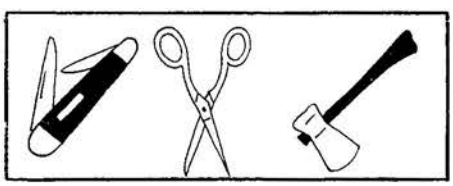

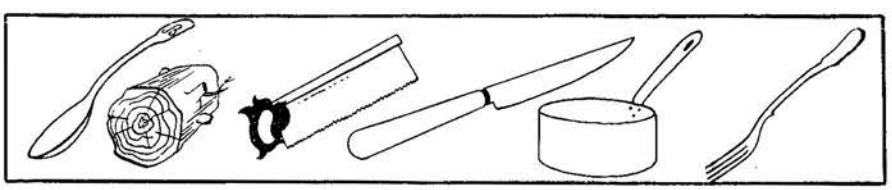

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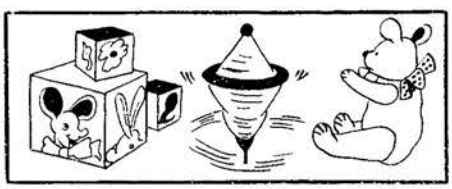

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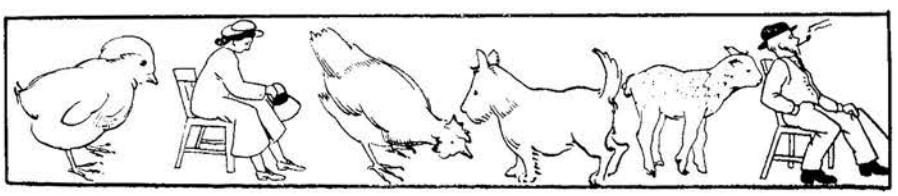

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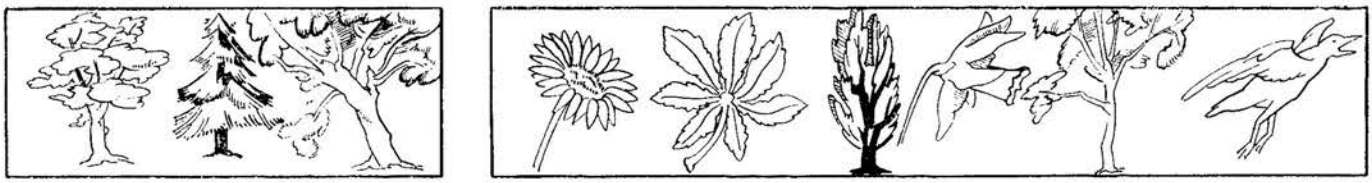
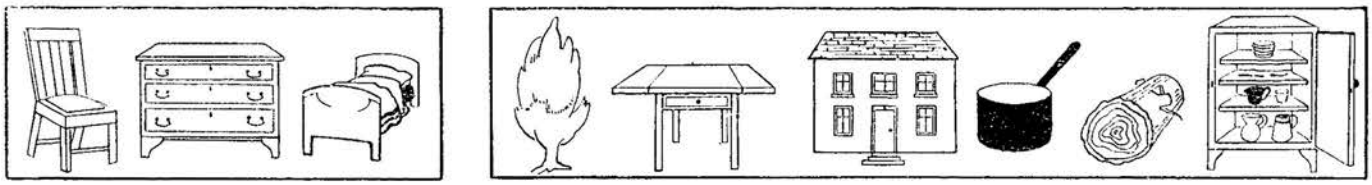
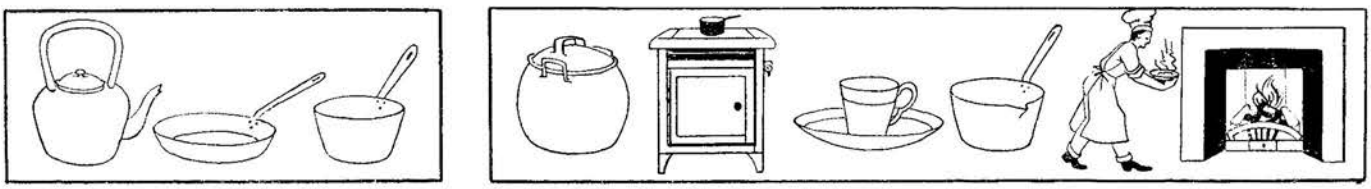
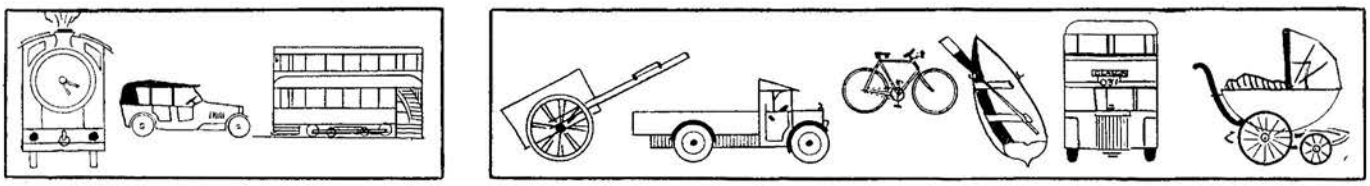
25 

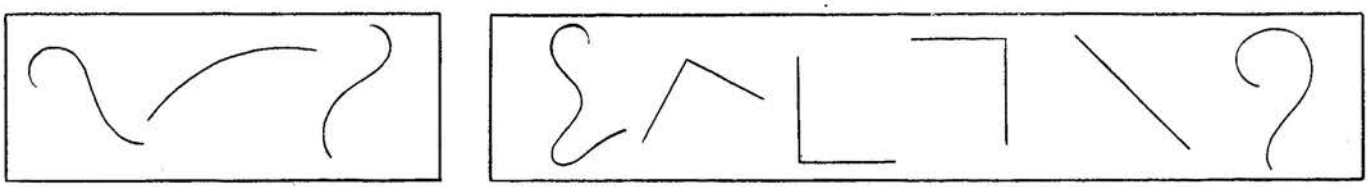
26 

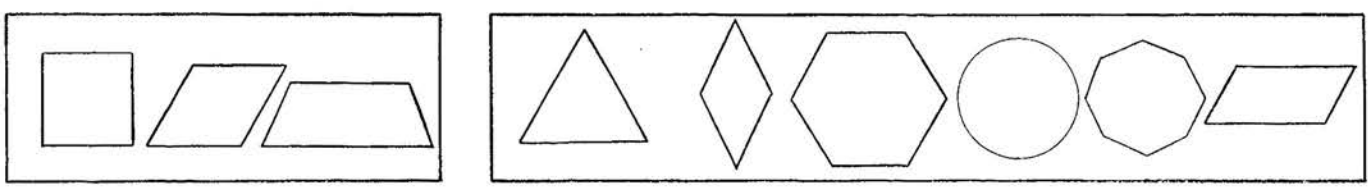
27 

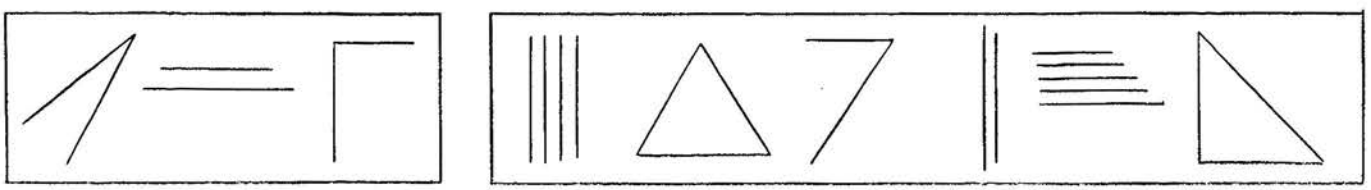
28 

29 1 9 3 8 d m e 5 b

30 A K L h x J y R S

31 

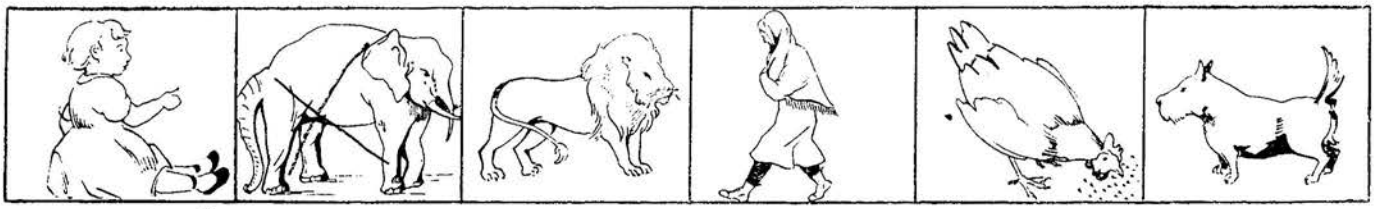
32 

33 

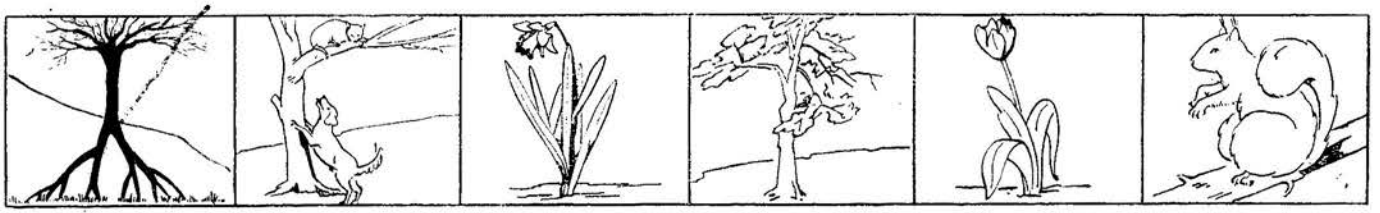
Score.....

TEST 3. Absurdities

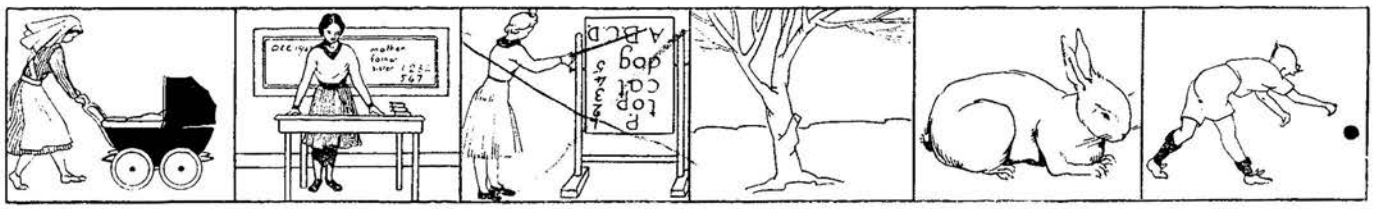
a



b



c



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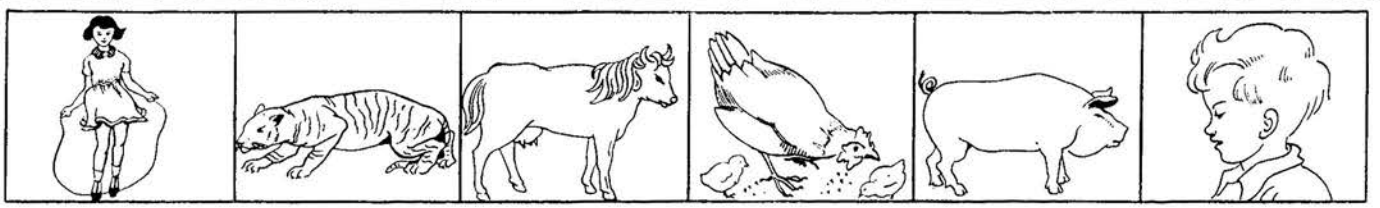

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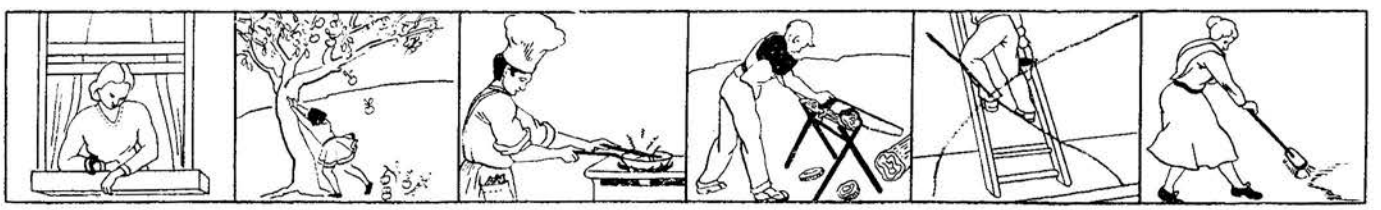

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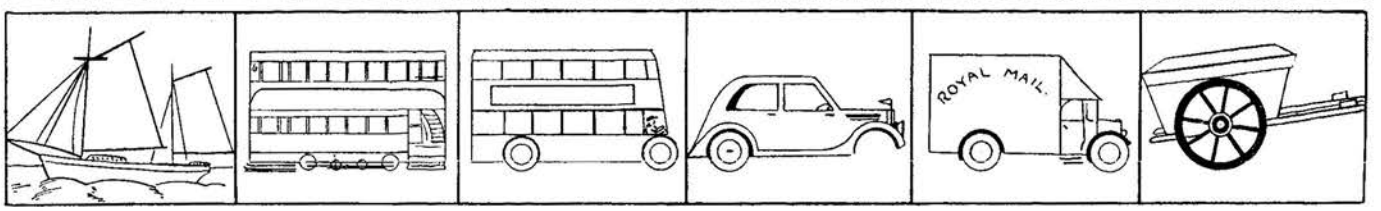

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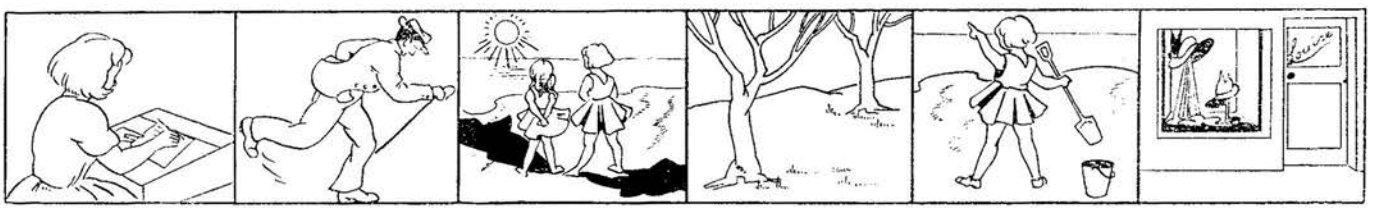

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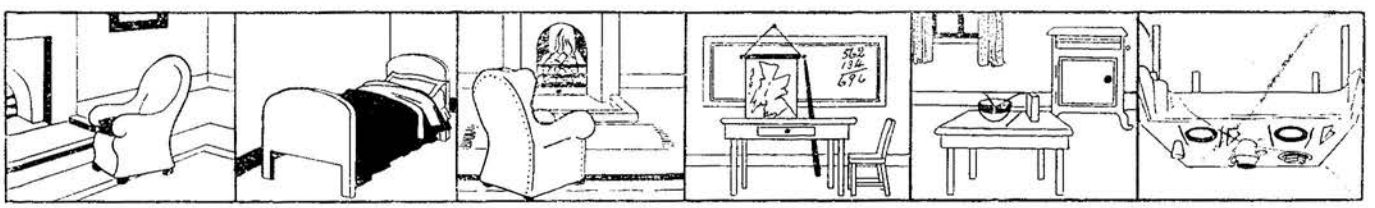

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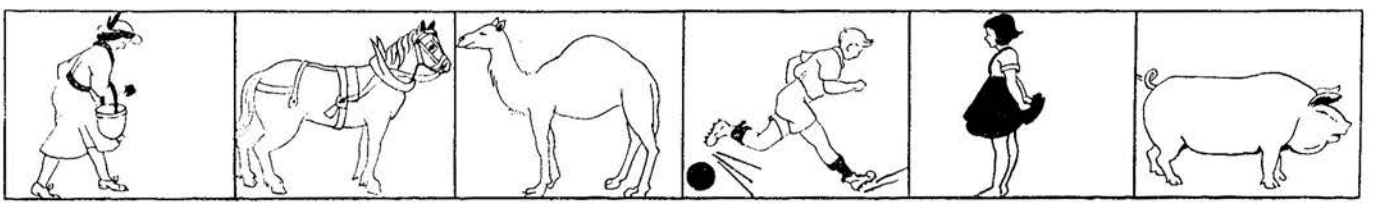
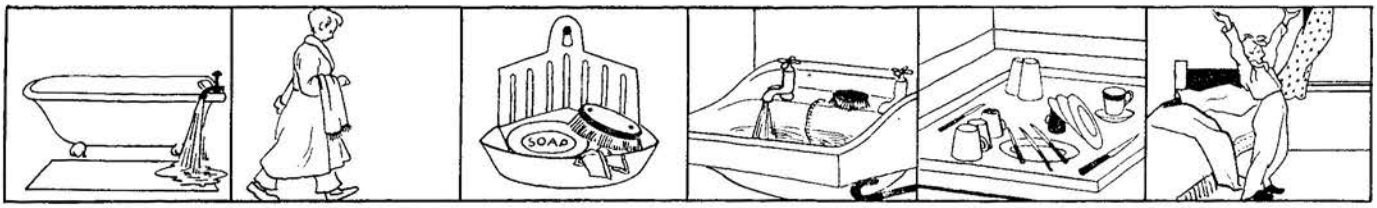


TEST 3 (contd.)

40



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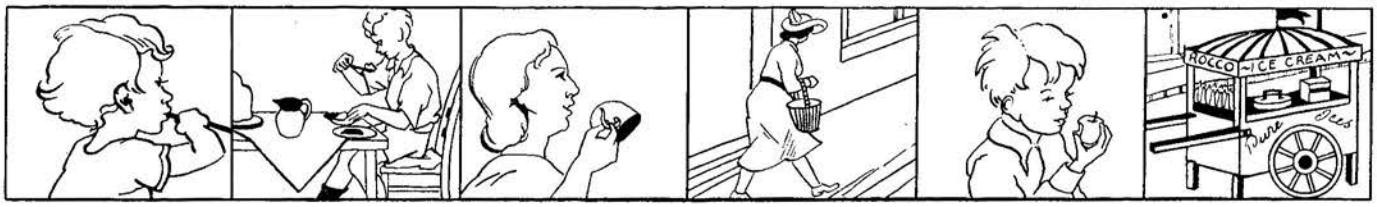

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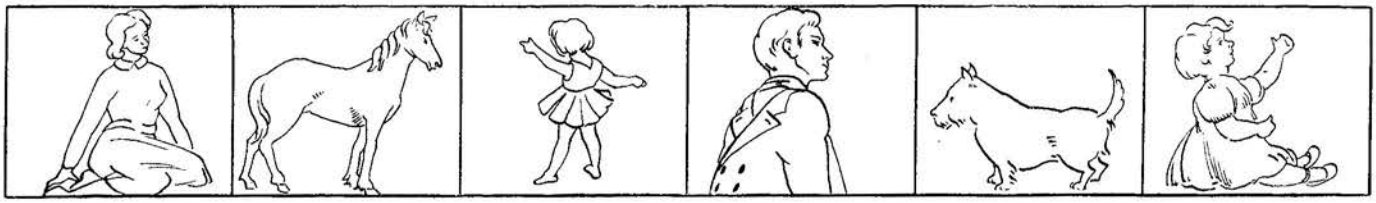

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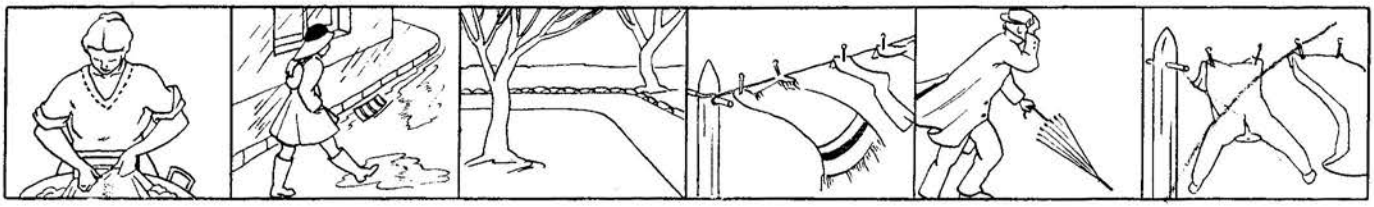

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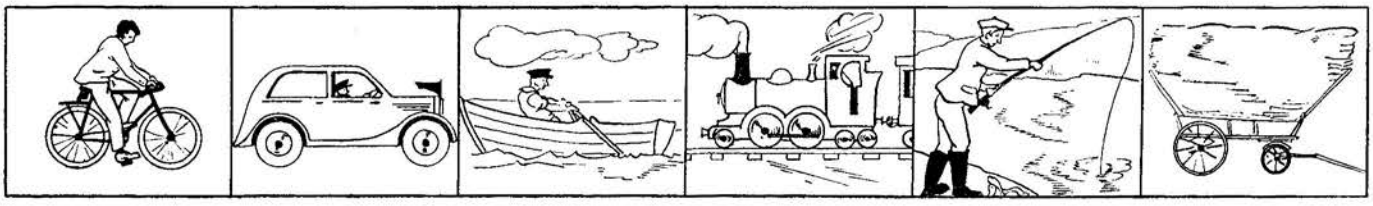

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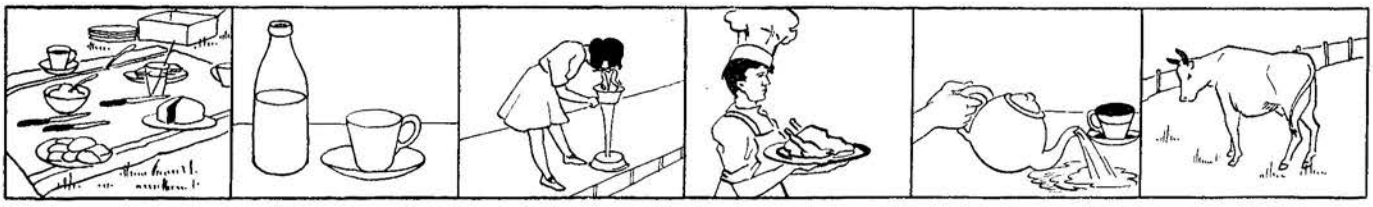

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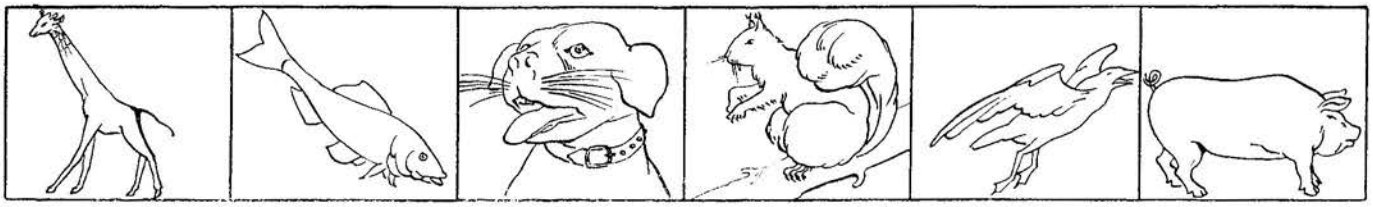

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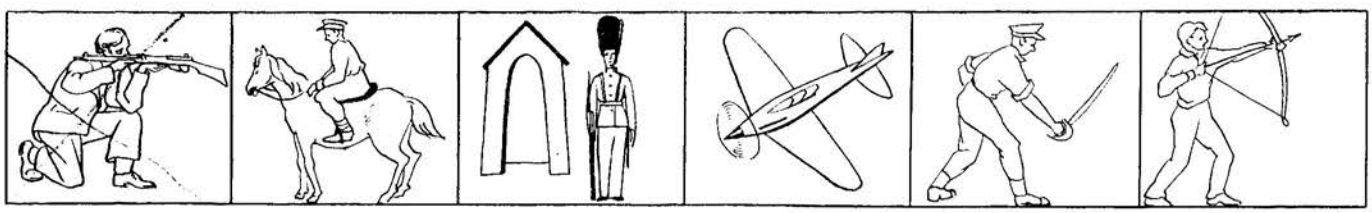

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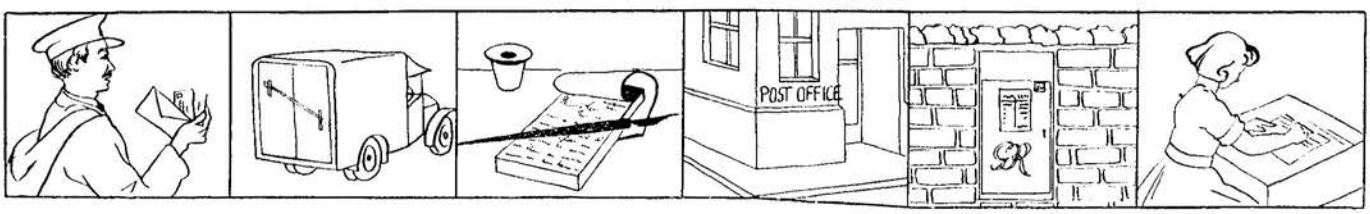
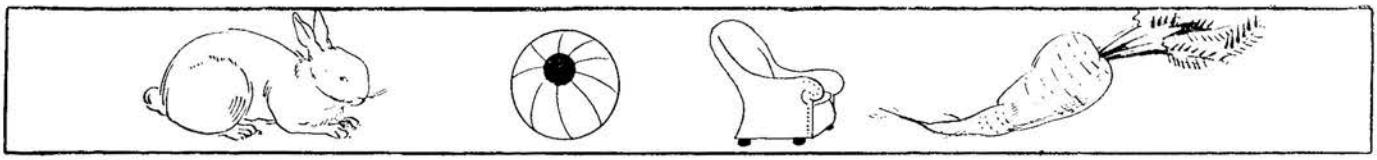
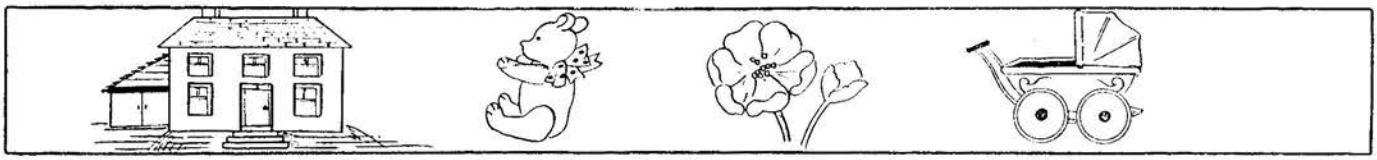


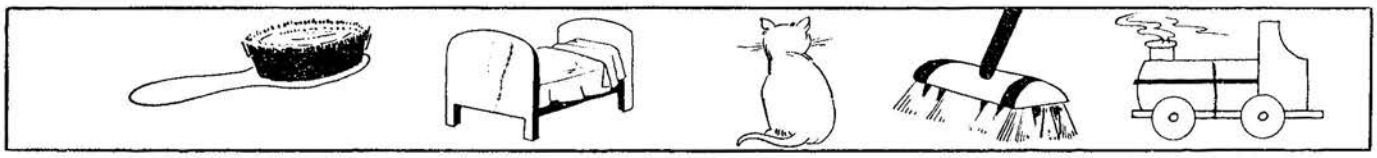
Score.....

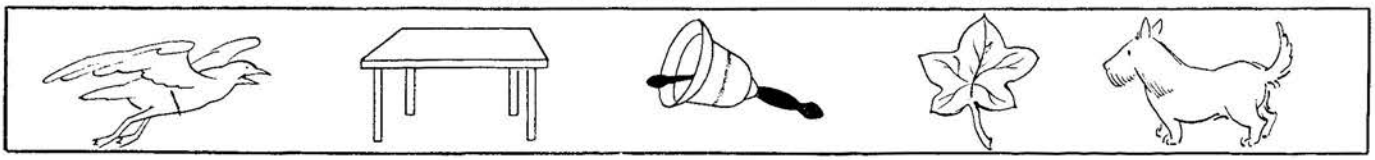
No

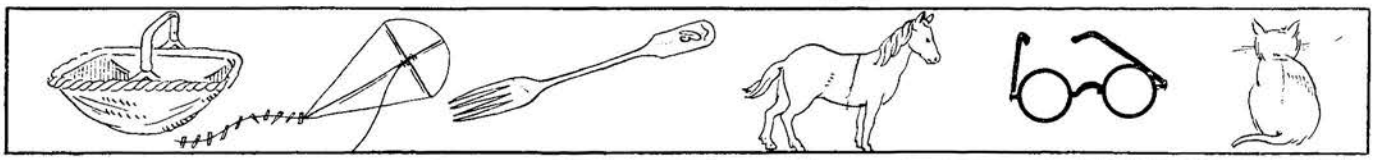
TEST 4 Memory Span

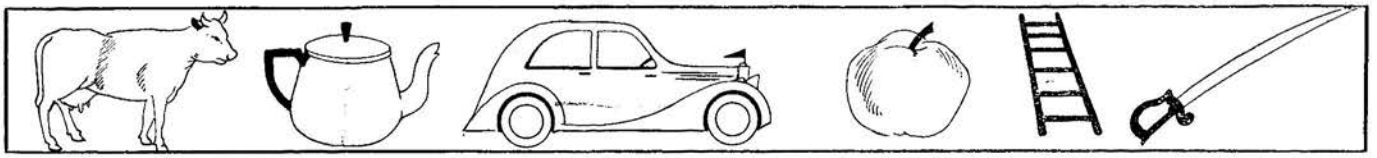
49 

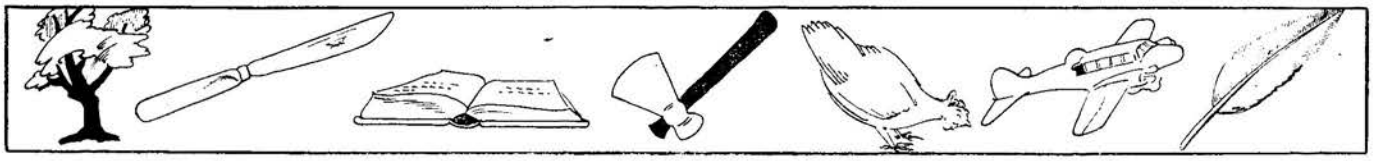
50 

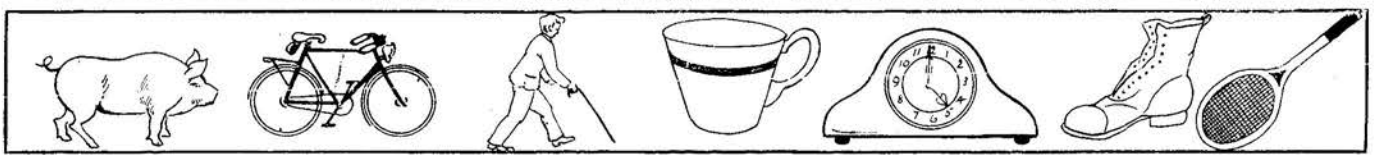
51 

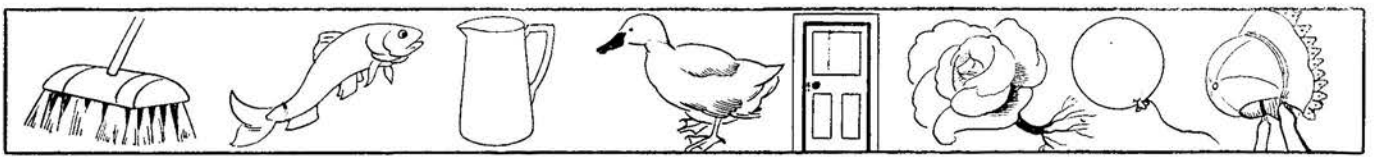
52 

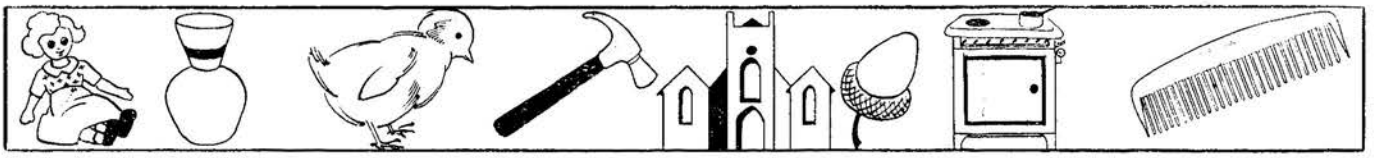
53 

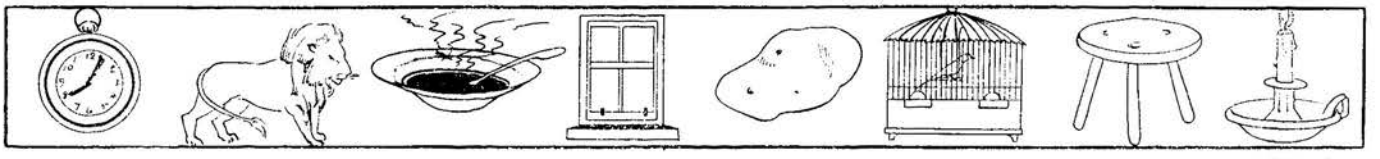
54 

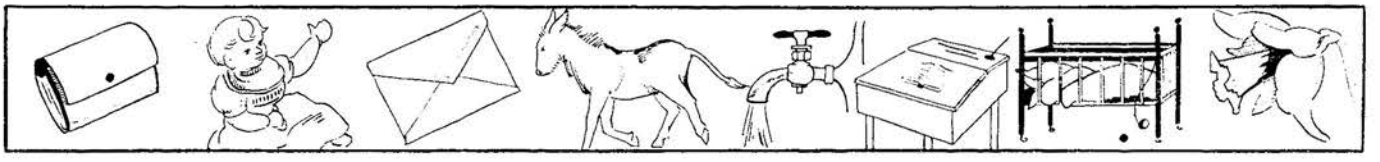
55 

56 

57 

58 

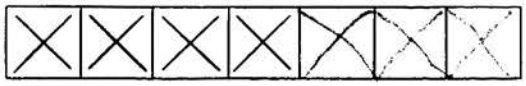
59 

60 

Score.....

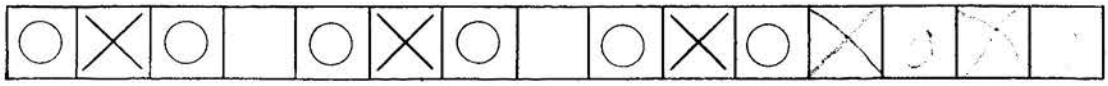
TEST 5. Series

a

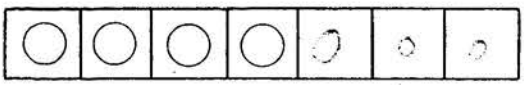


b

c

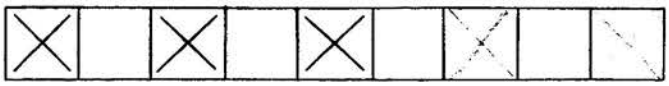


61



62

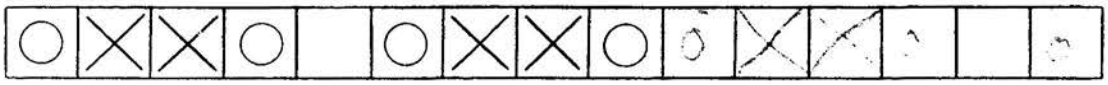
63



64

65

66



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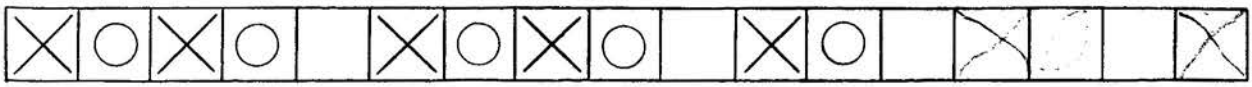

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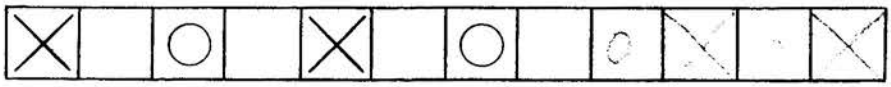
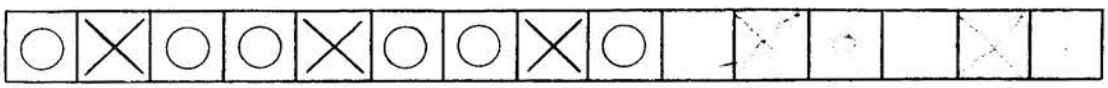


69



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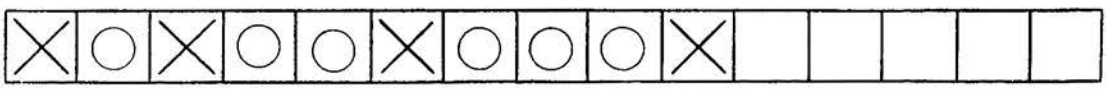
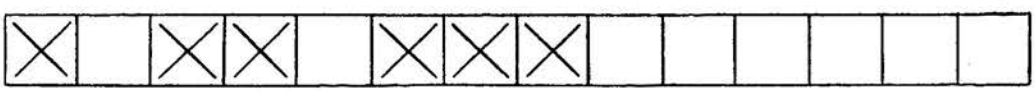


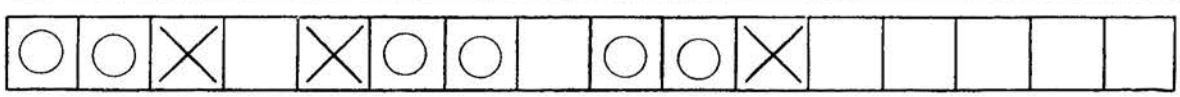
71

72



73

74



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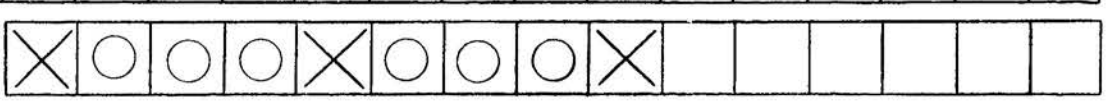
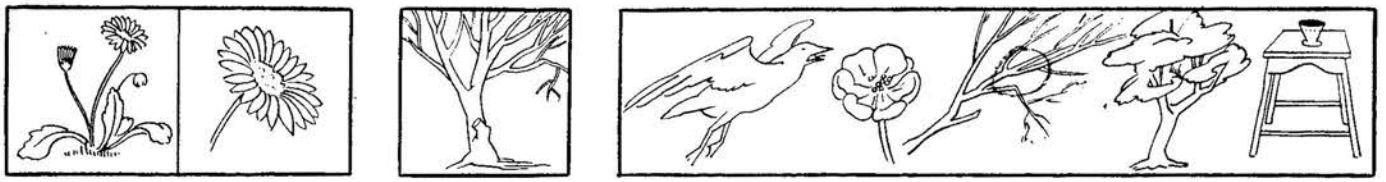


Score.....

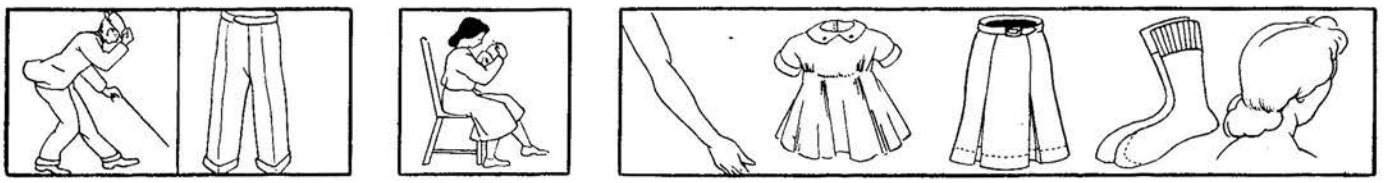
TEST 6. Analogies

a

b



c



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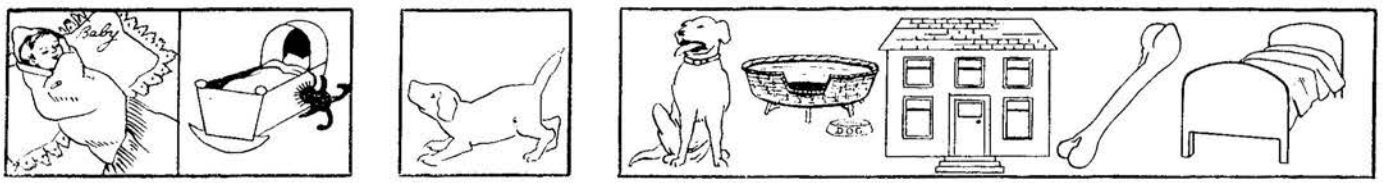
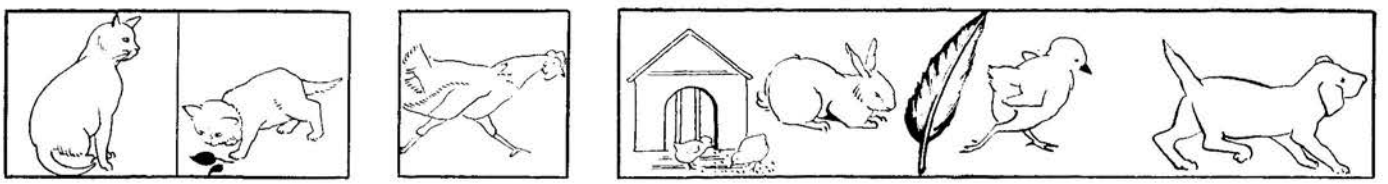
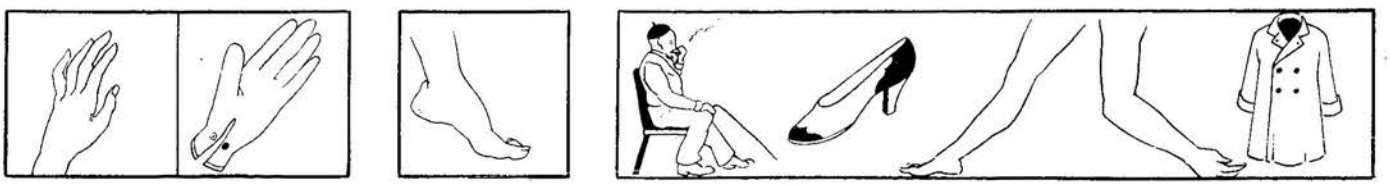


77



78



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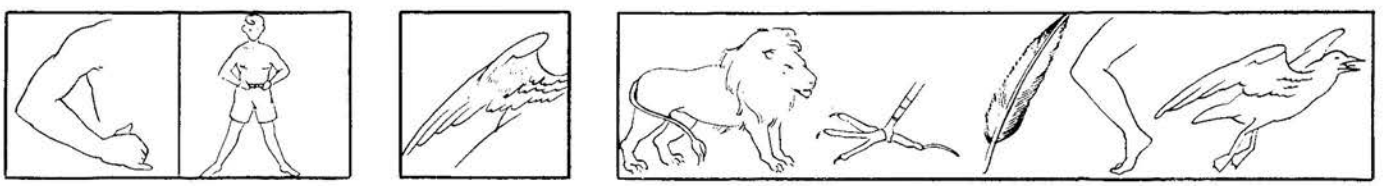

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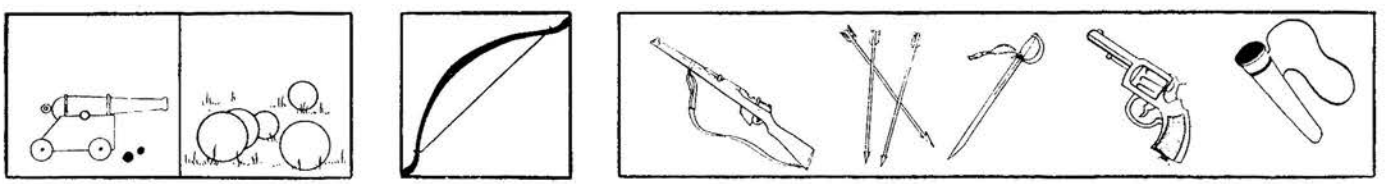
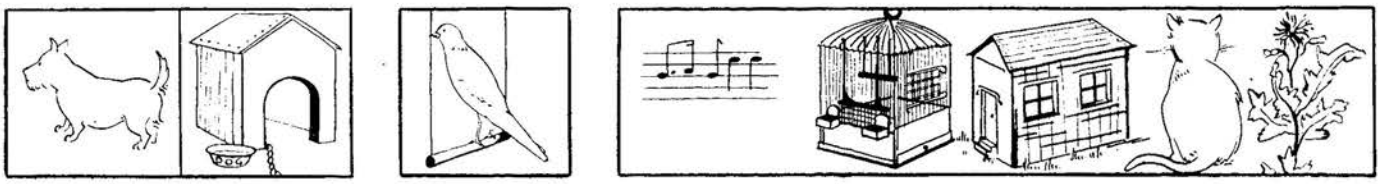
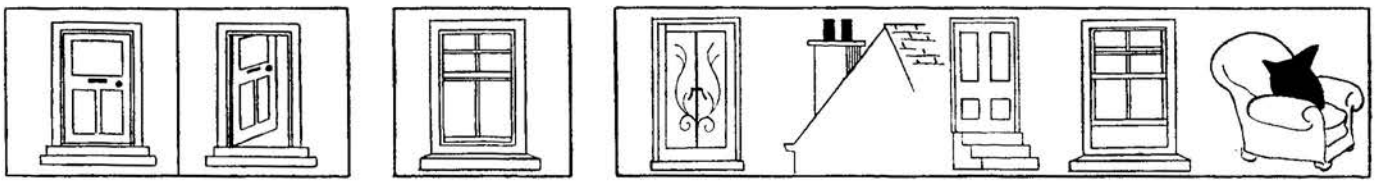
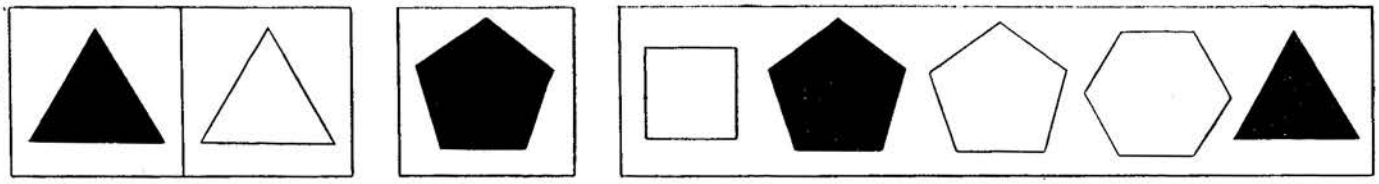


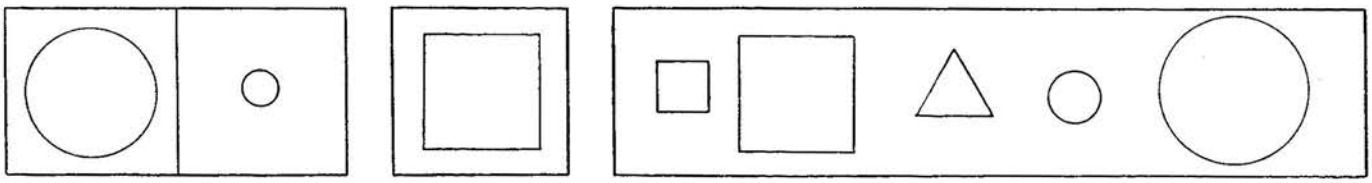
81

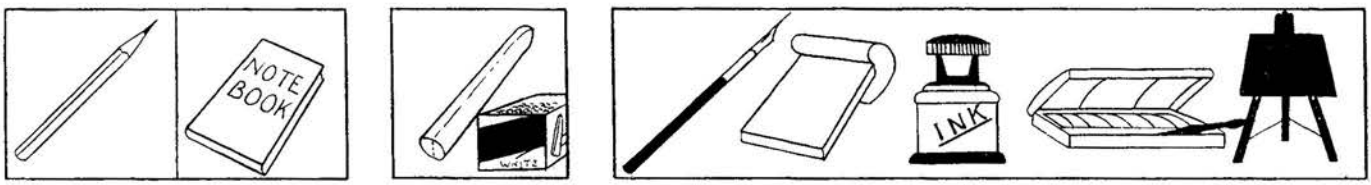


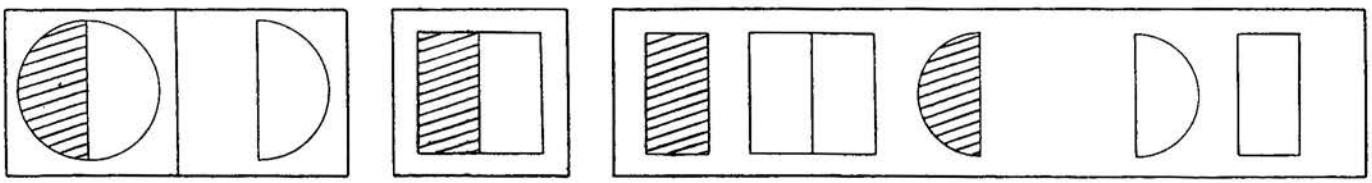
TEST 6 (contd.)

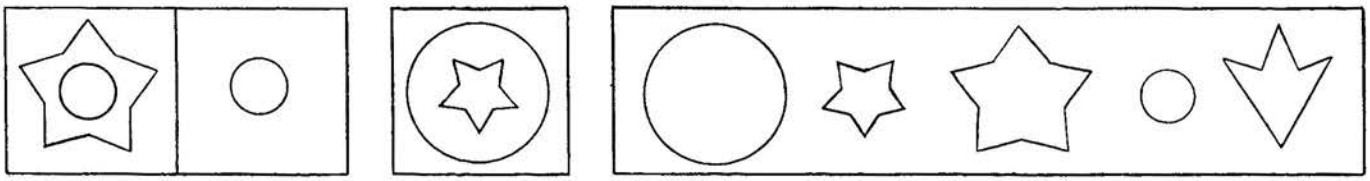
82 

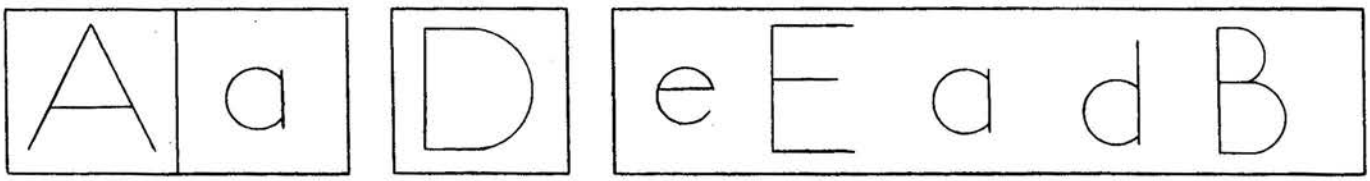
83 

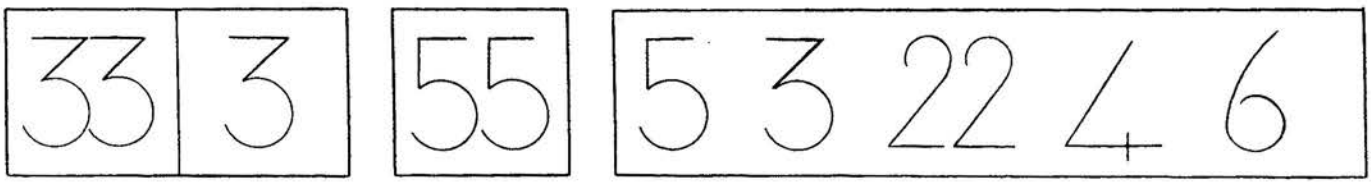
84 

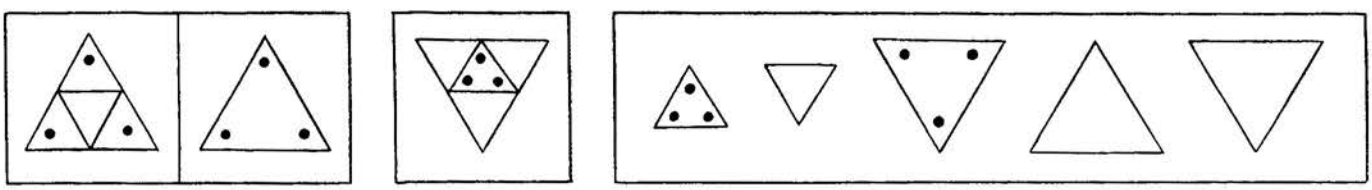
85 

86 

87 

88 

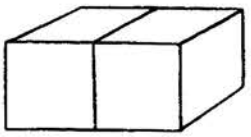
89 

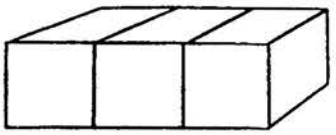
90 

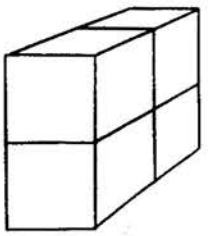
Score.....

TEST 7. Cube Counting

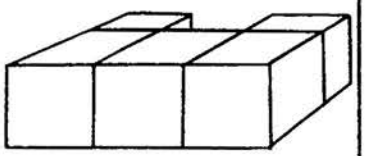
a
b
c

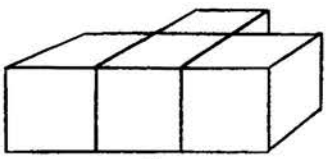


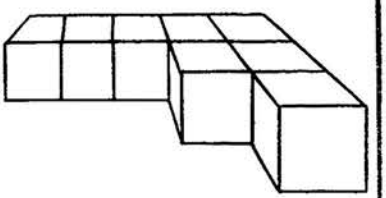




91
92
93







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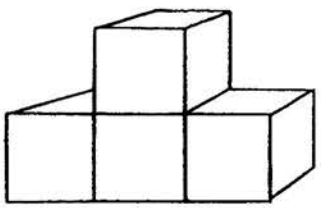
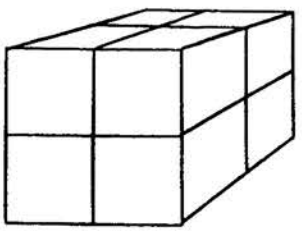
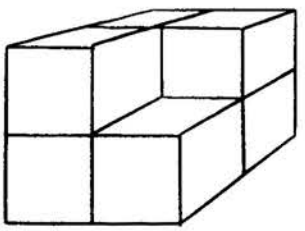
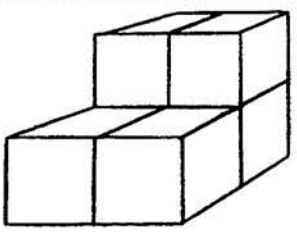
96

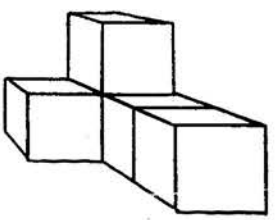


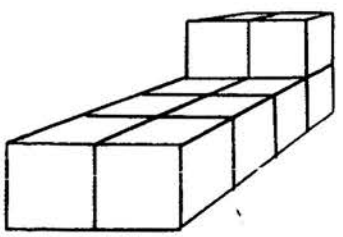




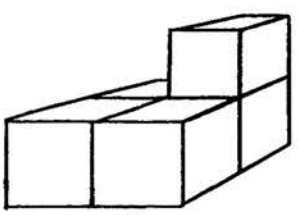
97
98
99

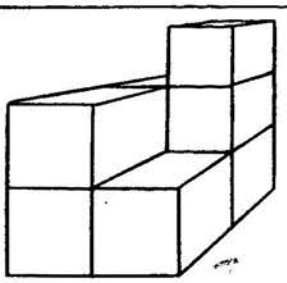


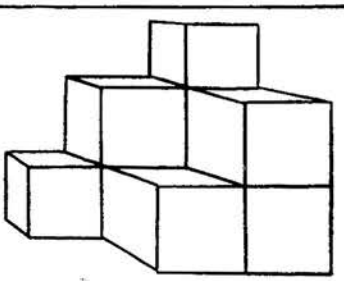




100
101
102







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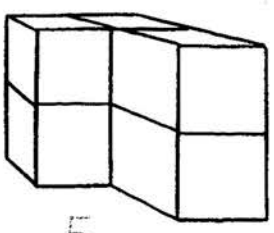
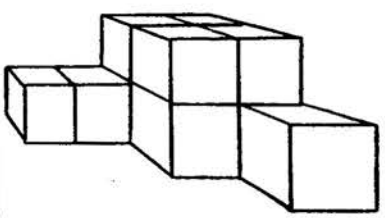
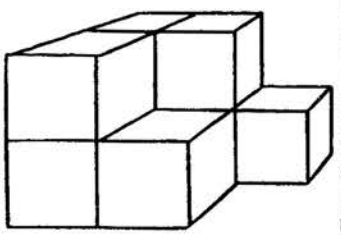
105







Score.....

D.P., Edin.—500—4/42.

MORAY HOUSE EXPERIMENTAL

PICTURE TEST

Name ..... Sex.....

Date of Birth..... Date of Test..... Age.....yrs.....m.

School..... Class .....

TEST	SCORE
1.	
2.	
3.	
4.	
5.	
6.	
7.	
TOTAL	
Signature of Marker:	

NOTES

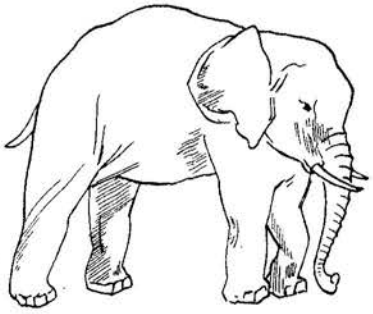
Binet I.Q. (if known)..... Date of Test.....

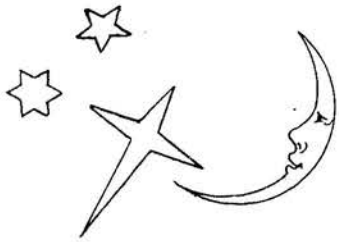
C.A. at date of Binet Test .....

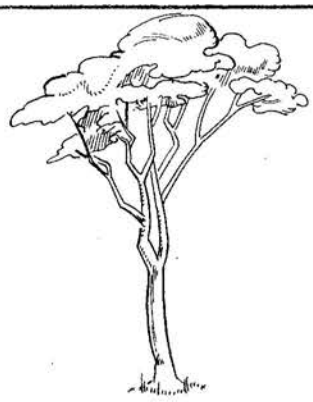
M.A. at date of Binet Test.....

TEST 1. Directions

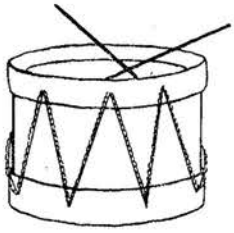
106 107 108

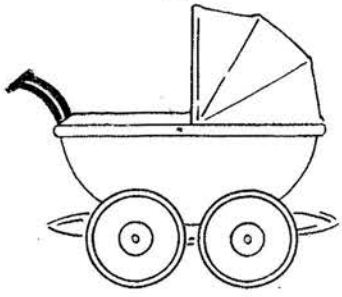




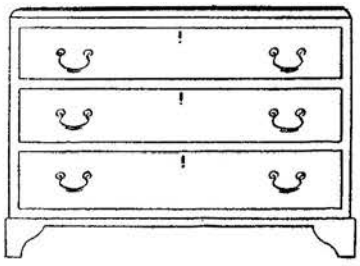


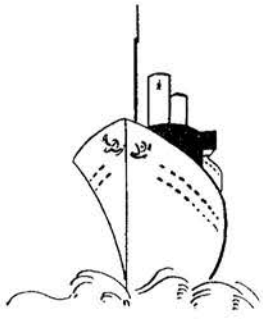
109 110 111



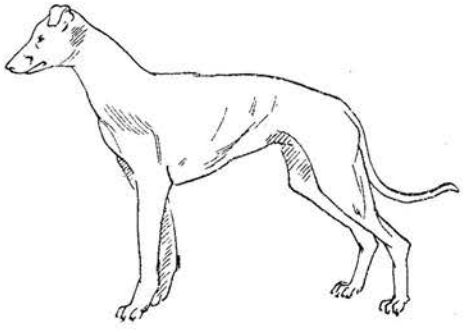


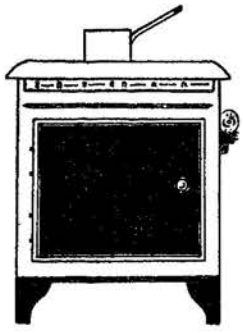
112 113 114



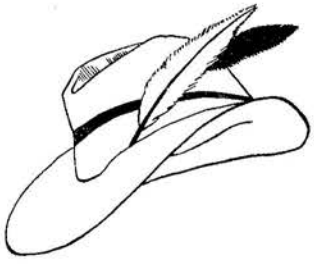


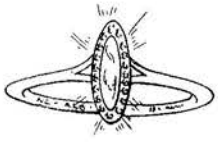
115 116 117

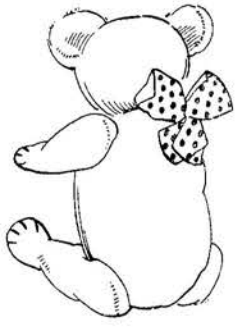




118 119 120



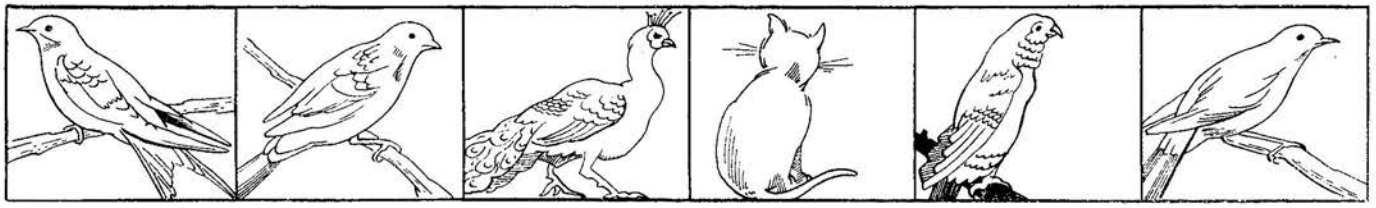




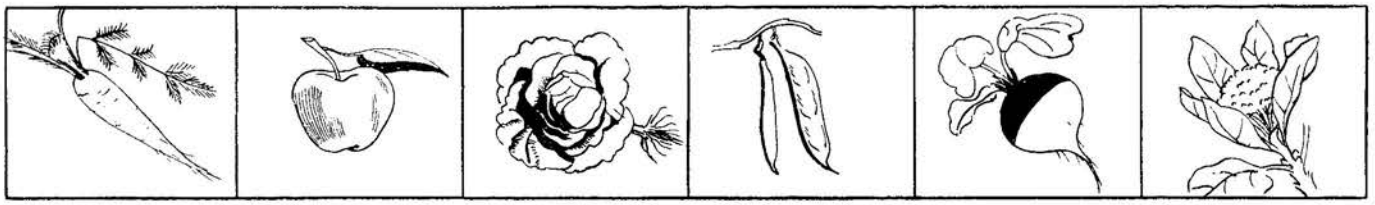
Score.....

TEST 2. Doesn't Belong

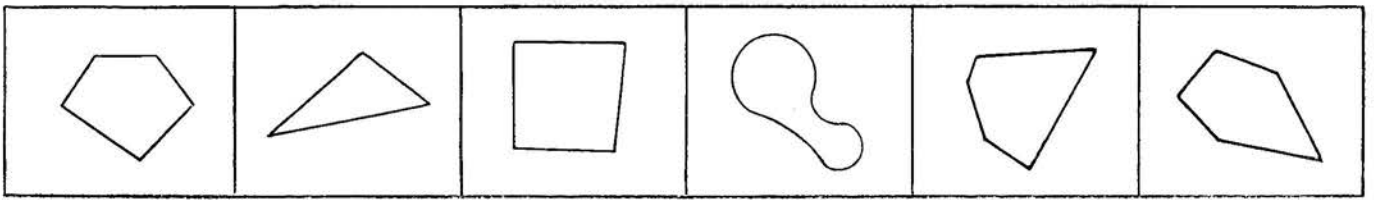
a



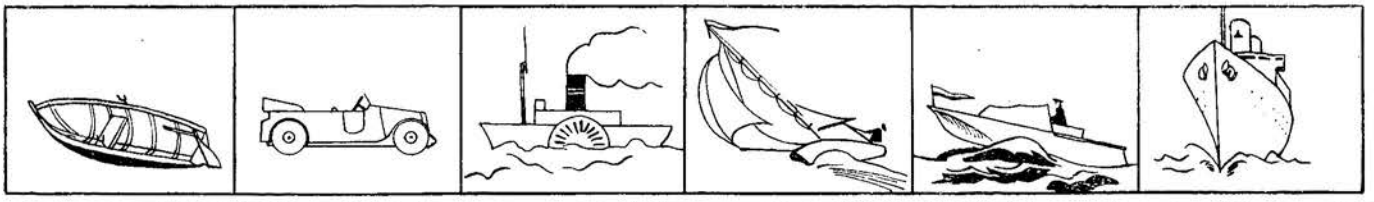
b



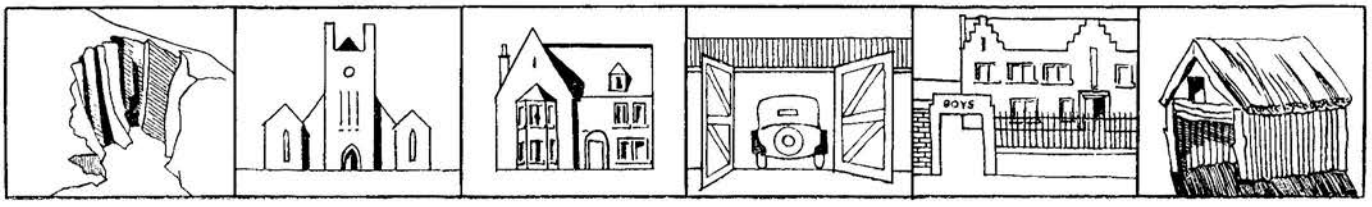
c



121



122



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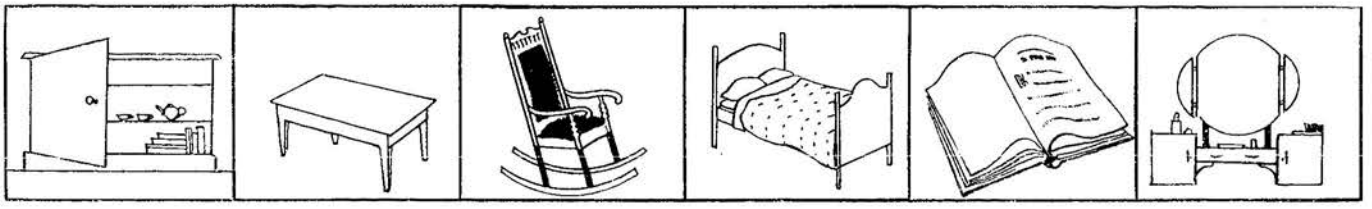

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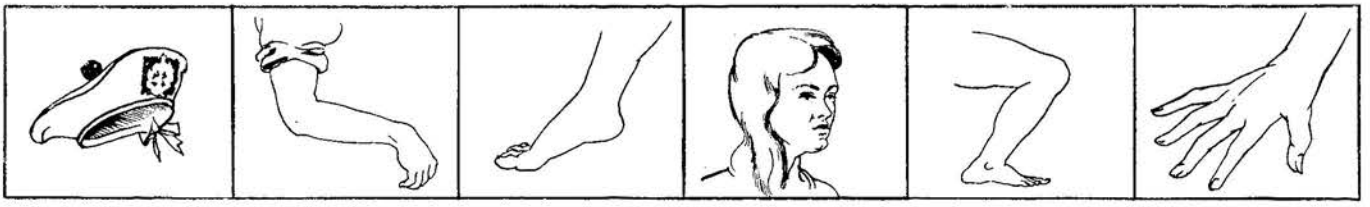
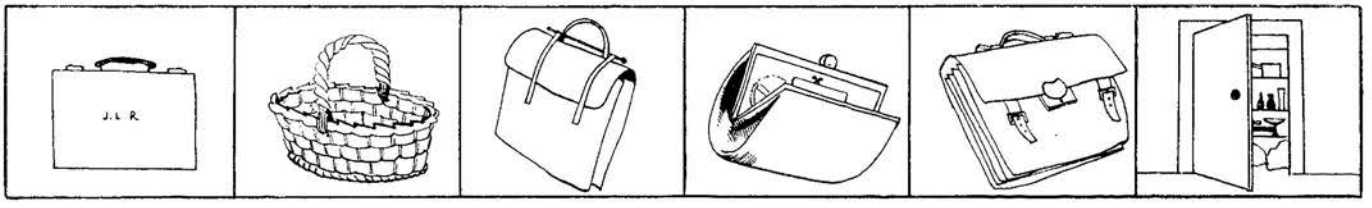
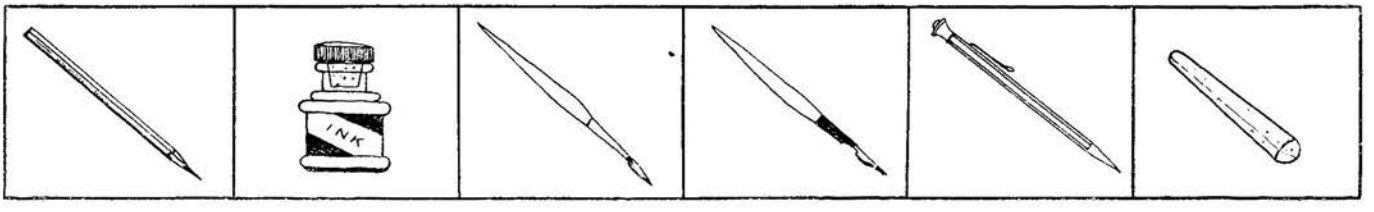


125

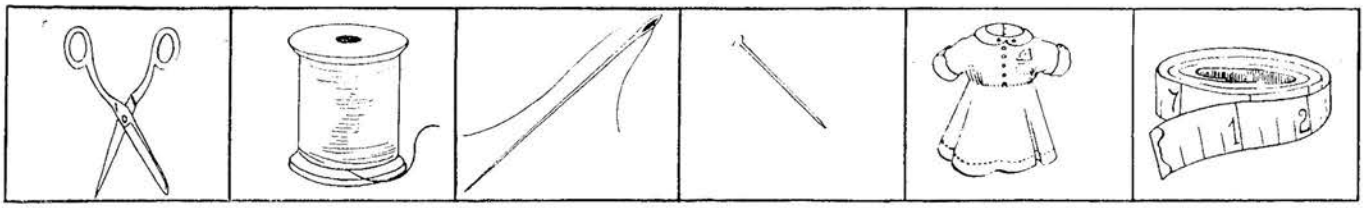


126

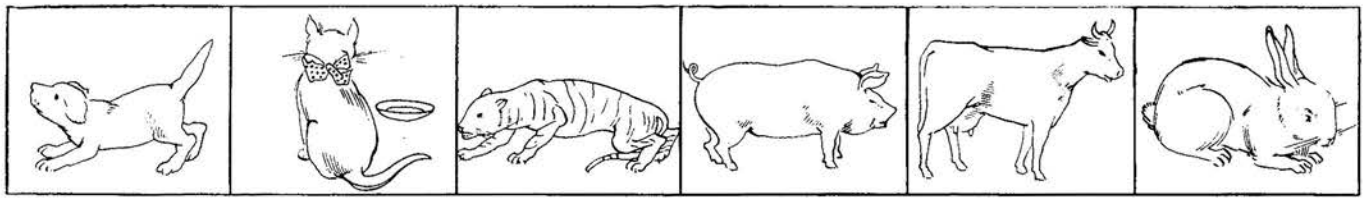


TEST 2 (contd.)

127



128



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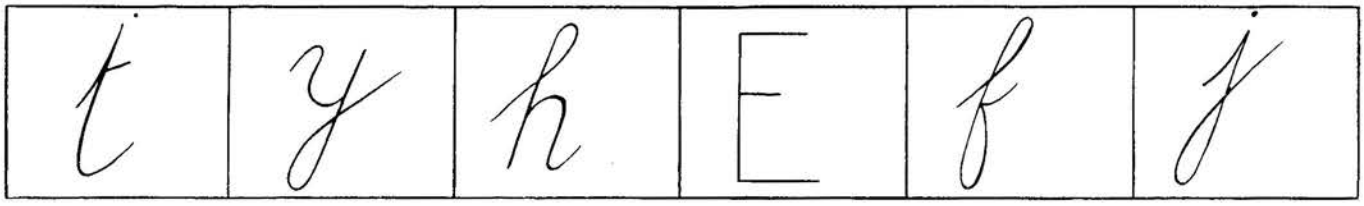
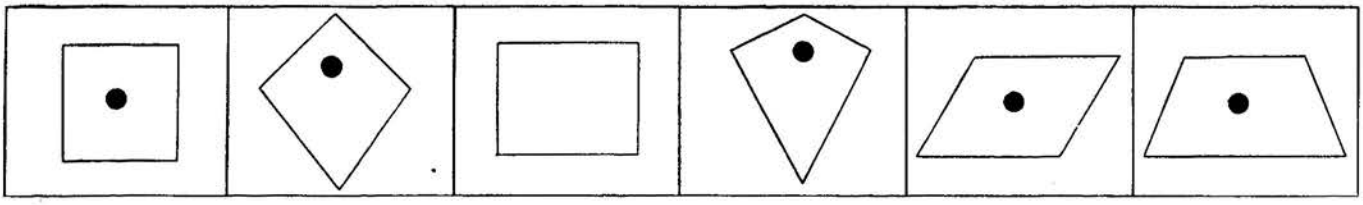
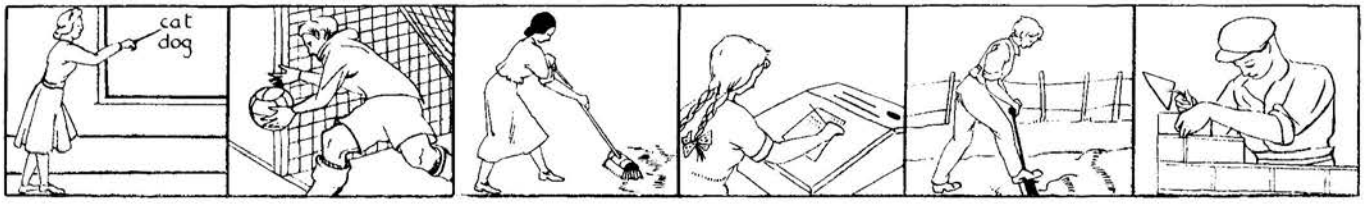


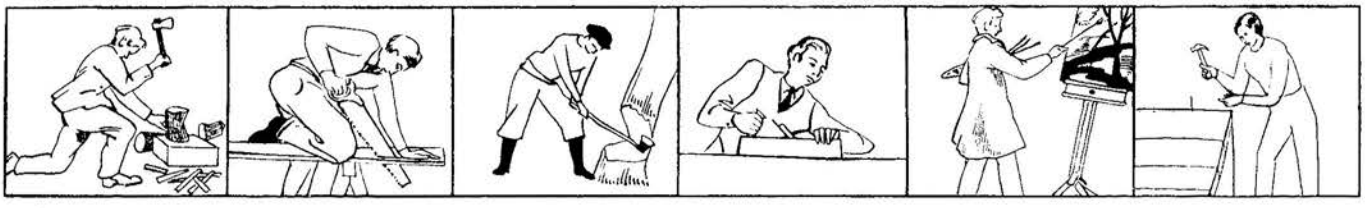
130



131



132



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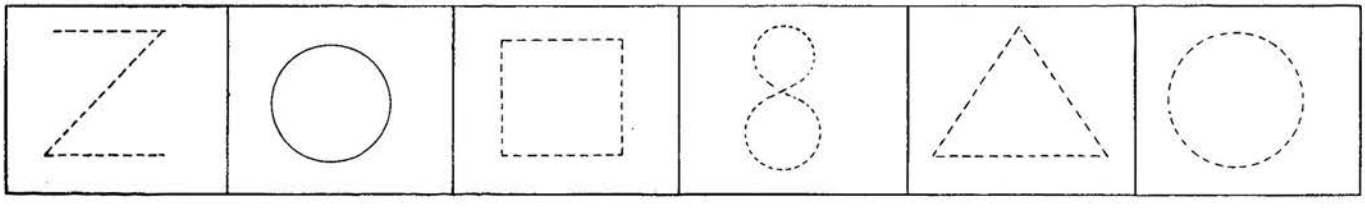
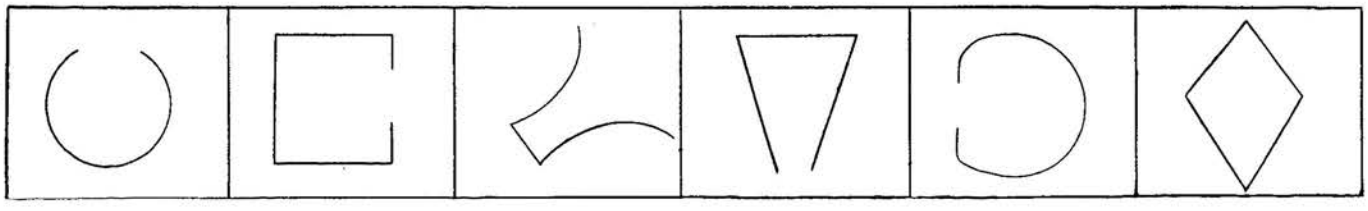
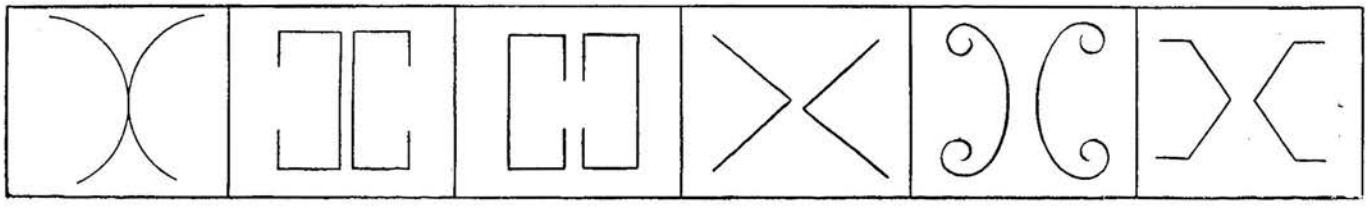


134



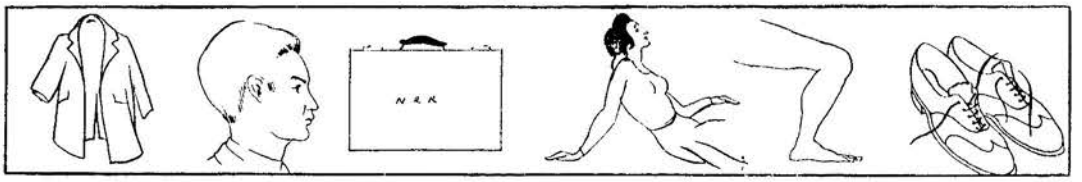
135

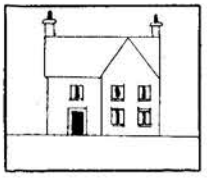


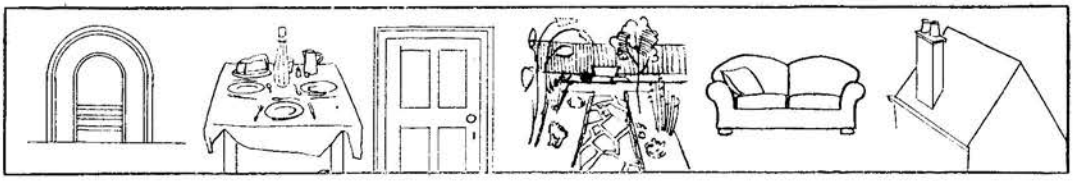
Score. .....

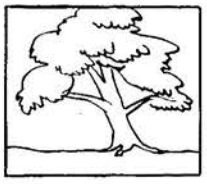
TEST 3. Always Has

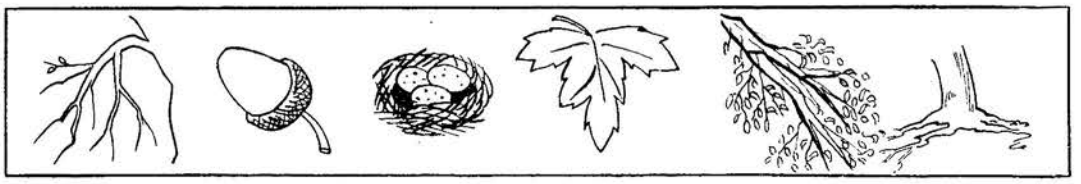
a 



b 



c 



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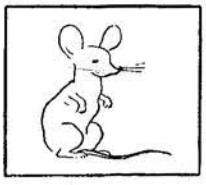
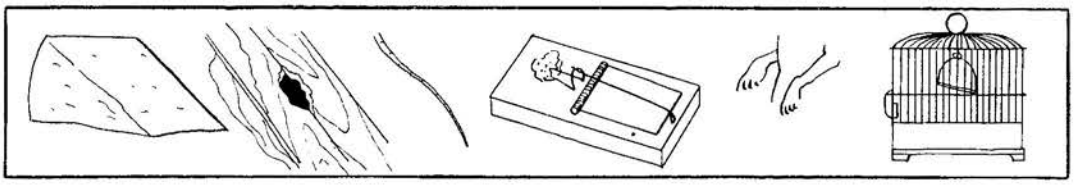
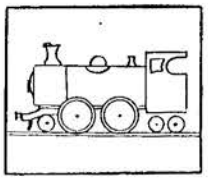
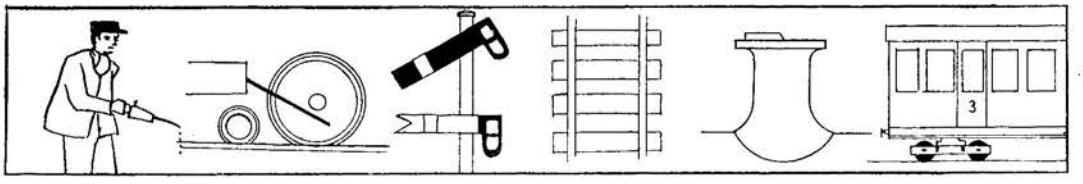
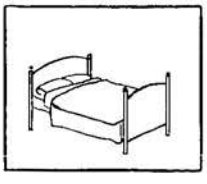
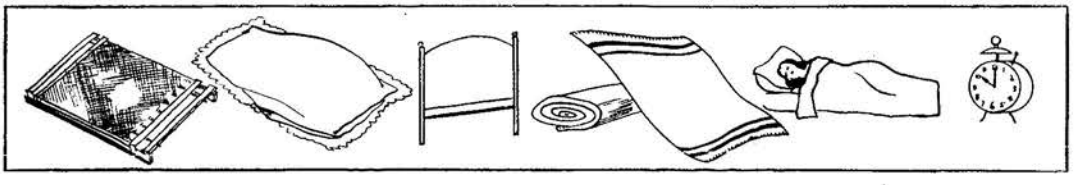
136 



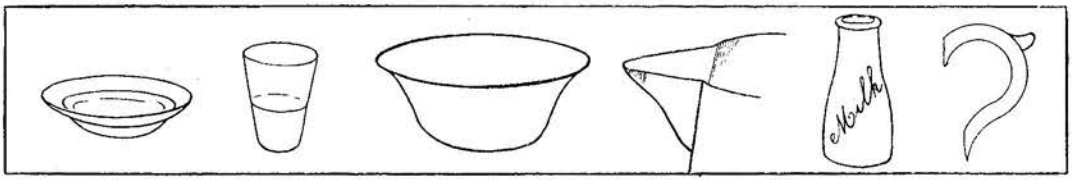
137 

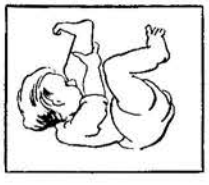


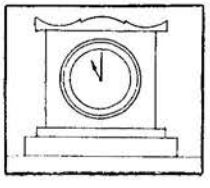
138 

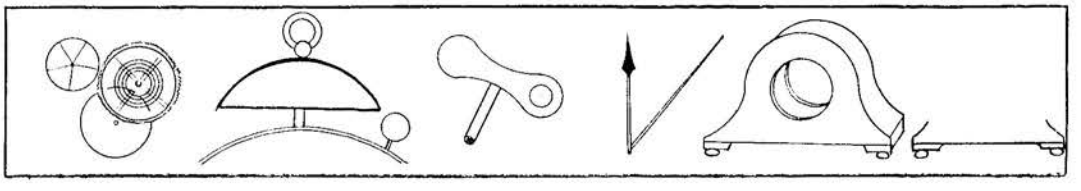


139 

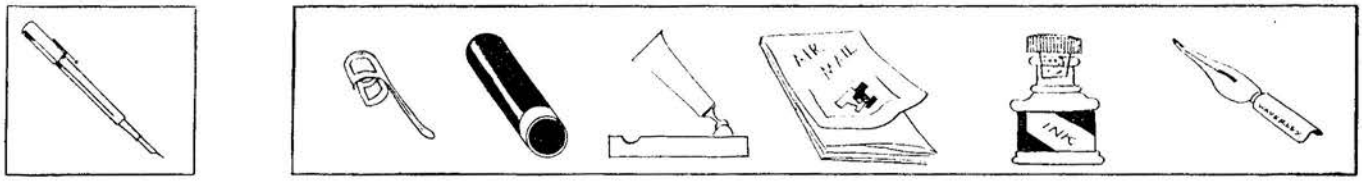


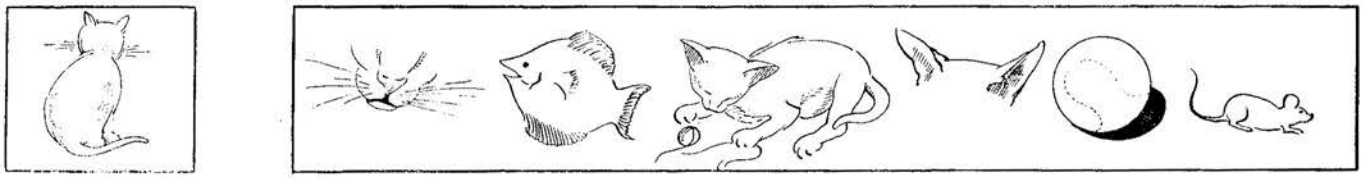
140 

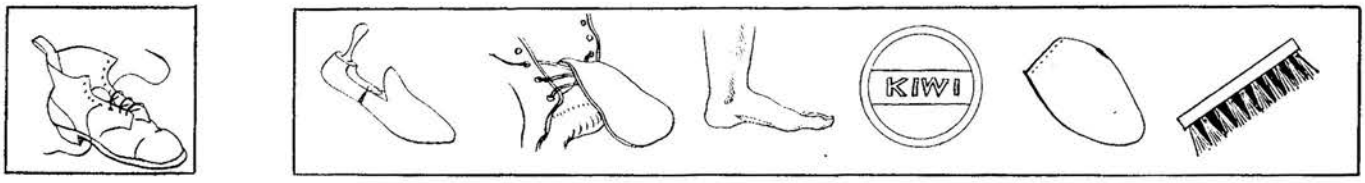
141 

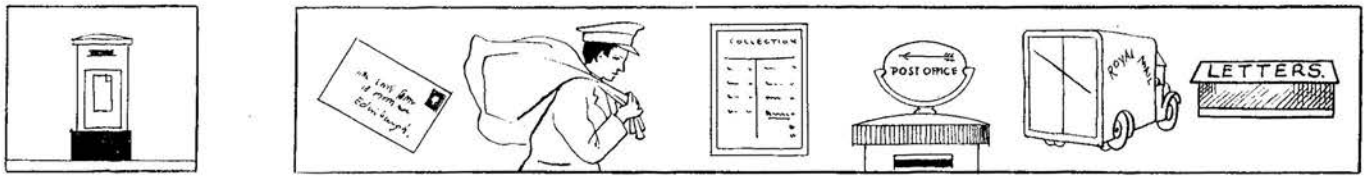


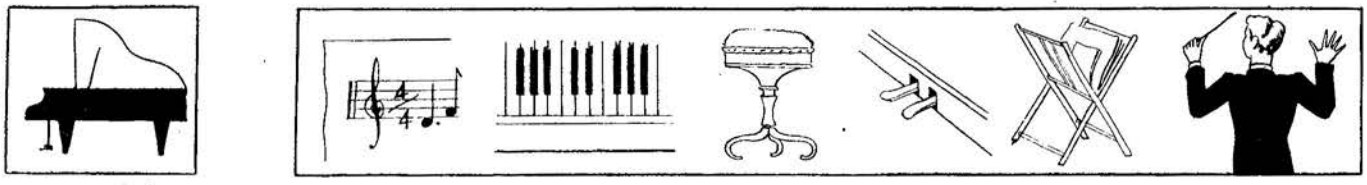
TEST 3 (contd.)

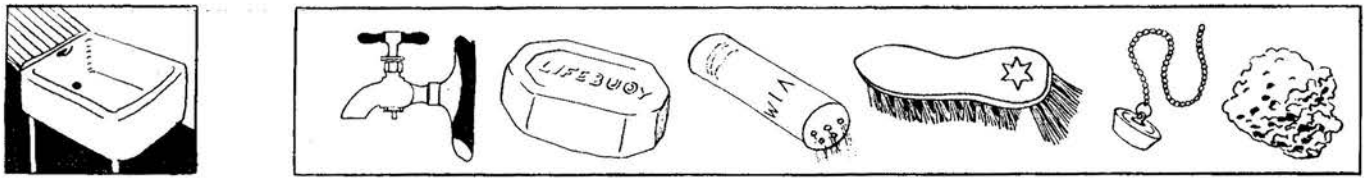
142 

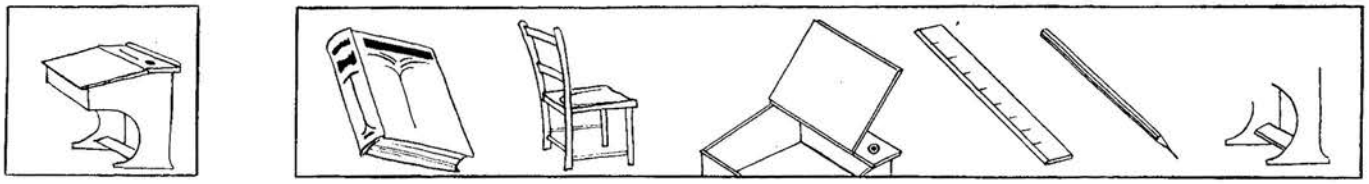
143 

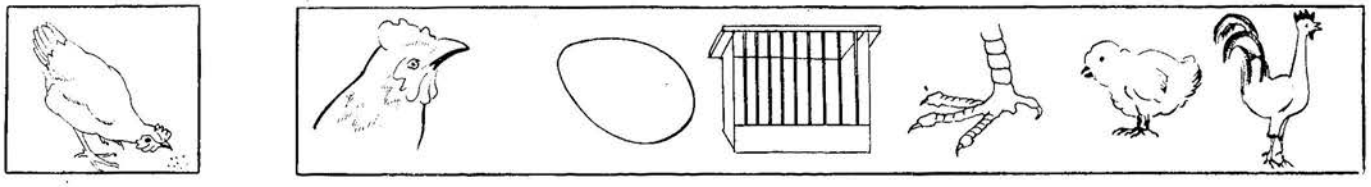
144 

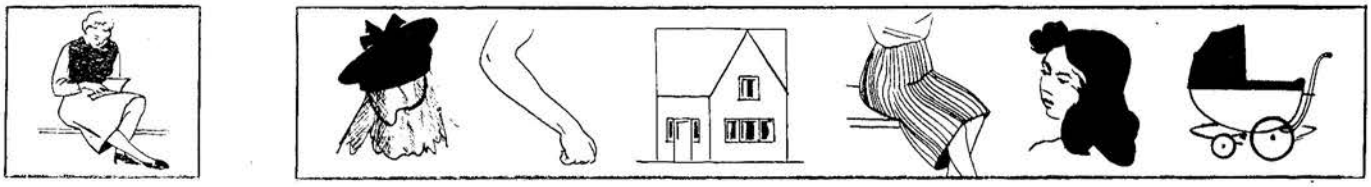
145 

146 

147 

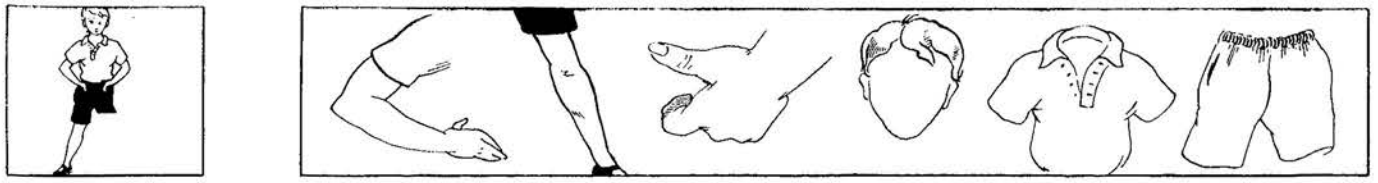
148 

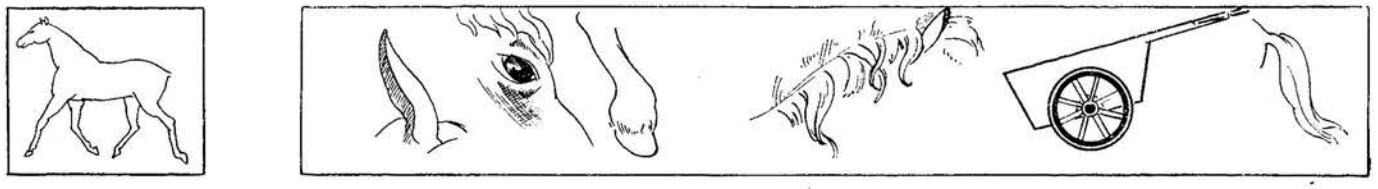
149 

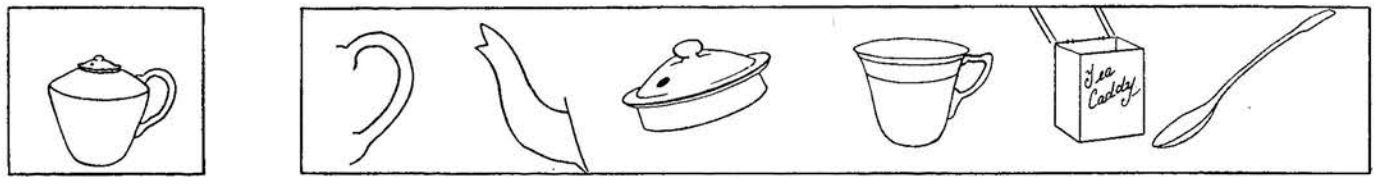
150 

Score.....

TEST 4. Completion

a 

b 

c 

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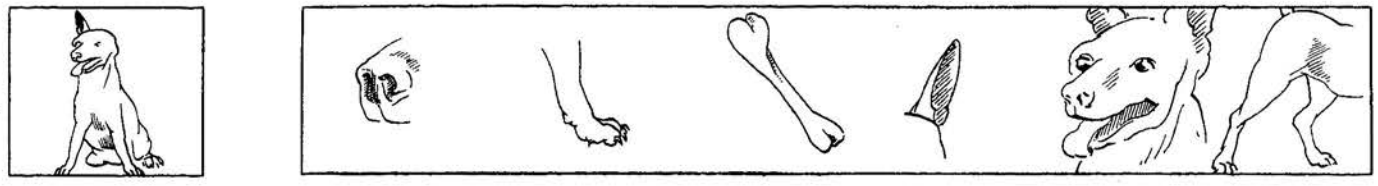
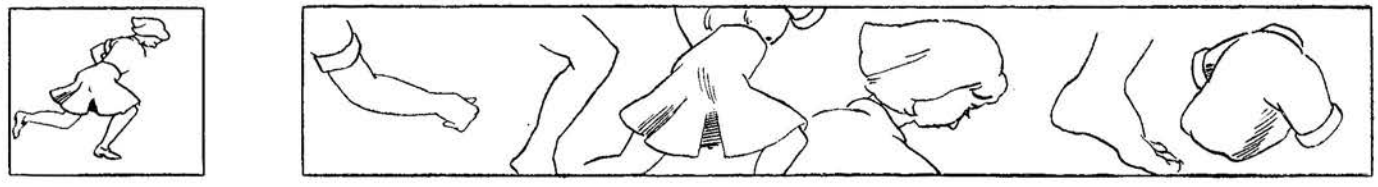
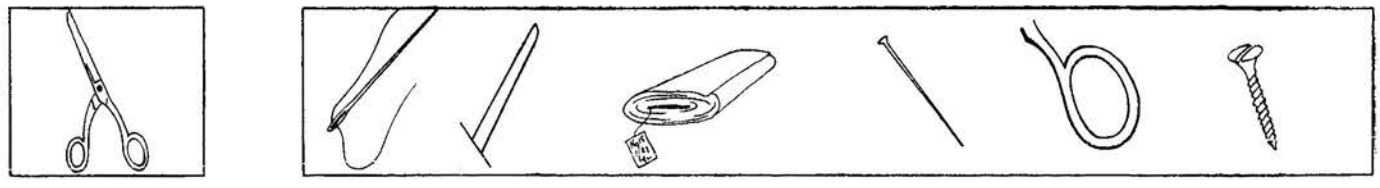
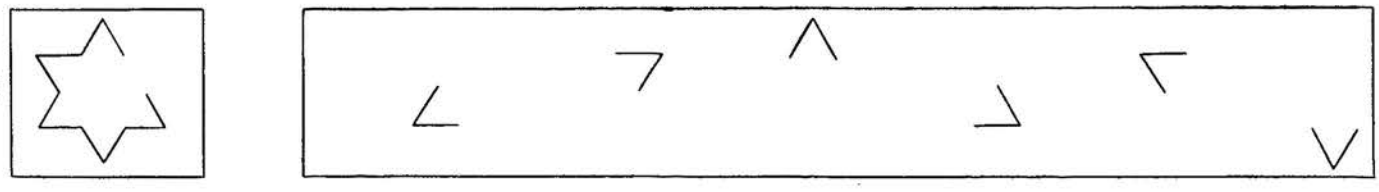
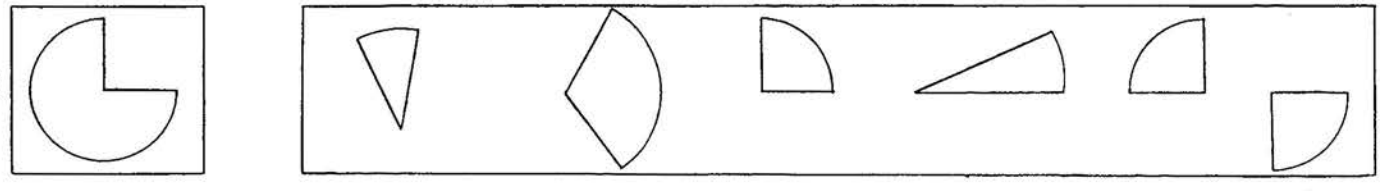
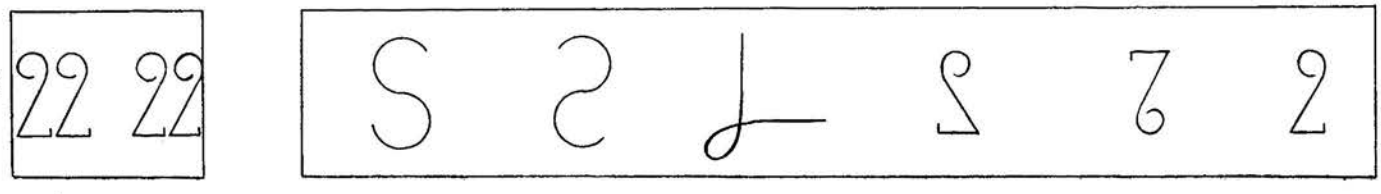
151 

152 

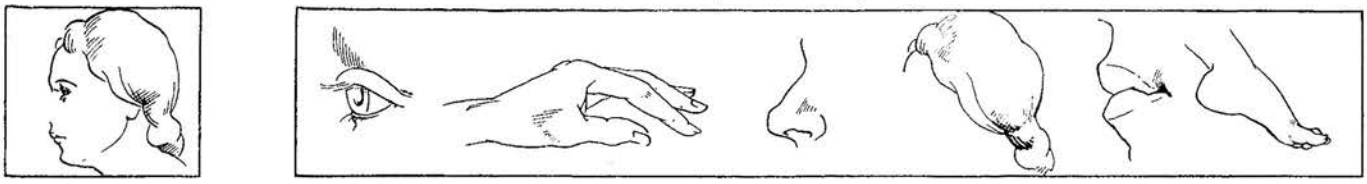
153 

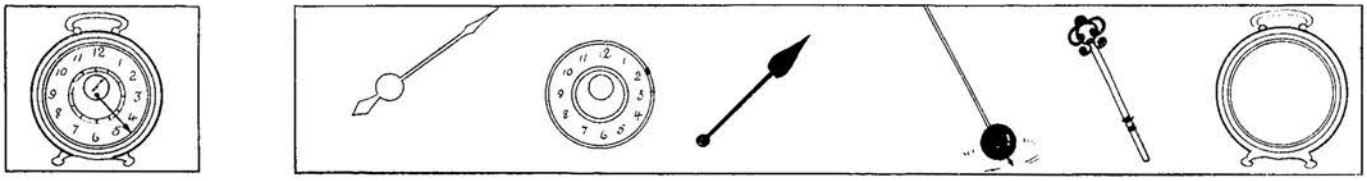
154 

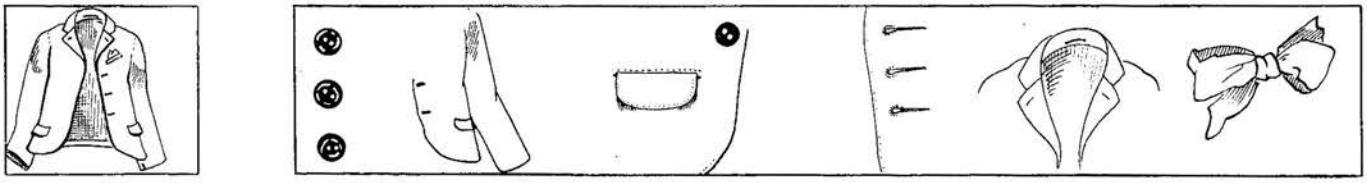
155 

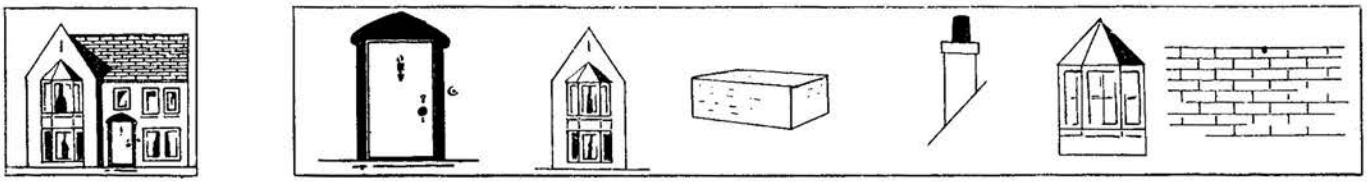
156 

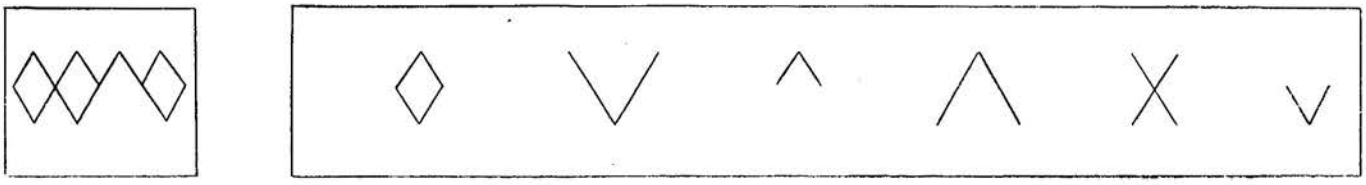
TEST 4 (contd.)

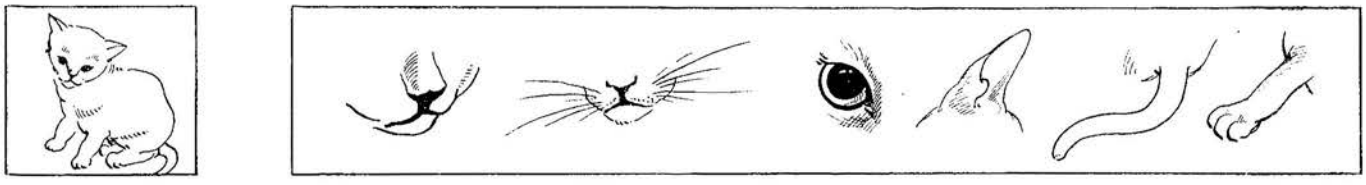
157 

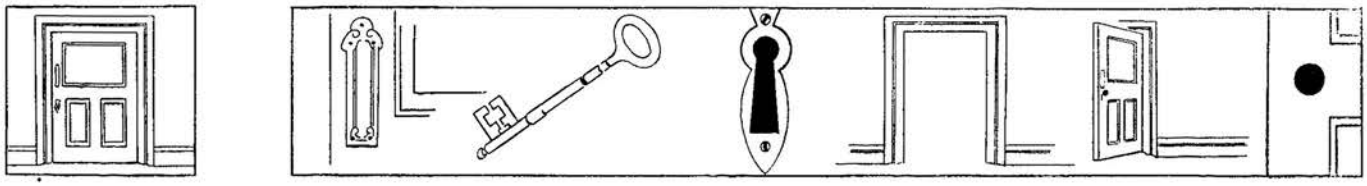
158 

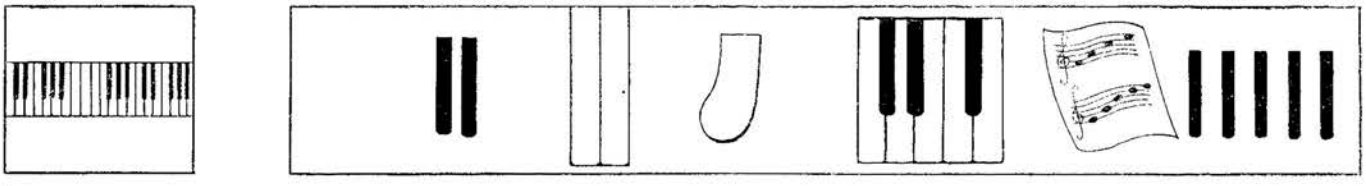
159 

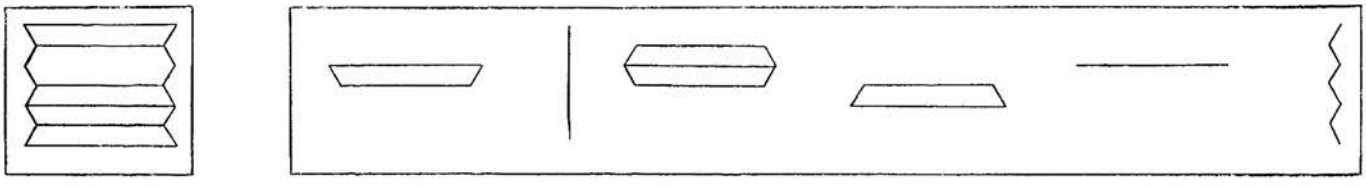
160 

161 

162 

163 

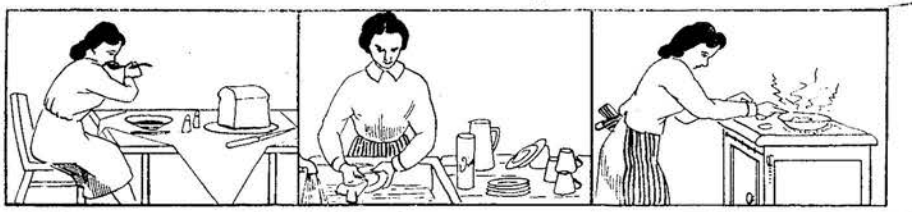
164 

165 

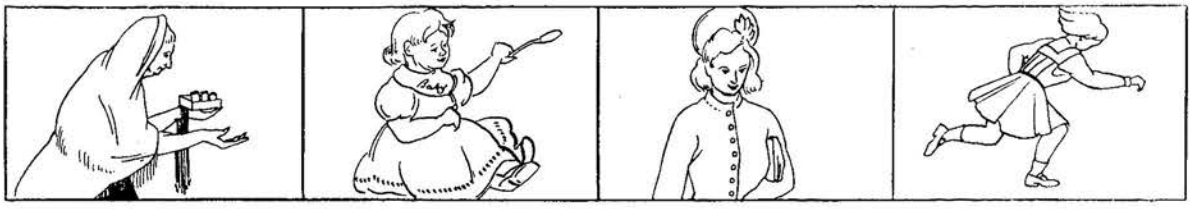
Score.....

TEST 5. Sequence

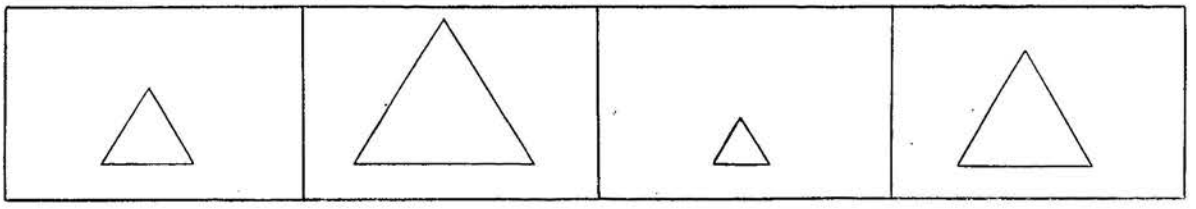
a



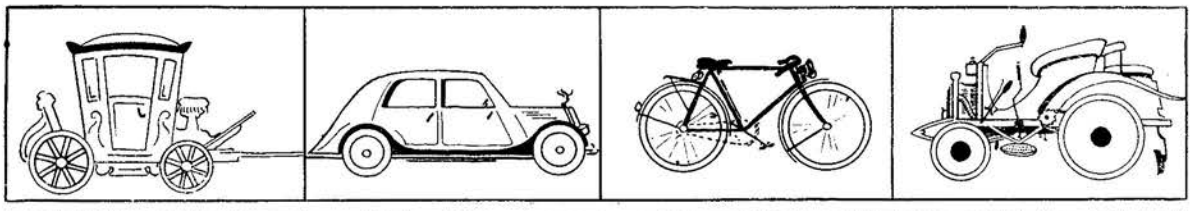
b



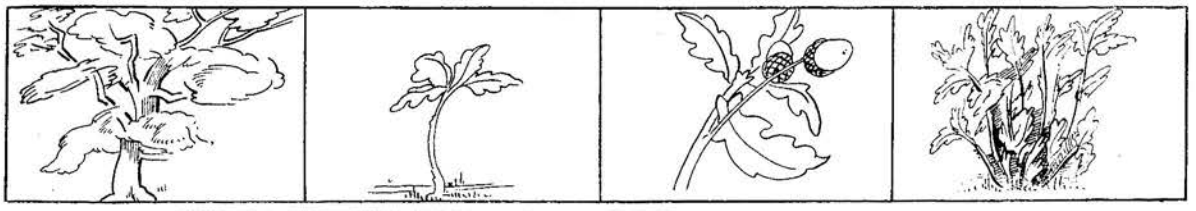
c



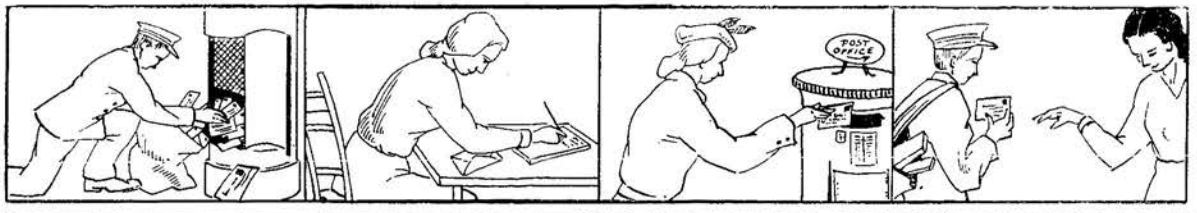
166



167



168



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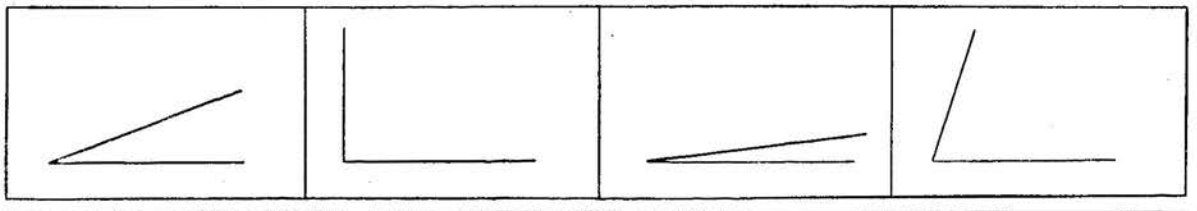
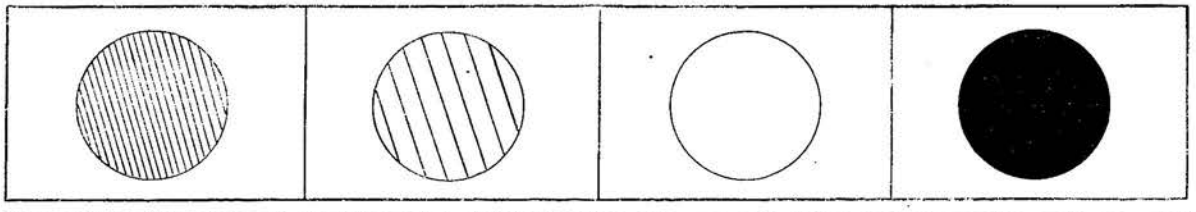
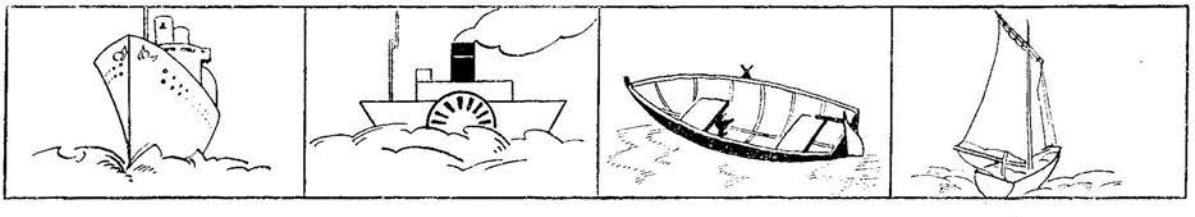


170

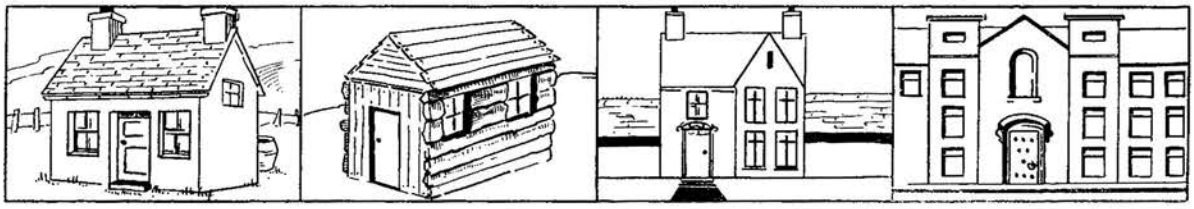


171

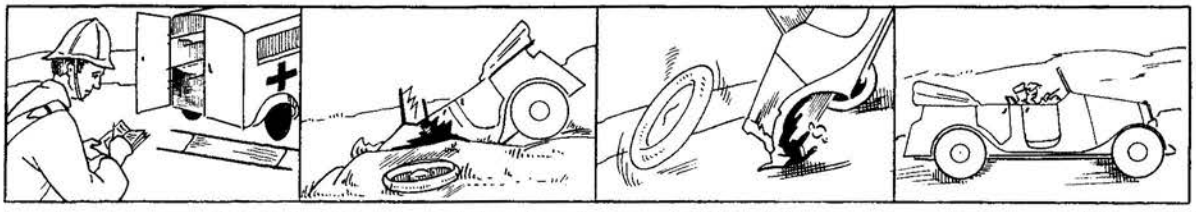


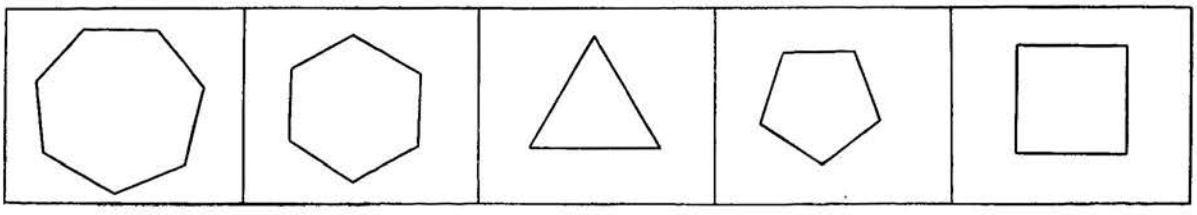
TEST 5 (contd.)

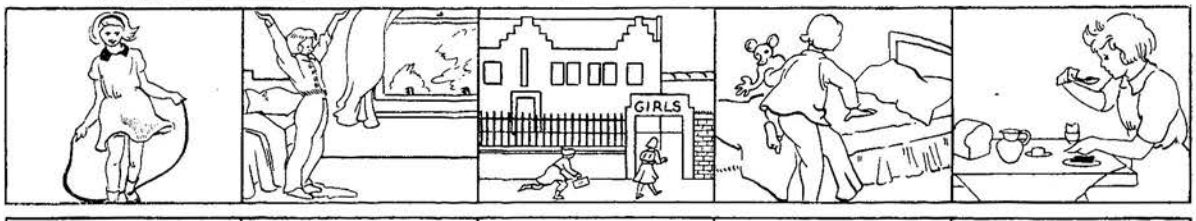
172 

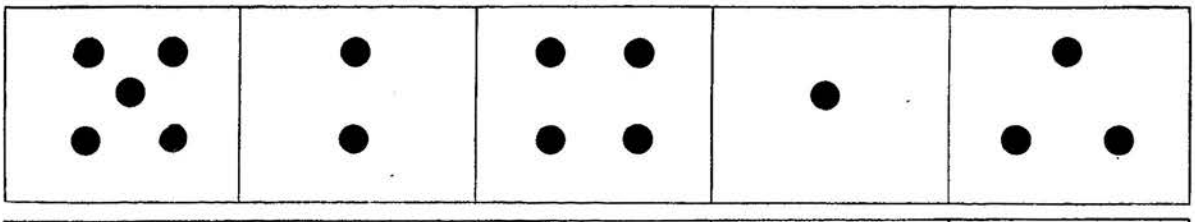
173 

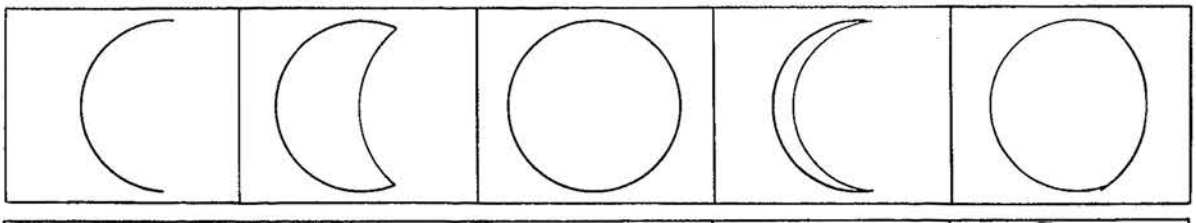
174

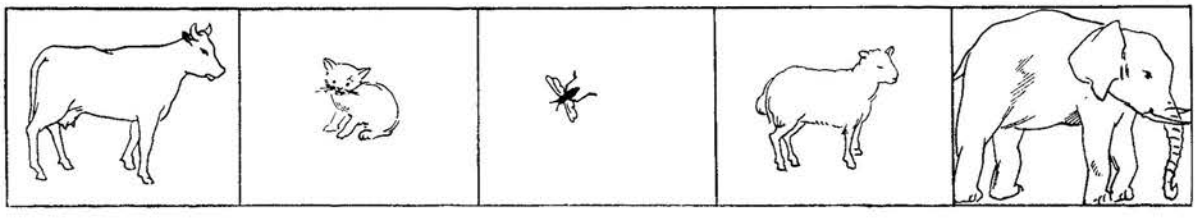
175 

176 

177 

178 

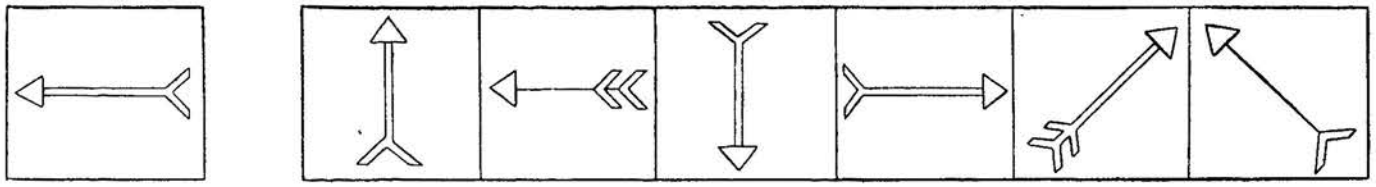
179 

180 

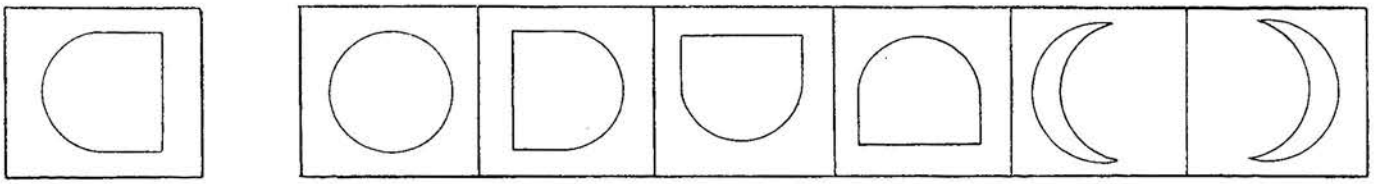
Score.....

TEST 6. Reversed Similarities

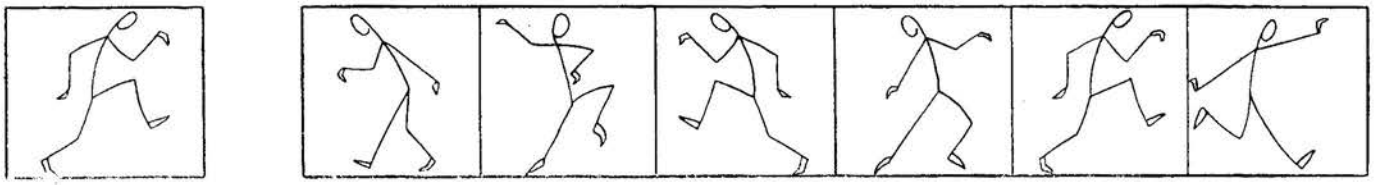
a



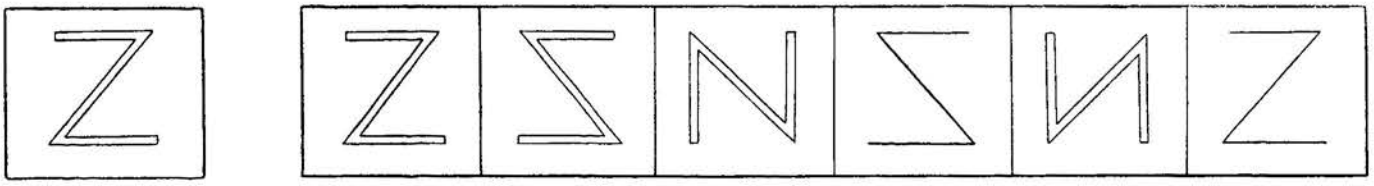
b



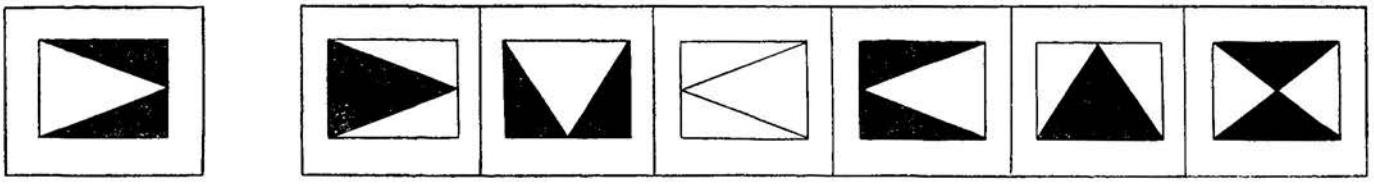
c



181



182



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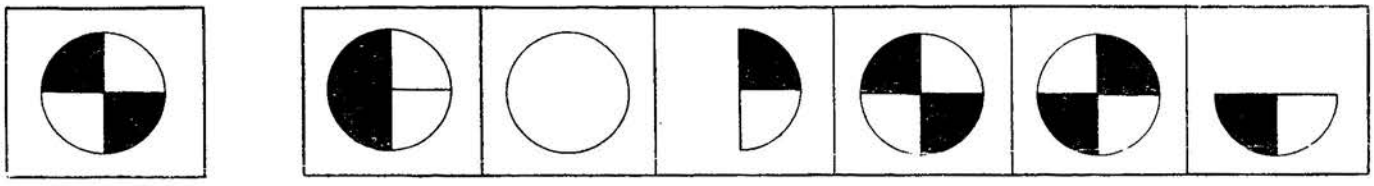

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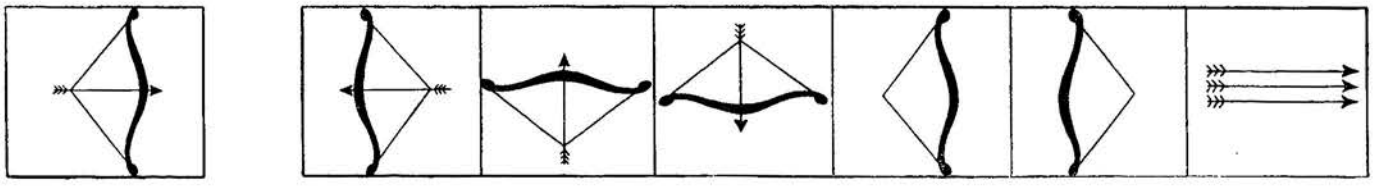

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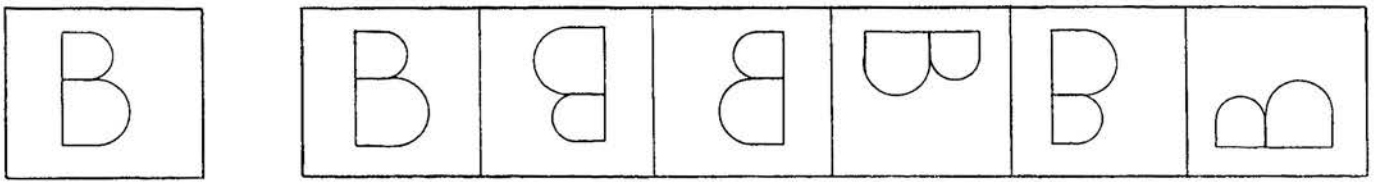

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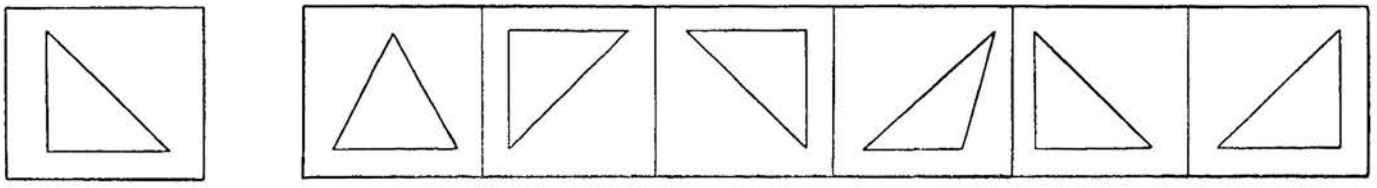

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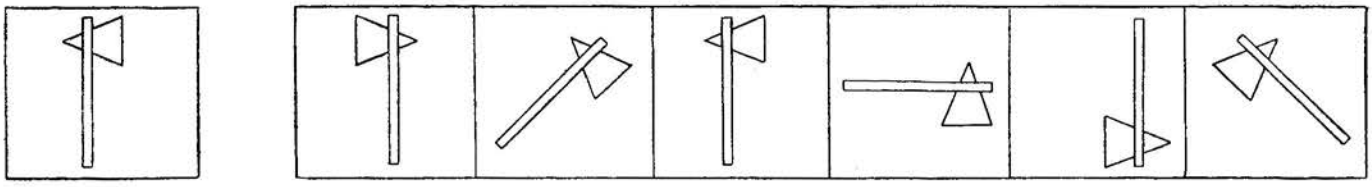
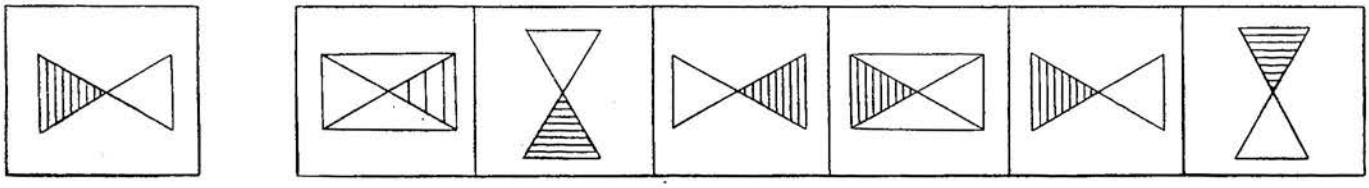
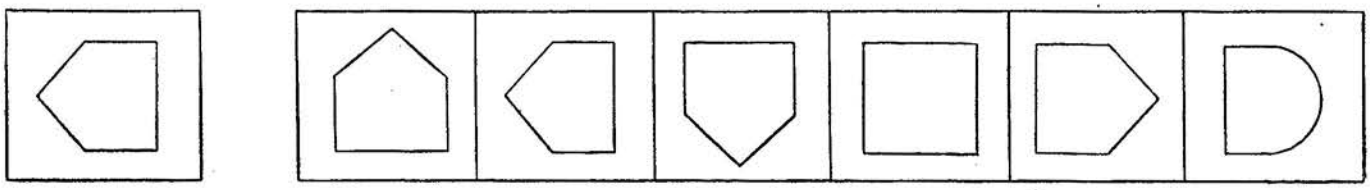
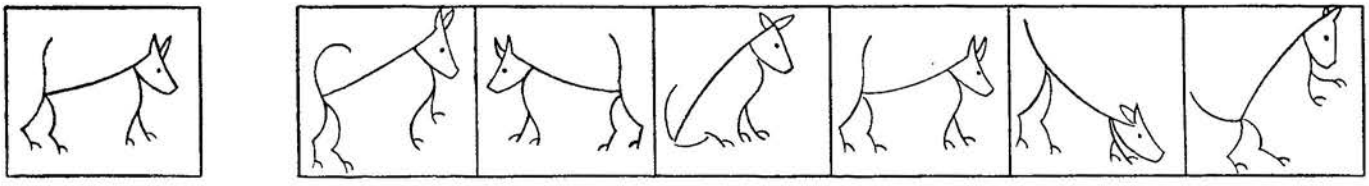
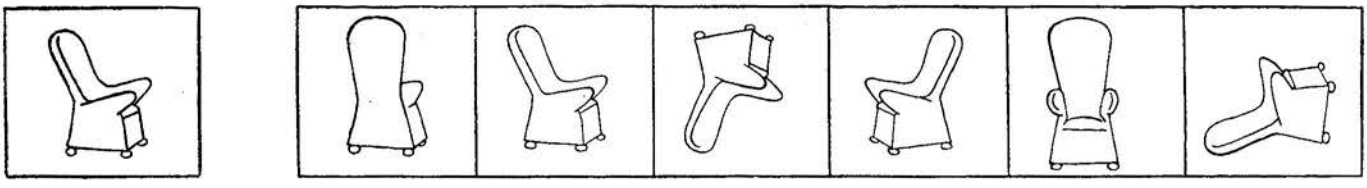
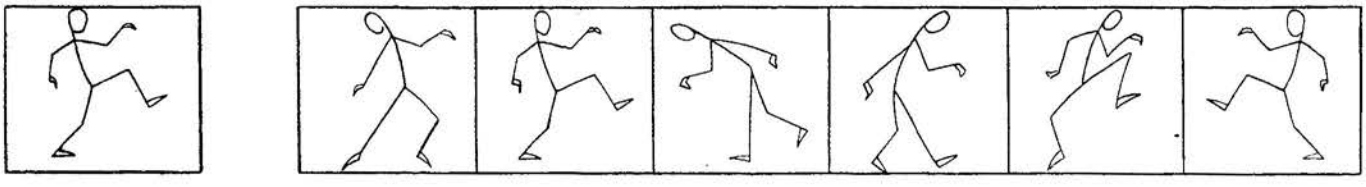
187 

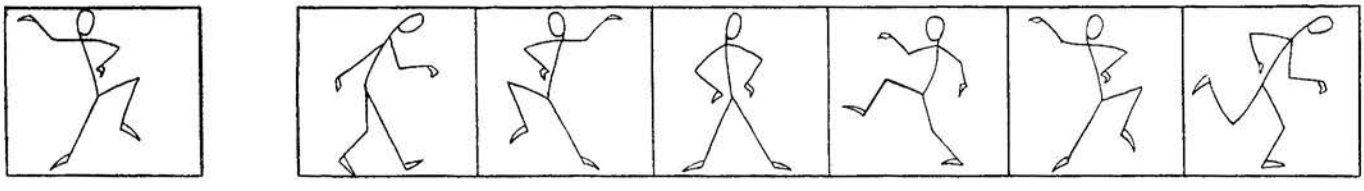
188 

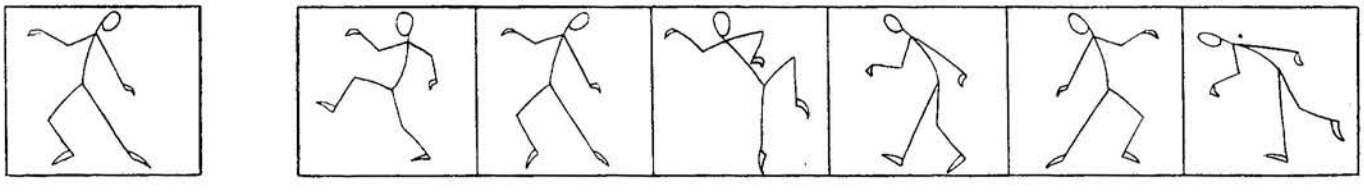
189 

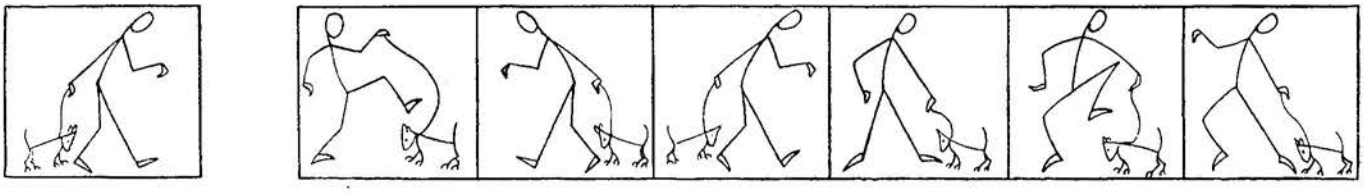
190 

191 

192 

193 

194 

195 

Score.....

TEST 7. Mazes

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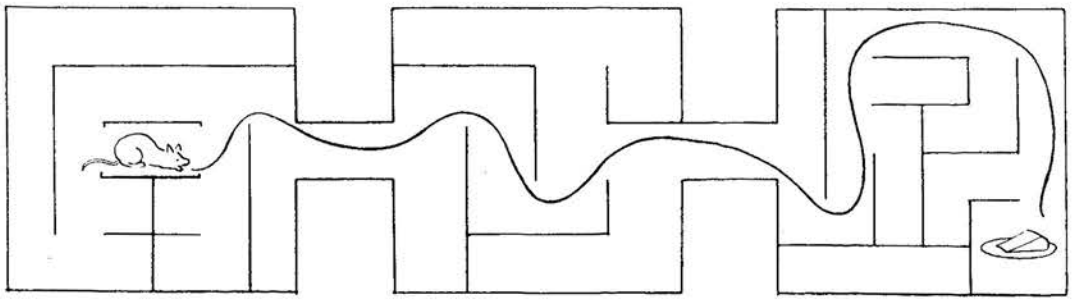

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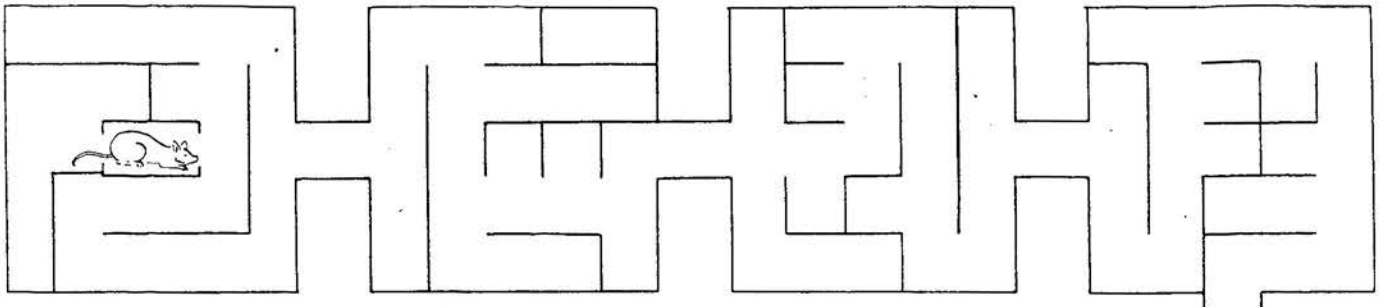

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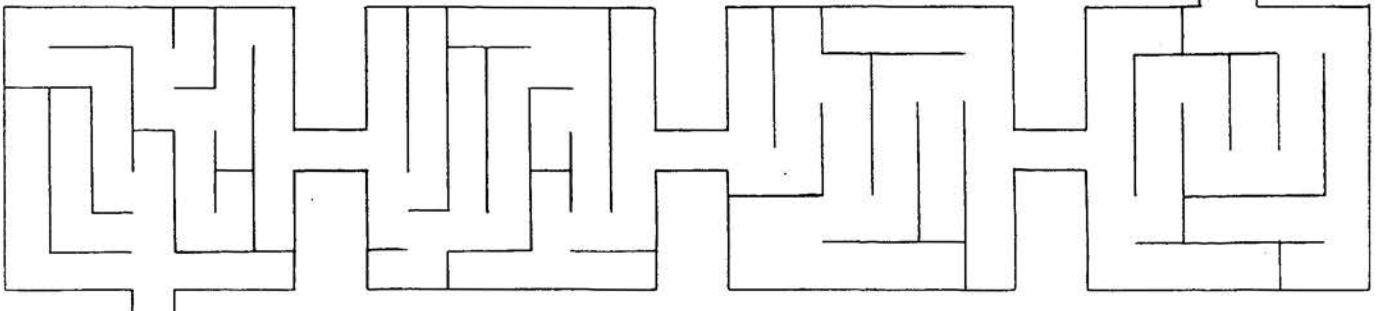

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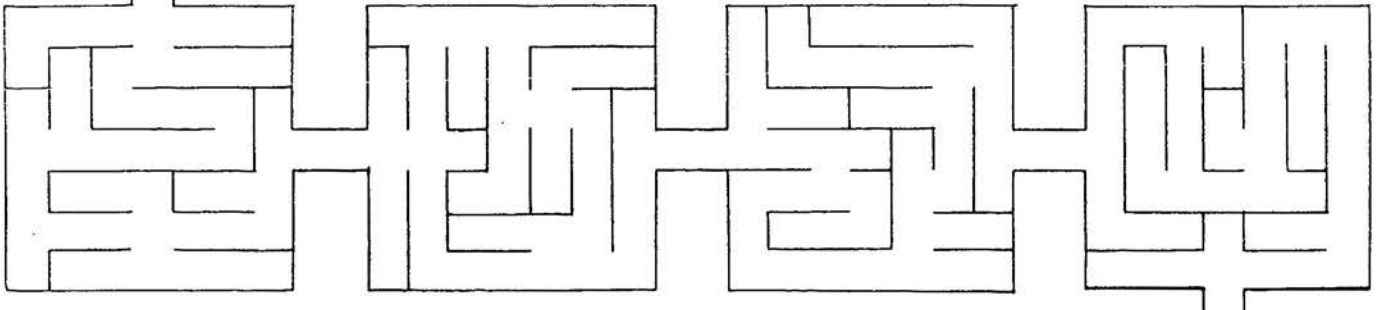

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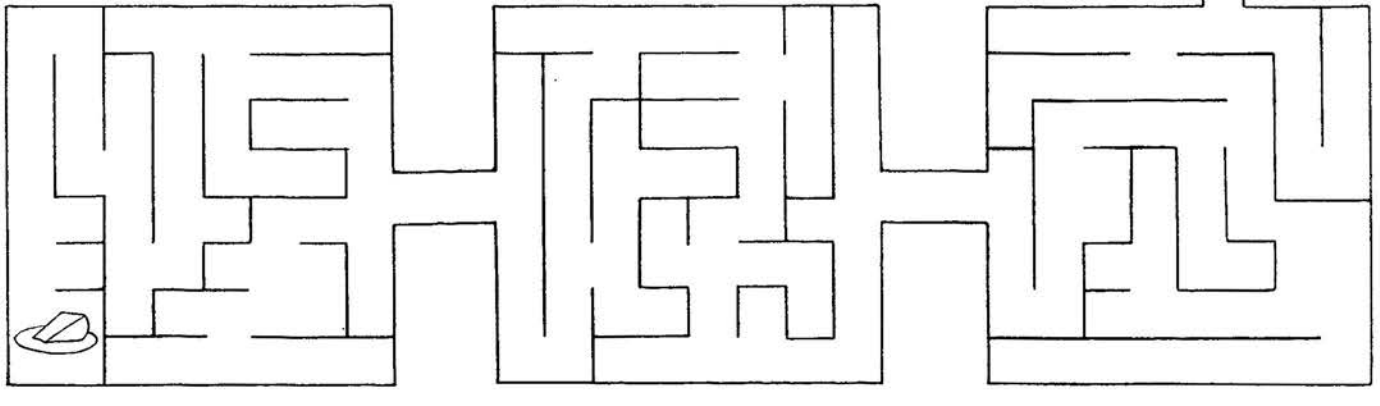


Score.....

D.P., Edin.—300—5/42

Instructions for administering M.H.T. (Pic.) 1 (Drafts 1a and 1b)

The complete test consists of 14 sub-tests, 7 in each booklet each separately timed, and each with three practice items at the beginning. The practice items are always done by the teacher with the class, and are ignored in correcting the test.

DRAFT 1a

The teacher should be provided with a stop watch for timing, and have a spare copy of the test booklet in which to point out to the children where to be looking. The chief aim of the practice items is to make sure that the children know what is the task they have to do in the rest of the test. The wording used for all explanations should be exactly as given in the instructions. A "dash" indicates that a pause is made for the class to answer verbally. It may be necessary to try one or two different children before the correct answer is given. If so, just say "That's not quite right" or any words that will not discourage the child who has given a wrong answer, and then proceed according to instructions. Time limits must be exactly observed, and there should be no pause between the end of the practice items and the beginning of the test items. But a short pause to relax between each test and the next is good, and the test should be given in two parts, with at least a 10 minutes break for play after Test 3 or 4.

Not more than 25 children should be given the Test together.

Before giving out the Test booklets, say, "In a few minutes I am going to give out some books and inside are lots of little pictures; we are going to do some puzzles with them. When you get the books, put your name on the top line, here (pointing) and then sit back to show you are ready. But you must not look inside till I tell you, for we are going to see who can do the puzzles best and most quickly."

Give the children some drill in how to stop and start each test together. Each test should be begun by saying "Pencils up" when the children will hold their pencils up, resting their elbows on the desk. Then say "Ready, Go" and all will start together. At the end of each test say, "Stop, Pencils up", and the children bring their pencils to the "up" position again. Then say "Pencils down, and sit up".

Except Tests 4a and 1b which have detailed instructions for each separate item.

As soon as the children have learned how to do this, give out the test booklets face up, and see that the children do not turn over. When all the books have been given out, show the children again where to put their names, and let everyone do it.

TEST 1.

When all are ready say,

"Now turn overthe page to TEST 1, here (holding up your copy for them to see) see, at the top of the page are a lot of little pictures and under each one is a mark; there is a cat, and an apple, and a chair, and a flower, and a table, and a dog. Under the cat is a dot, under the apple a cross, under the chair a ring, under the flower a ? - Yes, a line lying down. Under the table? - Yes, a line standing up. Under the dog? - Yes, 2 dots. Now let us do the next line. Put your finger on the cat at the beginning of the line. What should we put under the cat? - Yes, a dot, so everyone put a dot under the cat. Do it. What is the next one? - And what do we put under the chair? - Yes, a ring, so everyone put a ring under the chair. What is the next one? - And what do we put under the flower? - Yes everyone put a line lying down under the flower. And the next one? - What do we put under it? - Yes, everyone put a cross under the apple. And the next one? - Yes, a dot. Put it. And the next? - Yes, put it. And the next? - Put it. And the next? - Put it. And the next? - Put it. And the next? - Put it. Now pencils down and sit up.

Underneath are lots of drawings the same as these. I want you to put the right mark under each one. Work as quickly and as carefully as you can, and see how many you can do. Pencils up. Ready, Go."

Time: 3 minutes.

"Stop, pencils up. Turn to TEST 2 here, (showing it in your book). Pencils down and sit up".

TEST 2.

"Look at the pictures at the top of the page. Put your finger on the box with the snowdrop, the daisy and the crocus. Now all these pictures belong to one family. What are they all? - Yes, flowers. Now we want to find two more in the rest of

the line that belong to the flower family too. Put your finger on them as we look at them. Is it the bottle? - No. Is it the cup? - No. Is it the rose? - Yes, so we put a line through the rose. Everyone do that. And we still want one more. Is it the broom? - No. Is it the scissors? - No. Is it the daffodil? - Yes, so we put a line through the daffodil too. Now put your finger on the next row. What family do these three pictures belong to? - Yes, they are all hats. Now let us look for the other two that are hats. Is it the head? - No. Is it the next one? - Yes, that is a hat, so we put a line through it. Do it. And we want one more. Is it the boot? - No. the coat? - No. the next one? - Yes, so we put a line through it too. Now look at the next row. What family do those pictures belong to? - Yes, they are <u>triangles</u>. They all have <u>three</u> sides. (If no one gives the word triangle ask how many sides has each one? - Yes, three). So we must look for the other ones with three sides. Everyone look for them, and put a line through each one. Now, pencils down and sit up.

"We are going to do the others just the same way. First look at the three pictures at the beginning and think what family they belong to, then find the <u>two</u> others that belong to the same family and put a line through them. Do all this page, (pointing) and the next one down to here. Remember just to put lines through <u>two</u> things in each row. Pencils up. Ready, go."

Time: 5 minutes.

"Stop. Pencils up. Turn to Test 3, here. (Pointing). Pencils down and sit up."

TEST 3.

"Look at the pictures at the top of the page. Put your finger on the first one, the little girl. In that row there is <u>one</u> picture that has something wrong about it, something silly. Put your finger on them as we look at them. Is there anything wrong with the little girl? - No. Put your finger on the elephant now. Is there anything wrong with him? - Yes. What is it? - That's right, his trunk is behind, instead of in front. So we put a cross through him to show there's something wrong, like this. (Demonstrate how to make cross on blackboard). Now look at the next row. Put your finger on the first picture, the tree. Is there anything wrong with it? - Yes, what is it? - That's right, it's growing upside down (or, its roots are at the top, or its branches are at the bottom). So we put a cross

through it to show it's wrong. Now look at the next row. Put your finger on the first one, the nannie with the pram, is there anything wrong with that one? - No. Now look at the next one, put your finger on it, the teacher standing at her table. Is there anything wrong with that one? - No. Now put your finger on the next one, the teacher pointing to the blackboard. Is there anything wrong with that one? - Yes, the writing on the board is upside down. So we put a cross through that one, to show it's wrong. Now, pencils down, and sit up.

"We are going to do the others just the same way. First look at all the pictures in the row, then find which one is silly, or as something wrong, and put a cross through it. Remember just to put a cross through one picture in each row. Do all this page (pointing on your copy) and the next one, down to here. Pencils up. Ready, Go."

Time: 5 minutes.

"Stop, Pencils up. Turn to TEST 4 here, (showing on your copy). Pencils down and sit up."

TEST 4.

"See all the little pictures on this page. Put your finger at the first row, where there is a rabbit, a ball, a chair, and a carrot. I am going to tell you which ones to put a line through. While I am telling you, have your pencils up, and when I say 'Go', do it. Now, pencils up. You are to put lines through the rabbit and the chair. Go. (Pause 10"). Now put your finger at the second row. We shall do it the same way. Pencils up. You are to put lines through the teddy and the flower. Go. (Pause 10"). Now put your finger at the next row. Pencils up. You are to put lines through the bed, the broom, the engine. Go. (Pause 15").

Similarly for the other rows, naming the objects at the rate of 1 per sec.

52. The bird, the bell, the leaf (15")

53. The basket, the fork, the horse, the cat (20")

54. The teapot, the motor car, the apple, the ladder (20")

55. The tree, the knife, the axe, the aeroplane (20")

56. The pig, the bicycle, the man, the clock, the boot (20")

57. The fish, the duck, the door, the balloon, the bonnet (20")

58. The doll, the chicken, the hammer, the stove, the comb (20")

59. The watch, the lion, the soup, the potato, the cage, the candle (25")

60. The purse, the baby, the envelope, the tap, the desk, the cot. (25")

Pencils down. Sit up. Look at TEST 5, on the other page, here. (showing in your copy).

TEST 5.

"On this page there are a lot of lines of crosses and rings. (Copy X O on the board, and say "Call this one a cross, and this one a ring".) None of the lines is finished; there are empty spaces at the end of each line, and we must fill them. We must look at the line first to see what it is saying. Read the first one with me. (Read with the class "Cross, cross, cross, cross," then give three beats with the hand to help the class to read "cross, cross, cross," into the spaces. If they do not respond, ask, "What shall we put in to finish the line?" - "Yes, cross, cross, cross.") So all put cross, cross, cross in the empty spaces at the end. Now read the next line with me, Cross, ring, cross, ring, cross, ring." (Accentuate as indicated to give the rhythm. The children will probably continue the rest of the line, so say, "Yes, cross ring, cross, ring; everyone put it in.

"Now look at the next line, it has some empty spaces in the middle. We leave these spaces empty, and call them 'empty' when we read. We only fill in empty spaces at the end of the line. Now read it with me, ring, cross, ring, empty, ring, cross, ring, empty, ring, cross, ring - Yes, we leave the next space empty, then put ring, cross, ring. Everyone do it. Pencils down and sit up.

"Now we are going to finish the other lines on the page in just the same way. First find what they say, then put in the rest so that it says the same all the way along. Remember to leave the empty spaces in the middle of the line.

"Pencils up. Ready, Go".

Time: 5 minutes.

"Stop. Pencils up. Pencils down and sit up. Turn to TEST 6, here." (showing on your copy.)

TEST 6.

"Look at the pictures at the top of the page. In the first box is a sheep. Put your finger on it. Next to the sheep is some grass. What does a sheep do to grass? - Yes, she eats it. Now in the next box is a boy. Put your finger on him. And in the rest of the line we have to find something the boy eats. There is grass, and a little girl, and milk, and bread, and a book. Which does the boy eat? - Yes, bread. So we put a ring round the bread. All do it. Now read the line with me again; put your finger on the things as we way them. The sheep eats grass, the boy eats bread.

"Now we will try the next line. See, there is a whole daisy plant; put your finger on it. And next it is a bit of the plant. Then there is a whole tree, so we want to find? - Yes, a bit of the tree. Look for it. Is it the bird? - No. The flower? - No. The branch? - Yes, that's it, so put a ring round the branch.

"Now see if you can read the next line with me. Put your finger at it. See, there is a man, a pair of trousers, and then a woman. Now let's read it, a man wears trousers, a woman wears ? - Yes, a skirt. Find the skirt, and put a ring round it. Now, pencils down and sit up.

"We are going to do the rest of the page and the next one, right down here and here (pointing) just the same way. Read the first three lines with me once more, so that we remember what to do. Put your finger on them as we say them. A sheep eats grass, a boy eats bread. Yes. Now the next, a whole daisy plant, and a bit of it, a whole tree and a bit of a tree, a branch. Now the next, a man wears trousers, a woman wears a

skirt. Yes, Now, pencils up. Ready, Go."

Time: 6 minutes.

"Pencils Up. Stop. Now turn to TEST 7, here." (pointing on your copy).

TEST 7.

"See, here there are lots of different little piles of bricks. We are going to try and count how many bricks there are in each pile. Sometimes there will be some hidden behind the others, and we shall have to remember to count them too. Now look at the first one at the top, this one (pointing). Put your finger on it. Who can tell me how many bricks there are in that one? Yes, 2. So we write 2, down in the corner here (pointing). Everyone do it. Now look at the next one, here (pointing). How many bricks are there in that one? - Yes, 3. So we write 3 in the corner here (pointing). Now look at this one (pointing). How many are in this one? - Yes, 4. So we write 4 in the corner here (pointing). Pencils down, and sit up.

"Now we are going to do the rest of the page just the same way. Count how many bricks there are in each pile and write the figure in the corner. Begin here (pointing) and go across this line, and then the next one, down to here. Pencils up. Ready, Go."

Time: 5 minutes.

"Stop, pencils up. Now pencils down and sit up."

Collect the books at once.

DRAFT 1b

Before giving out the books remind the children of the previous test and give drill in starting and stopping. Then give out the books, and let the children put in their names.

TEST 1.

When all are ready say,

"Now turn over the page to TEST 1, here (holding up your copy for them to see). See, there are some drawings on the page, and I am going to tell you what to do with them. While I tell you, you will hold your pencils up, and when I say "Go" you will do what I have said. You must do exactly what I say.

"Now, pencils up. First draw a line from the elephant's tail to the top of the woman's head. Go." (Pause 20")

"Pencils up. Now you are to put a line right round the one we take baby out in. Go." (Pause 20")

"Pencils up. Now put a cross under the one we cook on. Go." (Pause 15")

"Pencils up. This time draw a line from the elephant's trunk, going over the moon and stars to the tree. Go." (Pause 20")

"Pencils up. Now put a cross over the one we put milk in. Go." (Pause 15")

"Pencils up. Put a line over the one we make a noise with. Go." (Pause 15")

"Pencils up. Now draw a ring under the one we live in. Go." (Pause 10")

"Pencils up. Now put a dot beside the one that grows in the ground. Go." (Pause 20")

"Pencils up. This time draw a ring over the one that goes in the water. Go." (Pause 15")

"Pencils up. Now put a dot under the one we keep things in. Go." (Pause 10")

"Pencils up. Draw a line through the one we put on our heads. Go." (Pause 10")

"Pencils up. Now put a line under the ones that shine in the sky at night. Go." (Pause 15")

"Pencils up. Draw a line from the dog's tail under the stove to the chimney on the house. Go." (Pause 20")

"Pencils up. Put a line right round the ring. Go." (Pause 10")

"Pencils up. Put a cross on the teddy's back. Go." (Pause 10")

"Pencils down. Turn to TEST 2 here (pointing), and sit up."

TEST 2.

a). "Look at the pictures at the top of the page. Put your finger on the first box, the one with the bird. Now all the pictures in that row but one are the same in some way. What are they all, all but one? - Yes, birds. But one that is not a bird has got among them, and we must find that one. Which is the one that is not a bird? - Yes, the pussy cat. So we put a cross through him like this (demonstrate on board) to show that he does not belong there. Everyone do it.

b). "Now look at the second row, where there is a picture of a carrot, an apple, a cabbage, a pea pod, a turnip, and a cauliflower. How are they the same, all but one? What are they all? - Yes, they are vegetables. And which is the one that is not a vegetable? - Yes, the apple, for it is a fruit. So we put a cross through it to show it does not belong there. Do it.

c). "Now look at the third row where there are a lot of different shapes. Put your finger at it. Who can see which is the different one there? - Yes, the curly one, so we put a cross through it to show it does not belong there. Do it."

(If no one spots the one that does not belong here, say "Well, Look at them with me, put your finger on them as we look. The first one, and the next, and the next all have straight lines, but the next one is - ? - The next one is curly, and then the last two have straight lines again. Which is the different one then?" -)

"Now, pencils down and sit up. We are going to do the rest of this page and the next one down to here (pointing) just the same way. First find how the pictures are the same, then find the different one and put a cross through it to show it does not belong. Pencils up. Ready, Go."

Time: 5 minutes.

"Stop, pencils up. Pencils down and sit up. Turn to TEST 3, here," (pointing).

TEST 3.

a). "Look at the first picture, the one in the little box, the man. Put your finger on it. In the big box beside him are a lot of things a man has. We have got to find the two things a man always has, and mark them. Put your finger on them as we look. Does he always have a coat? - No. (If they say "Yes" ask - "Even in bed at night?). Does he always have a head? - Yes, so we put a line through that one. Do it. Now, does he always have a case? - No. Does he always have a wife? - No. Does he always have a leg? - Yes, so we put a line through that one.

b). "Now look at the next row. Put your finger at it. In the first little box is a house, the outside of a house. Now we shall look in the big box for the things the outside of a house always has. Put your finger on them. Does a house always have a fire? - No. (If they answer 'Yes', say "Not really, it's the room that has the fireplace). Does a house always have a table? - No. Does it always have a door? - Yes, so we put a line through that one. Do it. Does it always have a garden? - No. A sofa? - No. A roof? - Yes, so we put a line through that one. Do it.

c). "Now look at the next row. In the first box is a tree. Put your finger at it. Now we shall look in the big box for

the two things a tree always has. Put your finger on them as we look. Does it always have a branch? - Yes, so we put a line through that one. Do it. Does it always have an acorn? - No. A nest? - No. A leaf? - No. (If they say 'Yes', say, "Not in winter does it?" -). Does it always have buds growing on it? - No. Does it always have roots? - Yes. So we put a line through that one. Do it. Pencils down, and sit up.

"We are going to do the rest of that page and the next one down to here (pointing) in just the same way. First look at the picture in the wee box then find the <u>two</u> things in the big box that it <u>always</u> has, and put lines through them. Remember just to put lines through <u>two</u> things in each line. Pencils up. Ready, Go."

Time: 5 minutes.

"Stop. Pencils up. Pencils down and sit up. Turn to TEST 4, here." (pointing).

<u>TEST 4.</u>

a). "Look at the first picture in the box by itself, the boy. Put your finger on it. There's something missing, something <u>not there</u>. What is it? - Yes, his other leg. So we must look for a leg in the big box. Put your finger on them as we look. Is it the first one? - No, that's an arm. Is it the next one? - Yes, that's it, so we put a ring round it to show it's the one. Do it.

b). "Now look at the next row. In the first box there is a horse. Put your finger on him. What is <u>not there</u> this time? - Yes, his tail. So we look for his tail in the big box. Who has found it? - Yes, it's the last one. Everyone find it, and put a ring round it. Do it.

c). "Now look at the next row. In the first box is a teapot. Put your finger on it. What has it <u>not</u> got? - Yes, a spout. (Or "the bit the tea comes out of", that is <u>the spout</u>). So we must look for the spout in the big box. Everyone find it and put a ring round it. Pencils down now and sit up.

"We are going to do the rest of the page just the same way, and the next page down to here.(pointing). First look at the picture in the little box by itself and think what is missing,

what it hasn't got, then find that bit in the big box ~~line~~ and put a ring round it. Remember just to put a ring round one thing in each line. Pencils up. Ready, Go."

Time: 4 minutes.

"Stop. Pencils up. Turn to TEST 5, here, (pointing). Pencils down and sit up."

TEST 5.

a). "Look at the pictures at the top of the page. Put your finger on the first box, the one with the woman eating. Then in the next box she's washing up, and in the last one she's cooking her meal. Those pictures have got into the wrong order, the woman doesn't eat, then wash up, and cook last. What does she do first, eat the meal, or wash it up or cook it? - Yes she cooks it first, so we put a line through that one. Do that. Then after she's cooked it, she ? - Yes, she eats it, and last of all she ? - Yes, washes up. So we put a line through the washing up one. Do that.

b). "Now look at the next line. Put your finger on the first box, the one with the old woman. In that row there's an old woman, a baby, a young woman and a little girl. Which of those should come first? - Yes, the baby, so put a line through the baby. And which one should come last? - Yes, the old woman, so put a line through the old woman."

c). "Now look at the next line; put your finger on the first box, the one with the wee shape with 3 points. They all have 3 points, but there's a wee one, then a very big one, the biggest of all, then a very wee one, the smallest of all, then a fairly big one. Which one should come first? - Yes, the smallest of all (or the biggest of all, if that is given). And which one should come last? First the smallest (or biggest) and the last the ? - Yes, the biggest (or smallest).

"Now pencils down, sit up, and listen. You are going to do all the ones on that page, and on the next down to here (pointing) just the same way. Look at all the pictures in the line, then think which one should come first, and put a line through it, and which one should come last and put a line through it too.

"Pencils up. Ready, go."

Time: 5 minutes.

"Stop. Pencils up. Turn to TEST 6, here (pointing). Now pencils down and sit up."

TEST 6.

"Look at the pig pointed shape on my paper here. (Hold up page with prepared wedge shape). Do you see it? Which way is the point looking? - Yes, to the window (or door, etc.). I am going to turn it over once. (Turn page to other side with same figure). Now which way is the point looking? - Yes, to the ..... ; it is looking the other way. (Repeat the whole demonstration once). You see it is just the same shape, but when we turn it over it looks the other way.

a). "Now look at your books. Put your finger on the first box, the arrow. Which way is it pointing? - Yes, to the ..... . Now we will think what it would look like if we could turn it over as we did the other one. Which way would it point if we turned it over? - Yes, to the ..... . Now look in the big box and see if there is one pointing to the ..... . Is it the first one? - No. The next? - No. The next? - No. The next? - Yes, that's the one, so all put a line through it.

b). "Now look at the next row, the one in the wee box. Which way is the straight side looking? - Yes, to the ..... . Now think what it would look like if we turned it over, and see if we can find that in the big box. Put your finger on them as we look. Is it the first one, the circle? - No. Is it the next one? - Yes, that's it, so all put a line through it.

c). "Now look at the next line; put your finger on the wee box, the one with the funny man running. Which way is he going? - Yes, to the ..... . And which way would he be going if we turned him over? - Yes, to the ..... . Now see if you can find the one just like him that is going to the ..... . and put a line through that one. Emphasise that it is the same man we want by pointing out his bent front leg.

"Now listen. You are going to do all the ones underneath just the same way, this page (pointing) and this, down to here. First look at the drawing in the wee box, then think what it would look like if we turned it over, and then find that one in the big box and put a line through it. Pencils up; ready, go."

Time: 4 minutes.

"Stop. Pencils up. Now turn to the back page with '7' at tge top, this one." (pointing).

TEST 7.

"See the wee mouse in the first box here. Put your finger on him. And see the cheese in the last box at the end of the line. Do you see it? - Now that wee mouse wants to get to the cheese, but the lines round these boxes and all the lines in them, are walls and he can't climb over the walls, he has to go round them, and this wavy line here (pointing) shows how he does it. He goes round all the walls, and at last he gets to the cheese, see?

"Now see the other wee mouse, this one (pointing). Put your finger at him. And he wants some cheese too; see here it is down at the bottom. Now he has to go round all the walls too. He'll have to go through every box, along here (pointing) and back here, and here, and back here. He mustn't climb over any walls, but go round them all.

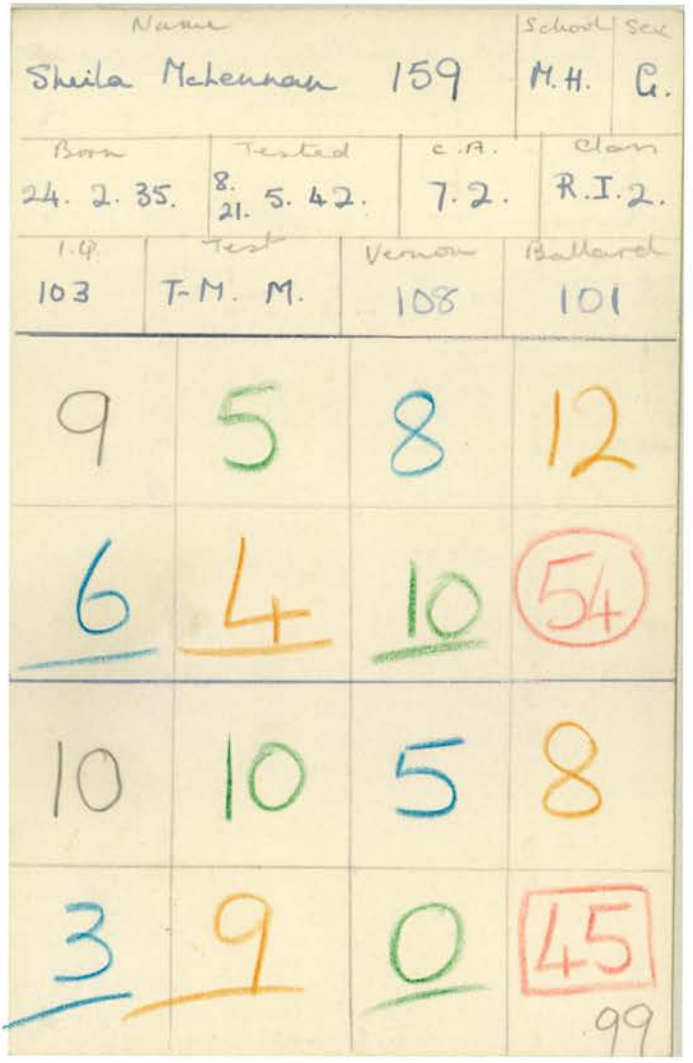
You are going to take your pencils and start at the mouse, and draw a line to show how he can get to the cheese. Remember to go through every box, and to go round the walls. Now see if you can find the way for him. Pencils up. Ready, go."

Time: 5 minutes.

"Stop; pencils up. Now put your pencils on your desks, and turn your books over, so that your name is on top."

Collect the books at once.

Subject's Score Card



Name		School	Sex
Sheila McKennan 159		M.H.	G.
Born	Tested	C.A.	Class
24. 2. 35.	8. 21. 5. 42.	7. 2.	R.I. 2.
I.Q.	Test	Vernon	Ballard
103	T-M. M.	108	101

9	5	8	12
6	4	10	54
10	10	5	8
3	9	0	45
			99

APPENDIX V.

Construction and Standardisation of M.H.T. (Pic.) 1.

The construction and administration of Drafts 1a and 1b of the test have already been described in the main body of the present work. From the 210 items in these two drafts it was hoped that there would be 100 survivors which would form a suitable Intelligence Test for the use of the Education Authority.

After the actual testing and correction of the scripts, an Answer Pattern was made: all the scripts, boys and girls separately in case there were sex differences in any of the tests, were divided into sixths according to total score on the two drafts together. Then in each sixth the number of children who answered each item correctly was counted and set down as in the following Table.

The "Total" column shows the total number of girls answering each item correctly, the "%" column gives the same figure as a percentage, and shows the "difficulty value" of the item. The Answer Pattern for boys was made separately, but the percentage of boys answering each item correctly is also shown for purposes of comparison.

TABLE I.

Answer Pattern. M.H.T. (Pic.) 1. Drafts 1a and 1b.

GIRLS
N.= 202

"Doesn't Belong"

Item No.	Top N.= 34 Sc=156-111	2nd 33 110-93	3rd 34 93-81	4th 33 81-72	5th 34 71-57	Bottom 33 56-10	Total	% Girls	% of Boys	
121	32	26	28	30	22	16	154	77	77	·30
122	26	18	14	12	12	9	91	45	46	·34
123	21	18	15	13	5	12	84	42	45	·33
124	19	17	20	17	13	12	98	49	47	·16
125	32	19	25	17	12	10	115	57	67	·43
126	22	14	22	21	11	11	101	50	48	·21
127	23	15	16	9	11	7	81	40	44	·30
128	11	1	9	6	2	2	31	15	19	·12
129	14	17	14	6	9	1	61	30	41	·31
130	25	21	15	14	14	7	96	48	48	·37
131	16	8	10	7	5	6	52	26	35	·19
132	20	13	14	8	6	8	69	34	32	·28
133	22	12	10	6	5	3	58	29	26	·39
134	14	4	10	2	3	-	33	16	13	·22
135	12	6	5	6	3	4	36	18	18	·16

This particular test is on the whole satisfactory. There is practically no difference in difficulty value between boys and girls, and most of the items show a distinct downward trend in the number of correct answers from the top to the bottom sixth. This test was therefore retained for Draft 2, item 128 being rejected because it does not discriminate well, and item 135 because it was found that two possible answers had been allowed to creep in. Item 134 was verging on too difficult, but it was decided to give it another trial in one more draft. It did not survive till the final version.. The aim was to retain to the end items of a difficulty value between 15% and 85%, as those easier or harder than this were considered not to give sufficient discrimination even at one end of the scale to be worth using.

The Memory Span test had to be rejected on these grounds, being altogether too easy, and the Classification test, being too difficult. The Block Counting test had also to be entirely rejected. The complete answer pattern for the girls is shown in the following table, along with the percentage of boys answering each item correctly.

This test gives rather poor discrimination, that is to say it is measuring something different from the test as a whole; but the chief objection to it is that it is consistently easier for the boys than the girls. The Mazes test had also to be entirely rejected for the same reason.

TABLE II.

N=209 Employees.

Answer Pattern. Block Counting Test. Girls. Test 7.

Item No.	Top	2nd	3rd	4th	5th	Bottom	Total	Girls %	% of Boys	E_{13} girls
91	33	33	32	30	27	24	179	89	90+	.22
92	31	30	32	29	28	19	169	84	89	.21
93	32	29	28	28	28	19	164	82	89	.21
94	31	30	27	26	28	22	164	82	89	.16
95	20	19	13	16	13	12	93	46	68	.21
96	16	13	17	11	6	7	70	35	61	.24
97	21	20	18	21	15	12	107	53	69	.21
98	7	4	9	6	11	3	40	20	36	−.04
99	18	18	12	9	9	8	74	37	55	.27
100	25	22	21	20	16	13	117	58	75	.27
101	13	11	6	9	14	4	57	28	49	.09
102	3	3	-	1	2	-	9	4	10	.06
103	18	15	13	12	8	8	74	37	58	.25
104	9	7	8	5	5	1	35	17	28	.15
105	10	10	9	7	3	4	43	21	31	.19
							Overall %	46.2 %	59.8 %	

See also page 54.
(Practical difficult means Test)

All the other tests showed some good and some bad items. Table III shows the answer pattern for Always Has for instance.

TABLE III.

Answer Pattern. 'Always Has' Test. Girls.

Item No.	Top	2nd	3rd	4th	5th	Bottom	Total	%	% of Boys	
136	5	2	2	1	1	-	11	-	-	
137	4	4	3	2	-	-	13	-	-	
138	4	3	-	1	-	-	8	-	-	
139	12	6	-	3	2	-	23	12	16	✓
140	9	2	3	-	1	2	17	8	12	✓
141	4	2	-	-	1	-	7	-	-	
142	7	6	5	1	3	1	23	11	14	✓
143	23	19	9	10	7	1	69	34	36	✓
144	18	15	8	5	1	2	49	24	24	✓
145	2	-	-	1	-	-	3	-	-	
146	13	12	10	6	1	3	45	22	34	✓
147	22	19	11	9	4	1	66	33	35	✓
148	11	8	2	2	2	2	27	13	14	
149	14	11	4	2	-	-	31	15	17	✓
150	11	3	4	1	1	-	20	10	11	✓

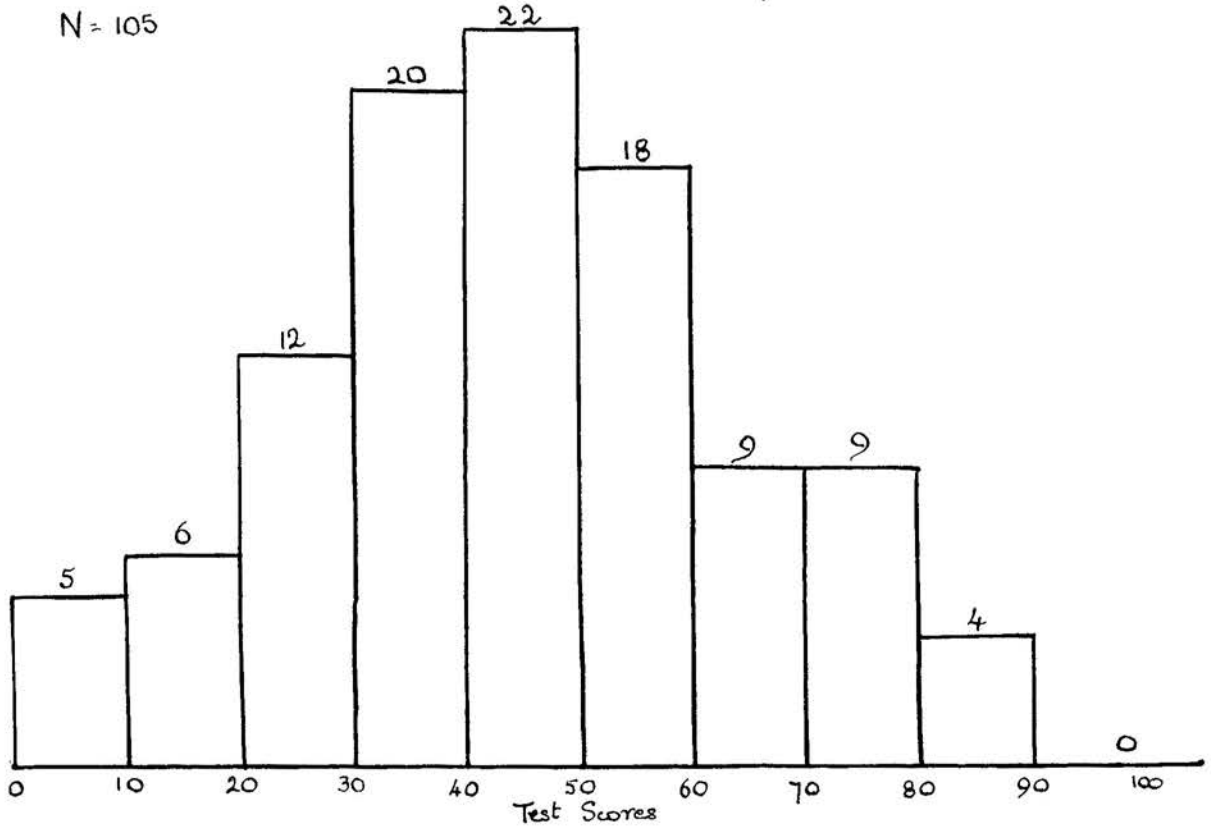
The items retained for Draft 2 were those marked with a tick in the table. One or two of these items were doubtful, but all were considered worth a second trial. Indeed the test as a whole is verging on too difficult. But it was hoped that by eliminating the very difficult items at the beginning of the test the children might find the whole thing easier, as in fact they did.

By a process of elimination such as this Draft 2 was made up, consisting of nine tests and 105 items in all. The nine tests were, in the order in which they appear in this and the final version, Following Directions, Doesn't Belong, Completion, Absurdities, Sequence, Reversed Similarities, Always Has, Analogies, Series. Of the rejected tests the first try-out had shown that Substitution was not measuring general intelligence, that Classification was too difficult, Memory Span too easy, and that Block Counting and Mazes were easier for the boys than for the girls. The items in each of the tests were rearranged in order of difficulty, so that the easiest came first, the hardest last.

Draft 2 was tried out in Musselburgh on an almost complete age-group of children between 6¾ and 7¾ years of age. There were 105 children in the group, and the distribution of total scores was very satisfactory.

The teachers in each school had been asked to divide the children into five groups according to their estimate of the children's intelligence, so that we might see how well each item agreed not only with the internal criterion of test score, but also with an external/

Fig. 1. Score Distribution, Draft 2.



external criterion, namely the teachers' estimates of the children's intelligence. The children came from three different schools, and the writer had expected to find some difficulty in fitting the judgments from one school into those from another, but all three did seem to have had some absolute standard in mind, for it was found/

found that the best school had placed the largest proportion of children in the A group, while the worst had graded only one child as B and all the rest as C, D, or E. For convenience in handling the data the group was reduced to 100, and it was then found that we had 27 children who had been judged A or B, 46 who had been judged C and 27 who had been judged D or E. The answer pattern was therefore made in three groups, the A and B children in the top, the C's in the middle and the D and E ones in the bottom group. Boys and girls were this time kept together, as the tests showing sex differences had already been rejected after the first try-out. For each item we then had the difficulty value, that is to say the percentage, in this case the actual number, of children answering it correctly, and we also calculated an efficiency coefficient by taking the number correct in the top group minus the number in the bottom group and dividing this by the total number in each group. Table IV below shows the answer pattern for three sample items, all of a difficulty within the required range, but one of exceptionally high efficiency, one of exceptionally low, and one average.

TABLE IV.

Answer Pattern M.H.T.(Pic.) 1. Draft 2.

Item No.	A, B N.27 Sc.= 87-49	C N.46 Sc.= 84-17	D, E N.27 Sc.= 49-17	Total %	Diff-:erence	Efficiency Coeff.
70	23	16	3	42	20	.740
100	11	18	11	40	0	.000
80	15	11	2	28	13	.481

It will have been observed that to select items as was done in the first try-out on the basis of agreement with total test-score does assume that the complete test is a valid measure of intelligence. This assumption is reasonable if the test is constructed by a competent psychologist of types of item which have been known to be successfully used previously, but as this was the first attempt made in the Moray House Education Department to construct a non-verbal test for young children we were very anxious to have an external criterion of validity. This we obtained by using teachers' estimates of intelligence in the Musselburgh try-out. One of our Advanced Students was at this time engaged in writing a Thesis on the relative merits of the external and the internal criterion in selecting items. At the same time as the writer was making an Answer Pattern on the basis of teachers' estimates, she was making one by dividing the scripts into three groups according to total test score, taking the same number of cases in each group as the external division gave, i.e. 27, 46, 27. She then calculated the efficiency coefficient of each item by her answer/

answer pattern and compared them with the writer's figures. The results were very striking: the average efficiency coefficient of a single item using the external criterion was .387, using the internal criterion .472. The latter is significantly higher, but it is clear that the items are almost bound to agree better on the average with the actual test from which they are taken than with any other criterion whatever the relative merits of test and criterion. The correlation of the whole test with teachers' estimates was .792. The important point is whether the external and the internal coefficient both select the same items as the best. How closely they do this is illustrated in the following diagrams.

Fig. 2.

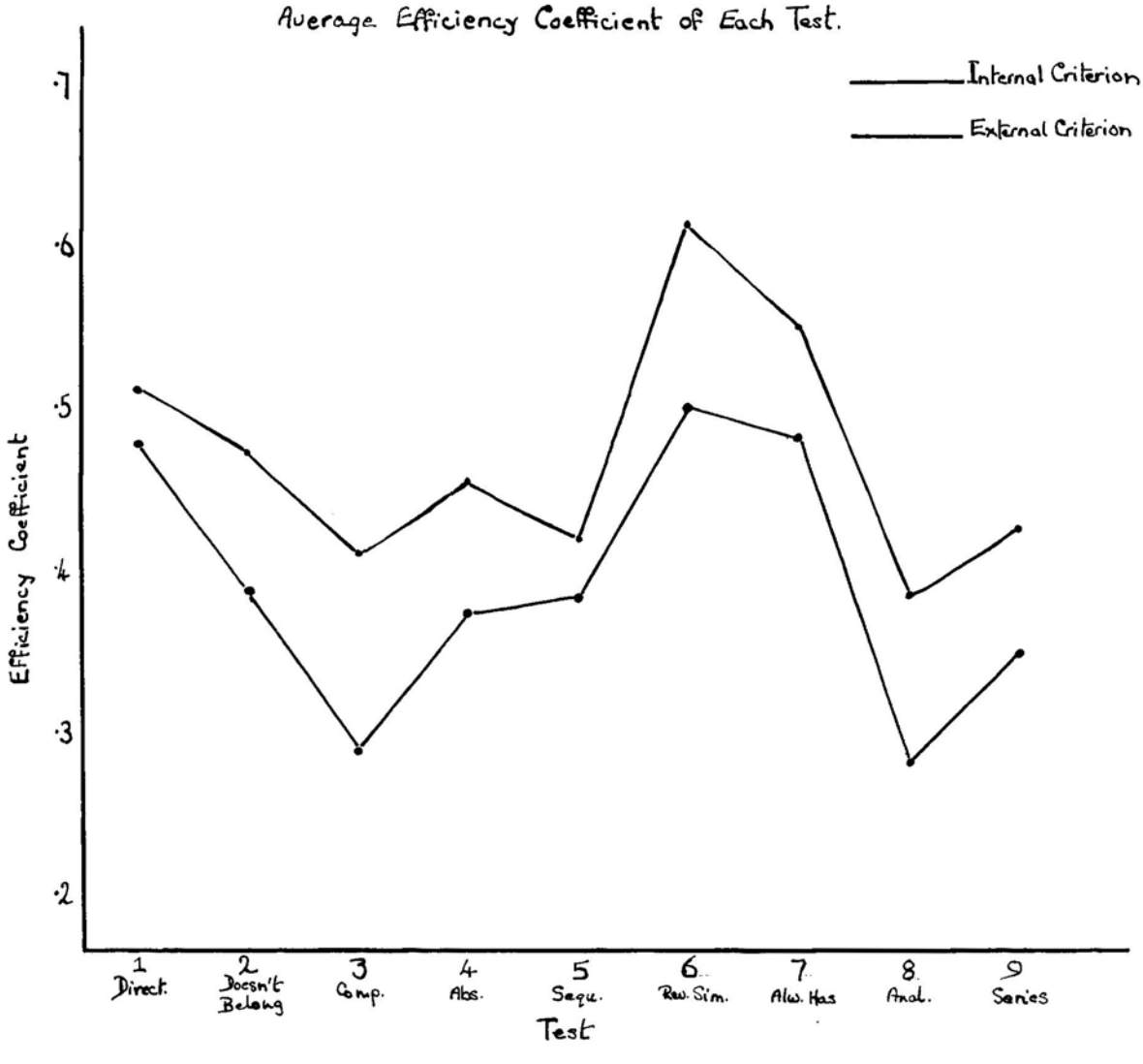


Fig. 3.

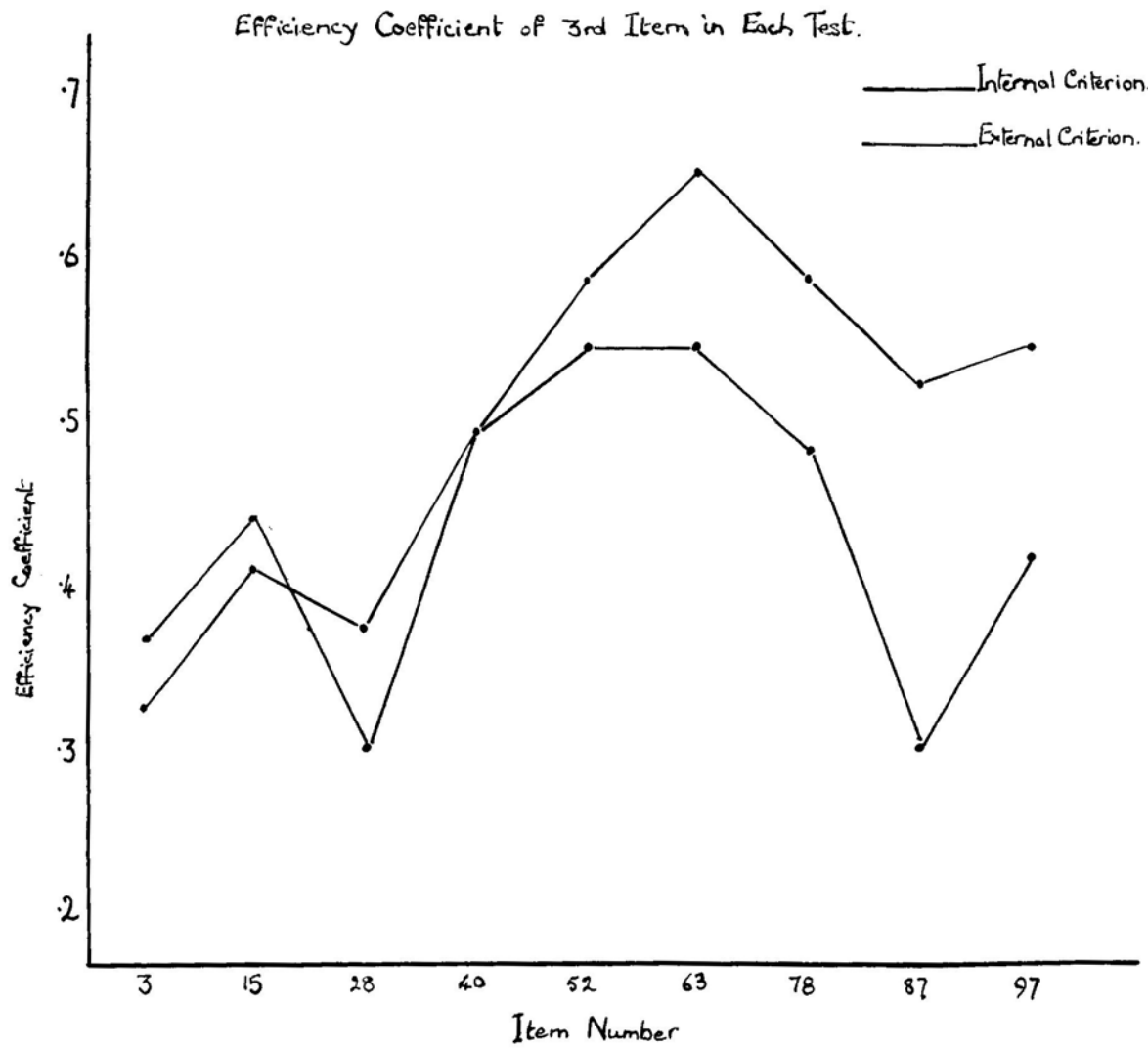
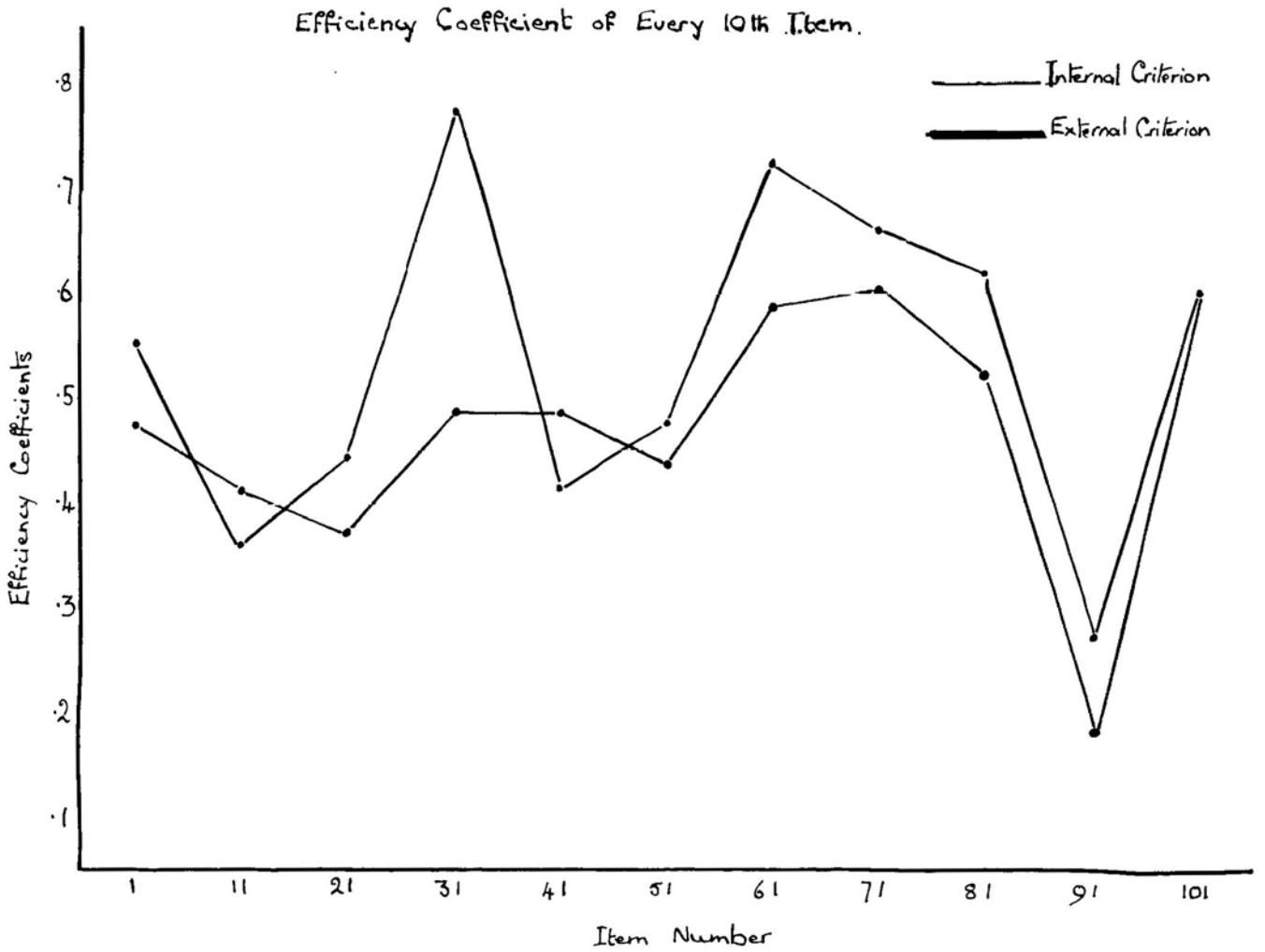

Efficiency Coefficient of 3rd Item in Each Test.
Internal Criterion.
External Criterion.
Efficiency Coefficient
·7
·6
·5
·4
·3
·2
3
15
28
40
52
63
78
87
97
Item Number

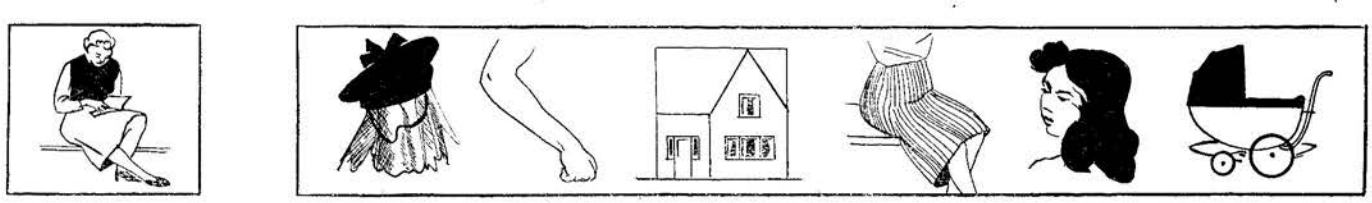
Fig. 4.


Efficiency Coefficient of Every 10th Item.
Internal Criterion
External Criterion
Efficiency Coefficients
·8
·7
·6
·5
·4
·3
·2
·1
1
11
21
31
41
51
61
71
81
91
101
Item Number

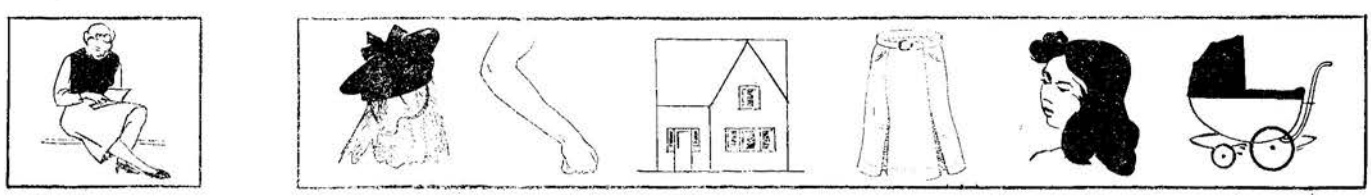
Taking the average efficiency coefficient for each sub-test we find that the line representing the external criterion and that for the internal criterion follow almost the same path. When we come to the efficiency coefficients of single items the agreement is not quite so close, but the two lines still follow very similar paths.

In deciding which items to reject from this try-out, account was taken both of the difficulty value and the efficiency co-efficient. The six most difficult items were first rejected, all of them being answered by under 10% of the children. Then in the next worst items, that is to say both the most difficult and those with the lowest efficiency co-efficients, the mistakes of all the best children were examined, as in this way possible ambiguities could be detected. Some of these were then rejected, and in others slight alterations were made within the item to improve it. Item 83, for example, is shown in Figure 5.

Fig. 5. Item 83.



(a) As in Drafts 1 and 2.

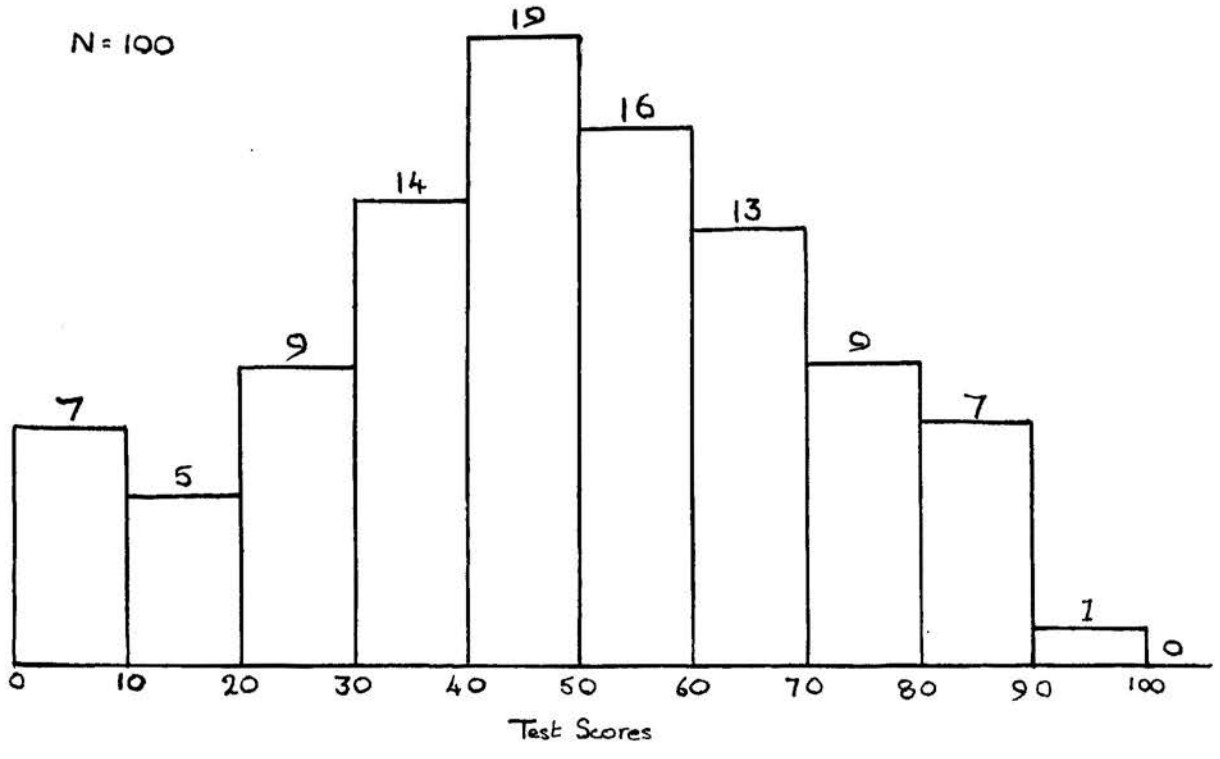


(b) As in Draft 3 and Final Test.

This item comes from the 'Always Has' test, the task being to find the two things in the big box that the woman always has. Originally it was as shown in the top line. But in this version it was answered by less than 15% of the children, and was not discriminating well. When mistakes made by children in the top group were examined it was found that most of them consisted in marking one of the right answers, either the head or the arm, along with the skirt. It seemed as if the children were seeing this not as a skirt but as a body or legs. This drawing was therefore taken out, the one shown below it, with no body or legs within the skirt, being substituted. When tried out in this new form the item did very well, and survived to the final version of the test.

A third draft of the test was now made up, consisting of the surviving items from Draft 2 and 5 altogether new ones. This was tried out on a complete age group in Dalkeith, an Answer Pattern constructed, and efficiency coefficients calculated. This time the internal criterion only was used as the previous try-out had demonstrated that the whole test was a valid measure of intelligence. The distribution of scores was again very satisfactory.

Fig. 6.
Score Distribution, Draft 3.

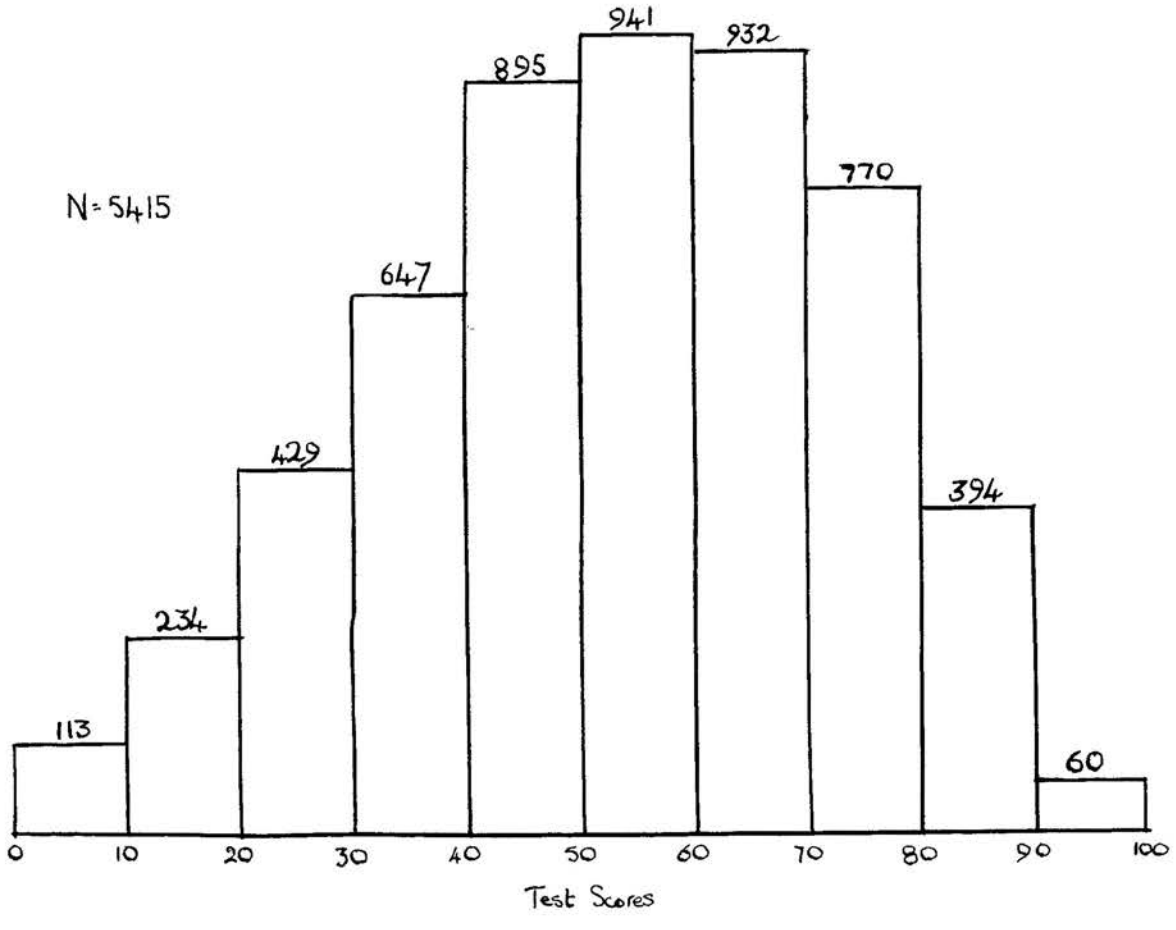


From this draft the final version for use of the Education Authority and for standardisation was made up.

For purposes of standardisation we arranged to test every child in schools under the Education Authority, including special schools, aged from 6 years 9 months to 7 years 8 months inclusive. As there are a good many schools in Edinburgh not under the Authority we also obtained the co-operation of the four large Merchant Company Schools, George Heriot's Boys' School, and the Demonstration School at Moray House. In this way we had results from an age group complete except for the few children being/

being educated in small private schools or at home, and were justified in assuming for the group a normal distribution of I.Q. with average 100 and s.d. 15. The total number of children tested was 5,415 and the distribution of raw scores, shown in Figure 7, was almost normal, with a slightly greater spread at the lower end.

Fig. 7. Score Distribution, Edinburgh Age Group.



The results were sent to us in the form of a score-age distribution of which Figure 8 gives a summary. This figure was made before the results came in from the last half dozen schools, but these made no difference to the general trend.

Fig. 8.

Summary of Score-Age Distribution, Edinburgh.

	Ages											
Score	6.9.	6.10.	6.11.	7.0.	7.1.	7.2.	7.3.	7.4.	7.5.	7.6.	7.7.	7.8.	Totals
90–100													59
80–89	55	55	63	84	81	85	96	102	116	120	160	156	377
70–79		171			250			314			436		735
60–69													889
50–59	279	290	334	273	271	271	240	262	265	247	243	264	891
40–49													832
30–39													627
20–29		311			200			147			94		415
10–19	116	94	101	61	68	71	51	50	46	41	25	28	229
0–9													108
Totals	448	439	498	418	420	427	387	414	427	408	428	448	5162

The standardisation is made by calculating for any fixed score the I.Q. corresponding to any given age, assuming the mean I.Q. in the population to be 100, with standard deviation 15. Table V shows the raw scores corresponding to I.Q's of/

of 115, 100 and 85 at each month of age, for the final version of M.H.T. (Pic.) 1. These norms have been extrapolated down to 6 years 6 months and up to 8 years 6 months, thus covering the whole effective age range of the test.

TABLE V.

Scores in M.H.T. (Pic.) 1 corresponding to I.Q's of 115, 100, 85.

Age	6.9	6.10	6.11	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8
I.Q.												
115	66	67	69	70	71	72	74	75	76	77	78	79
100	45	46	48	50	51	53	55	56	58	60	61	63
85	23	25	26	28	29	31	33	35	36	38	40	41

The reliability of the Test, calculated by the formula[1]

$$r_{tt} = \frac{n}{n-1} \times \frac{kSs + Si - T(T+k)}{kSs - T^2}$$

when T = sum of scores, Ss = sum of squares, Si = sum of numbers correct squared, n = number of items and k = number of subjects, was found to be .9603.

The test - retest correlation of 1085 subjects with a four months' interval was .8606.

(1) C.J. Hoyt: Note on a Simplified Method of Computing Test Reliability. Educ. & Psych. Measurement. Vol. I. No.1. Jan. 1941.

EDINBURGH CORPORATION EDUCATION COMMITTEE

PICTURE TEST

Name ..... Sex.....

School..... Class .....

Date of Birth..... Date of Test..... Age.....yrs.....m.

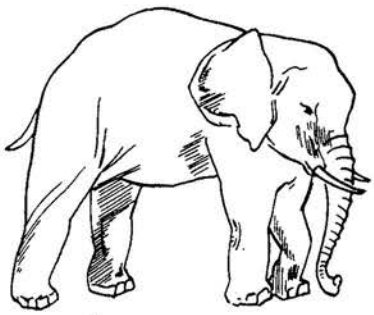
Total Score.....

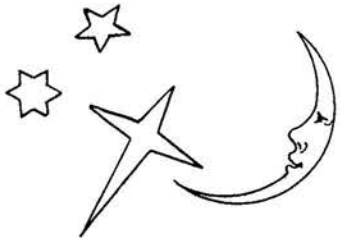
I.Q. .....

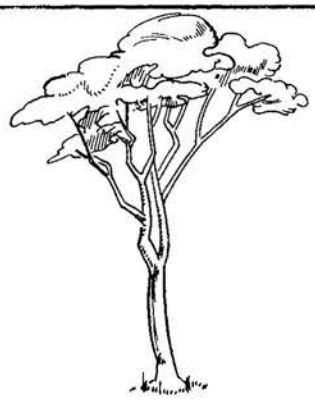
TEST	SCORE
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
TOTAL	
Signature of Marker:	

TEST 1. Directions

1
2
3







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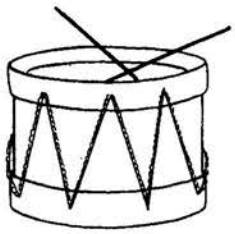

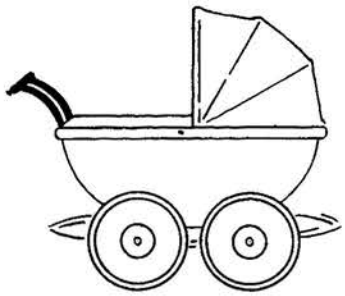

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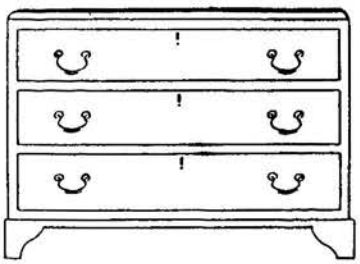

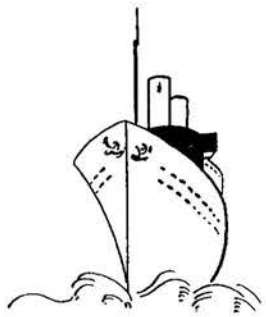

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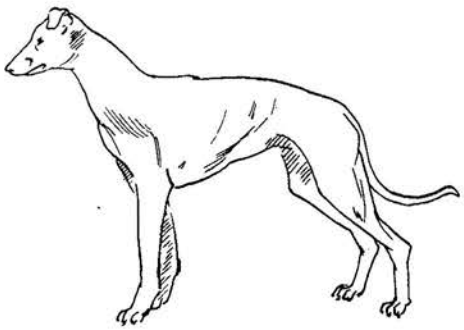

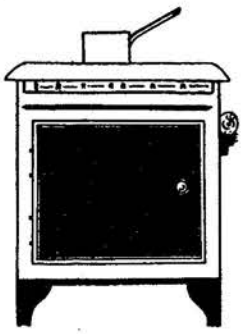

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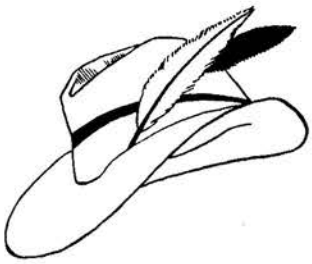
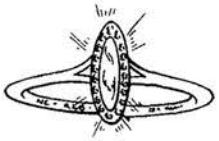
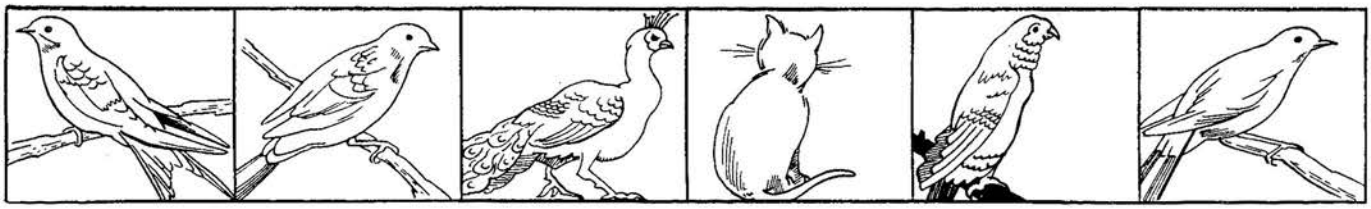




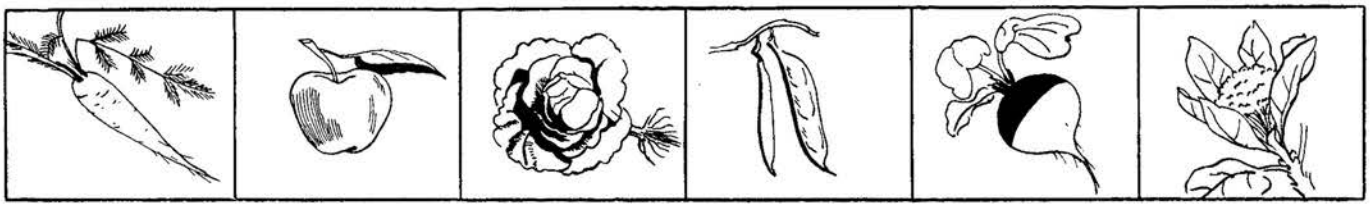
Score.... ....

TEST 2. Doesn't Belong

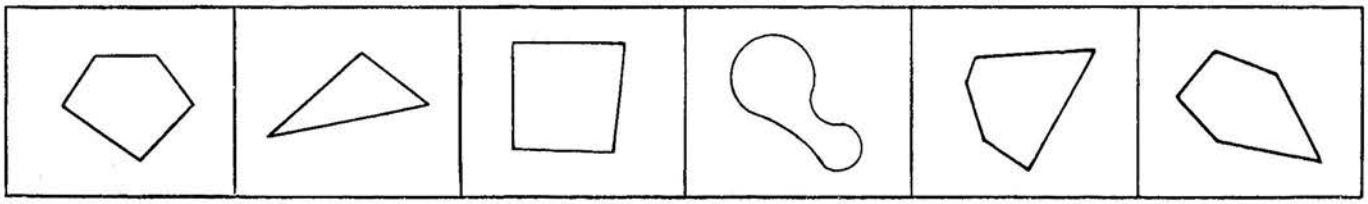
a



b



c



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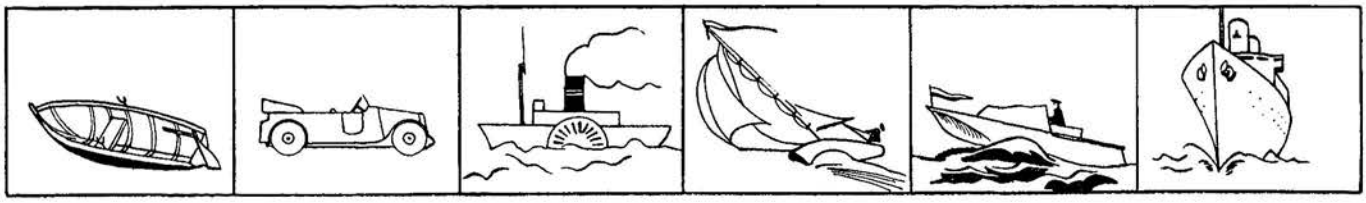

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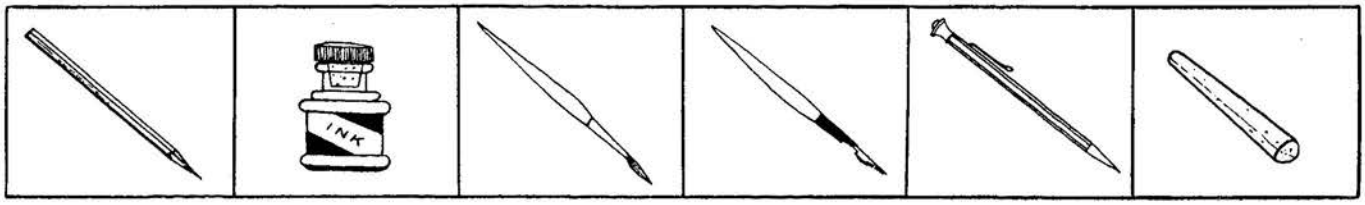

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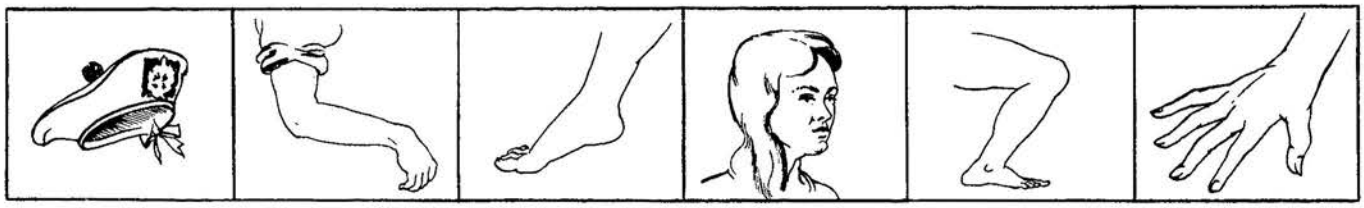

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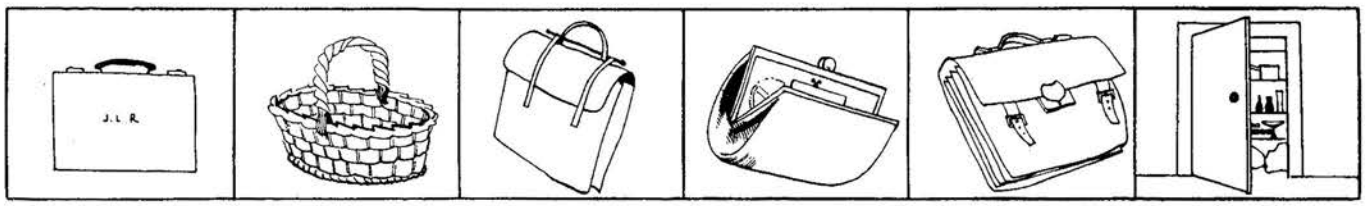

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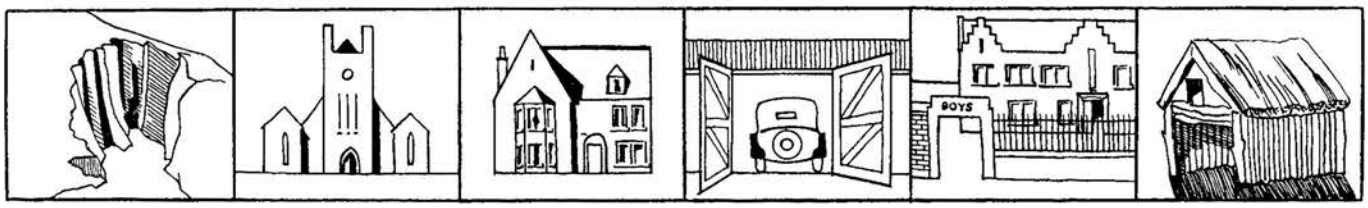
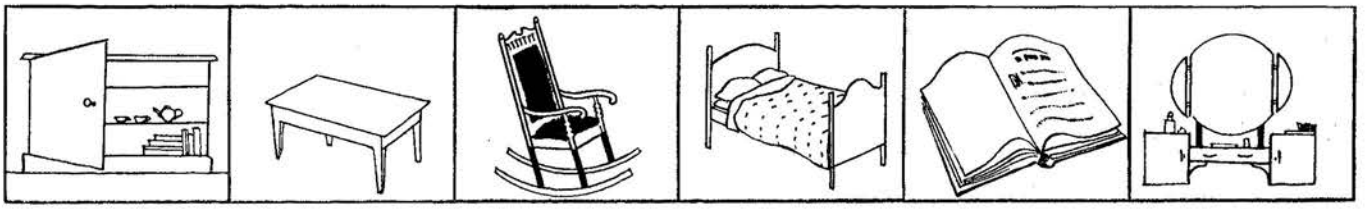
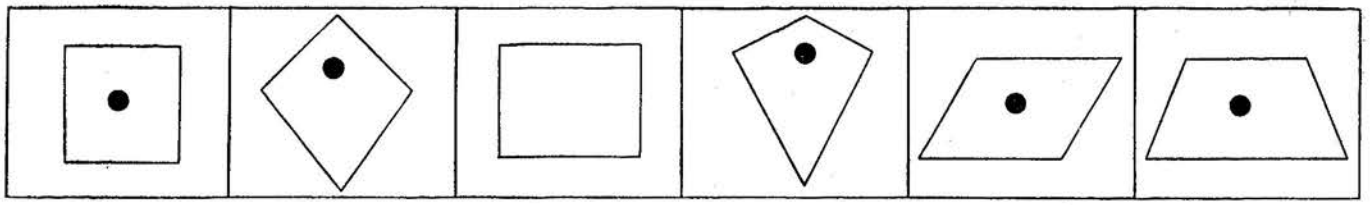
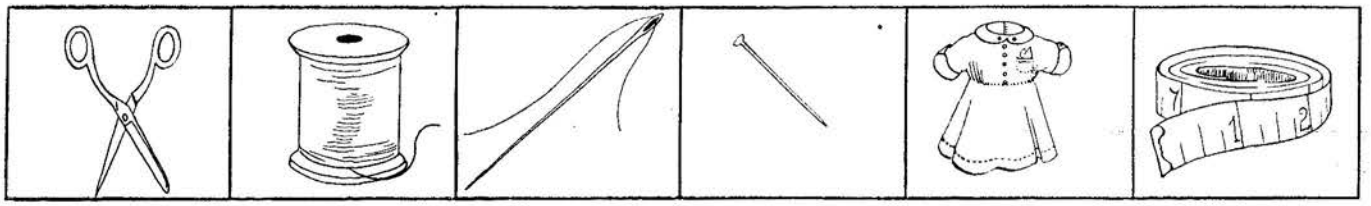
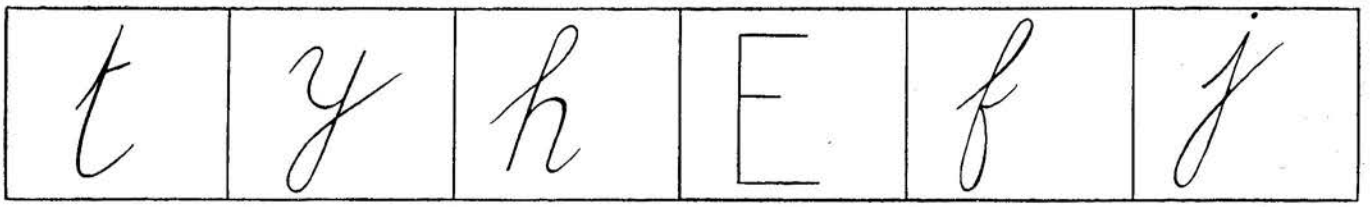


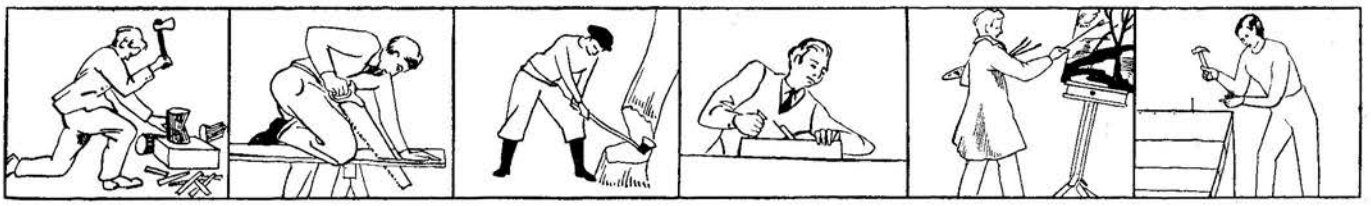
TEST 2 (contd.)

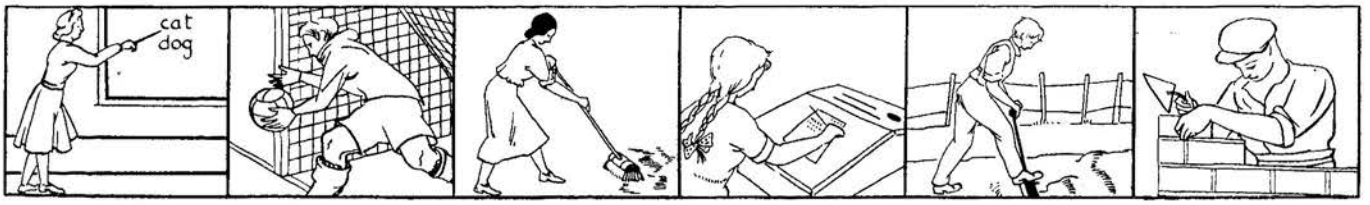
20 

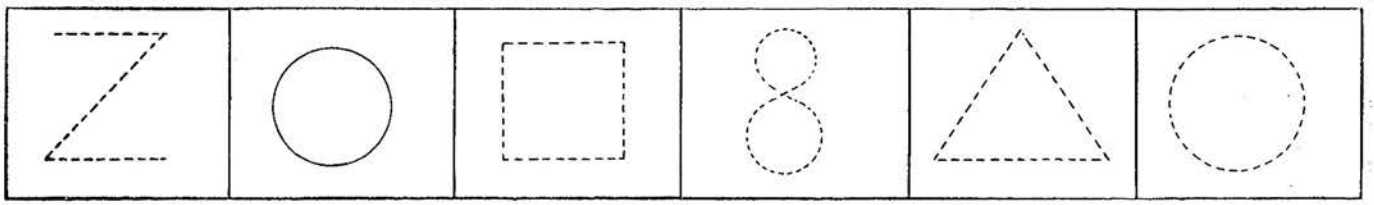
21 

22 

23 

24 

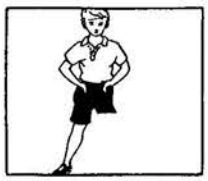
25 

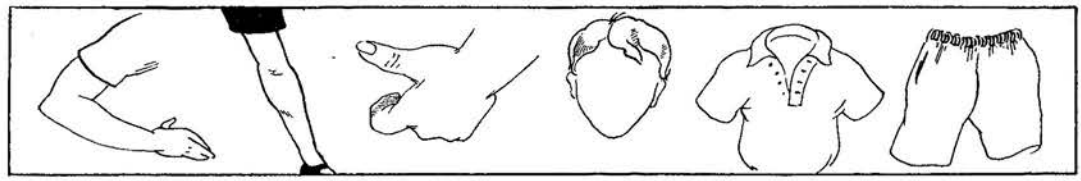
26 

Score.....

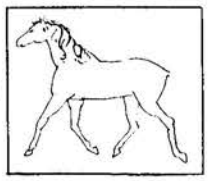
TEST 3. Completion

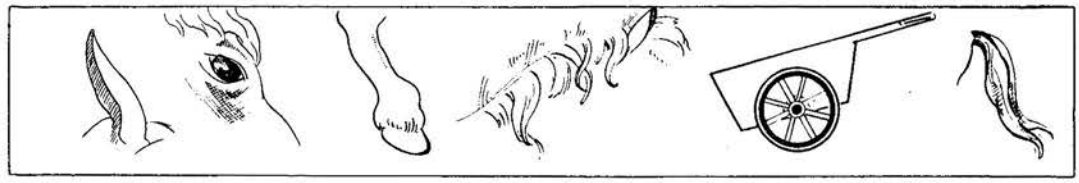
a



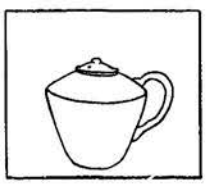


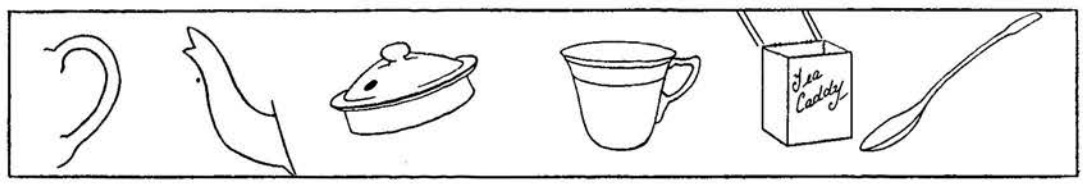
b





c





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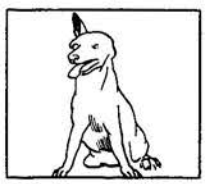

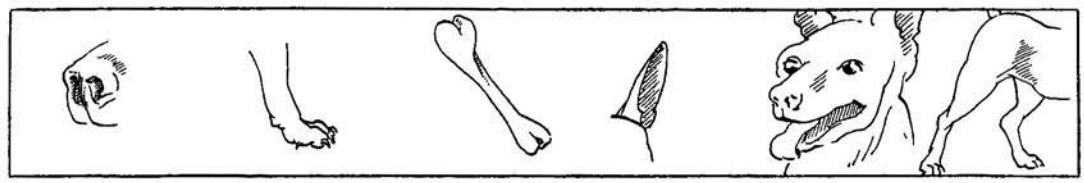

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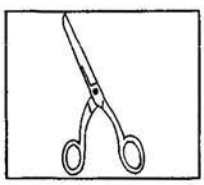

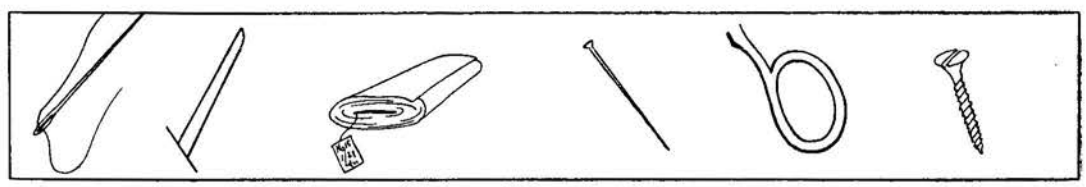

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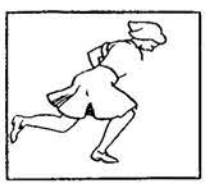

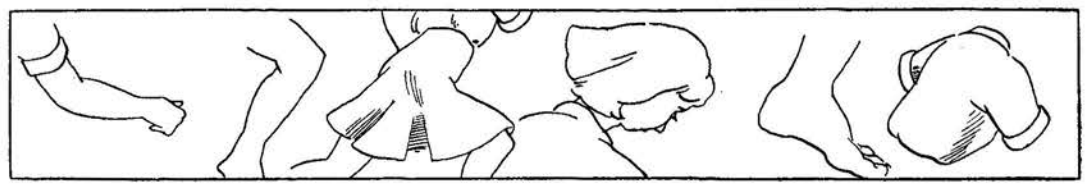

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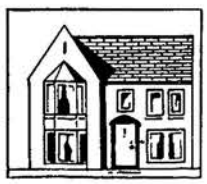
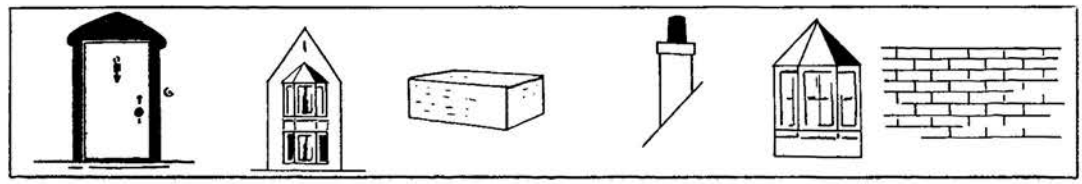
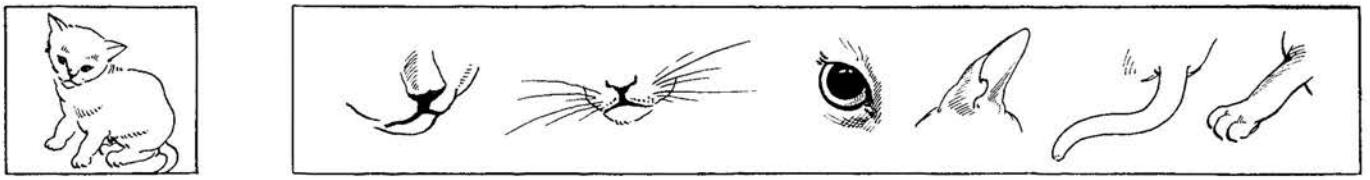
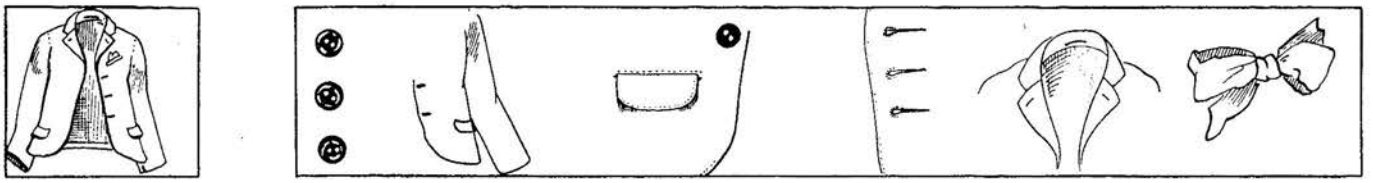
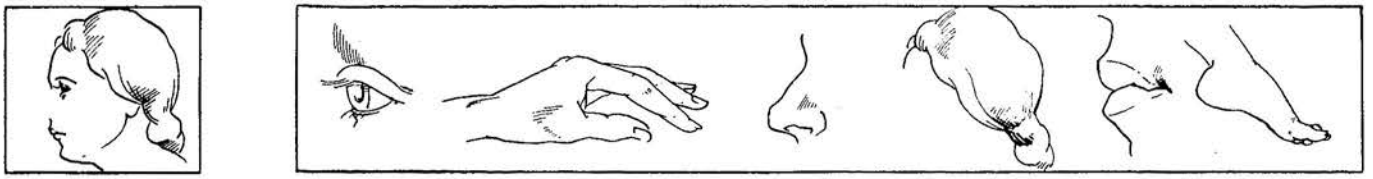


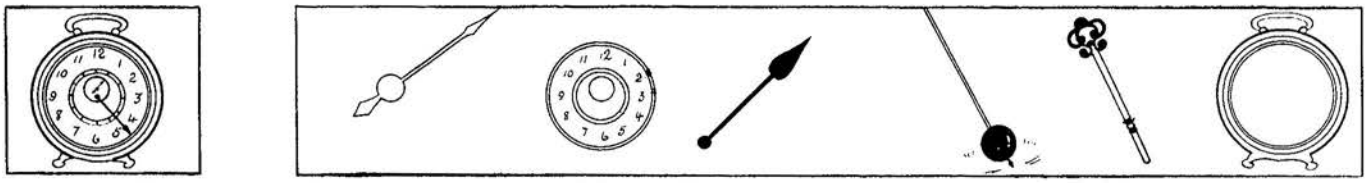


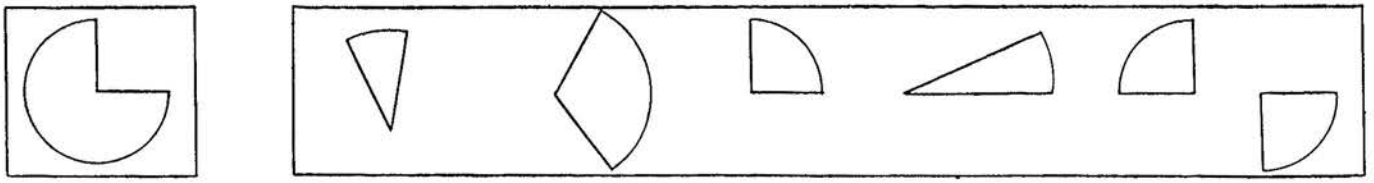
TEST 3 (contd.)

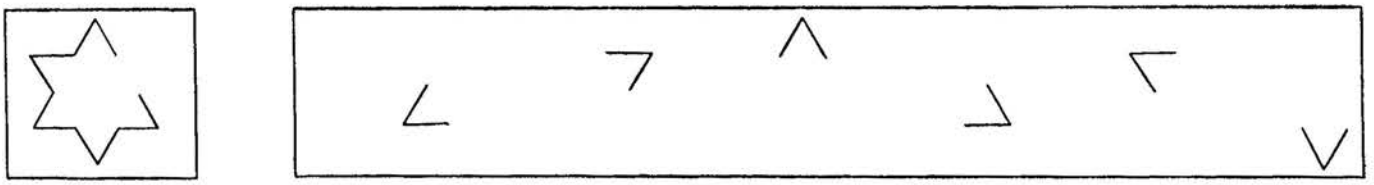
31 

32 

33 

34 

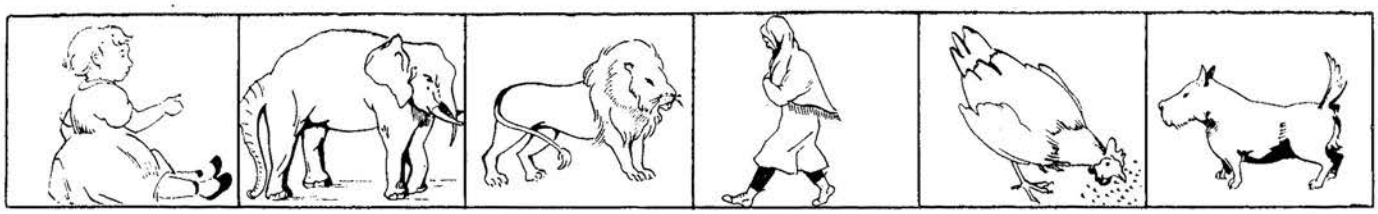
35 

36 

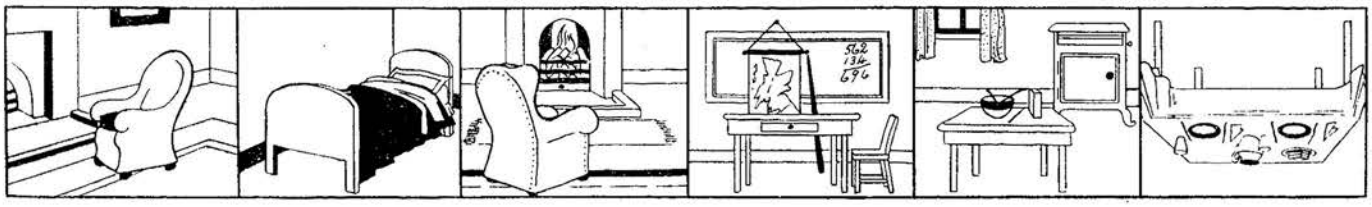
Score.....

TEST 4. Absurdities

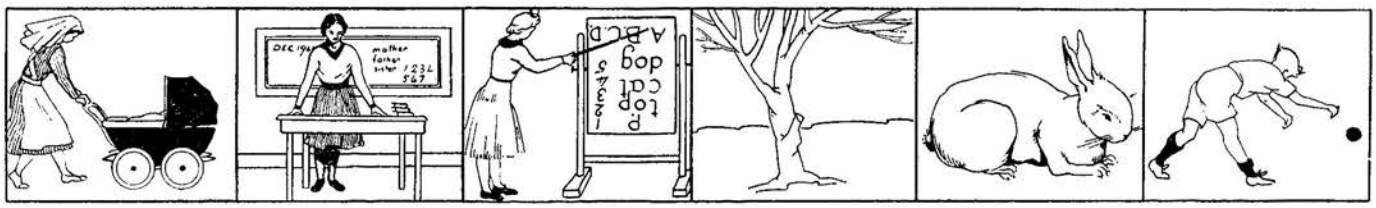
a



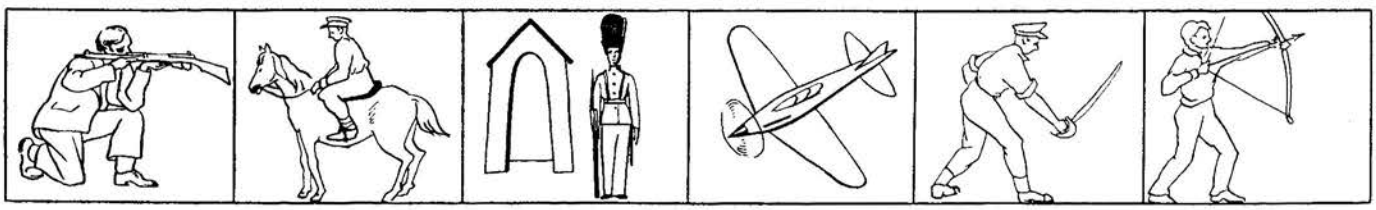
b



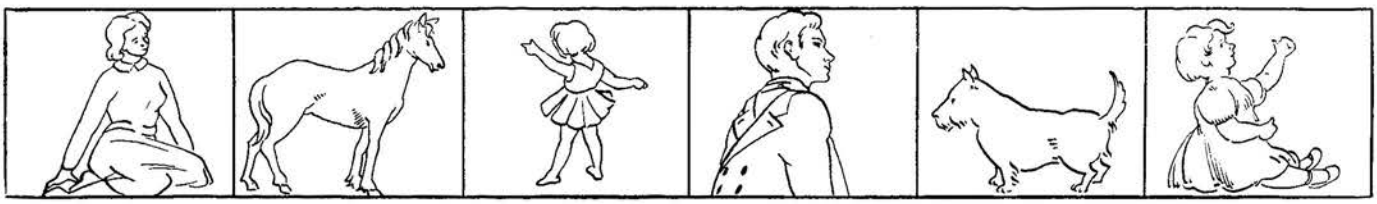
c



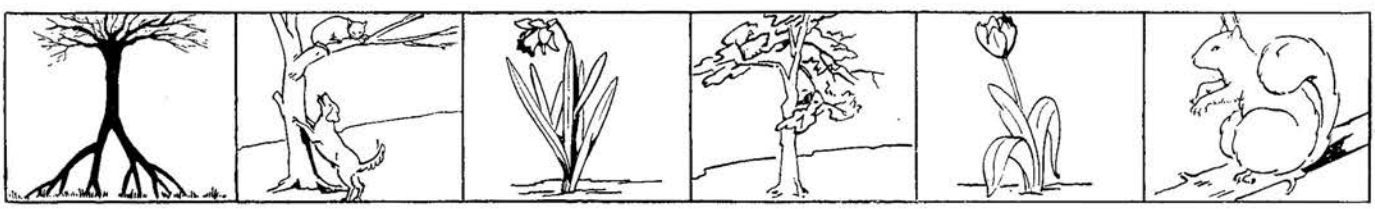
37



38



39



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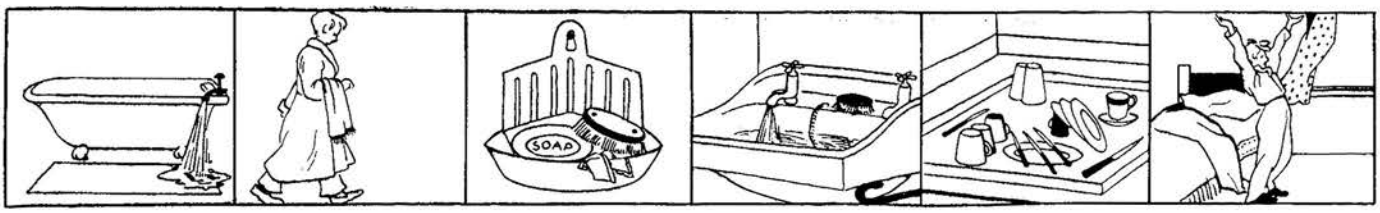
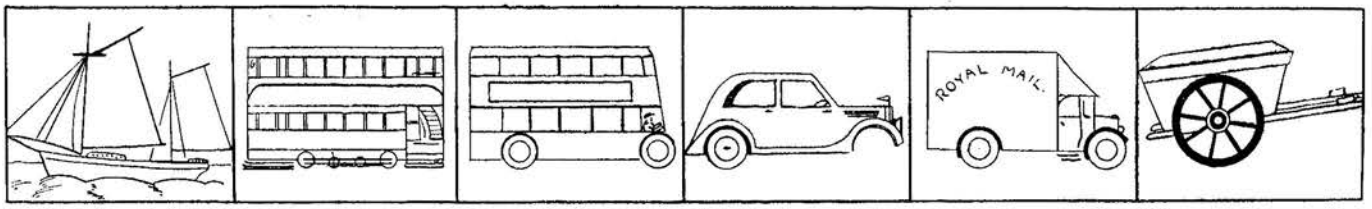
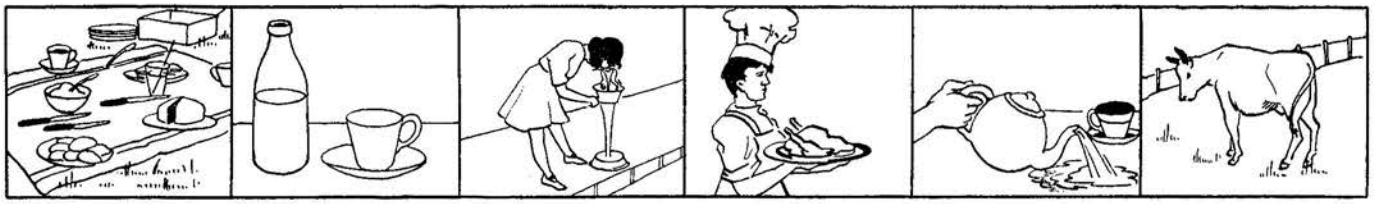


TEST 4 (contd)

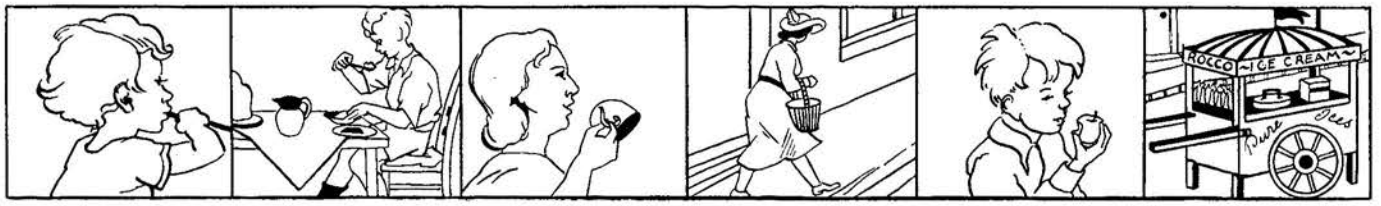
41



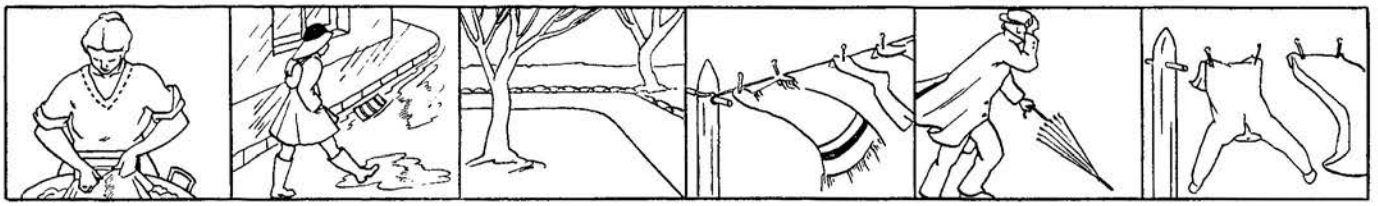
42



43



44



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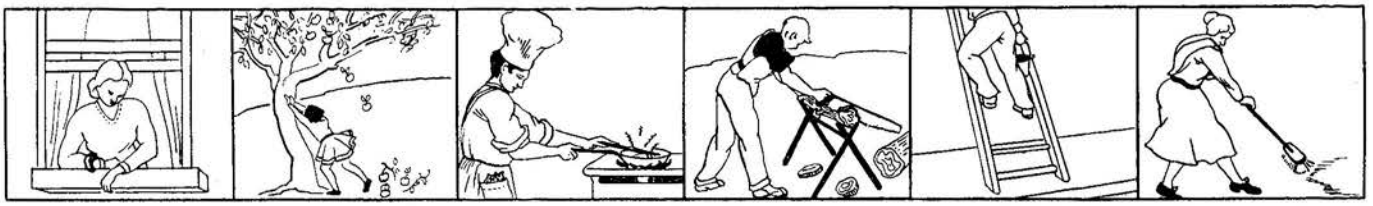
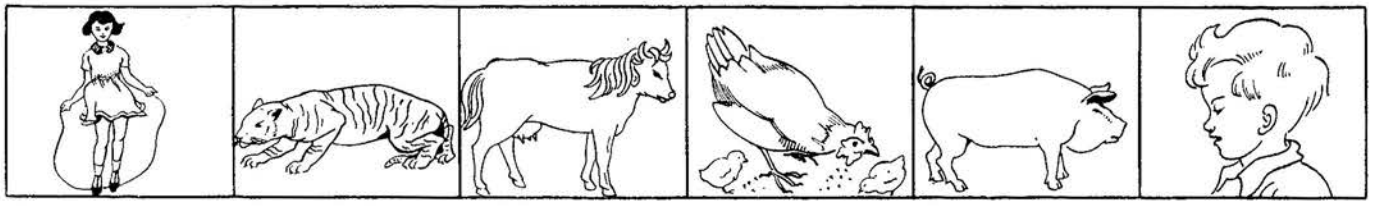
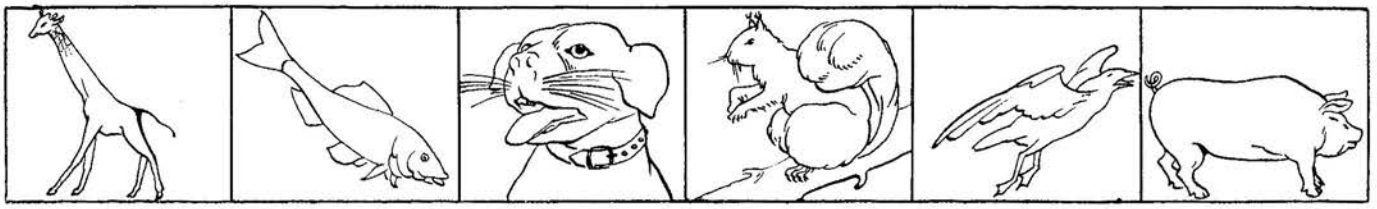


46



47

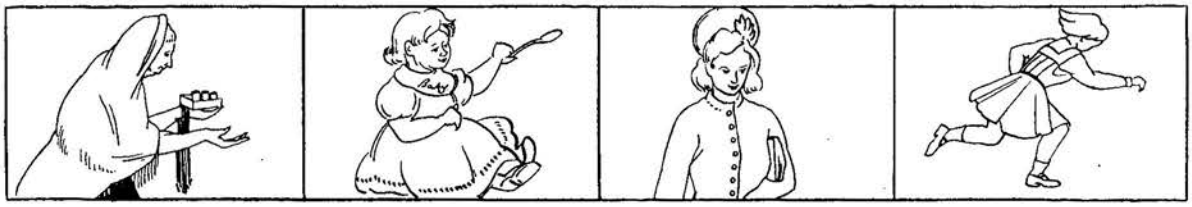


Score.....

TEST 5. Sequence

a

b



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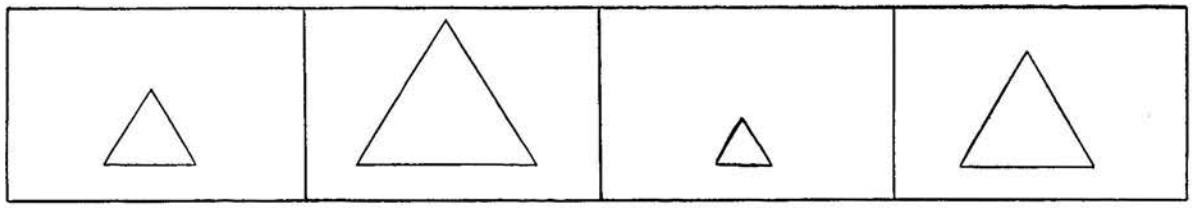

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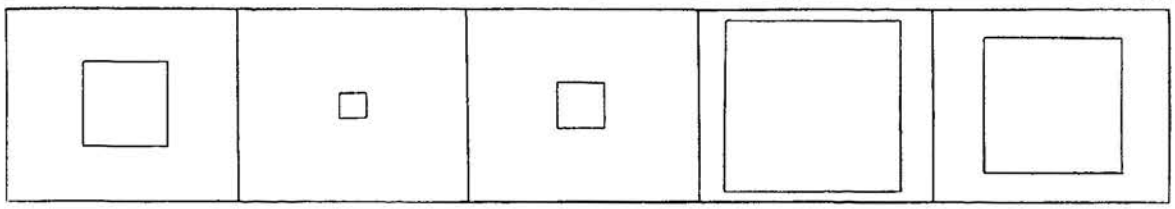

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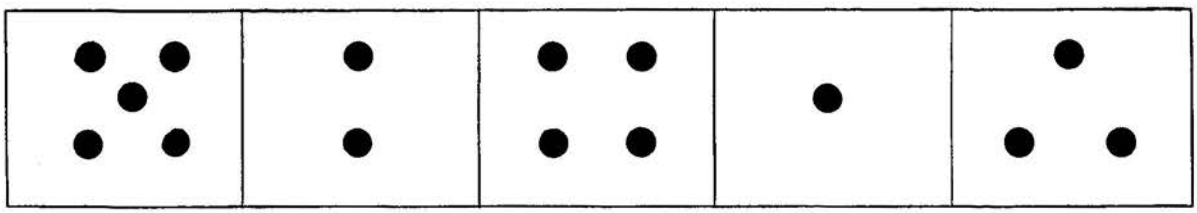

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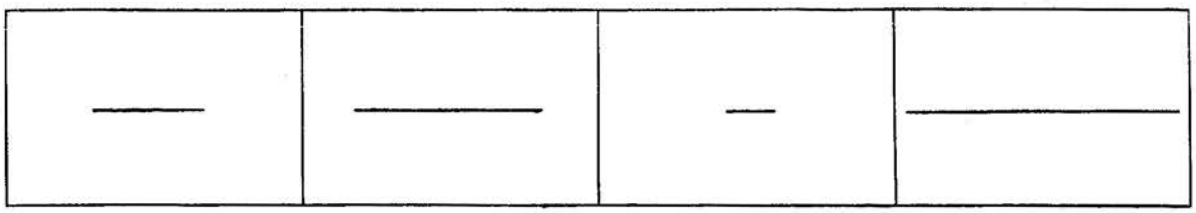

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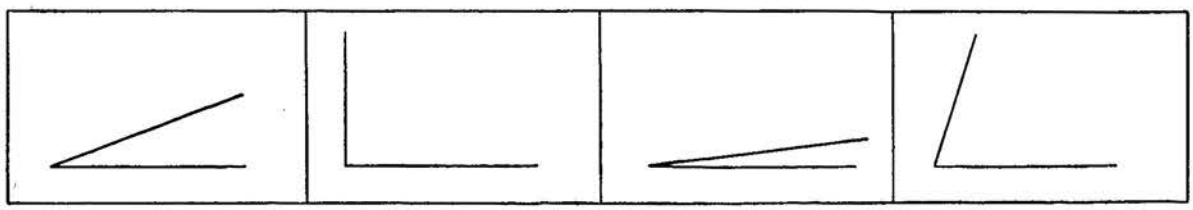

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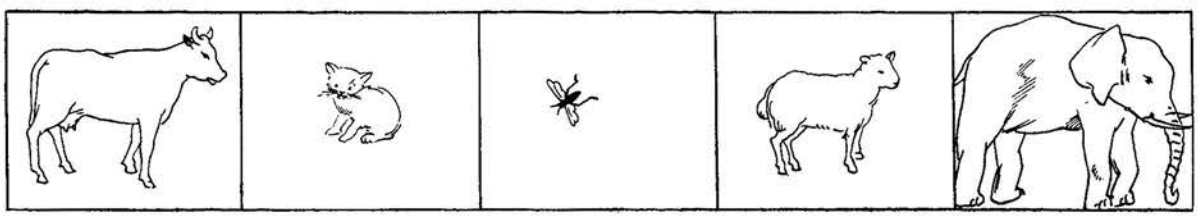

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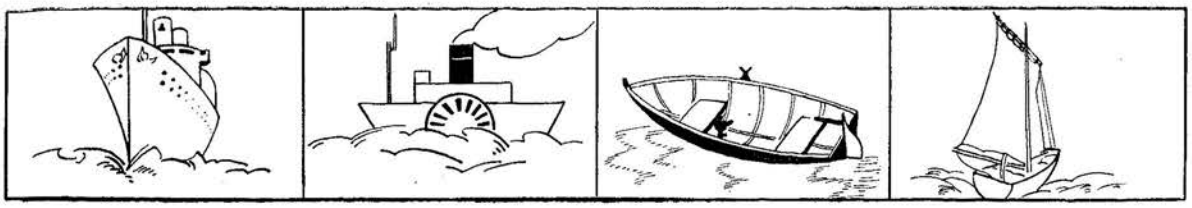
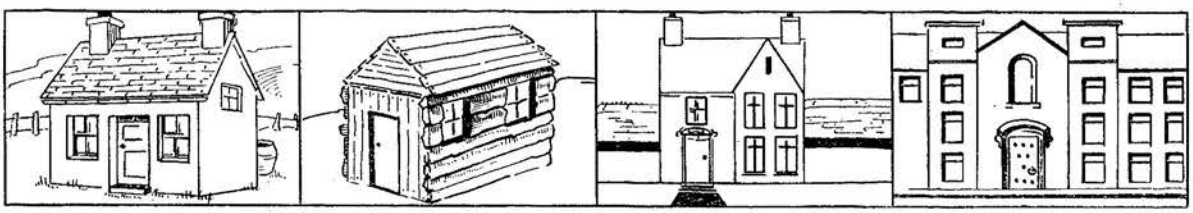
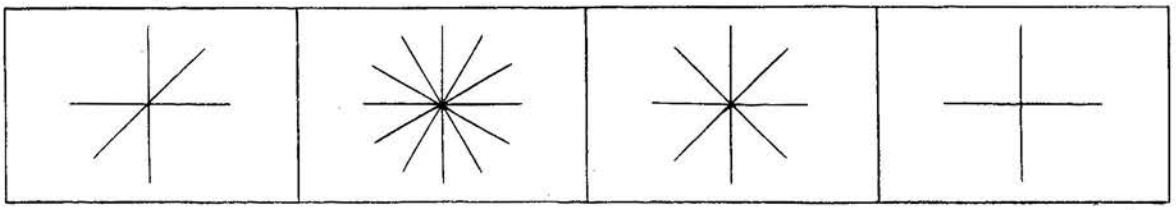
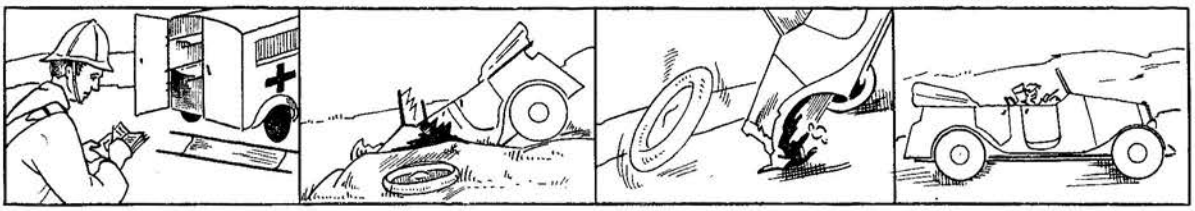
53 

54 

55 

56 

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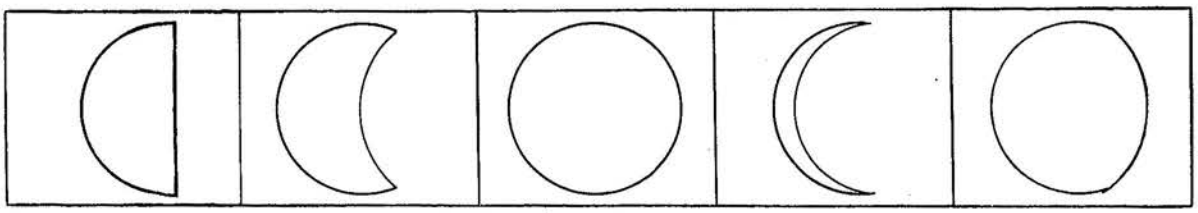
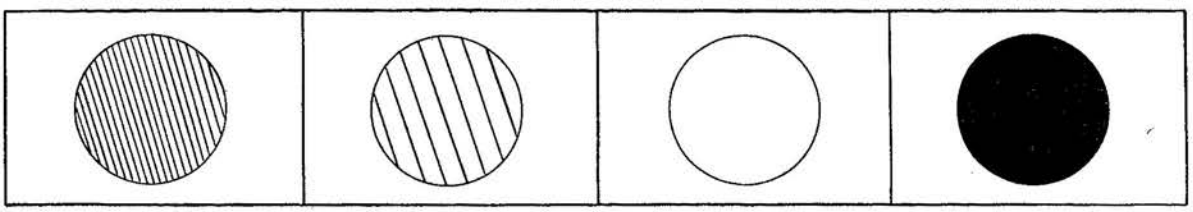
58 

59 

Score.....

TEST 6. Reversed Similarities

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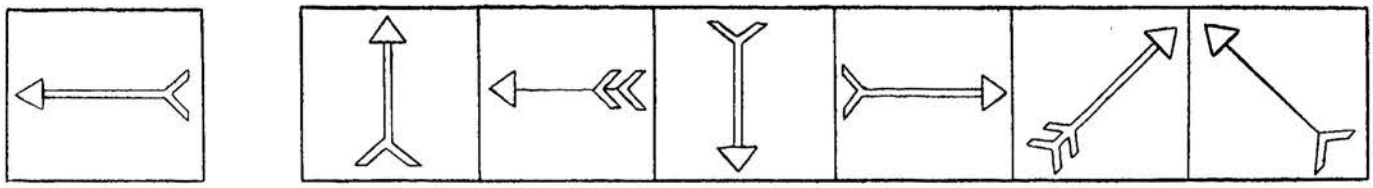
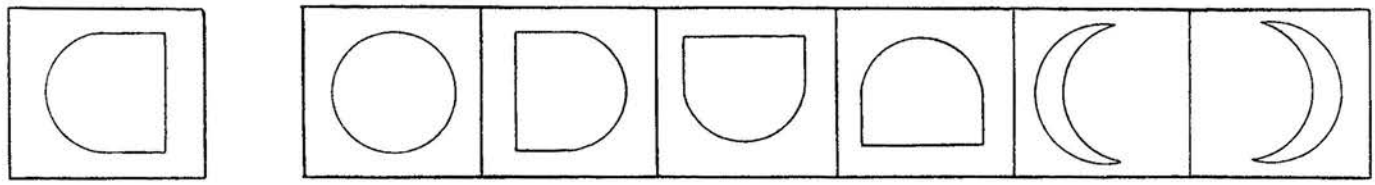
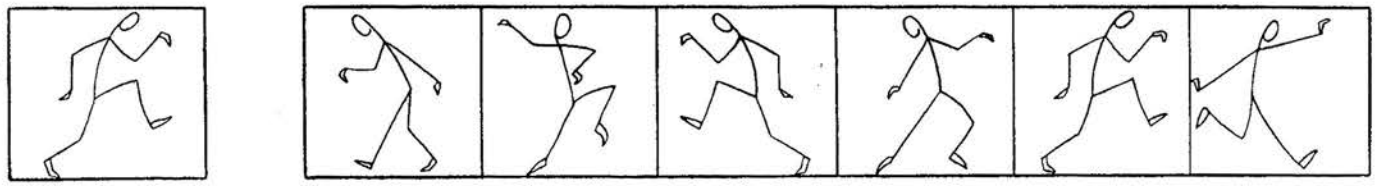


b



c



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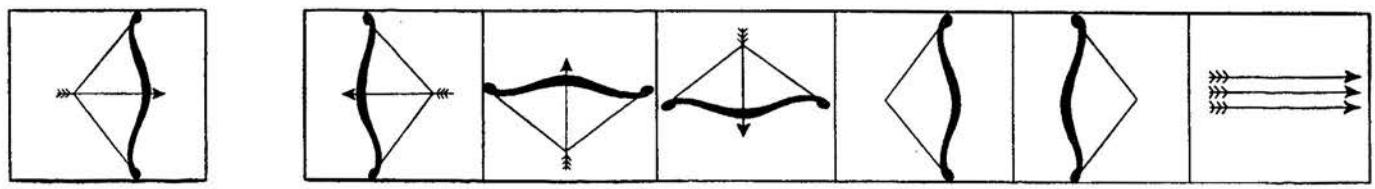

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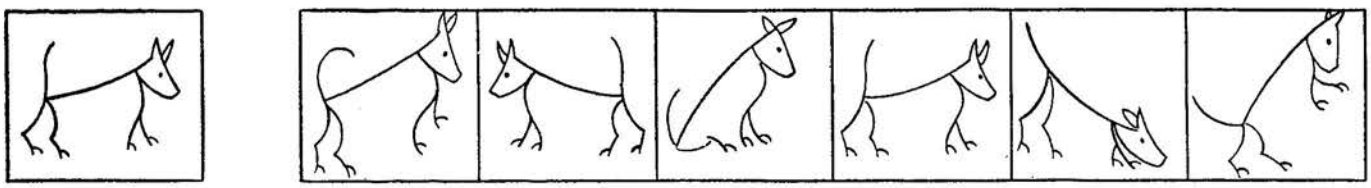

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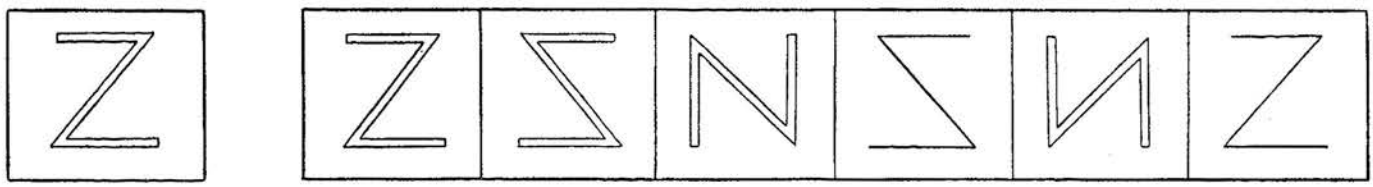

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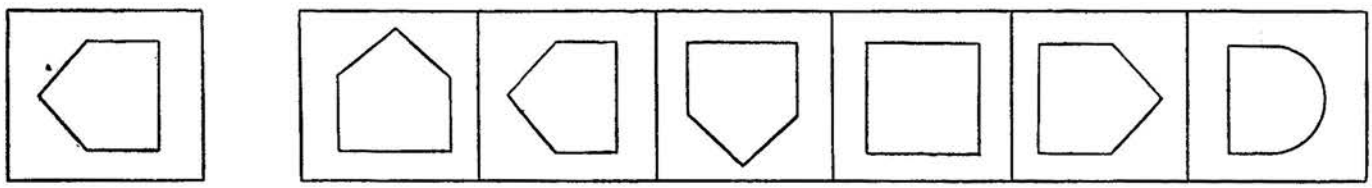

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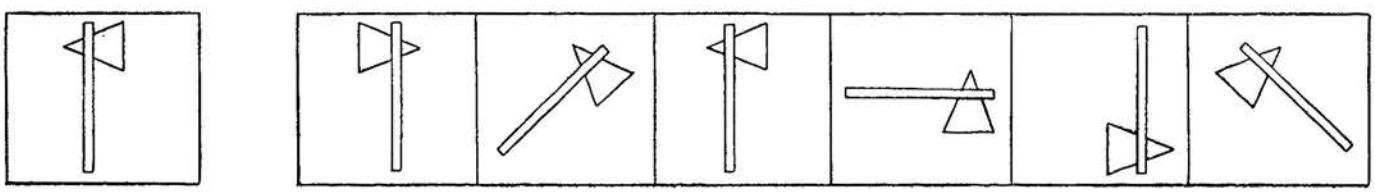
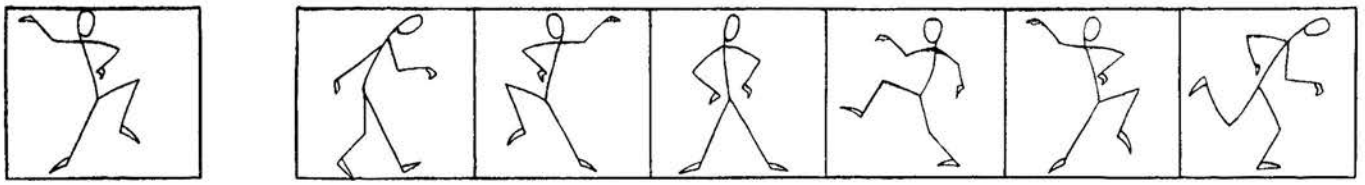
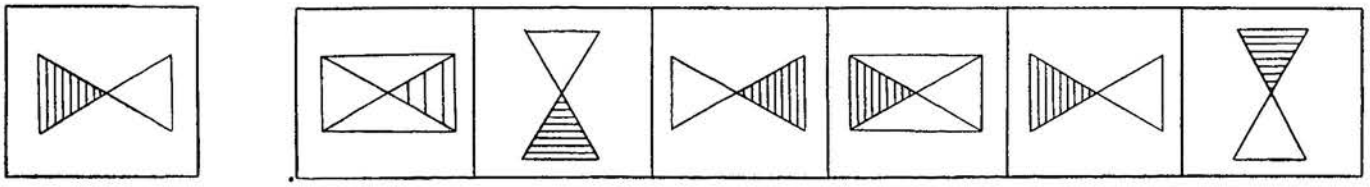
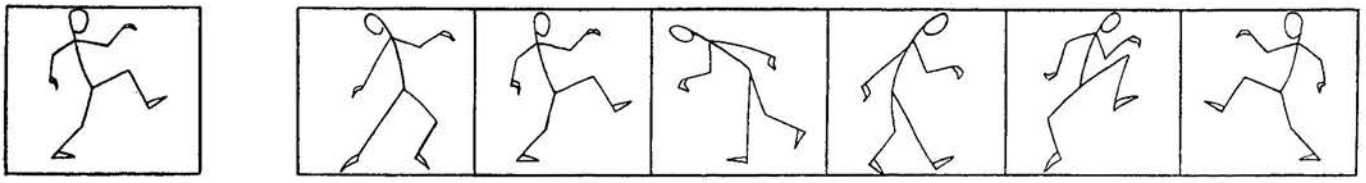
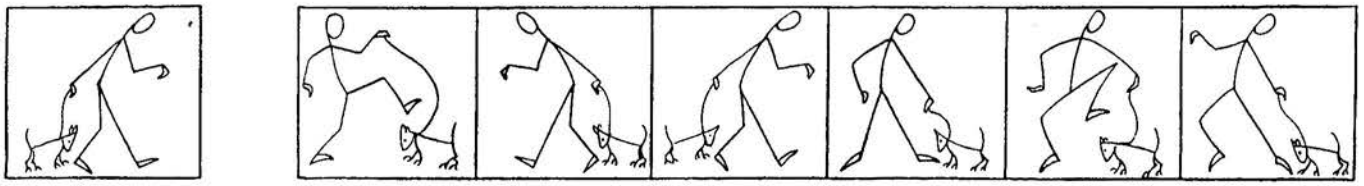


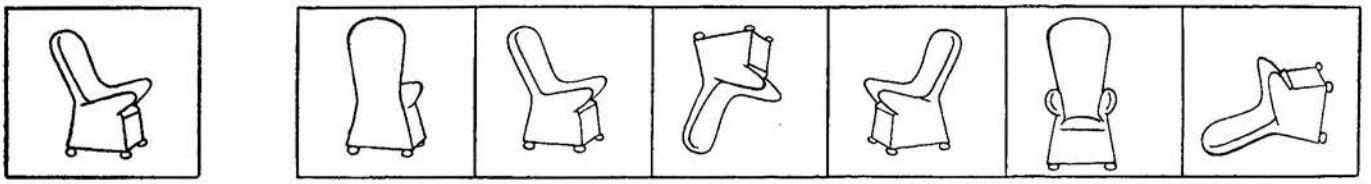
TEST 6 (contd.)

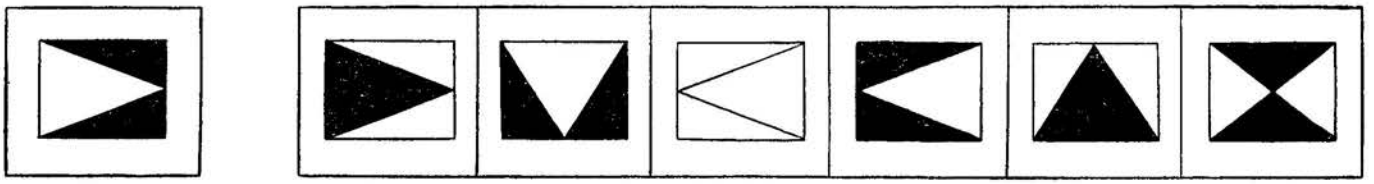
65 

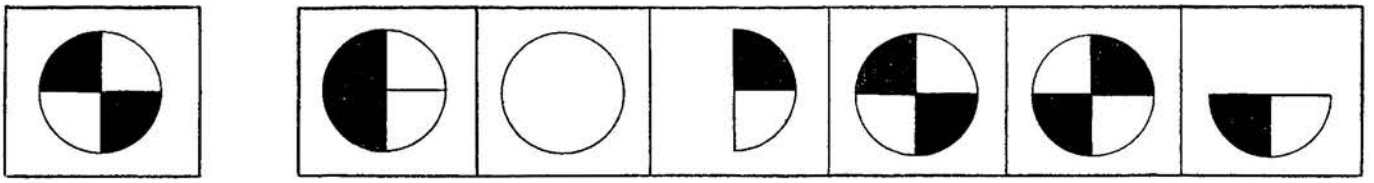
66 

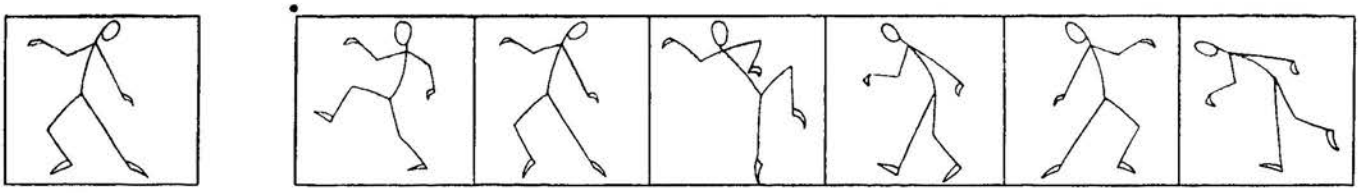
67 

68 

69 

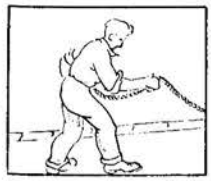
70 

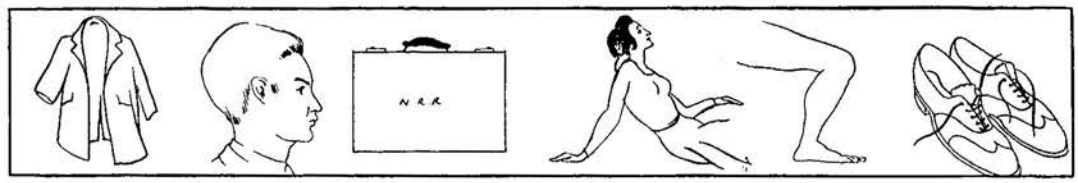
71 

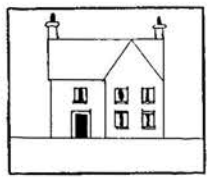
72 

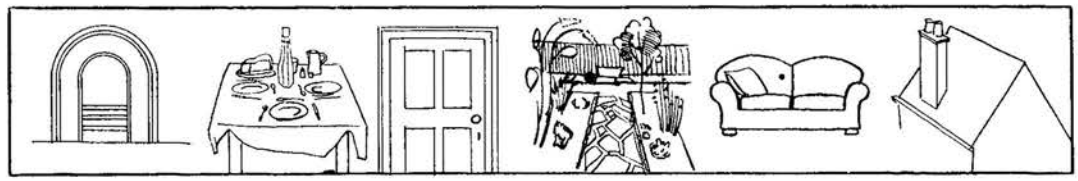
Score.....

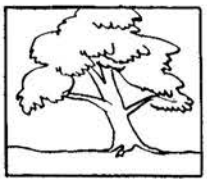
TEST 7. Always Has

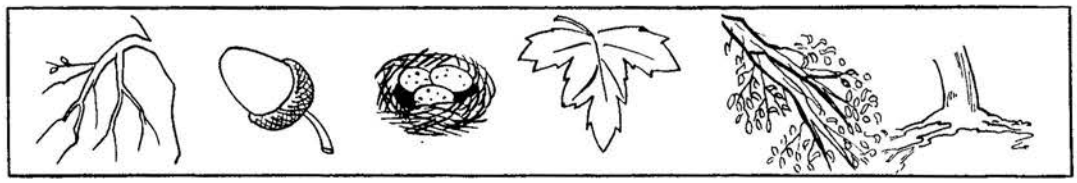
a 



b 



c 



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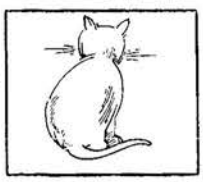
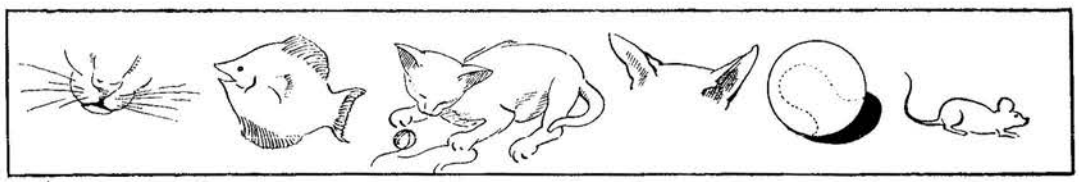
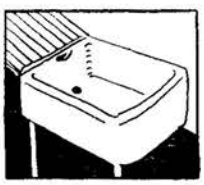
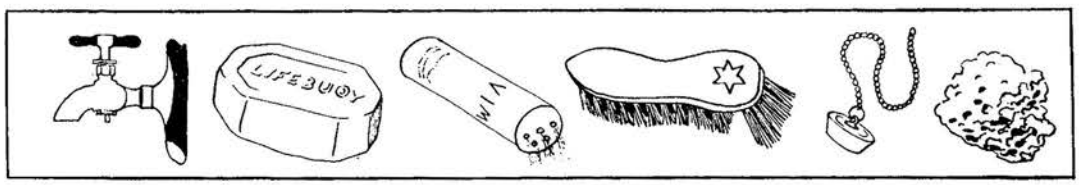
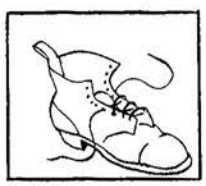
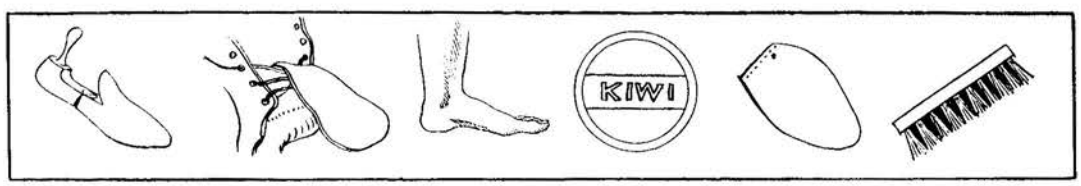
73 



74 

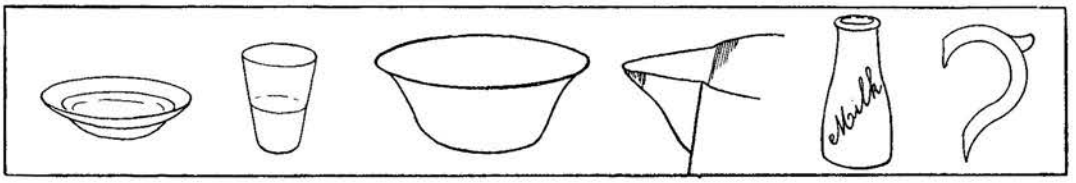


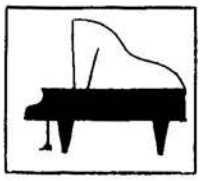
75 

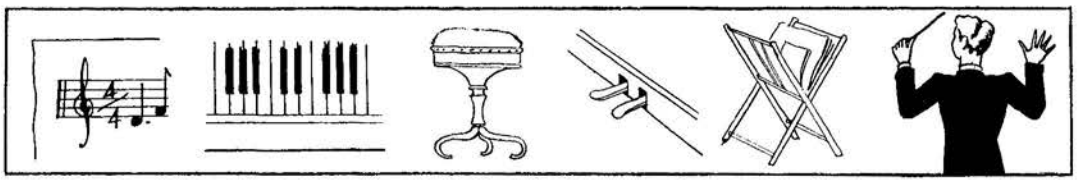


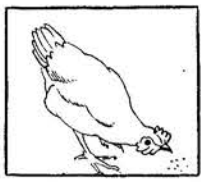
TEST 7 (contd.)

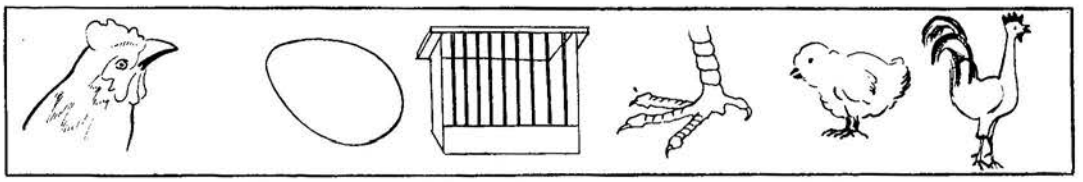
76 

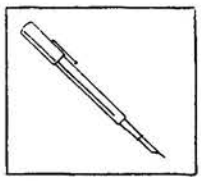


77 



78 



79 

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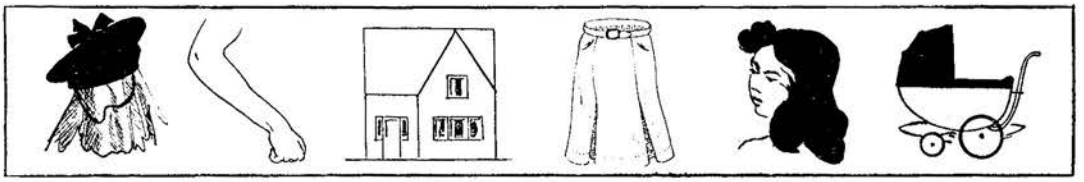

Score.....

TEST 8. Analogies

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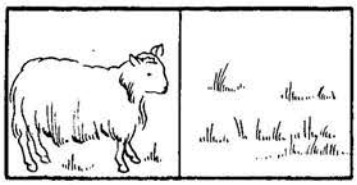

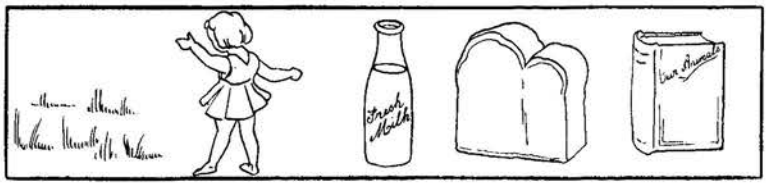

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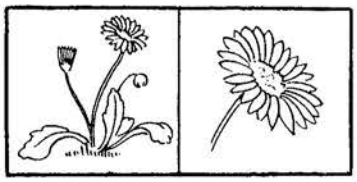

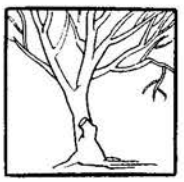

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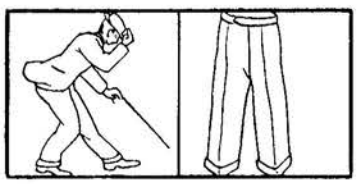

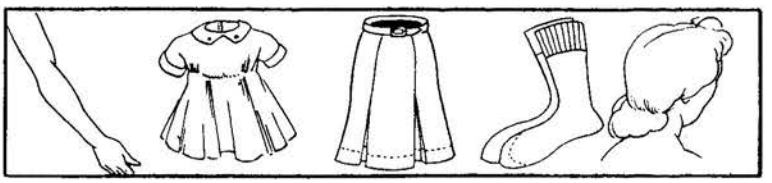

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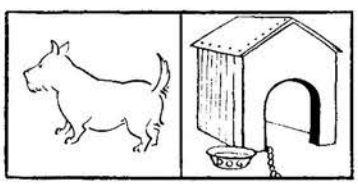
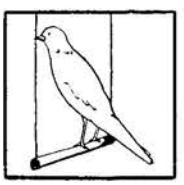
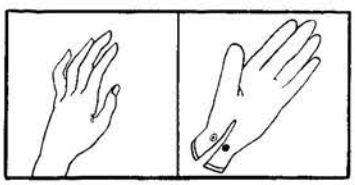
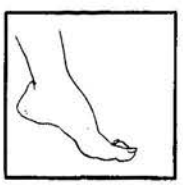
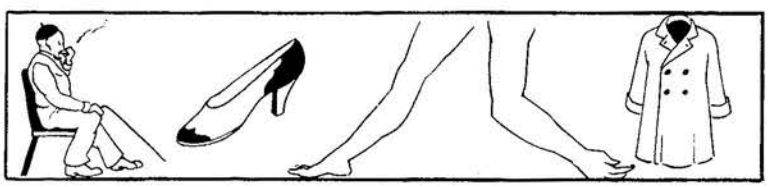




82







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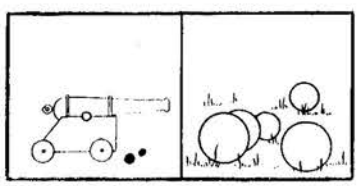

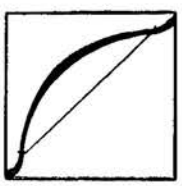

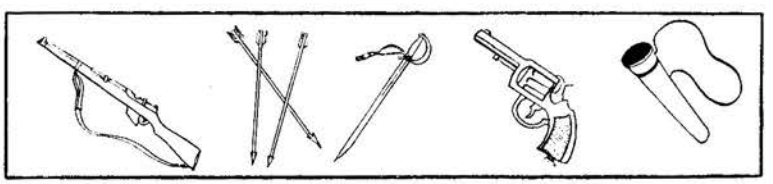

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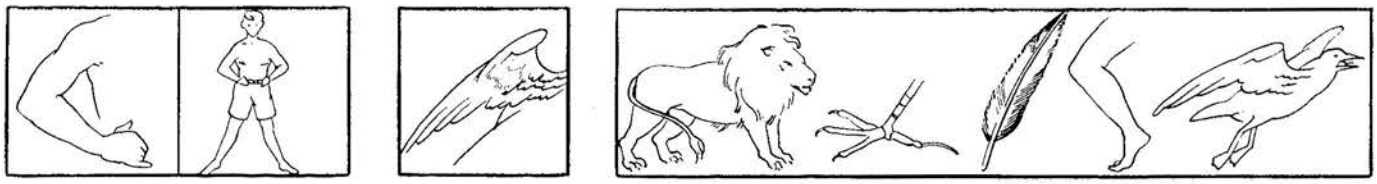
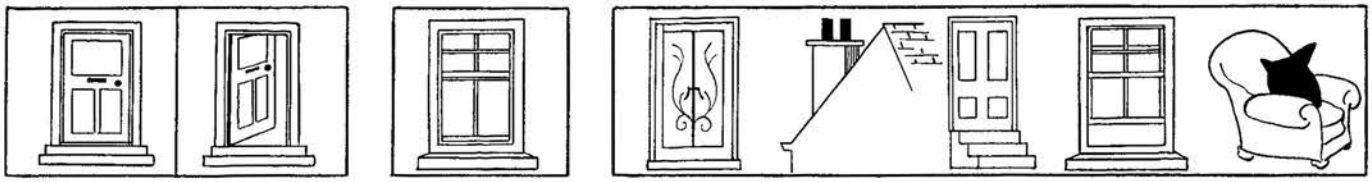
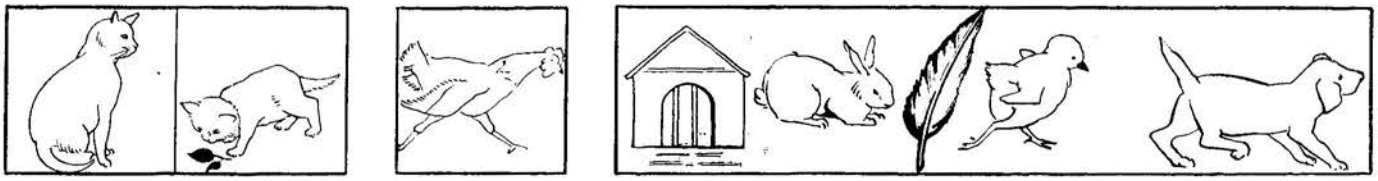
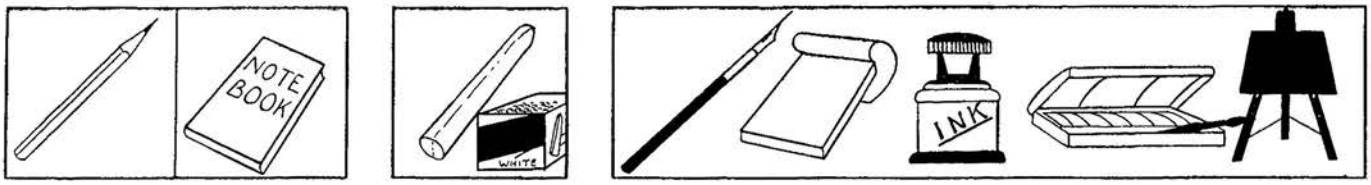
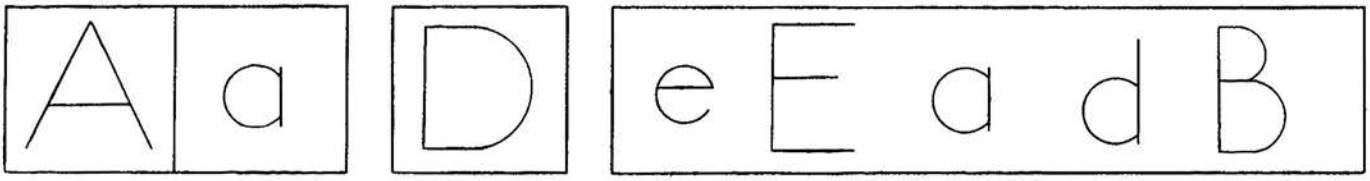
84 

85 

86 

87 

88 

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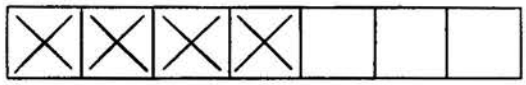
a 

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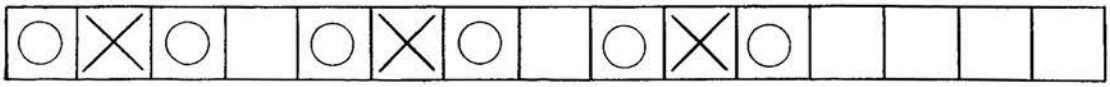
c 

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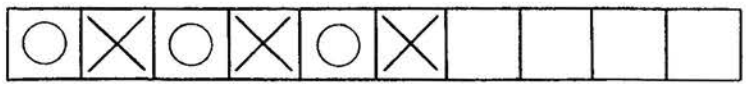
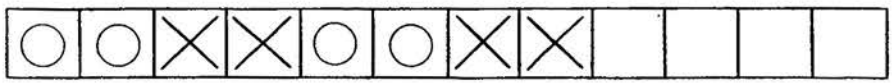
90 

91 

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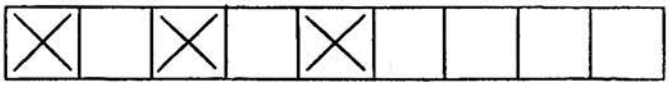
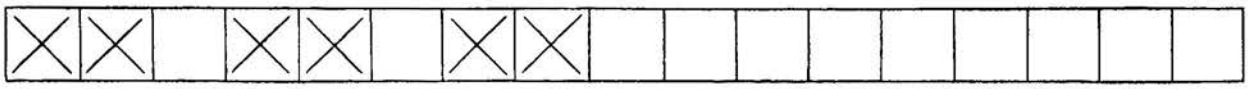
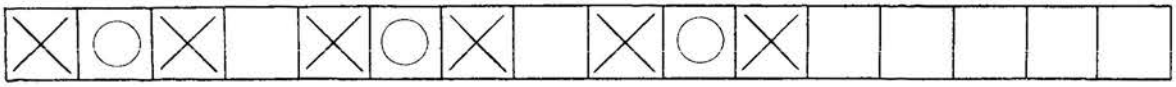
93 

94 

95 

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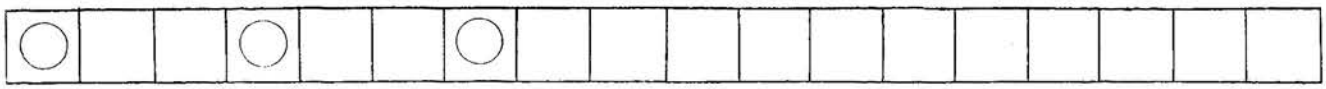
97 

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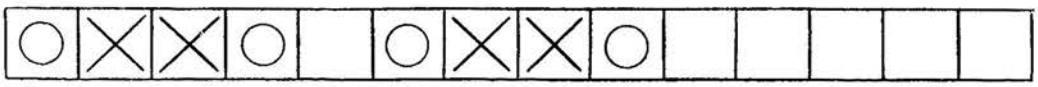
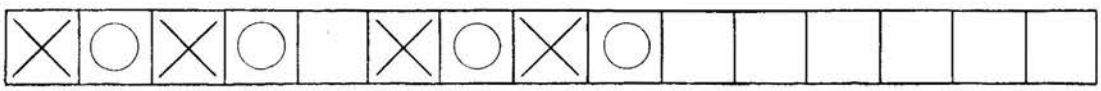
99 

100 

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D.P., Edin.—7,000—1/43.

MANUAL OF INSTRUCTIONS

FOR

MORAY HOUSE PICTURE INTELLIGENCE TEST I

M.H.T. (Pic.) 1

FOR SEVEN-YEAR-OLDS

EDUCATION DEPARTMENT
MORAY HOUSE
UNIVERSITY OF EDINBURGH

PRINTED IN GREAT BRITAIN
AT THE DARIEN PRESS, EDINBURGH

MORAY HOUSE
PICTURE TEST No. 1.

I. GENERAL INSTRUCTIONS.

1. The complete test consists of nine sub-tests each separately timed and each with three practice items at the beginning.* The practice items are always done by the teacher with the class and are ignored in correcting the test.

2. If possible the teacher should be provided with a stop-watch for timing; if this is not possible a watch with a seconds hand is essential. If this latter is used, for intervals longer than one minute, the exact time at which "Go" is said should be noted on a slip of paper and the exact time at which it will be necessary to say "Stop."

3. It is essential to have two adults in charge of the children: one, the Examiner (referred to hereafter as E.), should read the instructions and keep the times; the other, the Assistant, should patrol the room quietly and unobtrusively to see that the children have their books open at the right places, that they are following E.'s instructions, that they do not begin working on any test till the word "Go," and so on, but she must in no case give any assistance on how to do any part of the test.

4. The questions are answered in pencil on the pages of the test booklets. Ideally, each child should be provided with two sharpened pencils. In any case the Assistant should have a supply of spare pencils and be ready to hand one at once to any child who breaks his.

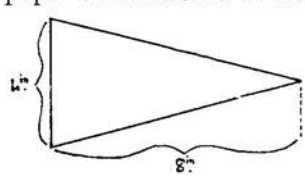
* Except Test 1, which has detailed instructions for each separate item.

The children should be told that anyone who breaks his pencil-point should hold up his hand. Apart from the test booklets and pencils, no other material is to be allowed—no rulers, rubbers, etc.

5. The chief aim of the practice items is to make sure that the children know what is the task they have to perform in the rest of the test. The wording for all explanations should be exactly as given in the instructions. All words actually spoken by E. to the children are shown hereafter in black type. It may be necessary to try one or two different children before the correct answer is given. If so, say, "**That's not quite right,**" or any words that will not discourage the child who has given a wrong answer, and then proceed according to the instructions.

6. Time limits must be exactly observed, and there should be no pause between the end of the practice items and the beginning of the test items. But a short pause to relax between each test and the next is good, and the test should always be given in two parts with a break of 5 or 10 minutes for play after Test 4. The actual working time is only 25 minutes, but the complete test, including practice items, assembling the children and the break in the middle, will occupy about an hour and a quarter.

7. Before the test E. should prepare, for Test 6, on a piece of thick paper or cardboard 10 in. by 7 in. a figure as follows :



The figure should be made on both sides of the paper, the reverse one exactly behind the other, and should be filled in in Indian ink. This, along with a spare copy of the booklet, and a watch are all the materials E. will need.

8. The particulars asked for on the front page of the test booklet should be previously filled in by E. It is better for the children not even to have to write in their own names. Ages should be given in years and completed months at date of test or on the date fixed by the examining authority.

9. It is essential that the children should regard the test as a kind of game, and should not be made in any way nervous about the results.

10. Not more than thirty children should be given the test together, and each child must have a separate desk. It is also necessary that all the children should be seated facing in one direction, not round tables, etc.

11. Before the test E. should thoroughly familiarise herself with the general instructions and with the method of administering the various tests.

II. ADMINISTRATION OF THE TEST.

Before giving out the test booklets, say, "**In a few minutes I am going to give out some books. Inside are lots of little pictures and we are going to do some puzzles with them. You must not look inside till I tell you, for we are going to see who can do the puzzles best and most quickly.**"

Give the children some drill in how to begin and stop each test together. Each test should be begun by saying, "**Pencils up,**" when the children will hold their pencils above their heads. Then say, "**Ready? Go,**" and all will begin together. At the end of each test say, "**Stop. Pencils up,**" and the children will bring their pencils to the "up" position again. Then say, "**Pencils down and sit up.**"

As soon as the children have learned how to do this give out the test booklets face up, and see that the children do not turn over.

TEST 1.

When all are ready, say, "**Now turn over the page to the one that says '1,' here.**" (Holding up your copy for them to see.) "**See, there are some drawings on this page, and I am going to tell you what to do with them. While I tell you, you will hold your pencils up, and when I say 'Go' you will do what I have said. You must do exactly what I say.**" Each instruction is to be repeated once after saying "Go," but the time is to be taken from the moment when "Go" is said, *e.g.* :

"**Pencils up. First draw a line from the feather on the hat to the teddy bear's ear. Go.**" (Time, 15 seconds.) "**Draw a line from the feather on the hat to the teddy bear's ear.**"

"**Pencils up. Now put a cross above the one we put milk in. Go.**" (Time, 15 seconds.)

"**Pencils up. This time draw a line right round the one we take baby out in. Go.**" (Time, 20 seconds.)

"**Pencils up. Now put a cross under the one we cook on. Go.**" (Time, 15 seconds.)

"**Pencils up. Now put a line through the one we keep things in. Go.**" (Time, 10 seconds.)

"**Pencils up. This time draw a line from the elephant's tail to the top of the woman's head. Go.**" (Time, 20 seconds.)

"**Pencils up. Now draw a line right round the one a lady wears on her finger. Go.**" (Time, 15 seconds.)

"**Pencils up. This time draw a line from the elephant's trunk, going above the moon and stars, to the tree. Go.**" (Time, 15 seconds.)

"**Pencils up. Now put a line under the ones that shine in the sky at night. Go.**" (Time, 15 seconds.)

"**Pencils up. This time draw a ring above the one that sails on the water. Go.**" (Time, 10 seconds.)

"**Pencils up. Put a line above the one we make a noise with. Go.**" (Time, 10 seconds.)

" Pencils up. Now draw a ring under the one we live in. Go." (Time, 10 seconds.)

" Pencils up. Now draw a line from the dog's tail, going under the stove, to the chimney on the house. Go." (Time, 15 seconds.)

" Pencils up. Now put a big fat dot beside the one that grows in the ground. Go." (Time, 15 seconds.)

" Now put your pencils on your desks, and turn to the one that says ' 2,' here." (Showing your copy.)

TEST 2.

(*a*) " Look at the pictures at the top of the page. Put your finger on the first box, the one with the bird. Now in that row all the pictures but one are the same in some way. What are they all, all but one?*——Yes, birds. But one that is not a bird has got among them, and we must find that one. Which is the one that is not a bird?——Yes, the pussy cat. So we put a cross through him like this " (demonstrate on board) " to show that he does not belong there. Everyone do that."

(*b*) " Now look at the second row, where there is a picture of a carrot, an apple, a cabbage, a pea-pod, a turnip, and a cauliflower. How are they the same, all but one? What are they all?——Yes, they are vegetables that we cook and eat with our meat or potatoes at dinner time. And which is the one that is not a vegetable?——Yes, the apple. So we put a cross through it to show it does not belong there. Do that."

(*c*) " Now look at the third row where there are a lot of different shapes. Put your finger at it. Who can see which is the different one there?——Yes, the curly one, so we put a cross through it to show it does not belong there. Do that." (If no one spots the one that does not belong here, say, " Well, look at them with me; put your finger

* Wherever there is a dash, pause for the children to reply.

on them as we look. The first one, and the next, and the next all have straight lines, but the next one is?——The next one is curly, and then the last two have straight lines again. Which is the different one, then? ")

" Now, pencils down and sit up. Look at me, and do not touch your pencils again till I say so. If you come to one you can't do, leave it out and try the next. If you make a mistake, scribble it out. We are going to do the rest of this page and the next one down to here " (pointing) " just the same way. First look at all the pictures in the row, then find the different one, the one that does not belong there, and put a cross through it to show it does not belong. Pencils up. Ready? Go."

TIME : 4 minutes.

" Stop. Pencils up. Pencils down and sit up. Turn to the one that says ' 3,' here." (Pointing.)

In this and all the following tests the Assistant must watch that the children do not stop after doing only one item or at the end of the first page, and must say, " Go on " or " Do the next one now," etc., to anyone who does. This is very necessary.

TEST 3.

(*a*) " Look at the first picture in the box by itself, the boy. Put your finger on it. There's something missing, something not there. What is it?——Yes, his other leg. So we must look for a leg in the big box. Put your finger on them as we look. Is it the first one?——No, that's an arm. Is it the next one?——Yes, that's it, so we put a ring round it like this " (demonstrate) " to show it's the one. Do that."

(*b*) " Now look at the next row. In the first box is a horse. Put your finger on him. What is not there this time?——Yes, his tail. So we look for his tail in the big box. Who has found it?——Yes, it's the last one. Everyone find it, and put a ring round it. Do that."

(*c*) "Now look at the next row. In the first box is a teapot. Put your finger on it. What has it not got?——Yes, a spout." (Or "The bit the tea comes out of, that is the spout.") "So we must look for the spout in the big box. Everyone find it and put a ring round it."

"Pencils down now and sit up. And do not touch them again till I say so."

"We are going to do the rest of the page just the same way, and the next page down to here" (pointing). "First look at the picture in the little box by itself and think what is missing, what it hasn't got, then find that bit in the big box and put a ring round it. Remember just to put a ring round one thing in each row. Pencils up. Ready? Go."

TIME : 3 minutes.

"Stop. Pencils up. Pencils down and sit up. Turn to the one that says '4,' here." (Pointing.)

TEST 4.

(*a*) "Look at the pictures at the top of the page. Put your finger on the first box, the little girl. In that row there is one picture that has something wrong about it, something silly. Put your finger on them as we look at them. Is there anything wrong with the little girl?——No. Put your finger on the elephant now. Is there anything wrong with him?——Yes. What is it?——That's right, his trunk is behind, instead of in front. So we put a cross through him to show there's something wrong, like this." (Demonstrate how to make cross on blackboard, or point to one previously made for Test 2.)

(*b*) "Now look at the next row. Put your finger on the first box, the room with the chair. Is there anything wrong with it?——No. Now put your finger on the next one, the bed. Is there anything wrong with it?——No. Is there anything wrong with the next one?——No. Or

the next one, the schoolroom?——No. Or the kitchen?——No. What about the last one, the dinner table?——Yes, it's upside down. So we put a big cross through it to show it's wrong. Do that."

(*c*) "Now look at the next row. Put your finger on the first box, the nannie with the pram. Is there anything wrong with that one?——No. Now look at the next one. Put your finger on it, the teacher standing at her table. Is there anything wrong with that one?——No. Now put your finger on the next one, the teacher pointing to the blackboard. Is there anything wrong with that one?——Yes, the writing on the board is upside down. So we put a cross through that one to show it's wrong."

"Now, pencils down and sit up. Look at me, and don't touch your pencils again till I say so."

"We are going to do the others just the same way. First look at all the pictures in the row, then find which one is silly, or has something wrong, and put a cross through it. Remember just to put a cross through one picture in each row. Do all this page" (pointing on your copy) "and the next one, down to here. Pencils up. Ready? Go."

TIME : 4 minutes.

"Stop. Pencils up. Put your pencils on your desks, shut your books and leave them with your names on top."

Give a 5 minutes break here, or longer.

"Now find the one that says '5,' this one." (Showing your copy.)

TEST 5.

(*a*) "Look at the pictures at the top of the page. Put your finger on the first box, the one with the woman eating. Then in the next box she's washing up, and in the last one she's cooking her meal. Those pictures have got into the wrong order, the woman doesn't eat her dinner, then

wash it up, and cook it last. What does she do first, eat the meal or wash it up or cook it?——Yes, she cooks it first, so we put a line through that one, like this." (Demonstrate with vertical line.) "Do that. Then after she's cooked it, she?——Yes, she eats it, and last of all she?——Yes, washes up. So we put a line through the washing up one. Do that."

(*b*) "Now look at the next line. Put your finger on the first box, the one with the old woman. In that row there's an old woman, a baby, a young woman, and a little girl. Which of these should come first? Which are you first, an old woman, a baby, a young woman, or a little girl?——Yes, the baby, so put a line through the baby. Do that. And which one should come last?——Yes, the old woman, so put a line through the old woman. Do that."

(*c*) "Now look at the next line. Put your finger on the first box, the one with the little shape with 3 points. They all have 3 points, but there's a small one, then a very big one, the biggest of all, then a very small one, the smallest of all, then a fairly big one. Which one should come first? ——Yes, the smallest of all" (or "the biggest of all," if that is given), "so put a line through that one. And which one should come last? First the smallest (or biggest) and last the?——Yes, the biggest (or smallest). So put a line through that one too."

"Now, pencils down; sit up and listen. You are going to do all the ones on that page, and on the next one down to here" (pointing) "just the same way. Look at all the pictures in the row, then think which one should come first and put a line through it, and which one should come last and put a line through it too. Remember just to put lines through two things in each row."

"Pencils up. Ready? Go."

TIME : 4 minutes 30 seconds.

"Stop. Pencils up. Pencils down and sit up. Turn to the one that says '6,' here" (pointing).

TEST 6.

"Look at the big pointed shape on my paper here" (hold up paper with prepared wedge shape). "Do you see it? Which way is the point looking, to the window or the door?——Yes, to the window (or door, etc.). I am going to turn it over once." (Turn page to other side with same figure.) "Now which way is the point looking? ——Yes, to the .....; it is looking the other way." (Repeat the whole demonstration once.) "You see it is just the same shape, but when we turn it over it looks the other way."

(*a*) "Now look at your books. Put your finger on the first box, the arrow. Which way is it pointing?——Yes, to the ..... Now we will think what it would look like if we could turn it over as we did the other one. Which way would it point if we turned it over?——Yes, to the ..... Now look in the big box and see if there is one pointing to the ..... Is it the first one?——No. The next one?——No. The next?——No. The next?——Yes, that's the one, so all put a line through it—like this." (Point to the line on the blackboard.)

(*b*) "Now, look at the next row, the one in the little box. Which way is the straight side looking?——Yes, to the ..... And which way would it look if we turned it over?——Yes, to the ..... Now we shall see if we can find the one with its straight side looking to the ..... in the big box. Is it the first one, the circle?——No. Is it the next one?——Yes, that's it, so all put a line through it."

(*c*) "Now look at the next line. Put your finger on the little box, the one with the man running. First of all, is his front leg down straight, or is it up and bent?——Yes, it's up and bent. And which way is he going?——Yes, to the ..... And which way would he be going if we turned him over?——Yes, to the ..... Now see if you can find one in the big box with his front leg up and bent that is going to the ....., and put a line through him. Everyone do that."

" Now, pencils down and listen. You are going to do all the ones underneath just the same way; this page " (pointing) " and the next, down to here. First look at the drawing in the little box, then think what it would look like if we could turn it over, and then find that one in the big box and put a line through it. Pencils up. Ready? Go."

TIME : 3 minutes.

" Stop. Pencils up. Pencils down and turn to the one that says ' 7,' here " (pointing). " Now sit up and listen."

TEST 7.

(*a*) " Look at the first picture, the one in the little box, the man. Put your finger on it. In the big box beside him are a lot of things a man has. We have got to find the two things a man always has, and mark them. Put your finger on them as we look. Does he always, even in bed at night, wear a coat?——No. Does he always have a head?——Yes, so we put a line through that one, like this " (point to line on blackboard). " Do that. Now that is one thing he always has, but we have still to find another. Does he always carry a case?——No. And does every man, think of all the men you know, always have a wife? ——No. But does he always have a leg?——Yes, so we put a line through that one. Do that."

(*b*) " Now look at the next row. Put your finger at it. In the first little box is a house, the outside of a house. Now we shall look in the big box for the things the outside of a house always has. Put your finger on them. Does a house always have a fireplace? No." (If they answer " Yes," say " Not really, it's the room that has the fireplace.") " Does a house always have a table?——No. Does it always have a door?——Yes, so we put a line through that one. Do it. Does every house have a garden?

——No. A sofa?——No. A roof?——Yes, so we put a line through that one. Do that."

(*c*) "Now look at the next row. In the first box is a tree. Put your finger at it. Now we shall look in the big box for the two things a tree always has. Put your finger on them as we look. Does it always have a branch?——Yes, so we put a line through that one. Do that. Does it always have an acorn?——No. A nest?——No. Does it always, even in winter, have a leaf?——No. Does it always, even in winter, have flowers growing on it?——No. Does it always have roots?——Yes, so we put a line through that one. Do that."

"Pencils down now, and sit up. We are going to do the rest of that page and the next one down to here" (pointing) "in just the same way. First look at the picture in the little box then find the two things in the big box that it always has, and put lines through them. Remember just to put lines through two things in each row. Pencils up. Ready? Go."

TIME : 2 minutes 30 seconds.

"Stop. Pencils up. Pencils down and sit up. Turn to Test 8, here" (pointing).

TEST 8.

(*a*) "Look at the pictures at the top of the page. In the first box is a sheep. Put your finger on it. Next to the sheep is some grass. What does a sheep do to grass? ——Yes, she eats it. So those ones say a sheep eats grass. Now in the next box is a boy. Put your finger on him. And in the rest of the line we have to find something the boy eats. There is grass, and a little girl, and milk, and bread, and a book. Which does the boy eat?——Yes, bread. So we put a ring round the bread like this" (point to the one on board). "All do that. Now read the story that row tells with me again; put your finger on the things

as we say them. It says the sheep eats grass, the boy eats bread."

(*b*) "Now we shall try the next row. See, there is a whole daisy plant ; put your finger on it. And next it is a bit of the daisy. So that says a whole daisy and a bit of a daisy. Then there is a whole tree, so who can tell what we want to find in the big box? A whole daisy and a bit of a daisy, then a whole tree and a?——Yes, a bit of the tree. Look for it with me. Is it the bird?——No. The flower?——No. The branch?——Yes, that's it, so put a ring round the branch. Now read the story that one tells with me. It says a whole daisy and a bit of a daisy, then a whole tree and a bit of a tree."

(*c*) "Now put your finger at the next row. See, there is a man and a pair of trousers. What does a man do with trousers?——Yes, he wears them (or puts them on). And in the next little box is a woman. What does a woman usually wear instead of trousers?——Yes, a skirt. So we must find the skirt in the big box and put a ring round it. Do that. Now let's read the story that one tells. It says, a man wears trousers and a woman wears a skirt. Now, pencils down and sit up."

"We are going to do the rest of the page and the next one, right down here and here" (pointing), "just the same way. Find the story the pictures in the little boxes tell, and then make the rest of the line tell the same story. Read the first three lines with me once more, so that we remember what to do. Put your finger on them as we say them. The sheep eats grass, the boy eats bread. Yes. Now the next, a whole daisy plant, and a bit of it, a whole tree and a bit of a tree. Now the next, a man wears trousers, and a woman wears a skirt. Yes. Now, pencils up. Ready? Go."

TIME : 3 minutes 30 seconds.

"Stop. Pencils up. Pencils down and sit up. Now turn to Test 9, here" (pointing on your copy).

TEST 9.

(*a*) "**On this page there are a lot of lines of crosses and rings.**" (Copy X O on the board, and say "**Call this one a cross and this one a ring.**") "**None of the lines is finished ; there are empty boxes at the end of each line, and we must fill them. We must look at the line first to see what it is saying. Read the first one with me.**" Read with the class "**Cross, cross, cross, cross,**" then give three beats with the hand to help the class to read "**Cross, cross, cross**" into the spaces. If they do not respond ask, "**What shall we put in to finish the line?——Yes, cross, cross, cross. So all put cross, cross, cross in the empty boxes at the end.**"

(*b*) "**Now read the next line with me. It says, Cross, ring, cross, ring, cross, ring.**" (Accentuate as indicated to give the rhythm.) "**How shall we finish that one? ——Yes, cross, ring, cross, ring. Everyone put that in.**"

(*c*) "**Now look at the next line. It is different from the others, for it has some empty boxes in the middle. We leave these boxes empty, and call them 'empty' when we read. Now read it with me. It says, ring, cross, ring, empty ; ring, cross, ring, empty ; ring, cross, ring. How shall we finish that one?——Yes, we leave the next box empty, then put ring, cross, ring. Everyone do that. Don't forget to leave the empty box.**"

"**Now, pencils down and sit up. We are going to finish the other lines on the page in just the same way. First find what they say, then put in the rest so that it says the same all the way along. Remember to leave the empty boxes in the right places. Pencils up. Ready? Go.**"

TIME : 5 minutes.

"**Stop. Pencils up. Pencils down, shut your books, and leave them with your names on top.**"

Collect the books at once.

III. MARKING.

Tests are best marked with a coloured pencil. Each item that is correct should be marked with a dash; in Tests 1 and 9 it is more convenient to put these by the number of the item in the left-hand margin, in the other tests they may be put opposite the item in the right-hand margin. No mark need be made opposite wrong items or ones that have not been answered.

To facilitate marking, one test booklet should be filled in with the correct answers from the following notes and used as an answer key.

The total score on each of the nine tests should be entered in the space provided at the foot of the page and on the title page. The total score on the whole test should be entered in both the appropriate spaces on the title page.

Each question correctly answered counts 1 point. No half credits are to be given.

In all items except Tests 1 and 9 credit is to be given if the intention is clear and correct although the method of answering is wrong, *e.g.*, by marking with a cross instead of a ring, etc.

Where a child has changed his answer, credit is to be given if the final intention is clear and correct.

If more than one drawing is marked, except by way of alteration, where only one should be, give no credit. But neglect all marks on drawings in the small separate boxes at the beginnings of the lines in Tests 3, 6, 7, 8.

When a question requires two responses, give credit only if both responses are correct and no other is marked.

In no tests are marks given for the practice items (*a*), (*b*), and (*c*).

LIST OF CORRECT ANSWERS.

Test 1.—1. A line from any part of the elephant's trunk going above the moon and stars to any part of the tree. It may touch the top star or the top point of the moon, but must not go among them or across them.

2. One line under the moon and stars or separate lines under each of at least two of them.

3. A dot on either side of the tree, high or low, but not above or below it.

4. A horizontal or vertical line above the drum.

5. A line going from any part of the elephant's tail by any route to touch any part of the woman's head.

6. A line right round the pram. It may touch the pram at any point but must not cross it, unless a very little obviously by lack of hand control.

7. A line in any direction going right through the chest of drawers.

8. A cross above the milk jug.

9. A ring above the ship. It need not be a good ring, but must not be a completely filled in dot or blob.

10. A line from any part of the dog's tail going under the stove to either chimney on the house. It may cross the legs of the stove, but must not go up on to the body part.

11. A cross under the stove.

12. A ring under the house.

13. A line from any part of either of the feathers on the hat to either of the teddy's ears.

14. A line right round the ring. It may touch the ring, but may not cross it unless very slightly and obviously from lack of hand control.

Test 2.—Numbering the drawings in each item 1, 2, 3, 4, 5, 6 from left to right, the correct responses are :—

15. **2.** 16. **2.** 17. **1.** 18. **6.** 19. **1.** 20. **5.** 21. **3.** 22. **5.** 23. **4.** 24. **5.** 25. **2.** 26. **2.**

Test 3.—Similarly, the correct responses are :—

27. **4.** 28. **2.** 29. **1.** 30. **4.** 31. **2.** 32. **1.** 33. **3.** 34. **3.** 35. **3.** 36. **2.**

Test 4.—The correct answers are :—

37. **1.** 38. **4.** 39. **1.** 40. **1.** 41. **4.** 42. **5.** 43. **3.** 44. **6.** 45. **5.** 46. **3.** 47. **3.**

Test 5.—Numbering the drawings in each row from left to right, the correct responses are :—

48. **2** and **4.** 49. **1** and **4.** 50. **3** and **4.** 51. **2** and **3.** 52. **3** and **5.** 53. **1** and **3.** 54. **2** and **4.** 55. **2** and **4.** 56. **1** and **4.** 57. **1** and **2.** 58. **3** and **4.** 59. **3** and **4.**

Test 6.—Numbering the drawings from left to right, disregarding the separate box at the beginning of each row :—

60. **1.** 61. **2.** 62. **2.** 63. **5.** 64. **1.** 65. **2.** 66. **3.** 67. **6.** 68. **2.** 69. **4.** 70. **4.** 71. **5.** 72. **5.**

Test 7.—Similarly the correct responses are :—

73. **1** and **4.** 74. **1** and **5.** 75. **2** and **5.** 76. **4** and **6.** 77. **2** and **4.** 78. **1** and **4.** 79. **2** and **6.** 80. **2** and **5.**

Test 8.—Similarly the correct responses are :—

81. **2.** 82. **2.** 83. **2.** 84. **5.** 85. **4.** 86. **4.** 87. **5.** 88. **4.**

Test 9.—The rows must be completed as follows :—

89. O O O.

90. O X O X.

91. O O X X.

92. X X O O.

93. Empty X empty X.

94. Empty X X empty X X empty X X.

95. Empty X O X empty.

96. Empty X empty O empty.

97. Empty, empty, O, empty, empty, O, empty, empty, O, empty, empty.

98. O O O X O O.

99. Empty O X X O.

100. Empty X O X O empty.

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