MENTAL ADAPTATION DURING THE SCHOOL DAY AS MEASURED BY ARITHMETICAL REASONING.—PART II.

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(Continued from the January number.)

IV. THIRD SERIES OF EXPERIMENTS.

1. *General Plan.*

A third series of experiments was made in an infants' department of a school situated in a rather poor neighborhood in the south of London. The whole of a Standard I class, which contained all the Standard I boys and girls in the department, did the work. All these children were 6 or 7 years of age; the average age was 6 years 11 months, and the experiment began with 56 children. The tests were administered by the head mistress, who had had much experience of experimental work with young children.

2. *The Tests and the Method of Marking.*

Sets of problems were called out, one problem at a time, by the head mistress of the school, and the children wrote down the answers, and the answers only. The following is one such set, given as one of the preliminary tests, on the results of which the class was divided into equal groups:

1. There were 15 flowers in a vase: some were red and the rest were white. If 9 were red, how many were white? (One step.)
 2. If there were 6 panes of glass in one window, how many panes would there be in 4 windows? (One step.)
 3. Out of 12 plums I eat 2. I share the rest between two boys. If each boy gets the same number, how many does each get? (Two steps.)
 4. Four rows of trees were planted, with 5 trees in each row. If 10 trees die, how many remain alive? (Two steps.)
 5. A boy plays 3 games of marbles and wins 4 marbles each game. Then he loses 2 marbles. How many has he left of what he won? (Two steps.)
 6. A girl threaded 6 red beads on a string and then 4 blue beads. Five of the beads came off. How many beads were left on the string? (Two steps.)
- Maximum mark per test = 10.

All the sets of tests were constructed on the same plan. The sums set on every occasion were identical in principle, but the figures and wording varied with each set, the subject-matter of the corresponding problems being never twice alike. The order of the problems was also varied; for example, the type of problem used as number 1 of the first set became number 6 of the second set. The questions contained little, if any, numerical difficulty for these children. If they knew how to work the problems, they were nearly certain to get the right answers. At any rate, we had only the answers to go by, for it would have been absurd to ask these children *how* they did the sums, and to work them in full on paper would have introduced novel features, which I was anxious to avoid. Marks were given in accordance with the scale appended to the problems. Each rational step carried one mark.

3. *Chronology of the Experiment.*

The experiment began on Friday, September 1, 1911, the fifth day after the midsummer vacation. Seven problems were given, only one rational step being necessary for the solution of each problem. These "one-step" problems, however, presented so little difficulty to this class that the results would have been useless for experimental purposes. Accordingly these results were disregarded and sets of problems were used similar to those given above. Four sets of preliminary tests were given—at 11.30 A. M. on Tuesday, September 5; Wednesday, September 6; Thursday, September 7, and Friday, September 8. Though the procedure of writing down answers to problems given orally was well known to these children, they did not appear to settle down into their proper places at once. The marks for the first set of answers were consequently discarded. The preliminary tests, therefore, on which the class was divided, were those of September 6, 7 and 8.

A few children had been lost through absences, but we were able to pair off 25 children in each group. Then three final tests were given on Thursday, September 14; Friday, September 15, and Tuesday, September 19. The exigencies of the school arrangements rendered necessary the unequal intervals between the final tests.

Group A worked their final tests each day at 9.40 A. M., whilst Group B took a Reading lesson in the school hall under their own teacher. Both groups had, of course, worked together for the Scripture lesson, which occupies the first school period from 9 to 9.40 A. M. Then, at 10.25, Group B worked the problems, whilst Group A took the Reading lesson.

No other arithmetical work of any kind was done by either group on the days on which any of the tests were given.

4. Results.

The coefficients of correlation between the results of the first and second preliminary tests was + .78, and between the second and third + .78. The correlation coefficients between the results of the first and second of the final tests was + .84, and that between the second and third was + .79.

The total marks of the Group A series correlated with those of the Group B series to the extent of + .99 in the preliminaries and to the extent of + .88 in the finals.

Let me now show the comparative results of Groups A and B. First, I will show them in gross. Group A scored an average mark per child per test of 6.9 (mean variation 2.2) in the preliminary tests and 7.5 (mean variation 2.3) in the final tests, whilst Group B scored 6.9 (mean variation 2.2) in the preliminary and 7.9 (mean variation 2.2) in the final tests.

The group working at 9.40 A. M. improve on their preliminary record 8.7 per cent., whilst the group working at 10.25 improve 14.5 per cent. I will next give the comparative results test by test:

Table V, showing the comparative results of Group A and Group B. test by test, in the preliminary and final tests.

		—Preliminary Tests.—			—Final Tests.—		
		1st.	2d.	3d.	1st.	2d.	3d.
Group A.	Av.....	6.6	6.9	7.4	7.4	7.5	7.6
	M. V.....	2.3	2.4	2.3	2.4	2.5	2.4
Group B.	Av.....	6.6	6.9	7.4	7.8	7.8	8.0
	M. V.....	2.4	2.3	2.1	2.2	2.0	2.8

I will next show how far these differences between the results of the final tests were common to the more as well as to the less proficient pupils of the two groups:

Table VI. showing the results of Group A and Group B compared, section by section, in the preliminary and final tests.

Marks for 3 preliminary tests.	No. of children.	Av. mk. for 3 pre'y tests.	Av. mk. for 3 final tests.	No. of children.	Av. mk. for 3 pre'y tests.	Av. mk. for 3 final tests.
		11.30 A. M.	9.40 A. M.		11.30 A. M.	10.25 A. M.
28, 29, 30.....	3	9.6	9.8	3	9.6	10.0
25, 26, 27.....	9	8.7	9.3	9	8.7	9.5
18 to 24.....	7	7.0	8.0	6	7.3	8.9
8 to 17.....	3	4.3	4.2	4	4.5	5.0
Below 8.....	3	1.2	1.9	3	1.4	2.8

The differences between the results of the final tests seem steadily to favor the sections of the later working group.

V. FOURTH SERIES OF EXPERIMENTS.

1. *General Plan.*

A fourth series of experiments, now to be described, was carried out with the whole of a Standard VII class, of an average age of 13 years 2 months, in a municipal girls' school situated in a poor district in the southeast of London. As in other cases, a whole class, working under the same teacher and in accordance with the same syllabus of instruction, was set to do the work. Then, subsequently, one of the two equal groups continued the work early in the school session, while the other group did the same work late in the same session, and comparisons were made to discover which was the more favorable time. All the tests were administered by the teacher of the class, who had had a great deal of experience of experimental work with children.

2. *The Tests and the Method of Marking.*

We began the experiment with a set of problems which were too easy, and the results had to be discarded. The first set of problems actually utilized was as follows:

1. The charge for keeping 35 horses for 14 days was £52. At this rate what would be the cost of keeping a horse for one day? (Two steps.)
2. How much money should be paid to a blouse-maker who works for seven hours a day for six days if she is paid 4d. a dozen for making blouses and makes three blouses in an hour? (Four steps.)

3. A woman had £84, with which she bought a piano, a bicycle and a ring. The ring cost twice as much as the bicycle and the piano twice as much as the ring. What did each article cost? (Seven steps.)*

4. A draper has 18 boxes, each containing 90 reels of cotton. Each reel holds 250 yards. How many aprons can be machined from this amount of cotton if the amount wasted is 40 yards and it takes 37 yards of cotton to do 36 yards of machining? On each apron there are nine yards of machining. (Six steps.)

5. Every five trees in my orchard yield 320 pounds of apples. I have eight rows of trees, with 15 trees in a row. The care of each tree costs me 3s. a year, and I want to make a profit of £100 on the whole orchard. At what price per pound must I sell the apples in order to do this? (Six steps.)

Maximum mark = 25.

The girls were required, not to solve the problems numerically, but to write down how they would solve them. One mark was given for every correct rational step which was on the way to a solution by any method. The marks for steps assigned at the end of each problem were assessed from the *general* method of attack. A few clever children, who "telescope" some of the rational processes, of course receive marks on the more generous scale.

All the other sets of tests contained problems identical in *principle* with these, problem for problem, but the wording and numbers were changed, and the subject-matter of the corresponding problems was also changed. Further, the order of the corresponding problems was changed from test to test.

3. *Chronology of the Experiment.*

The experimental work began on Friday, July 14, 1911, at 10 minutes past 10 in the morning session. On this date, and also at the same time on the following Tuesday morning, July 18, sets of problems were given which are not shown above. They were found to be too easy, and the results were too high to allow of any subsequent differential improvements to be adequately shown. These results were therefore discarded, but the tests performed a useful function as preparatory exer-

*The children found this sum very difficult, as, indeed, all children tend to do who cannot use algebraic or equational arithmetic. In such cases the sum has to be worked as a problem in shares. I incline to regard the final multiplication required of the value of the single share as rationally identical with the assessments of the shares before the process of division can be done: but the teacher was anxious that this, being admittedly a difficult problem for these children, should be marked in the highest possible way, consistent, of course, with the general system of marking.

cises, and doubtless "steadied" the preliminary tests whose results we *did* use for the purpose of dividing the class. The preliminary tests proper were given Friday, July 21; Monday, July 24; Tuesday, July 25, and Wednesday, July 26. They were all worked between 10.10 and 10.45 in the morning after short recapitulatory lessons involving no arithmetical reasoning. The short oral lessons were, as is usual in English schools, preceded by a Scripture lesson, which lasted from shortly after the opening of school at 9 A. M. to about 9.40 A. M.

On the result of these four tests the class was divided into two equal groups. Children who would be likely to leave during the coming vacation were marked, so that they might be placed in opposite groups and, if possible, be paired.

On July 26 the schools "broke up" for their midsummer vacation. They opened again on August 28, and, after allowing four days for a resumption of general mental adaptation to school work, the final tests were begun. The days of the final tests were Friday, September 1; Monday, September 4; Tuesday, September 5, and Wednesday, September 6. These were given at 11.25 to Group B and at 10 A. M. to Group A. Whilst Group A were working their tests, Group B were studying Geography from their books in another room under another teacher, and whilst Group B were working the tests, Group A studied the Geography. At 10.45 came the 15 minutes' recreation interval, and after that a short oral lesson differing in subject on different days, but in no case involving any arithmetical computation or reasoning. No arithmetical work other than the tests was done on the dates given above. The children were told before commencing each fresh set of problems how many marks they had obtained before, but no errors were pointed out nor were the marks for particular problems indicated. The geographical work was not questioned.

4. Results.

The preliminary tests were worked by 30 girls. The results of the first test correlated with those of the second to the extent of + .86, those of the second with the third to the extent of + .89, and those of the third and fourth to the extent of + .89.

The correlation coefficients for the final tests were, between the first and second + .91, between the second and third + .95, and between the third and fourth + .91.

The total marks for the A series correlated with those of the B series to the extent of + .97 in the preliminary tests and to the extent of + .81 in the final tests.

The average age for each group was 13 years 2 months.

The comparative results in gross of the work of Group A and Group B are as follows:

For Group A in the preliminary test the average mark per child per test was 13.0 (mean variation 3.8); for Group B it was also 13.0 (mean variation 3.9). In the final tests the corresponding marks for Group A—the earlier-working group—was 14.9 (mean variation 3.6), and for Group B—the later-working group—was 15.7 (mean variation 4.0).

Group A improves 15 per cent. on its preliminary record, and Group B improves 21 per cent. It is interesting to note that nearly the whole period between the preliminary and final tests was holiday.

I will show next the comparative results of Groups A and B, test by test:

Table VII, showing the work of Group A and Group B compared, test by test, in the preliminary and final tests.

		—Preliminary Tests.—				—Final Tests.—			
		1st.	2d.	3d.	4th.	1st.	2d.	3d.	4th.
Group A.	Av. mk.	10.9	12.8	13.3	14.9	14.3	14.6	15.5	15.4
	M. V.	3.4	3.6	4.5	3.7	3.2	3.8	3.6	3.4
Group B.	Av. mk.	10.7	12.5	13.5	14.9	14.9	15.3	15.5	17.0
	M. V.	3.3	3.8	4.0	4.5	3.7	3.8	4.6	3.7

Finally, I propose to show the work of the two groups compared, section by section:

Table VIII, showing the work of Group A and Group B compared, section by section, in the preliminary and final tests.

		—Group A.—		—Group B.—	
		Av. mk. per child per test	Av. mk. per child per test	Av. mk. per child per test	Av. mk. per child per test
Marks in 4 preliminary tests.	No. of girls.	in 4 prel'y tests.	in 4 final tests.	No. of girls.	in 4 prel'y tests.
Over 65.	3	18.5	19.3	3	18.1
45 to 65.	3	13.3	15.7	3	14.6
35 to 45.	3	10.3	9.8	3	9.7
25 to 35.	2	7.5	15.0	2	7.7
					11.6

It will be noticed that the number of children is considerably diminished from the number with which the experiment commenced. There were eight children marked as likely to leave during the summer vacation, and they had been fairly adequately paired in opposite groups. One of the girls, M. R., at the bottom of Group B, who was marked to leave, did not do so, whereas K. H., at the bottom of Group A, also marked to leave, had done so before the final tests were given. M. R.'s results were, therefore, not included in the above summary. The average mark for the third section of Group A contains that of K. W., who was absent from school the first week after the summer holiday, and therefore worked her final tests below the "form" of the other girls. The mark for this section should, therefore, be a little higher. The mark for the last section of Group A is also unsatisfactory. One of these two girls, R. A., worked her four preliminary tests in July with the following results: First test, 6; second, 7; third test, 8; fourth test, 9. In September she worked her four final tests, with the result that she obtained 15, 19, 20 and 17 marks from the first to the fourth, respectively. This is an unprecedented improvement, and it seems likely that some important factor was influencing this result apart from any question of a favorable or unfavorable time; indeed, for Group A, there was practically no change in the time from the preliminary to the final tests.

It is probably worth noting that the factor of habituation, if it operates at all, does so in favor of Group A; yet, notwithstanding this, the advantage in the final tests is found on the side of the later-working group.

VI. FIFTH SERIES OF EXPERIMENTS.

1. *General Plan.*

A fifth series of experiments was carried out in a boys' school situated in a very poor neighborhood in the southeast of London. The work was done with the whole of the First Class, of an average age of about $12\frac{1}{2}$ years. On the ordinary school grading they would have been classified as Standard VI, a, and Standard VII. Work of this kind, dealing with

children of approximately this age and mental level, has already been described, but the present investigation was not superfluous, for the circumstances of these boys were exceptional. Three-fourths of them rose early every morning, and half of them were at work at 6.30 A. M. daily. It would not seem improbable in such cases that the highest mental adaptation would show itself earlier in the morning, and that a time chosen for severe mental work near the end of the morning session at school would be likely to be less favorable. To test this hypothesis the class was divided into two equal groups on the results of some preliminary tests, which were worked about the middle of the morning session. Then, subsequently, one of the two groups continued the tests as early in the morning sessions as school regulations allow, namely, at 9.40, immediately after the Scripture lesson, whilst the other group continued them late in the morning session, namely, at 11.30. Comparisons between the work of the two groups, when working at the same time and when working at different times, were instituted, as in the experiments previously recounted.

It has been suggested to me that if I had put into one group all the boys who went to work early in the morning before beginning school at 9 o'clock, and in the other group all those boys who did not do so, I should have obtained some valuable comparisons. This might have been so, but I could not, in that case, have worked by the method of equal groups, for of the first ten boys in the class in arithmetical reasoning no less than eight were boys who began their day's work at 6.30 A. M. It is true that the two boys at the bottom of the list also went to work very early; but, on the whole, the greater natural ability of the "working" boys would give them the pre-eminence, whatever time in the morning the work was done. In order, therefore, to get the groups equal, it was necessary to divide the class without regard to the existence or non-existence of early morning work. The teacher of the class was a young man of vigor and capacity. He had had a good deal of experience in experimental work, and all the tests were administered by him.

2. *The Tests and the Method of Marking.*

After one or two sets of problems had been tried unsatisfactorily, the following set was constructed and found successful. Perhaps a word may be of service as to the failure of the preceding tests. The test must be of such a nature that there is plenty of room for improvement, for we are working from a basis of differential improvement, it will be remembered. Therefore, it must be rather hard. But it must not be so hard that the children can do little at it, for in such a case we find them all "slumped" together at the bottom of the lists. Also it is important that the marks shall run gradually down from the best boys to the worst, otherwise it is extremely difficult, if not impossible, to get corresponding pupils nicely paired in the equal groups; indeed, it is difficult to get really equal groups at all. The following problems, however, seemed to be satisfactory:

1. A load of hay costing £5 10s. and 16s. worth of cake last a cow six weeks, during which time the cow gives $3\frac{3}{4}$ gallons of milk per day, sold at $1\frac{1}{2}$ d. a pint. What is the weekly profit? (Seven steps.)

2. A horse and a dog commence running side by side. The horse takes 522 strides in half a mile. Supposing the dog to take 11 steps to every 3 taken by the horse, find the length of the dog's strides. (Three steps.)

3. A man bought 120 cows in Holland, paying £9 7s. each for them. Their carriage to London was one-thirty-fourth of their cost price. He then exchanged them for 105 ponies, which he sold for £13 10s. each. What did he gain? (Five steps.)

4. I buy 325 sheep at 27s. 6d. each and 48 lambs at 15s. each. Just 13 weeks afterwards I sell the sheep at 39s. 3d. each and the lambs at 22s. 9d. each. If the cost of their keep is 6d. for each animal a week, what is my gain? (Ten steps.)

5. A school boy receives 6d. weekly while at school, but he has to pay away 4d. every five school weeks. Supposing there are 40 weeks in a school year, how much will he have had for himself in three years? (Six steps.)

6. There are 1259 men, women and children in a train. The men and women together number 1146; the women and children number 982. How many are there of each? (Four steps.)

The boys were not required to work the problems, but to state clearly how they would work them. Their work was marked in the usual way. Every rational step indicated which was on the way to a correct solution by any method received one mark. If a boy "telescoped" into *one*-step processes which, when analyzed, were really *two* rationally, he, of course, received the marks on the more generous scale. For some

purposes it might fairly be argued that such a boy should receive more than two marks, but the question is of little practical importance so far as these tests are concerned. It will be noticed that the system of marking adopted gives a total mark of 35.

3. *Chronology of the Experiment.*

It has already been stated that several sets of tests were given before we finally found a set which was suitable. This preparatory work, however, was by no means wasted, for the children gained facility, and, what was more important from an experimental point of view, settled down rapidly into their proper places when the actual preliminary tests were given. There were four of these preliminary tests, given from 10.15 A. M. to 10.45 A. M. on Thursday, August 31; Friday, September 1; Monday, September 4, and Tuesday, September 5. The preceding lessons were Scripture and Silent Reading. During the latter lesson the children were acquiring information subsequently tested. There were also four final tests, but in these one of the two equal groups—Group A—worked their tests from 9.40 to 10.10 A. M., whilst Group B “read up” a subject on which, in another lesson, they were required to write an English composition. From 10.10 to 10.45 for both groups, the lessons, though different on different days, were always oral lessons. The recreation interval occurred between 10.45 and 11 o’clock. From 11 to 11.30 the lessons were Geography on Friday, History on Monday and Tuesday, and Physical Exercises on Wednesday. It would probably have been more satisfactory to have moved the lesson on Physical Exercises to the afternoon, but that point was overlooked until it was too late to change the lesson. From 11.30 to 12 o’clock Group B worked the problems previously worked by Group A, whilst Group A “read up” for composition.

The four final tests were given on Friday, September 15; Monday, September 18; Tuesday, September 19, and Wednesday, September 20.

4. *Results.*

The coefficients of correlation in the preliminary tests, worked out from the individual cases by the moment-product formula, were, between the first and second, $+ .77$; between the second and third, $+ .69$, and between the third and fourth, $+ .77$. The corresponding coefficients of correlation between the final tests were $+ .77$, $+ .93$, and $+ .73$.

The coefficients of correlation between the total marks for the Group A series and the Group B series were, in the preliminary tests, $+ .94$, and, in the final tests, $+ .86$.

Three boys belonging to the group working at 11.30 were absent in the final tests, so the work of the three boys who corresponded to them in the group working at 9.40 was omitted. There then remained 13 pupils in each group.

The average mark per child per test for Group A in the preliminary tests was 26.8 (mean variation 3.2), and in the final tests 29.6 (mean variation 3.1); for Group B the corresponding marks were 26.8 (mean variation 3.1) and 29.2 (mean variation 3.0). The group working at 9.40 improved on its preliminary record to the extent of about 14 per cent.; the group working at 11.30 A. M. improved on its preliminary record to the extent of 9 per cent., which gives a difference of 5 per cent. in favor of the earlier working group.

I will next show the comparative work of the two groups, test by test:

Table IX, showing the work of Group A and Group B compared, test by test, in the preliminary and final tests.

		—Preliminary Tests.—				—Final Tests.—			
		1st.	2d.	3d.	4th.	1st.	2d.	3d.	4th.
Group A.	Av. mk.....	23.0	26.5	28.1	29.5	27.1	30.4	30.5	30.5
	M. V.....	3.8	4.7	2.9	3.3	4.0	3.4	2.9	3.0
Group B.	Av. mk.....	22.8	26.5	28.4	29.5	27.4	29.0	29.8	30.4
	M. V.....	3.9	4.0	2.8	2.9	3.3	2.8	3.0	2.9

There certainly seems some advantage on the part of the earlier working group, but it is rather undecided, and it may be well to analyze the results, section by section, to see how far it is common to the more proficient as well as to the least proficient pupils:

Table X, showing the work of Group A and Group B compared, section by section, in the preliminary and final tests.

	Group A.			Group B.		
	No. of boys.	Av. mk. per boy per test in 4 prel'y tests.	Av. m ¹ / ₂ . per boy per test in 4 final tests, 9.40 to 10.10 A. M.	No. of boys.	Av. mk. per boy per test in 4 prel'y tests.	Av. mk. per boy per test in 4 final tests, 11.30 to 12 A. M.
Marks for 4 preliminary tests.						
120 and over.....	3	31.8	33.4	3	31.7	33.1
110 to 120.....	3	28.9	32.6	3	29.0	31.3
100 to 110.....	3	25.8	27.8	3	26.0	27.9
Below 100.....	4	22.3	26.0	4	22.1	25.7

In the case of every section we find the children working their final tests earlier in the morning have made a greater advance on their preliminary work than those working later. It is true that a factor of habituation, if it is operative, would work in favor of the earlier working group, for the arithmetic lesson is usually given at the earlier hour. But, in other cases, this factor, if it exists, has not been able to overcome the advantage consequent upon the greater general mental adaptation of a later hour. It is suggested that the opposite result in this case is due to the fact that no less than 12 of the boys whose work is summarized in the above table began work every day at 6.30 A. M.

VII. PEDAGOGICAL CONCLUSIONS.

If the conclusions arrived at throughout this series of experiments are well based, a very considerable change in the present arrangements of school time-tables seems desirable. Whereas, in the previous experiment conducted by similar methods,* the results were in agreement with the best current pedagogy, those of the present research are in flat contradiction to it. The earlier in the morning the better is the opinion which governs the place of problematic arithmetic in school time-tables at present.

It is true that in elementary schools in England the first school lesson is Scripture, but that fact is due to historical.

*W. H. WINCH: *Mental Fatigue in Day-School Children as Measured by Arithmetical Reasoning*, British Journal of Psychology, December, 1911.

reasons, and not because the Scripture lesson is regarded as specially suitable for rapidly producing a vigorous state of general mental adaptation. Then in most cases follows problematic arithmetic.

These experiments seem to indicate that a later hour in the morning would be more suitable, in consequence, most probably, of greater mental adaptation at a later hour in the morning. But in classes containing many children who rise early and go to work before coming to school the present early hour for problematic arithmetic is probably better than a later one. In the cases of those children the maximum of mental adaptation appears to be reached earlier than in the case of children who do not work before coming to school.