# MENTAL FATIGUE IN DAY SCHOOL CHILDREN AS MEASURED BY IMMEDIATE MEMORY. PART II.

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SUMMARY.

Tests of immediate memory on a class of fifty-one boys, averaging eleven years of age, showed a slight relative inefficiency in the work of the late afternoon as compared with that of the early morning. The decrease in efficiency was about two per cent.

## IV. A Second Experiment in a Boys' School.

This experiment was carried out with the whole of a Standard IV class, numbering 51, of an average age of 11 years, 1 month, on June 30, 1911. The school was the same as that in which the previous experiment was done, but the standard of mental proficiency and the age of the boys were different and they were taught by a different teacher. This class was also taught by a young man of capacity, but differing from the teacher of the preceding class somewhat in the greater evenness, though, perhaps, slighter intensity of his demands upon the mental energy of his pupils.

### i. *Tests and Method of Marking.*

The tests were tests of memory of auditory percepts. Six consonants, for example, r, l, p, x, m, s, were called out twice in 25 seconds by the teacher of the class, whose voice and enunciation were familiar to the children. A slight pause was made after each consonant with a slightly longer pause after the third. One minute five seconds was allowed for the boys to write out as much as they could remember of each set of con-



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sonants immediately after they had been called out. They were required to write them in two lines of three consonants each. Ten sets of consonants constituted one test or exercise, the whole procedure lasting exactly 15 minutes. The boys' papers of answers were marked exactly as in the preceding experiment. Three marks were given for each consonant correctly remembered and rightly placed; two marks, if the consonant were rightly remembered, but was one place before or behind its proper position; and one, if it were two places out. As before, the children were instructed to leave a space in the place of any consonant which they knew they had forgotton.

### ii. *Chronology of the Series.*

Four sets of preliminary tests were given to afford a basis for the division of the class into two equal groups. They were worked from 10.45 to 11 A. M. on Tuesday, June 13; Wednesday, June 14; Friday, June 16, and Tuesday, June 20.

The school lessons which preceded these preliminary tests were in all cases the same, namely, Scripture, arithmetic and recreation, so that no difficulty arises on that score, but I regret that the exigencies of the school work in relation to the forthcoming coronation festivities prevented me from spreading the work over a longer period and, above all, of getting more regular intervals between the successive tests. Coronation holidays followed immediately upon the preliminary tests, and it was not until some twelve days afterwards that the school once more settled down to work. In the interim the boys taking the experiment had been divided into two equal groups on the results of the preliminary tests and henceforward one of the groups continued the tests in the mornings from 9.45 to 10 A. M., whilst the other group worked the same tests in the afternoons of the same days from 4 to 4.15 P. M.

Four of these tests were given—henceforward called the final tests—on Wednesday, July 5; Friday, July 7; Wednesday, July 12, and Friday, July 14.

The lessons which preceded the morning tests were in each case Scripture lessons: the lessons which preceded the afternoon tests were, on Wednesdays, arithmetic, physical exer-

cises and reading, and on Fridays, English, physical exercises and history.

Whilst Group A were working their tests in the morning, Group B, in another room, were drawing common objects, and whilst Group B worked their memory tests in the afternoon Group A drew common objects. The children in both groups were told the results of their previous work both in drawing and in memory work before proceeding to the next test.

In every respect other than those just indicated the time-table of school work for the two groups was precisely the same throughout the period of the experiment.

### iii. *Results.*

It is of little value to attempt to divide a class into equal groups on results which vary so much from exercise to exercise that the children seem to be jumping about in the lists and rapidly exchanging places. An inspection of the results will give a fairly good notion as to the "steadiness" of the work, but, of course, a calculation of a coefficient of correlation enables more careful comparison to be made. Calculated on the moment-product formula $r = \frac{\Sigma xy}{N\sigma_1\sigma_2}$, the correlation coefficient between the results of tests 1 and 2 is + .743, of tests 2 and 3 is + .741 and of tests 3 and 4 is + .746. With correlations of this size and a number of cases amounting to 51, the "probable error" of the coefficient of correlation is practically negligible. I decided to make the division on the results of these four tests, but I was well aware that I had not divided the class in the case of the previous experiment until the positive correlations between the results of successive tests had become decidedly higher than these, and I should have continued the preliminary tests had not the coronation holidays stood in the way. It is probable, therefore, that the division into equal groups is not so satisfactorily effected as in the case of the previous experiment. That it is fairly satisfactory, however, will appear from tables which follow.

I propose first to show the work of the two groups as wholes both in the preliminary and final tests.

*TABLE I, *Showing the Work of the Two Groups as Wholes, Test by Test, in Both the Preliminary and Final Tests.*

| | | Preliminary Tests. | | | | Final Tests. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1st. | 2d. | 3d. | 4th. | 1st. | 2d. | 3d. | 4th. |
| Group A. | Av. mark.... | 15.4 | 16.1 | 16.0 | 16.0 | 16.6 | 16.2 | 16.4 | 16.9 |
| | M. V..... | 1.4 | 1.2 | 1.5 | 1.4 | 1.2 | 1.6 | 1.2 | 1.1 |
| Group B. | Av. mark.... | 15.2 | 16.2 | 16.0 | 16.0 | 16.0 | 16.1 | 16.1 | 16.3 |
| | M. V..... | 1.4 | 1.3 | 1.6 | 1.2 | 1.4 | 1.1 | 1.2 | 1.3 |

The average mark for the whole of the preliminary tests for Group A is 15.9, with a mean variation of 1.2, and for Group B is also 15.9, with a mean variation of 1.2. In the final tests Group A scores an average mark of 16.5 (mean variation 1.1) and Group B an average mark of 16.1 (mean variation 1.1). Group A—the morning group—improves on its preliminary record to the extent of 3 per cent.: Group B—the afternoon group—improves on its preliminary record to the extent of 1 per cent. There is apparently an advantage of 2 per cent. in improvability of the morning over the afternoon workers.

There are one or two comments which may usefully be made on the above table. It will be noticed how little improvement is shown in the preliminary tests, even though the exercises are quite new. But surprise will no longer be felt when it is remembered that they were all worked within the space of seven days. An improvement in mental work of this kind is very little evident unless there are suitable intervals between the successive exercises. It will also be seen that the morning group did better work in each of the final tests as compared with the group of afternoon workers, though, in one case, the difference is slight.

I next propose to show, section by section, the work of the two groups in the preliminary and final tests respectively.

*The calculations are made to the nearest ten.

*TABLE II, *Showing the Work of Groups A and B Compared, Section by Section, in the Work of the Preliminary and Final Tests, Respectively.*

| Marks for four preliminary tests. | Group A. | | | Group B. | | |
|---|---|---|---|---|---|---|
| | No. of boys. | Av. mark per boy per test of four prelim'y tests. | Av. mark per boy per test of four final tests. | No. of boys. | Av. mark per boy per test of four prelim'y tests. | Av. mark per boy per test of four final tests. |
| Over 65..... | 12 | 17.1 | 17.5 | 12 | 17.1 | 17.0 |
| Over 60..... | 7 | 15.8 | 16.7 | 7 | 15.7 | 16.1 |
| Over 55..... | 2 | 14.0 | 15.5 | 2 | 14.6 | 15.1 |
| Under 55..... | 4 | 13.3 | 13.8 | 4 | 13.1 | 14.1 |

There appears to be some advantage on the side of the early morning workers in the first, second, and third sections; but in the lowest sections, consisting of boys who obtain less than 55 marks in the four preliminary tests, the group of afternoon workers show more improvement than those who work early in the mornng. This is contrary to the suggestion, previously made, that, perhaps, it is the more strongly endowed who do better work in the afternoon, for these boys are among the weakest in the class mnemonically, as shown by both the preliminary and final tests. The differences between the improvements shown by the morning and afternoon workers appear small. This may be partly due to the fact that the tests were a little too easy. Eighteen (or rather one hundred and eighty) is the maximum mark per test and it will be at once seen that in the highest sections, which score 17.1 marks in the preliminary tests, that there was not very much room for improvement. I propose, finally, to show the comparative improvements of the individual pupils of Group A and Group B. The improvements are calculated on the average of the four preliminary tests on which the class was divided. The averages and percentages are calculated to the nearest unit only.

*The calculations are made to the nearest ten.

TABLE III, *Showing the Comparative Improvement of the Pupils in Groups A and B in the Morning and Afternoon Work, Respectively.*

| Group A. | | | | Group B. | | | |
|---|---|---|---|---|---|---|---|
| Name. (Initials only.) | Av. of four prelim'y tests. | Av. of four final tests. | Percentage of improvement. | Name. (Initials only.) | Av. of four prelim'y tests. | Av. of four final tests. | Percentage of improvement. |
| I. F..... | 177 | 176 | — 1 | S. S..... | 177 | 180 | + 2 |
| F. C..... | 172 | 179 | + 4 | W. V..... | 175 | 174 | — 1 |
| F. G..... | 171 | 174 | + 2 | M. A..... | 174 | 174 | 0 |
| R. D..... | 173 | 173 | 0 | G. H..... | 172 | 170 | — 1 |
| G. E..... | 172 | 176 | + 2 | O. S..... | 172 | 178 | + 3 |
| P. A..... | 170 | 170 | 0 | W. W..... | 172 | 177 | + 3 |
| P. G..... | 168 | 173 | + 3 | R. R..... | 170 | 169 | — 1 |
| F. W..... | 170 | 176 | + 4 | P. W..... | 168 | 175 | + 4 |
| F. A..... | 164 | 176 | + 7 | N. L..... | 165 | 162 | — 2 |
| H. W..... | 168 | 173 | + 3 | S. W..... | 165 | 159 | — 4 |
| R. H..... | 167 | 175 | + 5 | O. S..... | 166 | 154 | — 7 |
| K. J..... | 164 | 166 | + 1 | McW. ..... | 164 | 171 | + 4 |
| S. A..... | 162 | 179 | + 10 | S. T..... | 161 | 161 | 0 |
| H. J..... | 160 | 168 | + 5 | P. A..... | 158 | 155 | — 2 |
| D. A..... | 157 | 163 | + 4 | H. W..... | 160 | 169 | + 6 |
| C. L..... | 155 | 165 | + 6 | D. R..... | 159 | 172 | + 8 |
| A. J..... | 158 | 167 | + 6 | C. J..... | 153 | 163 | + 7 |
| S. K..... | 155 | 158 | + 2 | M. A..... | 153 | 144 | — 6 |
| E. W..... | 154 | 162 | + 5 | N. W..... | 151 | 160 | + 6 |
| N. W..... | 138 | 144 | + 4 | McI. F..... | 148 | 152 | + 3 |
| W. E..... | 142 | 164 | + 15 | H. C..... | 143 | 151 | + 6 |
| W. E..... | 136 | 147 | + 8 | B. T..... | 136 | 136 | 0 |
| B. S..... | 133 | 148 | + 11 | D. H..... | 131 | 154 | + 18 |
| W. F..... | 132 | 126 | — 5 | H. E..... | 130 | 136 | + 5 |
| H. A..... | 127 | 128 | + 1 | R. F..... | 123 | 132 | + 7 |
| Totals...3945 | | 4106 | | Totals...3946 | | 4028 | |
| Averages. 157.8 | | 162.2 | | Averages. 157.8 | | 161.1 | |
| M. V..... 11.9 | | 11.1 | | M. V..... 12.2 | | 11.2 | |

An inspection of the table shows that in the group of morning workers improvement is shown in every case but four, whilst, in the afternoon group there are 11 such cases; but probably comparisons of this kind may be made more readily from the following tabular statement.

TABLE IV, *Showing the Comparative Percentages of Improvement Between the Members of Group A and Those of Group B.*

| | Number of Cases. | |
|---|---|---|
| | Group A. Morning Group. | Group B. Afternoon Group. |
| Gain of 15% and over | 1 | 1 |
| Gain of 10% to 15% | 2 | 0 |
| Gain of 5% to 10% | 7 | 7 |
| Gain of 0% to 5% | 11 | 6 |
| Neither gain nor loss | 2 | 3 |
| Loss of 0% to 5% | 2 | 6 |
| Loss of 5% to 10% | 0 | 2 |

The coefficient of correlation on the total results of the four preliminary tests between the corresponding cases (see Table III), of the two Groups A and B is, of course, as estimated by rank formulæ + 1. On the moment-product formula, which uses marks, not rankings, the coefficient is + .899. Similarly calculated, the coefficient for the final tests is + .862.

## V. SUMMARIZED CONCLUSIONS.

1. Again we find that the use of immediate memory tests indicates, in a normal group of school children constituting the whole of a class or grade, a certain amount of relative inefficiency in late afternoon as compared with early morning work.

If we accept this relative inefficiency as a measure of fatigue for mechanical memorizing it appears to be very small for children of this age and mental proficiency, namely, about 2 per cent. Unfortnately, however, the tests set were relatively, as well as absolutely, easier than those given to the older and abler boys who took the previous experiment, so that I feel very little confidence in making the suggestion that with lower classes the fatigue effects for purely mechanical work may be smaller than in higher ones. In any case the fatigue effects for mechanical mental work of this kind appear small amongst children, at least so far as boys of this type are concerned.

2. As in the class previously dealt with there are to be found children who cease to improve and tend downward. It is not argued that no fatigue is present if improvement continues, indeed, I have tried to measure fatigue by differential improvements made under differing conditions; but it is ar-

gued that an actual deterioration in work of this kind shows such fatigue that there are indications to the educationist of the advisability of a cessation for a time of that or other work or what amounts to much the same thing, of a longer interval between the successive exercises. Two of the morning workers and eight of the afternoon workers appear to have deteriorated during the course of the work. With one-third of the afternoon group, therefore, the work appears to have been futile, as was found to be the case in the previous experiment. On the other hand a considerable proportion of the children have continued to improve.

3. The ordinarily accepted pedagogical maxim that, with most children, mental work of a mechanical kind may be done, with fair satisfaction, late in an afternoon session, appears to receive some corroboration.