THE EFFECT OF PRACTICE UPON VISUAL APPREHENSION IN SCHOOL CHILDREN. PART II.

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VII. RESULTS.

1. *Effect of practice in general:* Table I gives the subjects, the classification according to the results of the fore-practice, the results of the fore-practice, of the test series, and of the drill series, the class standing, and the age of each subject.

Tables II and III, which follow, give the composite results for the Test-Series and the Drill-Series, respectively. These tables are not constructed from the data in Table I, *i. e.*, they are *not the averages of averages*, but are compiled directly from the original data.

Table II shows the averages of the *Test-Series* for the three classes of subjects (the good, the medium, and the poor), the general average of the entire class, and the averages for the girls and the boys.

Table III shows the averages of the *Drill-Series* for the three classes of observers, the general averages of the entire class, the average of the girls and the boys, also the average age for each class of subjects, and the average age of the class as a whole.

These Tables and Curves show the effect of practice upon visualization. When the total results are considered alone, they agree very closely with those of Whipple and Foster, and the other investigators upon the problem of practice. There was a very appreciable gain in the efficiency of the subjects' reports during the course of the experiment. This improvement was very large at first and small in the later part of the work. In the Test-Series (Table II; also Plate III) the in-

TABLE I.

Classification, Net Average Scores by Periods, School Standing, and Average Age of Each Pupil.

	Pupil	Av. of Fore- Practices, 1st Wk.	Av. of Test- Series A, 2d Wk.	Av. of Drill- Series 1, 3d-6th Wk.	Av. of Test- Series B, 7th Wk.	Av. of Drill- Series 2, 8th-11th Wk.	Av. of Test- Series C, 12th Wk.	Av. of Drill- Series 3, 13th-16th Wk.	Av. of Test- Series D, 17th Wk.	Av. of Test- Series E, 18th Wk.	School Standing	* Age
Class I	Lloyd	46.6	43.5	54.2	52.4	63.0	53.2	55.3	44.6	53.5	A	7 : 9
	Lura	45.0	40.0	51.0	40.6	55.6	54.3	50.1	52.3	...	A	8 : 6
	Ezra	44.9	40.7	48.1	45.5	52.9	44.5	50.0	42.9	...	B	8 : 6
	Raul	44.7	44.6	60.3	53.3	63.4	54.6	71.7	55.0	...	A	9 : 6
	Edward B.	44.1	36.6	49.7	51.4	53.7	49.3	53.5	55.4	53.1	A	7 : 10
	Reginald	42.3	39.1	45.8	45.1	55.4	41.0	50.3	43.5	49.5	A	9 : 3
	Ethel	42.0	42.1	48.3	51.6	56.2	48.2	56.4	47.9	55.7	A	10 : 0
	Frank	40.7	29.1	42.2	43.8	50.3	44.5	46.2	49.5	51.9	B	8 : 3
	Sylvia	38.6	35.8	45.5	42.8	48.3	45.7	49.5	48.2	50.8	A	8 : 5
Class II	Paul	38.3	34.8	47.4	45.6	56.1	50.0	54.1	47.4	...	A	8 : 6
	Dorothy	37.5	37.0	44.0	47.8	50.0	47.6	49.5	46.6	50.0	B	8 : 3
	Clarence	37.0	32.0	44.0	37.5	41.9	40.0	40.3	39.5	42.3	B	9 : 2
	Lindsay	36.5	39.0	45.5	41.0	50.2	46.0	53.8	52.0	48.1	A	7 : 5
	John Cn.	36.4	31.6	42.0	45.2	51.5	48.6	48.5	44.9	51.9	A	7 : 10
	Carl	36.0	32.0	44.4	45.1	50.5	43.8	52.2	43.6	47.5	A	10 : 9
	Eileen	34.5	30.6	38.5	36.8	41.6	38.4	43.8	38.8	42.0	A	8 : 11
	Levena	34.1	32.2	39.8	42.0	50.7	42.0	50.4	48.5	...	B	6 : 6
	Truman	34.0	25.6	45.6	47.5	54.7	44.1	57.0	45.1	44.3	A	9 : 10
Class III	Wilkinson	33.7	26.2	38.8	36.0	38.0	38.2	35.5	37.7	37.7	A	8 : 1
	Bernice	33.5	36.0	43.7	44.0	46.5	42.2	43.6	41.9	48.5	B	8 : 8
	Chester	32.8	35.5	36.5	36.0	43.0	45.5	40.7	44.5	47.0	A	9 : 1
	Margaret	29.8	29.0	39.1	37.5	40.8	44.1	51.8	42.4	...	B	7 : 6
	Edward D.	29.8	29.2	44.6	43.3	46.5	43.3	51.5	45.3	45.4	A	9 : 1
	Francis	29.5	32.7	40.5	38.7	39.9	43.0	41.0	41.1	44.6	B	7 : 11
	John Cy.	28.9	33.4	44.4	42.2	51.1	40.3	43.0	41.5	...	B	7 : 6
	Evert	28.4	30.6	43.5	42.5	42.5	42.1	51.3	47.3	...	B	6 : 6
	Mercedes	26.6	29.1	34.2	33.5	35.9	39.4	39.2	46.1	48.4	B	7 : 7
	Helen	25.8	28.3	39.6	40.8	42.9	36.0	38.8	40.5	...	A	6 : 6
	Harry	25.5	27.0	40.5	38.5	46.8	40.0	52.1	42.1	...	B	9 : 0

*Age in years and months at beginning of experiment.

TABLE II.

Average Scores in the Test-Series.

Class	Main Experiment				Re-test, Series E, 58th Week.
	Series A, 2d Week.	Series B, 7th Week.	Series C, 12th Week.	Series D, 17th Week.	
I.....	38.662	48.256	48.108	48.243	52.400
II.....	32.266	43.166	43.400	42.650	45.700
III.....	30.441	39.455	41.176	43.014	46.350
Total*	33.905	43.782	44.376	44.856	48.000
Girls	33.392	41.357	42.595	43.452	48.571
Boys.....	34.423	45.536	45.644	45.855	47.666

*The totals in this and the following tables are not averages of averages, but final averages from all the data.

TABLE III.

Average Scores in the Drill-Series.

Class.	*Av. Age.	Drill-Series 1.	Drill-Series 2	Drill-Series 3
I	8.65	49.059	56.046	54.276
II.	8.54	42.737	47.852	47.618
III.	7.83	40.423	43.839	44.325
Total.	8.26	43.882	49.137	48.988
Girls	8.07	41.989	46.746	47.184
Boys	8.54	44.885	50.719	50.299

*Average age given in years and fraction of years.

crease between *Series A* and *Series B* was about ten units, between *Series B* and *Series C*, 0.6 of a unit, and between *Series C* and *Series D* only 0.5 of a unit. In the Drill-Series (Table III) there is actually a loss after the initial improvement. This loss is slight, however, 0.2 of a unit, and it can be explained by the fact that more difficult series were given to the subjects during this period than during either of the two preceding periods; for, as we have before reported, the series during this period and especially during the last week of this period were nearly as difficult as those of the Test-Series. To be sure, there were greater opportunities for larger scores, but this advantage was outweighed by the disadvantage of greater complexity.

2. *Effect of practice for different types of material:* Table IV shows the average number of units reported by the girls.

Plate III.

the boys, and the class as a whole for each type of material during the Test-Series, and the general averages for each type and for each series.

TABLE IV.

Average Record for Each Type of Material.

Test Series		Average.	Average, Type I.	Average, Type II.	Average, Type III.	Average, Type IV.	Average, Type V.	Average, Type VI.	Average, Type VII.	*General Av. of Tests.
A.	Girls.	8.07	3.33	2.83	3.37	2.00	3.90	4.38	3.44	3.33
	Boys	8.54	3.60	3.20	3.92	2.23	4.20	4.26	3.61	3.44
	Total	8.36	3.50	3.06	3.71	2.14	4.10	4.31	3.54	3.39
B.	Girls.	8.15	4.40	4.61	4.77	3.27	5.07	5.00	4.77	4.13
	Boys.	8.62	4.94	4.67	4.77	3.26	5.37	4.76	4.47	4.55
	Total	8.44	4.72	4.64	4.77	3.23	5.26	4.85	4.58	4.37
C.	Girls.	8.23	4.45	4.36	4.56	3.75	5.30	4.75	4.35	4.25
	Boys.	8.70	5.05	4.63	5.05	3.39	5.59	4.91	4.62	4.56
	Total	8.52	4.84	4.53	4.87	3.52	5.48	4.85	4.52	4.43
D.	Girls.	8.31	5.18	4.93	4.72	3.73	5.36	4.90	4.40	4.34
	Boys.	8.78	5.62	4.75	5.53	3.43	5.47	4.65	4.80	4.58
	Total	8.60	5.44	4.82	5.20	3.55	5.42	4.76	4.65	4.48
E.	Girls.	9.90	4.16	4.20	5.11	3.72	5.52	4.91	4.58	4.85
	Boys.	9.70	6.33	4.63	4.94	3.98	6.03	4.91	4.56	4.76
	Total	9.75	5.61	4.50	5.00	3.89	5.83	4.91	4.57	4.80
Gen'l Av. of Types	Girls.		4.30	4.18	4.50	3.29	5.03	4.79	4.31	4.31
	Boys.		5.10	4.37	4.84	3.26	5.33	4.70	4.41	4.54
	Total		4.82	4.31	4.71	3.27	5.21	4.73	4.37	4.46

*The values here ascribed are obtained from Table II. It is the average number of units per exposure card for each Test Series—there being ten such cards in each series. The choice and arrangement of the several types of material varied from series to series. The average of the averages for the seven types, therefore, would not equal the value given under this caption.

Plate IV

This improvement in visual reproduction was common for every type of material, as can be seen by Table IV. The curves of practice for the different materials are virtually identical (Plate IV). The increase is very rapid at first and then becomes more gradual. Types II, V and VI actually suffer a decrease after the initial increase in *Test-Series B*. Though the greater part of the improvement in the other types of material was made also in *Series B*, nevertheless these reports (Types I, III, IV and VII) steadily improve to the end.

The table further shows that the average number of numerals, letters, combinations of numerals and letters, and of other discrete symbols that can be grasped in a 5-seconds exposure by the average pupil in the second grade lies before

practice between 3-4, after practice between 4-6. The average number of words of 2, 3 and 4 letters each that can be grasped is before practice only a little over 2; after practice it is a little over 3.

3. *Practice for the two sexes:* The general results are in no way altered by sex. What is true of the class as a whole is also true of the girls and the boys when considered separately. The improvement is the same in both cases: great at first and small toward the end of the experiment.

4. *Practice for the three classes:* The division of the school into good, medium and poor observers discloses some very interesting facts. The results of Class I and Class II offer nothing new; they merely confirm the general results. In both of these classes the improvement is very great at first, 10 and 11 units in the Test-Series, and 7 and 5 units in the Drill-Series respectively. After this initial gain there is in both cases no appreciable improvement; indeed, there is actually in the case of Class II a slight loss toward the end of the experiment.

Inspection of these data (Classes I and II or Classes I, II and III combined) would give little warrant for the conclusion that systematic practice would improve the native ability of visualization. The improvement, which we have seen was concomitant with the practice during the early part of the experiment, could, in the light of previous investigation, readily be explained by reference to other determining factors, such as familiarity with the material, the application of more efficient methods of work, the use of tricks of counting, grouping, and naming, the direction and restriction of attention.

The results of Class III, however, are not so easily explained. This class, composed of the poorer pupils, shows an entirely different practice curve from that which we have been led to expect. The initial improvement is not so large as that of the other two classes, but the efficiency increases throughout the entire experiment. The total increase is very marked and substantial, so that the members surpass their schoolmates of Class II in the last two Test-Series. The total improvement of Class III in the Test-Series, *i. e.*, between *Series A* and *Series D*, is 13 units, while that for Classes I and II is only 10.

5. *Retention of practice:* When *Test-Series E* was submitted to the class (58th week) the number of drilled pupils had been reduced by various causes to 19. The results and the personnel of this test appear in Table I. The average results are shown in Table II. There is a surprisingly large increase in the number of elements reported correctly to this test. The net gain amounts on the average to about 4 units. This improvement can not be explained on the grounds that the poorer subjects were absent from this re-test, and that the reports were given only by the more efficient pupils, for such is not the case, as can be seen by Table I. The loss of subjects in Class I and III was very evenly distributed, and Class II, since but one subject was absent, may be considered unchanged. We are forced, then, to inquire how it is possible that our practiced pupils, after a lapse of 41 weeks in the training, could display a net gain over their previous records. Three factors may have operated to produce this. In the first place we should expect some improvement due to age, for reasons to be advanced which will show a slight but positive correlation between age and efficiency in this test. In the second place, other investigators (*e. g.*, Book, quoted by Colvin,² p. 45) have shown that in experimental studies of learning there is often seen an increased efficiency of performance after an interval of rest—an increase which is usually attributed to the dropping out of partly formed bad habits of work. In the third place, despite the fact that the teacher was able satisfactorily to conserve the interest of the pupils throughout the experiment, nevertheless, continuous practice, as is well known, often tends strongly toward a reduction in spontaneous interest on the part of the learner, and it was perfectly evident to us that there was manifested during the retesting (*Series E*) a very exceptional degree of zeal and enthusiasm on the part of the pupils who had participated in the earlier work. Whether these three factors were all operative or to what degree they were severally operative is not clear; the fact remains that some agency or agencies were at work sufficient to more than counteract the loss of efficiency that would

²S. S. COLVIN *The Learning Process*. New York, 1911

be anticipated by the lapse of time after the period of steady drill.

6. *Comparison of practiced and unpracticed subjects:* When *Test-Series E* was submitted to the children 11 new pupils took the tests. Of the new pupils, 9 were girls and 2 boys. The results of this test for both the practiced and unpracticed pupils, and the average age of each, appear in Table V.

TABLE V.
Comparison Between Practiced and Unpracticed Pupils.

TEST SERIES E.			
Practiced.		Unpracticed.	
Av. Record	Av. Age	Av. Record	Av. Age
48.000	9.75	41.418	9.45

These data show that, even after a lapse of 9 months in the training, the practiced pupil is a much better observer than the unpracticed. The record of the former is nearly 7 units better than that of the latter. There can be no doubt that this is due to practice, for the probable error of the difference is only 1.5. Such a great difference can not be the result of mere accident; and it leads us to the conclusion that training such as ours does more or less permanently increase the subjects' ability to reproduce our sort of material.

Whether the practice is specific, and whether the improvement is due to a change in the native ability or merely to a change in method of observation, or whether it is due, as Colvin (page 44) suggests, to the feeling of familiarity and confidence with which the trained observers take up the work are not questions which can be considered at this point. We shall, however, take them up in their proper order.

7. *Comparison with adults:* Miss Aiken reported that her pupils who had gone through the training that she prescribed were able to give better records than the students of Clark University. To discover what was actually the relation between the reports of children and adults under our conditions of experimentation, one of the most difficult sections of *Drill-Series 3* was given to a class in Educational Psychology in Cornell University. There were 31 in the class, 12 women and 19 men, all of whom were juniors or seniors. The data were

graded according to the method that we have described before, and the students were divided, upon the basis of these grades, into equal groups of good, medium and poor observers: Classes I, II and III, respectively. The average record of each of these classes, the total average, and the average according to sex appears in comparison with the records of the children in Table VI.

TABLE VI.

Comparison Between Children and Adults

	Aver No Grammar- School Pupils	Units Reported University Students.
Class I	55.5	71.0
Class II	49.4	62.7
Class III. . . .	48.1	54.2
Total	51.5	62.3
Girls	46.9	61.0
Boys	54.4	63.2

These results show that the adults are, on the whole, better observers than the children, even though the children had had about three months' special training and the students none. It is, however, worthy of note that Class I of the grammar-school pupils give better reports than Class III of the adults; *i. e.*, the upper third of the children of the second grade give better reports than the lower third of the juniors and seniors of a large University. These results are, indeed, most surprising, for it is only commonly assumed that the brightest of any elementary school can survive the cuts up to and through the junior and senior years in college. These results then do in a measure resemble Miss Aiken's results, but only in a measure.

8. *Dependence on sex:* The results already reported show that the course of practice is the same upon the girls as upon the boys. A sex difference does, however, appear in another connection. In all of the test-series (with the exception of *Test-Series E*) in all of the drill series, and with nearly all the types of material, the boys do on the average better than the girls. They rank about two units above the girls in the test-

series (in Series E the girls rank 0.9 of a unit above the boys) and about three units above them in the drill-series.

The individual records of the subjects confirm these average results. The best observer in the school was a boy. There were 3 girls in the first ten observers (Class I), 4 girls in the next ten (Class II), and 4 girls in the last, the poorest, nine. The ratios are 3:7, 4:6, and 4:5, respectively.

The data obtained from the adult observers likewise corroborate these results, for both the average and the individual records show that the women students are slightly inferior to the men. The best observer among the adults was a man with a record of 82.5; the nearest woman had a record of 72.5. The poorest record was given by a woman who scored only 48.0; the lowest man was not much above her, however, for his record was only 48.5. Class I of the adult observers was composed of 6 men and 4 women, Class II of 7 men and 3 women, and Class III of 6 men and 5 women.

These results are very constant. They show that the effect of sex, though slight, is nevertheless real and apparent; and they lead us to the conclusion that men and boys are superior to women and girls in visual apprehension.

9. *Dependence on age:* There are numerous indications of a direct, though not very strong correlation between age and efficiency in these tests. In Table IV the average age of the school children and also that for the girls and boys is shown. The boys are nearly 6 months (0.47 years) older than the girls, and, as we have noted before, the boys give, with one exception, better records in these tests than the girls. In case of the single exception, *Test-Series E*, the relation still holds, for in this test the difference in age is reversed—the girls are over two months (0.2 years) older than the boys. This is further confirmed by the results in Table III, in which the average ages of the pupils for each Class are given. Class I, in which the best records in both the test and drill series are made, average the oldest (8.65); Class II, the medium, the next oldest (8.54); while Class III, which gives the poorest records in both the Test and Drill Series, averages the youngest (7.83). Table IV, in which the average age of the class and of the girls and the boys are given for each for each

type of material and period, likewise shows this relation between age and efficiency in work, as does also Table VI, in which the adults' and the children's averages for a single series are compared. The correlation between age and efficiency in these tests is evidently, therefore, positive. But when the coefficient was figured from the data in Table I, and not estimated from the averages in these tables, it was found to be surprisingly low. Pearson's familiar "Product Moments" method was used to calculate the coefficient of correlation from the data appearing in the first and the eleventh columns in Table I; *i. e.*, the average number of units credited each subject during the fore-practice was correlated with their age.¹⁰ The correlation thus figured was found to be only 0.19, with a probable error of 0.109; it is not as high as would have been expected from mere inspection of the averages in Tables III, IV, V and VI. This apparent discrepancy is due to the extreme variation of the data of a few subjects—Edward M., Lloyd M., Harry, Edward D., and Chester. The ages of these pupils are all over the average of the class, and their work is well under the average. Their ages show them to be pedagogically retarded 5, 1, 2, 2, and 2 years, respectively. A positive correlation under these circumstances is therefore significant, even though it be small. We may, therefore, safely conclude from the evidence at hand that there is a direct correlation between age and the efficiency in visual apprehension.

But that age, while a conditioning factor, is not of primary importance in the determination of the efficiency of the subjects in these tests is clearly shown by the low coefficient of correlation, by the small difference in age (0.3) of the practiced and unpracticed subjects in Table V and the corresponding difference in the value of their reports, which difference is too great to be explained on the basis of age; and also by the results shown in Table VI. In this table the record of Class I of the grammar-school pupils, whose average age, as is shown by Table III, is between 8 and 9 years, is better than that of Class III of the adult observers.

¹⁰To the list appearing in this table were added the data of three other pupils, Lyle, Edward M. and Lloyd M., whose names were omitted from Table I for reasons already assigned. Their average reports during the fore-practice were 61.1, 32.7 and 21.7, and their ages were 9.5, 12.0 and 8.5 years, respectively.

Neither can the difference of sex expressed throughout all of the Tables be explained entirely on the basis of age. The results of Table VI in which the men observers give better records than the women lead us to the conclusion that the effect of sex, though slight, is nevertheless real and apparent.

10. *Individual differences:* In the results of both the adult and the grammar-school subjects there appear very great individual differences. The records of the adults ranged from 82.5 to 48; those of the children of the first series of the experiment, *i. e.*, the first day of the fore-practice, from 67.5 to 20; and for the particular series given to the adult subjects, from 67.5 to 36. The most striking case of individual variation is that of Lyle B. His scores were so extraordinary that they seem worthy of report. His records always ranked at the head of the class. The cards with one seven-place, or one eight-place number, or the cards with two five-place numbers never seemed to bother him, and his records for the six three-place numbers varied usually between 14 and 16 out of a possible 18. Once he reported all of the numbers correctly. A duplicate of this card is shown among the sample cards in Type I. Unfortunately, we are unable to give a complete report of his work, for he only served in the experiment for a short time. As the data were not graded until long after the end of the experiment, the precocity of this subject was not discovered, otherwise a special study would have been made of his case.

11. *Relation to school standing:* The classification into Classes I, II, and III, which appears in all the tables, agrees fairly well with the division of the school made by the teacher on the basis of the school work, as can be seen by Table I. The school grade was divided into an A-class and a B-class. In our Class I, based, as we have said before, on the average score of the first week's work, there were 10 children, of whom eight were from the school's A-class and two from the B-class. In our Class II, composed also of 10 children, six were from the A-class and four from the B-class. In our Class III, composed of nine children, three were from the A-class and six from the B-class. The average score of the children in the A-class during the period of fore-practice was 37.8: that of the children in the B-class was 32.9.

These results seemed to indicate a close correlation between visual apprehension, as indicated by efficiency in these tests, and school work. The records of the childrens' school work were therefore obtained, and a correlation was drawn between their school grades and their efficiency as shown by their average score in the period of fore-practice. In computing the correlation the average grades for the first term, the term just preceding our work alone were used. These grades were chosen so as to eliminate the effect of practice. The correlation was also calculated separately for the two classes (A and B), because the school work was different for each class, and therefore the basis of the teacher's grading was different. The correlation for the A-class, figured by Pearson's method, was 0.85, the probable error 0.044; for the B-class 0.20, the probable error 0.167.

12. *Effect of training on school work; problem of transfer:*

Table I and Table VII give the data upon which these correlations were based. The school grades appear in Table VII. The grades in all of the school studies and the averages are given here for both terms; for the term preceding the experiment, and for the term during which the experiment was conducted.

An inspection of this table shows, if the marks are reliable, that the pupils uniformly did better work during the second term than the first. This is more clearly shown in Table VIII, in which appear the averages for each study and the total average of all the studies for each class of subjects (divided according to the previous tables into our Classes I, II and III), for the entire school, and for the girls and boys.

The results of this table agree with the conclusions already drawn. There is a close correlation between the school work and visual apprehension on every score but that of sex. Class I gives the highest score during the fore-practice, and their school grades average the highest; Class II occupies a medium position in both tests and school work; and Class III ranks the lowest in both. Sex, however, shows a different relation. The girls rank higher in their school work than the boys, whereas in the tests their records were uniformly lower. Not only is the general average of the school

TABLE VII.

School Grades.

Pupils		Reading		Writing		Arithmetic		Spelling		Grammar		General Studies		Average	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2
Class I	Lloyd M.	88	90	60	75	75	85	85	90	90	90	85	90	80	87
	Lura	85	85	85	85	85	85	85	85	90	92	85	85	86	86
	Ezra	70	85	70	80	75	75	60	80	80	85	80	80	72	83
	Raul*	..	..	90	90	90	90	..	..	..	..	80	85	86	88
	Edward B.	90	90	75	80	75	75	85	90	85	90	85	90	85	86
	Reginald	80	85	80	85	85	85	80	90	80	85	85	85	81	86
	Ethel	90	95	88	90	80	85	90	90	85	90	85	90	86	90
	Frank	75	85	70	80	70	80	50	70	75	80	80	85	70	80
	Sylvia	78	80	75	85	60	70	60	80	60	75	80	80	69	78
Class II	Paul	85	85	75	80	80	90	75	80	80	80	80	85	79	83
	Dorothy	90	90	80	80	85	90	75	85	75	85	85	90	82	87
	Clarence	75	75	75	80	60	60	80	85	80	85	80	80	75	78
	Lindsay	85	80	75	75	85	75	60	60	85	85	80	80	78	76
	John Cn.	85	90	50	85	90	95	85	90	85	90	85	90	80	90
	Carl†	..	80	..	75	..	75	..	75	..	70	..	75	..	75
	Eileen	85	80	85	90	85	70	85	85	80	85	80	85	83	82
	Leven†	..	85	..	60	..	70	..	80	..	85	..	85	..	77
	Truman	80	75	90	85	80	75	60	60	80	80	75	75	76	75
Class III	Wilkenson	80	75	70	70	80	75	75	82	80	80	80	85	78	77
	Bernice	80	75	85	80	60	60	82	85	80	80	75	80	77	77
	Chester	80	85	75	75	75	65	75	75	80	80	75	80	77	77
	Margaret	80	85	85	85	50	50	75	80	80	85	80	85	75	78
	Edward D.	65	70	85	85	85	80	60	70	80	85	75	80	75	78
	Francis	80	80	80	85	85	85	80	80	75	75	75	80	79	81
	John Cy.	50	75	60	85	85	90	75	75	50	70	75	80	67	79
	Evert	70	80	85	90	75	50	70	70	80	90	80	85	77	78
	Mercedes	80	85	70	70	40	35	70	75	75	85	80	75	69	70
Class III	Helen	80	85	50	60	80	85	70	80	90	90	80	85	75	81
	Harry	60	30	40	70	70	50	40	50	50	60	70	70	55	55

1 = grade for first term.

1 = grade for second term.

*Raul had just immigrated to this country from Spain. His English was very poor, therefore no grades were given him in studies requiring a knowledge of the English language.

†These pupils were not members of this class during the first semester, and consequently their grades for this semester were not reported.

work higher for the girls than for the boys, but their averages in every study except arithmetic are higher.

Special attention is called to the fact that the averages for all of the studies (with the single exception of arithmetic) are higher for the second than for the first term. Whether this improvement is due to the training in our tests, whether

TABLE VIII
Averages of the Grades of the Pupils

Classes	Reading.		Writing		Arithmetic		Spelling.		Grammar.		Gen'l Lessons		Average	
	1.	2.	1	2.	1	2	1.	2.	1	2.	1	2.	1	2
I.	82.3	86.6	76.8	83.0	77.5	82.0	74.4	83.8	80.5	85.2	82.5	85.5	79.0	84.3
II.	82.8	80.7	74.2	80.0	78.1	74.2	77.4	81.0	80.7	81.4	80.7	83.5	79.3	80.6
III.	71.6	72.8	70.0	78.3	71.6	65.5	68.3	72.7	73.3	80.0	76.6	79.4	70.9	75.1
Total results.	78.6	80.8	73.7	80.5	75.1	74.2	73.0	79.0	78.0	83.0	80.0	82.9	76.7	79.9
Girls.	82.8	84.0	78.3	79.0	70.0	70.5	77.2	82.5	77.0	84.2	80.5	83.0	77.6	80.5
Boys.	75.8	78.6	70.9	80.3	78.4	76.0	70.3	77.1	77.3	82.3	79.6	82.8	75.4	79.5

1==Average for first term.

2==Average for second term.

the transfer was direct or intermediate, we can not here say. The improvement was very uniform for all of the observers, as can be seen by Table VIII, and it is so large that it can not be neglected. All the more surprising are these results when it is considered that the improvement in the school work was made in spite of the adverse conditions under which the school was held during the last half of the year. These results at least strongly indicate a transfer of training.

It should be reported in this connection that the teacher during the early part of the experiment, in her enthusiasm for the work, and quite unknown at the time to us, copied our method of quick visual presentation in some phases of her daily work, *e. g.*, in teaching spelling. It is possible that the improvement in the school records during the second semester may be due in large measure to this direct application of the method.

VIII. THE "AUSSAGE" TEST.

In order to ascertain whether our training was specific, whether our pupils had really become noticeably better observers, and whether there was a transfer in training as the results of and improvement in the school work would seem to indicate, an Aussage test was given to the pupils who took *Test-Series E*. These tests were given to the children in April, 1913, in the sixty-sixth week of the experiment. They were administered by Mrs. L. R. Hill, who made the following report:

The children remaining in the class of those who had been practiced in the tests of visual apprehension (21 in number) and the newcomers who had not been thus practiced (15 in number) were all subjected, individually, to the Binet "card-of-objects" tests as described in Whipple's *Manual of Mental and Physical Tests* (First edition, Test 32, A). The comparison of these two groups, practiced and unpracticed, was made, first in terms of number of objects recalled, and secondly in terms of numbers of answers correctly made to the 50 questions embodied in the printed "interrogatory" for this test.

Table IX shows that the practiced group were superior to

the unpracticed group in the number of objects recalled after 30 seconds exposure of the card.

TABLE IX

Results of Supplementary Test of Observation

Total number of objects recalled	1	2	3	4	5	6	Aver
Children in practiced group			2	2	8	9	5.1
Children in unpracticed group			2	5	2	6	4.8

In ranking the children for their answers to the interrogatory one mark was given for each correct reply and 0.5 for each partially correct reply. The results show for the practiced group an average score of 32.8 (of a possible 50), for the unpracticed group an average score of 27.4. The difference between these two averages, 5.4, has a *P. E.* of 2.1, and is therefore not likely to be a mere chance difference.

We conclude from this subsidiary test, therefore, that the practice given the children in the visual apprehension of numbers, digits, drawings, etc., has had an effect that has persisted at least 50 weeks, and that has been sufficient after that interval to make the practiced children superior to their unpracticed mates in recalling and reporting correctly visual material of a different sort (colored instead of black and white, heterogeneous instead of homogeneous, displayed for 30 instead of for 10 seconds and demanding detailed description instead of mere enumeration). While it is true that the Binet card-of-objects is likewise a test of recall of material presented visually, it seems sufficiently unlike the material used in the practice series to lend support to the conclusion that the original work of drilling the children has produced a training that has not only persisted, but also "spread" to some extent to other functions.

IX. CONCLUSIONS.

A general statement of the problem, the method and the factual results obtained has been presented in the summary that precedes this article. The conclusions to be mentioned here refer to the general issue raised by the work. We conceive the moral of this study to be that, while the mental

processes of children are like in kind to those of adults, their lesser maturity alters appreciably the outcome of experiments dealing with the effects of prolonged drill in the exercise of a mental activity. The careful, though less extended experiments of Whipple and Foster showed no appreciable effects of drill upon adults, save those rather temporary effects explicable as adaptation to experimental conditions and to the specific task, that is, as the development of special devices for facilitating the exercise of already matured capacities. Our more lengthy experiments with children, however, have not only showed more decided practice-effects, but have also rendered it at least quite possible, if not practically certain, that these practice-effects have brought about a permanent modification in the mental traits exercised, and what is more, a modification that certainly seems to have made itself felt in a number of ways outside the special tests we made (as in improvement in school work and increased efficiency long afterward in supplementary tests of observation and report). In this respect our experiment, therefore, may be regarded as contributing some evidence in favor of a restricted belief in formal discipline.

We suggest that the general principle motivating our work—that of retrying in the classroom upon growing children experimental problems that have too often been regarded as settled by tests upon a limited number of selected adults—is one worthy of extension into many other phases of experimental psychology.

[THE END.]