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## STUDIES IN RETENTION

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The present investigation was planned with special reference to (1) the effect of recall on retention, (2) the relationship between the rate of forgetting and the ability of the subjects, and (3) the effect of item difficulty on the form of retention curves.

### PROBLEM

The importance of retention is shown by the fact that growth or improvement in skills, knowledges, and attitudes is dependent upon the learner's retention of the effects of previous experience. The use of recall as an aid to retention has been emphasized by theorists on methods of study and by investigators in the field of memory. The lack of experimental evidence on the effect of recall on retention where conditions approach those of actual schoolroom practice prompted this investigation. The primary purpose of the investigation was to determine the effect of recall on retention of facts which children acquire through reading when the materials and the methods of study are similar to those used in classroom situations. Two subsidiary problems of the investigation relate to the effect of item difficulty upon the form of retention curves and to the relationship between the learning ability of the students and the rate of forgetting.

*Related Research.*—A number of experimental studies have dealt with various aspects of the problem of this investigation. Myers<sup>6</sup> found that immediate recall in the form of written reproduction was beneficial to later reproduction of a list of unrelated words. An indirect or incidental method of learning the words had been employed.

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Gates<sup>2</sup> found that some recall in the form of recitation was an aid in memorizing biographical prose. This was true when tests were given immediately and also after four hours. Gates also reports finding a high positive correlation between immediate and delayed recall. Yoakam<sup>7</sup> concluded that an immediate recall in the form of a test was of more value to retention than was a single reading. Jones<sup>3</sup> found that recall tests aided the retention of information acquired from lectures by college students. Other studies which are related to some phases of this study are reported by Dietze,<sup>1</sup> Keys,<sup>4</sup> Raffel,<sup>6</sup> and Young.<sup>8</sup>

#### SUBJECTS AND MATERIAL

The subjects for this experiment were thirty-six hundred five sixth-grade pupils of nine Iowa cities. This was the entire sixth-grade population of ninety-one elementary schools. These schools were arbitrarily divided into ten groups. Groups I, II, III, IV, V, VI, VII, and VIII, each comprising approximately four hundred children, were used to obtain the data for the main part of the experiment. Group IX was used to obtain data on the effect of immediate repetition of tests, and Group X was used to obtain information on previous knowledge. Thus Groups IX and X were, in a sense, used as control groups.

The reading materials used in this study were two articles, six hundred four and five hundred seventy-seven words in length, printed in a six-page folder. The first of these articles entitled "Peanuts," designated *A*, and the accompanying test, were used as a sectioning device; while the second article, entitled "Bamboos," designated *B*, and the accompanying test, were used to obtain the data on retention. An attempt was made to write articles with content that would be relatively new to the children, highly factual, authentic, of the proper difficulty, and similar in type to the material that children read in their regular school work. Both of the topics dealt with are treated briefly if at all in geography books used by the children. The first paragraph of Article *B* and five of the items of Test *B*, which are wholly or partially based on the content of this paragraph, are given below.

Near Savannah, Georgia, is the Plant Introduction Garden of the United States Department of Agriculture. In one section of this garden are the bamboos. These plants are members of the grass family. They resemble their relatives, corn and wheat, in structure of stem which is rounded, divided into joints, and more or less hollow. Bamboos also resemble pines and spruces by having tall, straight trunks and cone shaped heads or crowns, and

by being evergreens. Although they are evergreens, a new set of leaves appears each spring. On rare occasions bamboos flower and produce seeds. After flowering, the plant usually dies.

1. Who maintains an experimental garden near Savannah, Georgia?  
 The Bamboo Growers Association  The U. S. Government   
 The U. S. Custom Office  The florists of Savannah  The State of Georgia.

2. To which family of plants do bamboos belong?  trees  ferns  
 grasses  mosses  fungi.

4. Which two trees do the bamboos resemble most?  royal and date palms  
 willow and tamarack  white oak and burch  walnut and hickory  
 pine and spruce.

18. How often do bamboos produce seed?  every spring  never  
 on rare occasions  every other year  every third year.

19. What usually happens to a bamboo plant after the flowering period?  
 It dies  It begins a new growth  It sends up new plants from the roots  
 It begins to branch out  It begins to grow a rough bark.

A twenty-five item test (see example above) on each article was used to measure retention. Through an item analysis of each test, the difficulty and discriminating power (tetrachoric " $r$ ") of each item were obtained. Items too difficult or of poor discriminating power were eliminated after the preliminary trials, leaving a total of twenty-five items in each test. The reliability of the two tests determined by equal halves technique was .77 and .80, respectively. The correlation between Test A and Test B based on scores of six hundred twenty-two pupils who took both tests immediately after reading the articles was .76.

#### PROCEDURE

Both the reading material and the tests were presented to the pupils by their regular teachers according to directions supplied by the investigator. In the printed directions given at the beginning of the experiment, the children were told that they were taking part in a learning experiment. They were also told that they were to try to remember the information given in the articles. Similar directions were printed at the top of each article.

On the first day of the experiment, all the children in Groups I-VIII read Article A and took Test A. They also read Article B, but only Groups I and II took Test B<sub>1</sub>.\* The other six groups took a test

\* The first time pupils took Test B, it was labeled B<sub>1</sub>; the second time they took Test B, it was labeled B<sub>2</sub>; and the third time, it was labeled B<sub>3</sub>.

TABLE I.—DIAGRAM OF PROCEDURE

| Time in days | 0     | 1     | 7     | 14    | 21    | 28    | 63    |
|--------------|-------|-------|-------|-------|-------|-------|-------|
| Groups       |       |       |       |       |       |       |       |
| I            | $B_1$ | $B_2$ | ..    | ..    | $B_3$ |       |       |
| II           | $B_1$ | ..    | $B_2$ | ..    | ..    | ..    | $B_3$ |
| III          | ..    | $B_1$ | ..    | $B_2$ | ..    |       |       |
| IV           | ..    | ..    | $B_1$ | ..    | $B_2$ |       |       |
| V            | ..    | ..    | ..    | $B_1$ | ..    | $B_2$ |       |
| VI           | ..    | ..    | ..    | ..    | $B_1$ | ..    | $B_3$ |
| VII          | ..    | ..    | ..    | ..    | ..    | $B_1$ |       |
| VIII         | ..    | ..    | ..    | ..    | ..    | ..    | $B_1$ |

which had little relation to the content of Article *B*. This test was given in order to keep them from expecting a later test. The real Test *B* was given to these six groups (III–VIII) at varying time intervals after the start of the experiment. A diagram of the testing procedure followed is given in Table I. This table shows that the pupils of Group I took Test  $B_1$  immediately after reading Article *B*, repeated the test (Test  $B_2$ ) after one day, and again repeated the same test (Test  $B_3$ ) after twenty-one days. The pupils of Group IV took Test  $B_1$  seven days after reading Article *B* and repeated the test (Test  $B_2$ ) twenty-one days after reading the article. The procedure followed by the other six groups is shown in the table.

The reading materials were not referred to after the initial study period, nor did the pupils know that there were to be delayed tests. The teachers were instructed not to discuss the articles or the tests with the pupils. Pupils were given eight minutes to read the articles and ten minutes for each of the tests.

The pupils of Group IX read both articles and took both tests on the first day of the experiment. They took Test *B* a second time immediately after completing the first attempt. For this second test they were instructed to try to improve their first score. This procedure was followed for the purpose of obtaining information on the effect of repetition of the tests. The pupils of Group X took Test *B* without having read Article *B*, for the purpose of obtaining data on previous knowledge.

#### RESULTS

*Effect of Recall.*—From a single frequency distribution of the scores on Test *A*, the mean score and the standard deviation of scores of the

population studied were determined. The means and standard deviations of the scores of the pupils on Test A in each of Groups I-VIII were then calculated. A comparison of these means with the mean for the entire population showed that each of the groups was practically representative of the population. However, some pupil scores were deleted from two of the groups in order to make the groups more nearly equal. The means of these equated groups are given in Table II. The critical ratio of the largest difference between means on Test A of any two of these equalized groups is only .18.

TABLE II.—TEST B RESULTS OF THE GROUPS THAT MADE EQUIVALENT SCORES ON TEST A

| Group | N   | M test A | Test*          | M test B | SD test B |
|-------|-----|----------|----------------|----------|-----------|
| I     | 286 | 15.03    | B <sub>1</sub> | 13 23    | 4 69      |
| I     | 284 | ..       | B <sub>2</sub> | 13 07    | 4 57      |
| I     | 266 | ...      | B <sub>3</sub> | 12.18    | 4 59      |
| II    | 338 | 15 05    | B <sub>1</sub> | 13 20    | 4 50      |
| II    | 335 | .. .     | B <sub>2</sub> | 11 84    | 4 64      |
| II    | 312 | .. .     | B <sub>3</sub> | 10 74    | 4 22      |
| III   | 367 | 15.00    | B <sub>1</sub> | 9 56     | 4 24      |
| III   | 349 | ..       | B <sub>2</sub> | 8.93     | 4 06      |
| IV    | 337 | 15.00    | B <sub>1</sub> | 7 87     | 3 56      |
| IV    | 323 | ....     | B <sub>2</sub> | 8.15     | 3 83      |
| V     | 371 | 15.04    | B <sub>1</sub> | 6 97     | 3 53      |
| V     | 353 | .....    | B <sub>2</sub> | 7 10     | 3 21      |
| VI    | 379 | 15 04    | B <sub>1</sub> | 6.49     | 2 91      |
| VI    | 352 | .. .     | B <sub>2</sub> | 7 07     | 3 08      |
| VII   | 365 | 15 00    | B <sub>1</sub> | 6.80     | 3 03      |
| VIII  | 350 | 15.03    | B <sub>1</sub> | 6 38     | 2 71      |

\* For identification of various Test B's and the time after learning that each was taken, see Table I.

The mean scores of all groups of pupils who took Test B are shown in Table II. In interpreting the data of this table the assumption is made that the eight groups of pupils profited equally from the reading and that the groups possessed equal ability to retain the effects of the reading. This assumption is based on the fact that the groups were equated on the sectioning test (Test A). According to the assumption stated above, Group I would have made a mean score of approximately 9.56 (mean score of Group III on Test B<sub>1</sub>) one day after reading the article if the group had not been given the immediate recall test. This last statement is based on the fact that Groups I and III were originally

equal. Therefore, had Group I delayed taking Test *B* until one day after reading, the mean score made by the group would have been the same as that made by Group III, or 9.56. On the same basis, had Groups III, IV, V, VI, VII, and VIII been tested immediately after reading Article *B*, each group would have made a mean score of approximately 13.22. The data of this table show that more is forgotten in one day without recall than is forgotten in sixty-three days with the aid of recall, as is shown by a comparison of the scores of II *B*<sub>2</sub> and VIII *B*<sub>1</sub>. The differences between originally comparable groups and now differing by only one recall and the critical ratio of these differences are shown in Table III. These critical ratios would have been larger had the standard error of difference formula for matched groups been used.\* This formula was not used because a statistically significant difference was obtained without its use. The data summarized in Tables II and III show clearly that retention benefited significantly by recall.

The effects of recall on retention are shown graphically in the figures (see Figs. 1, 2, 3, and 4). The points on the graph represent the mean performance of the different groups. For example, the "Point III *B*<sub>1</sub>" represents the mean score of the pupils of Group III on their

TABLE III.—COMPARISON OF TEST *B* RESULTS FOR GROUPS DIFFERING BY ONLY ONE RECALL

| Group | Test                  | AM    | SE, AM | Difference | SE difference | CR    |
|-------|-----------------------|-------|--------|------------|---------------|-------|
| I     | <i>B</i> <sub>2</sub> | 13.07 | .27    |            |               |       |
| III   | <i>B</i> <sub>1</sub> | 9.56  | .22    | 3.51       | .346          | 10.10 |
| I     | <i>B</i> <sub>1</sub> | 12.18 | .28    |            |               |       |
| IV    | <i>B</i> <sub>2</sub> | 8.15  | .21    | 4.03       | .350          | 11.51 |
| II    | <i>B</i> <sub>2</sub> | 11.84 | .25    |            |               |       |
| IV    | <i>B</i> <sub>1</sub> | 7.87  | .19    | 3.97       | .317          | 12.50 |
| II    | <i>B</i> <sub>1</sub> | 10.74 | .24    |            |               |       |
| VI    | <i>B</i> <sub>2</sub> | 7.07  | .16    | 3.67       | .288          | 12.74 |
| III   | <i>B</i> <sub>2</sub> | 8.93  | .22    |            |               |       |
| V     | <i>B</i> <sub>1</sub> | 6.97  | .18    | 1.96       | .286          | 6.85  |
| IV    | <i>B</i> <sub>2</sub> | 8.15  | .21    |            |               |       |
| VI    | <i>B</i> <sub>1</sub> | 6.49  | .16    | 1.66       | .264          | 6.29  |
| V     | <i>B</i> <sub>2</sub> | 7.10  | .18    |            |               |       |
| VII   | <i>B</i> <sub>1</sub> | 6.80  | .16    | .30        | .241          | 1.25  |

\* Lindquist, E. F. and Wilks, S. S.: "The Significance of a Difference between Matched Groups." *J. Educ. Psycho.*, Vol. xxii, 1931, pp. 197-204, 205-208.

first attempt on Test B. This trial was taken one day after reading Article B. Since the eight groups were equalized according to their performance on Test A, which was quite similar to Test B, it is assumed that the facts which Groups I and II acquired through reading would have been forgotten at the rate shown by the solid line if they had not been given the intervening recall tests. Thus, the space separating a point on the solid line and a vertical point on any of the broken lines represents the effect of the recall test on retention for that particular situation. Figures 1 and 2, which are based on the entire population, show that immediate forgetting unaided by recall was very rapid and that in every case recall was beneficial to retention.

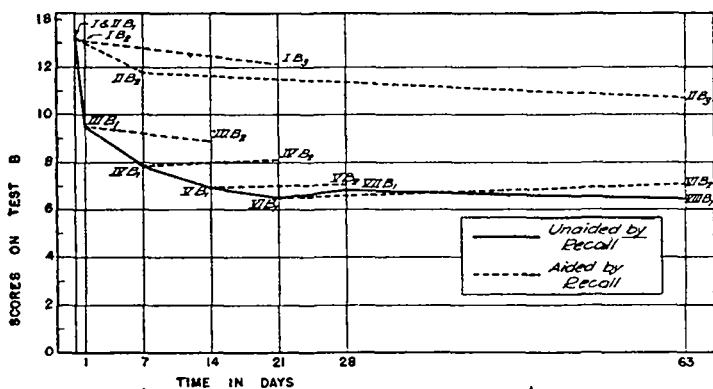


FIG 1 CURVES OF RETENTION FOR THE ENTIRE POPULATION WHEN THE AMOUNT RETAINED IS EXPRESSED IN RAW SCORES

When the papers were corrected for guessing through use of the formula,  $S = R - \frac{W}{(N - 1)}$ , the critical ratios of differences remained practically the same as those shown in Table III.

The one hundred sixty-nine children of Group IX who were given a second Test B immediately after taking the first test improved their mean score only .03. Thus, an immediate repetition of the test did not result in a large increase in the number of facts acquired.

The mean score of the three hundred one children of Group X who were tested for previous knowledge was 5.27. The assumption that this score represents the previous knowledge of Groups I-VIII is rather questionable since the foils or wrong responses of items in the test were not as plausible for those who had not read the article (group tested for previous knowledge) as these responses were for those

pupils who had read the article. The previous knowledge of Groups I-VIII, then, was probably less than 5.27. Since no other measure of previous knowledge was available, this amount was subtracted from the mean score of each group in obtaining the data from which Fig. 2 was constructed. This figure, subject to the limitation given above, shows the curves of retention when the amount retained is given as a per cent of the amount learned. The figure shows the same trend as that shown in Fig. 1. In this case, however, forgetting is more rapid

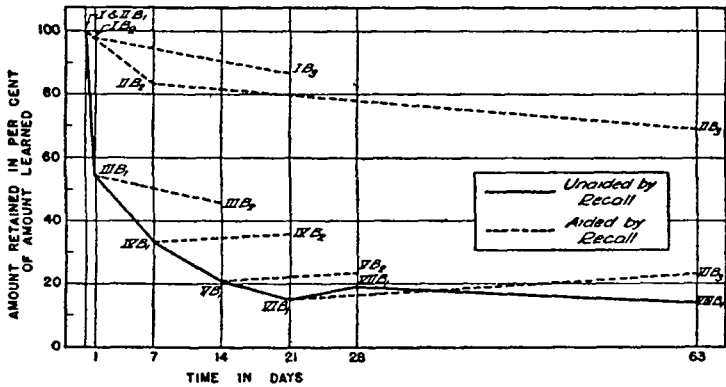


FIG. 2 CURVES OF RETENTION FOR THE ENTIRE POPULATION WHEN THE AMOUNT RETAINED IS EXPRESSED AS A PER CENT OF THE AMOUNT LEARNED

and the curve of retention unaided by recall begins to level much nearer the zero line.

#### LEARNING ABILITY AND RETENTION

In order to determine whether ability to learn affected the shape of the retention curve, the Test *B* scores of those pupils who scored in the upper one third on Test *A* were compared with the Test *B* scores of those in the lower one third on Test *A*. The data for making these comparisons are shown in Tables IV and V. The data on the upper and lower thirds are shown graphically in Figs. 3 and 4. An examination of these figures shows that the curve of retention of pupils of inferior learning ability begins to level or to have reached the horizontal seven days after learning. At the same time the curve for the pupils with superior learning ability does not begin to level until twenty-one days after the learning period.



TABLE IV.—TEST B RESULTS OF PUPILS WHO MADE SCORES IN THE UPPER AND LOWER THIRDS ON TEST A

| Group | Division | N   | AM test A | Test           | AM test B | SD of B scores |
|-------|----------|-----|-----------|----------------|-----------|----------------|
| I     | Upper    | 95  | 19.62     | B <sub>1</sub> | 17.02     | 3.57           |
| I     | Upper    | 95  | .....     | B <sub>2</sub> | 16.76     | 3.36           |
| I     | Upper    | 88  | .....     | B <sub>3</sub> | 15.47     | 3.87           |
| I     | Lower    | 95  | 10.42     | B <sub>1</sub> | 9.67      | 3.40           |
| I     | Lower    | 95  | ... .     | B <sub>2</sub> | 9.67      | 3.21           |
| I     | Lower    | 89  | .....     | B <sub>3</sub> | 9 19      | 3.36           |
| II    | Upper    | 112 | 19.17     | B <sub>1</sub> | 17.18     | 2.70*          |
| II    | Upper    | 120 | ....      | B <sub>2</sub> | 16.10     | 3.64†          |
| II    | Upper    | 111 | .....     | B <sub>3</sub> | 14.57     | 3.42†          |
| II    | Lower    | 112 | 10.92     | B <sub>1</sub> | 10.01     | 3.23           |
| II    | Lower    | 120 | .....     | B <sub>2</sub> | 8.55      | 3.25           |
| II    | Lower    | 111 | ... .     | B <sub>3</sub> | 7.39      | 2.49           |
| III   | Upper    | 123 | 19.33     | B <sub>1</sub> | 12.58     | 4.02           |
| III   | Lower    | 123 | 10.90     | B <sub>1</sub> | 7.09      | 2.52           |
| IV    | Upper    | 113 | 19.27     | B <sub>1</sub> | 10.39     | 3.36           |
| IV    | Lower    | 113 | 10.92     | B <sub>1</sub> | 5.48      | 2.43           |
| V     | Upper    | 124 | 19.54     | B <sub>1</sub> | 9.28      | 3.47           |
| V     | Lower    | 124 | 10.84     | B <sub>1</sub> | 5.22      | 2.30           |
| VI    | Upper    | 130 | 19.58     | B <sub>1</sub> | 8.46      | 3.21           |
| VI    | Lower    | 130 | 10.76     | B <sub>1</sub> | 6.33      | 2.03           |
| VII   | Upper    | 122 | 19.47     | B <sub>1</sub> | 8.50      | 3 11           |
| VII   | Lower    | 122 | 10.57     | B <sub>1</sub> | 5.57      | 2.13           |
| VIII  | Upper    | 117 | 19.43     | B <sub>1</sub> | 7.74      | 2.84           |
| VIII  | Lower    | 117 | 10.79     | B <sub>1</sub> | 5.16      | 1.95           |

\* Unusually small because high scores were deleted in the equalization procedure.

† Not equalized.

TABLE V.—COMPARISON OF TEST B RESULTS OF UPPER AND LOWER THIRDS FOR GROUPS DIFFERING BY ONLY ONE RECALL

| Group | Division | Test           | AM    | SE, AM | Difference of AM's | SE difference | CR    |
|-------|----------|----------------|-------|--------|--------------------|---------------|-------|
| I     | Upper    | B <sub>2</sub> | 16.76 | .34    |                    |               |       |
| III   | Upper    | B <sub>1</sub> | 12.58 | .36    | 4.18               | .495          | 8.44  |
| I     | Lower    | B <sub>2</sub> | 9.67  | .33    |                    |               |       |
| III   | Lower    | B <sub>1</sub> | 7.09  | .23    | 2.58               | .402          | 6.41  |
| II    | Upper    | B <sub>2</sub> | 16.10 | .33    |                    |               |       |
| IV    | Upper    | B <sub>1</sub> | 10.39 | .31    | 5.71               | .463          | 12.33 |
| II    | Lower    | B <sub>2</sub> | 8.55  | .30    |                    |               |       |
| IV    | Lower    | B <sub>1</sub> | 5.48  | .23    | 3.07               | .378          | 8.12  |

Because of the fact that the data of Tables IV and V and Figs. 3 and 4 are based on scores neither corrected for guessing nor corrected for previous knowledge, the rate of forgetting shown is probably much less rapid than the true rate of forgetting. According to the data as presented the pupils in the upper one third forgot twenty-six per cent

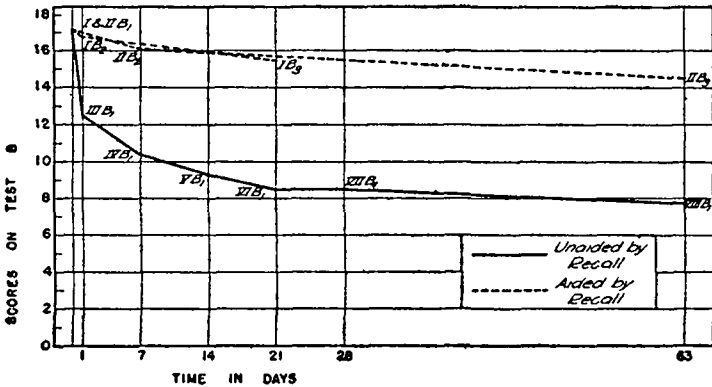


FIG. 3 CURVES OF RETENTION FOR THE PUPILS IN THE UPPER ONE THIRD OF SCORES ON TEST A

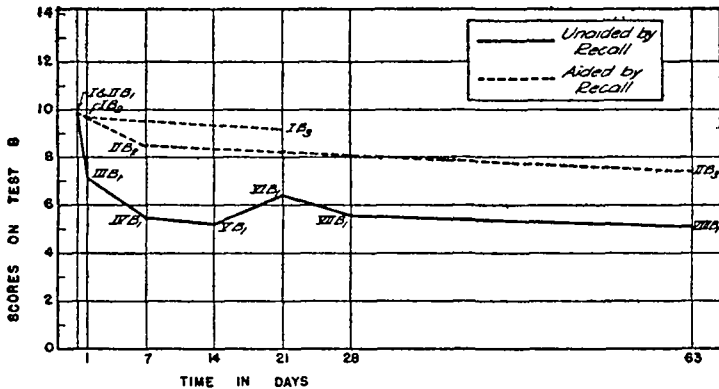


FIG. 4 CURVES OF RETENTION FOR PUPILS IN THE LOWER ONE THIRD OF SCORES ON TEST A

of their original score in one day while the pupils in the lower one third forgot twenty-eight per cent. For one week, the figures were thirty-nine per cent and forty-four per cent. When scores were corrected for guessing the upper one third forgot within one day thirty-three per cent while the lower one third forgot forty-nine per cent. It should be remembered that the upper and lower thirds referred to are

based on the pupils' scores on Test *A*. The data show that the pupils in the lower third tend to have a more rapid initial rate of forgetting.

Additional data on the relationship between learning ability and retention were secured by correlating the immediate score of pupils on Test *A* with their delayed score on Test *B*. The score on Test *A* was considered a measure of the pupils' ability to learn, while the delayed score on Test *B* was considered as a measure of the pupils' ability to retain. The "*r*'s" obtained in the above manner ranged from .60 for one day to .44 for sixty-three days. Since the correlation between the two tests on immediate recall was only .76, the "*r*'s" given for the relationship between immediate and delayed recall, or between ability to

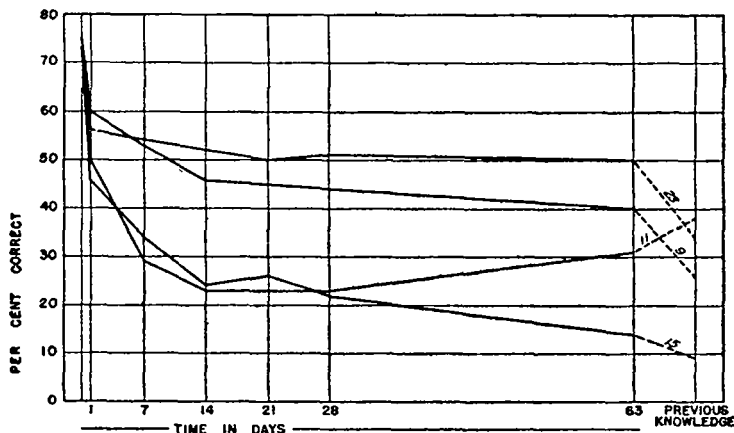


FIG 5 CURVES OF FORGETTING FOR ITEMS NUMBER 9, 11, 15, & 23.  
(PER CENTS UNCORRECTED)

learn and retention, are probably very conservative. In connection with the relationship between immediate and delayed recall, the attention of the reader is called to the fact that in some previous studies this relationship was found by correlating the immediate and delayed scores on the same test. The results of such a procedure are almost certain to be spuriously high because of the effect of recall on retention. When this procedure was used in the present investigation, a correlation of .91 between the scores on immediate recall and recall after one day was obtained.

#### EFFECT OF ITEM DIFFICULTY ON THE FORM OF RETENTION CURVES

From an item analysis of the papers of all pupils who took Test *B*, the data on forgetting of individual items shown in Table VI were

obtained. The first seven columns represent the per cent of pupils tested at various times who answered each item correctly. The last column shows the per cent of the pupils tested for previous knowledge who answered the items correctly. An examination of the data in Table VI will show that there is little relationship between the rate of forgetting of items and the initial difficulty of the items. This fact is shown graphically in Fig. 5. The four items (9, 11, 15, and 23) for which curves of retention are shown were approximately of equal difficulty on the initial test. Two of the items (11 and 23) were also about equal on the previous knowledge score. In spite of these similarities, widely differing curves of retention were found. The one general characteristic of the data on each item is the fact that the rate

TABLE VI.—THE PER CENT OF CORRECT RESPONSES FOR EACH OF THE ITEMS ON TEST B

| Item number | I and II | III | IV | V  | VI | VII | VIII | X  |
|-------------|----------|-----|----|----|----|-----|------|----|
| 1           | 40       | 28  | 21 | 19 | 17 | 20  | 14   | 10 |
| 2           | 61       | 30  | 20 | 15 | 16 | 16  | 15   | 14 |
| 3           | 81       | 62  | 52 | 45 | 43 | 43  | 50   | 60 |
| 4           | 80       | 56  | 38 | 36 | 31 | 33  | 28   | 18 |
| 5           | 55       | 42  | 40 | 37 | 39 | 41  | 46   | 56 |
| 6           | 76       | 57  | 57 | 55 | 59 | 61  | 61   | 66 |
| 7           | 43       | 40  | 33 | 29 | 25 | 24  | 25   | 17 |
| 8           | 32       | 24  | 18 | 19 | 22 | 18  | 19   | 9  |
| 9           | 75       | 60  | 53 | 46 | 45 | 44  | 40   | 26 |
| 10          | 55       | 28  | 21 | 20 | 14 | 18  | 13   | 11 |
| 11          | 72       | 50  | 29 | 23 | 23 | 23  | 31   | 38 |
| 12          | 29       | 22  | 19 | 16 | 15 | 14  | 10   | 6  |
| 13          | 67       | 30  | 24 | 19 | 20 | 25  | 26   | 19 |
| 14          | 77       | 64  | 57 | 44 | 46 | 41  | 33   | 20 |
| 15          | 73       | 46  | 34 | 24 | 26 | 22  | 14   | 9  |
| 16          | 41       | 28  | 27 | 17 | 13 | 17  | 14   | 7  |
| 17          | 40       | 28  | 22 | 18 | 19 | 19  | 13   | 8  |
| 18          | 37       | 20  | 19 | 17 | 14 | 14  | 9    | 4  |
| 19          | 68       | 39  | 32 | 22 | 17 | 17  | 9    | 4  |
| 20          | 53       | 39  | 32 | 34 | 33 | 27  | 32   | 21 |
| 21          | 63       | 27  | 16 | 14 | 16 | 13  | 13   | 14 |
| 22          | 24       | 17  | 14 | 19 | 16 | 13  | 17   | 9  |
| 23          | 73       | 56  | 54 | 52 | 50 | 51  | 50   | 34 |
| 24          | 35       | 31  | 27 | 27 | 26 | 29  | 28   | 22 |
| 25          | 31       | 21  | 21 | 19 | 17 | 21  | 20   | 10 |

SE of the per cents varies from 2.1 to 2.7.

of forgetting is more rapid during the first day than during any subsequent period.

The data for items 3, 5, 6, and 11 (Table VI) show that reading or study of material can be detrimental to success on a test over the content of that material. Children who had read the article made lower scores on some tests over these four items than those who had not read the articles. In the case of these four items, the difference ascribed to this interference was statistically significant.

The data on items 13, 24, and 25 seem to be evidence for reminiscence. However, none of the differences or gains ascribed to reminiscence are statistically significant.

When the amount of previous knowledge (last column in Table VI) is subtracted from the per cents given in the other columns of Table VI, a very different picture is presented. (See Table VII.) The difficulty

TABLE VII.—ITEMS IN RANK ORDER OF PER CENT ANSWERED CORRECTLY AFTER SUBTRACTION OF THE AMOUNT CREDITED TO PREVIOUS KNOWLEDGE

| Item number | I and II | III | IV  | V   | VI  | VII | VIII |
|-------------|----------|-----|-----|-----|-----|-----|------|
| 15          | 64       | 35  | 25  | 15  | 17  | 13  | 5    |
| 19          | 64       | 35  | 28  | 18  | 13  | 13  | 5    |
| 4           | 62       | 38  | 20  | 18  | 13  | 15  | 10   |
| 14          | 57       | 44  | 37  | 24  | 26  | 21  | 13   |
| 9           | 49       | 34  | 27  | 20  | 19  | 18  | 14   |
| 13          | 48       | 11  | 5   | 0   | 1   | 6   | 7    |
| 21          | 47       | 13  | 2   | 0   | 2   | - 1 | - 1  |
| 2           | 47       | 16  | 6   | 1   | 2   | 2   | 1    |
| 10          | 44       | 17  | 10  | 9   | 3   | 7   | 2    |
| 23          | 39       | 22  | 20  | 18  | 16  | 17  | 16   |
| 11          | 34       | 12  | - 9 | -15 | -15 | -15 | - 7  |
| 16          | 34       | 21  | 20  | 10  | 6   | 10  | 7    |
| 18          | 33       | 16  | 15  | 13  | 10  | 10  | 5    |
| 17          | 32       | 20  | 14  | 10  | 11  | 11  | 5    |
| 20          | 32       | 18  | 11  | 13  | 12  | 6   | 11   |
| 1           | 30       | 18  | 11  | 9   | 7   | 10  | 4    |
| 7           | 26       | 23  | 16  | 12  | 8   | 7   | 8    |
| 8           | 23       | 15  | 9   | 10  | 13  | 9   | 10   |
| 12          | 23       | 16  | 13  | 10  | 9   | 8   | 4    |
| 3           | 21       | 2   | - 8 | -15 | -17 | -17 | -10  |
| 25          | 21       | 11  | 11  | 9   | 7   | 11  | 10   |
| 22          | 13       | 8   | 5   | 10  | 7   | 4   | 8    |
| 24          | 13       | 9   | 5   | 5   | 4   | 7   | 6    |
| 6           | 10       | - 9 | - 9 | -11 | - 7 | - 5 | - 5  |
| 5           | - 1      | -14 | -16 | -19 | -17 | -15 | -10  |

rank of some items changes considerably. However, even after this change, no relationship between difficulty and rate of forgetting is evident.

TABLE VIII.—THE EFFECT OF RECALL ON RETENTION FOR INDIVIDUAL ITEMS

| Item number | Group II per cent correct on $B_1$ | Group II per cent correct on $B_2$ | Group VIII per cent correct | Difference $B_1 - B_2$ | Per cent forgotten | Difference $B_1 - VIII$ | Per cent forgotten |
|-------------|------------------------------------|------------------------------------|-----------------------------|------------------------|--------------------|-------------------------|--------------------|
| 1           | 39                                 | 25                                 | 14                          | 14                     | 36                 | 25                      | 64                 |
| 2           | 61                                 | 40                                 | 15                          | 21                     | 34                 | 46                      | 75                 |
| 3           | 81                                 | 63                                 | 50                          | 18                     | 22                 | 31                      | 38                 |
| 4           | 80                                 | 67                                 | 28                          | 13                     | 16                 | 52                      | 65                 |
| 5           | 55                                 | 61                                 | 46                          | - 6                    | -11                | 9                       | 16                 |
| 6           | 76                                 | 81                                 | 61                          | - 5                    | - 7                | 15                      | 20                 |
| 7           | 42                                 | 33                                 | 25                          | 9                      | 21                 | 17                      | 40                 |
| 8           | 31                                 | 17                                 | 19                          | 14                     | 45                 | 12                      | 39                 |
| 9           | 74                                 | 65                                 | 40                          | 9                      | 12                 | 34                      | 46                 |
| 10          | 51                                 | 37                                 | 13                          | 14                     | 27                 | 38                      | 75                 |
| 11          | 72                                 | 41                                 | 31                          | 31                     | 43                 | 41                      | 57                 |
| 12          | 28                                 | 21                                 | 10                          | 7                      | 25                 | 18                      | 64                 |
| 13          | 63                                 | 43                                 | 26                          | 20                     | 32                 | 37                      | 59                 |
| 14          | 76                                 | 65                                 | 33                          | 11                     | 14                 | 43                      | 57                 |
| 15          | 72                                 | 55                                 | 14                          | 17                     | 24                 | 58                      | 81                 |
| 16          | 41                                 | 33                                 | 14                          | 8                      | 20                 | 27                      | 66                 |
| 17          | 40                                 | 35                                 | 13                          | 5                      | 13                 | 27                      | 68                 |
| 18          | 37                                 | 37                                 | 9                           | 0                      | 0                  | 28                      | 76                 |
| 19          | 68                                 | 52                                 | 9                           | 16                     | 24                 | 58                      | 85                 |
| 20          | 54                                 | 36                                 | 32                          | 18                     | 33                 | 22                      | 41                 |
| 21          | 59                                 | 37                                 | 13                          | 22                     | 37                 | 46                      | 78                 |
| 22          | 26                                 | 22                                 | 17                          | 2                      | 8                  | 9                       | 35                 |
| 23          | 69                                 | 68                                 | 50                          | 1                      | 1                  | 19                      | 28                 |
| 24          | 35                                 | 37                                 | 28                          | - 2                    | - 6                | 7                       | 20                 |
| 25          | 31                                 | 26                                 | 20                          | 5                      | 16                 | 11                      | 35                 |

In order to determine what effect recall had on the retention of individual items, a comparison of the amount forgotten by Group II (with recall) and Group VIII (without recall) was made. In each case the time elapsed was sixty-three days. The data for making this comparison are given in Table VIII. The data show that recall was beneficial to retention for every item. When the pupils were divided into an upper and a lower group on the basis of their Test A scores and

data similar to that of Table VIII prepared, it was found that the superior pupils benefited more from recall.

The high scores made by the pupils of Groups I and II on the repeated tests might be attributed to the pupils' remembering how the test was marked the first time. If this assumption were valid, then, both correct and incorrect responses would be repeated with equal consistency. In order to test the assumption, one hundred of the Test  $B_1$  and Test  $B_2$  papers of Group II were analyzed to determine the consistency of responses. It was found that right answers were repeated seventy-nine per cent of the time; while wrong answers were repeated only fifty per cent. Since right answers were repeated more consistently than wrong answers, only a small portion of the unusually high scores on the second trial of the test can be ascribed to the pupils' remembering how the test was marked the first time. Chance alone would give twenty per cent repetition of responses. The fact that wrong answers were repeated more often than chance would allow is not in conflict with the assumption that recall and not mere repetition is the factor that aids retention. In giving some wrong responses, the pupils were sometimes recalling information given in the article, for many of the false responses were taken from the content of the article. Thus, recall can also aid the retention of erroneous ideas.

*Limitations.*—The findings of this study are subject to a number of limitations. The most important of these are the following: (1) The method of measurement employed a type of cue not used in recalling information in everyday school or life situations. (2) The tests were repeated. (3) The learning was of little practical use to the children. (4) The children were given no opportunity to refer to the material after the initial learning period. (5) The pupils did not know whether their responses were correct or incorrect. (6) The effect of reacting to one item upon the response to other items is not known.

#### EDUCATIONAL IMPLICATIONS

The findings of this study seem to warrant the following educational implications: (1) Immediate recall in the form of a test is an effective method of aiding the retention of learning and should, therefore, be employed more frequently in the elementary school. (2) Because recall can aid in fixing erroneous ideas, all tests or examinations should be returned to the pupil corrected, or the pupil should be given an opportunity to correct his own paper. (3) Achievement

tests or examinations are learning devices and should not be considered only as tools for measuring achievement of pupils. (4) Since reading about a topic can interfere with the knowledge the subject already possesses, careful consideration should be given to what is supposed to be learned and to the thoroughness of learning. (5) In all studies where the same tests are repeated, the possible effects of recall on retention should be recognized.

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