

THE EFFECT OF OVERLEARNING ON RETENTION

BY WM. C. F. KRUEGER

Psychological Laboratory, University of Chicago

This experiment is concerned with the following problems. (1) As the degree of learning is varied from 100% to 200 %, will the degree of retention vary proportionally, *i.e.* will 50% overlearning increase the amount retained by 50% or by some other proportion? (2) Will the relation between the degree of retention and the degree of learning vary with the interval between learning and recall? For example, if 50% overlearning increases retention by 40% after a one-day interval, will this latter percentage increase or decrease with the length of the interval?

Luh¹ obtained results bearing upon these problems. The subjects, college students and one instructor, memorized series of nonsense syllables of 12 each. The lists were presented on a memory drum, each word being exposed for two seconds. Only one degree of overlearning was used, namely 150% learning. The intervals between learning and recall were 4 hours, 1 day and 2 days. Retention was tested by the methods of unaided written reproduction, recognition and reconstruction. The increase of retention was always less than the degree of overlearning. The ratio of retentive increase to the degree of overlearning decreased with the interval, and in some cases overlearning even proved detrimental. For example, when retention was measured by written reproduction, the 4-hour interval showed an increase of 17.1%, while the 1-day interval gave an actual decrease of 7.1%, and the 2-day interval showed a decrease of 10.6%. The results were approximately the same for all three methods of measuring retention.

¹ C. W. Luh, The conditions of retention, *Psychol. Monog.*, 1923, 31, (no. 142), p. 44.

The present experiment was designed to supplement and to extend Luh's work by employing two degrees of overlearning and a wider range of intervals. Our experimental conditions differ from Luh's in the following respects. Instead of series of 12 nonsense syllables we used lists of 12 monosyllabic nouns. We had 2 degrees of overlearning, 50% and 100%. The range of intervals in our experiment was 1, 2, 4, 7, 14 and 28 days. Retention was tested (1) by anticipatory verbal recall and (2) by the 'saving method.'

A list of words was presented by means of a memory drum at the rate of two seconds per word. S was permitted to use any method of memorizing except that of writing down the words. The usual anticipatory method of verbal recall was employed to test the degree of learning, but the anticipatory test was given in alternate trials instead of in every trial, as is usual. By 100% learning we mean the degree or stage of perfection at which S was first able to anticipate correctly all the words in the list in a single presentation. To obtain 50% overlearning the presentations were continued until the number was increased by one-half of the number of trials required for the 100% degree of mastery, and 100% overlearning by giving twice the number of trials necessary just to learn the list. If, for example, 10 trials were needed to learn a list 100%, 5 more was the number arbitrarily set for 50% overlearning; if 12 trials were necessary, 6 more were added, etc. Only one new list was learned on any one day.

Different groups of subjects were utilized for the various intervals; but the lists employed were the same throughout. For each interval the same group was used for the three degrees of learning. Two methods were employed to eliminate the possibility that the differences between the three learning and retention scores might be due to practice. (1) All Ss were first required to memorize four practice-lists before being tested; (2) one-half took the three conditions in the order of 100%, 150% and 200% learning, while the other half took them in the reverse order of 200%, 150% and 100% learning. To avoid the possibility that the differences

in retention were due to differences in the difficulty of the lists, each of 20 Ss learned a different list for a given degree of mastery. Thus the average for each condition was based upon the retention scores for twenty lists. There was one exception. For each degree of learning with a one-day interval, the averages were computed from 40 retention scores, or 2 scores from each of the twenty lists. After the specified interval, the subjects were required to relearn the lists up to a 100% stage of mastery. The subjects were tested by the anticipatory method of verbal recall on the odd-numbered trials. This gave us two measures of retention, (1) the number of words correctly anticipated on the first presentation, and (2) the percentage of saving based upon learning and relearning scores.

In Table I is found, for each of the eighteen conditions, the average number of trials necessary (1) to learn and (2) to relearn a list. Column three states the average number of

TABLE I

AVERAGE NUMBER OF TRIALS TO LEARN AND TO RELEARN A LIST

Interval (days)	Degree Learn'g (%)	Trials req'd to Learn a List (av)	Trials for 100% Learn'g (av)	SD for 100% Learn'g Score	PE for 100% Learn'g Score	T'ls to Rel'n a List (av)	SD for Re-learn'g Score	PE for Re-learn'g Score
1	100	4.25	4.25	1.34	.14	3.20	1.01	.11
1	150	7.00	4.40	1.36	.14	2.73	.74	.08
1	200	8.86	4.43	1.22	.13	2.30	.75	.08
2	100	4.40	4.40	1.24	.19	3.65	1.06	.16
2	150	7.40	4.85	1.35	.20	3.15	.92	.14
2	200	9.60	4.80	1.44	.22	2.65	.65	.10
4	100	4.55	4.55	1.12	.17	4.30	.96	.14
4	150	7.30	4.70	1.27	.19	3.25	.92	.14
4	200	9.20	4.60	1.32	.20	3.00	1.00	.15
7	100	4.45	4.45	1.94	.29	4.20	1.57	.24
7	150	6.30	4.15	1.28	.19	3.00	.55	.08
7	200	9.10	4.55	1.66	.25	3.05	1.16	.17
14	100	4.40	4.40	1.01	.14	4.30	1.10	.16
14	150	6.95	4.50	1.20	.18	3.45	.74	.11
14	200	8.50	4.25	1.04	.16	3.05	.74	.11
28	100	4.65	4.65	1.49	.22	4.55	1.66	.25
28	150	7.40	4.85	1.11	.17	3.80	.93	.14
28	200	9.50	4.75	1.55	.23	3.50	1.18	.18

trials necessary to memorize a list to the specified degrees of learning. The fourth column gives the average number of trials required to attain a 100% degree of learning. The seventh column records the average number of trials required to relearn each list. All averages are based on twenty measures with the exception of those for the one-day interval which are based upon forty scores. The other columns give the measures of variability, such as the S.D.'s and P.E.'s for each average.

By inspection it may be seen that the learning scores, based upon 100% learning, were approximately the same for the eighteen conditions. Thus any differences in the amounts retained cannot be accounted for by differences in the learning scores.

The retention scores are given in Tables II and III. The verbal-recall scores which are found in the third column of Table II represent the average number of words recalled for

TABLE II

AVERAGE VERBAL RECALL SCORE AND RELIABILITY OF THE DIFFERENCE
BETWEEN OBTAINED AVERAGES

Interval (days)	Degree Learn'g	No. Words Recalled (av) (%)	SD for Verb. Recall Score	PE for Verb. Recall Score	Reliab'y of Means for 100% and 150% Learning	Diff. bet. Means for 150% and 200% Learning
1	100	3.10	2.30	.23		
1	150	4.60	2.43	.26	4.20	
1	200	5.83	2.86	.30		6.97
2	100	1.80	1.72	.26		
2	150	3.60	2.18	.33	4.30	
2	200	4.65	2.22	.33		6.73
4	100	.50	.81	.12		
4	150	2.05	1.88	.28	5.99	
4	200	3.30	2.26	.34		8.56
7	100	.20	.40	.06		
7	150	1.30	1.27	.19	5.48	
7	150	1.65	1.42	.21		6.50
14	100	.15	.36	.05		
14	150	.65	.65	.10	4.45	
14	200	.90	.77	.12		5.87
28	100	.00	.00	.00		
28	150	.25	.43	.07	3.80	
28	200	.40	.49	.07		5.40

each condition. In the next two columns of the same Table are the S.D.'s and P.E.'s for the corresponding averages. The last two columns give the ratio of the difference between the two obtained means to the P.E.(diff.). All values above 4 indicate a statistically significant difference between the two respective averages.

TABLE III

AVERAGE PERCENTAGE RETAINED AS MEASURED BY THE SAVING METHOD

Interval (days)	Degree Learn'g (%)	Retained as Meas'd by Sav. Method (av %)	SD for Retention Score	PE for Retention Score	Reliab'y of Means for 100% and 150% Learning	Diff. bet. Means for 150% and 200% Learning
1	100	21.73	27.97	2.98		
1	150	36.15	22.67	2.42	3.76	
1	200	47.10	24.62	2.64		6.34
2	100	13.40	23.97	3.62		
2	150	33.45	14.80	2.22	4.72	
2	200	42.05	14.10	2.13		6.83
4	100	3.40	20.12	3.03		
4	150	29.75	14.79	2.23	6.99	
4	200	32.30	25.50	3.20		6.53
7	100	1.75	21.21	3.20		
7	150	23.15	18.78	2.83	5.01	
7	200	27.55	24.14	3.64		5.32
14	100	1.65	14.14	2.13		
14	150	20.80	14.24	2.15	6.26	
14	200	25.45	21.28	3.21		6.48
28	100	1.50	20.32	3.06		
28	150	20.50	16.09	2.43	4.86	
28	200	25.10	14.53	2.19		6.53

Table III states the average retention-scores for all conditions, as derived by the saving method. These values were computed by the usual formula from the 100% degree of learning and the relearning scores of Table I. Column three gives the average percentage retained for each degree of learning and for the various intervals. The S.D.'s and P.E.'s for these averages are in the next two columns. The last two columns give the ratio of the difference between the respective means to the P.E.(diff.).

The retention scores of Tables II and III show that for every interval the highest amount retained was for 100%

overlearning, while 100% learning always gave the least score. The ratios of the differences between two obtained means to their P.E.(diff.) express a statistically valid difference between the two respective retention scores without a single exception.

In order to discover whether the relation between the degree of learning and the degree of retention varies with the interval between learning and recall, we computed the ratios between the retention-scores for 100% learning and 150% learning and the ratios of the retention-scores for 150% learning and 200% learning. The respective degrees of learning stand in the ratios of 1 : 1.5, and 1 : 1.33. By dividing the retention-scores for each interval by the retention-scores for the lesser degree of learning we get the corresponding ratios of retention. For example, according to Table II, the retention-scores for 100% and 150% learning for the one-day interval stand in the ratio of 3.10 : 4.60, and the retention-scores for 150% and 200% learning are in the ratio of 4.60 : 5.83. By dividing the first ratio by 3.10 and the second ratio by 4.60 (the retention-scores for the lesser degree of learning) we obtained the simplified ratios of 1 : 1.48 and 1 : 1.27. These ratios mean that an increase of learning from 100% to 150% gave a corresponding increase in retention of 48%, while increasing learning by an additional 33 $\frac{1}{3}$ % (from 150% to 200%) increased retention only by 27%. Tables IV and VI give the two series of ratios for the

TABLE IV

RATIO OF DEGREE OF LEARNING AND CORRESPONDING RATIOS OF RETENTION
FOR 100% AND 150% LEARNING

Ratio of Learning	Ratios of Retention as Measured by Verbal Recall					
	<i>Interval (days)</i>					
	1	2	4	7	14	28
1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.50	1.48	2.00	4.10	6.50	4.33	Infinity

TABLE V

RATIO OF DEGREE OF LEARNING AND CORRESPONDING RATIOS OF RETENTION
FOR 100% AND 150% LEARNING

Ratio of Learning	Ratios of Retention as Measured by the Saving Method					
	<i>Intervals (days)</i>					
	1	2	4	7	14	28
1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.50	1.66	2.50	8.75	13.23	12.06	13.67

TABLE VI

RATIO OF DEGREE OF LEARNING AND CORRESPONDING RATIOS OF RETENTION
FOR 150% AND 200% LEARNING

Ratio of Learning	Ratios of Retention as Measured by Verbal Recall					
	Intervals (days)					
	1	2	4	7	14	28
1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.333	1.27	1.29	1.61	1.27	1.38	1.60

TABLE VII

RATIO OF DEGREE OF LEARNING AND CORRESPONDING RATIOS OF RETENTION
FOR 100% AND 150% LEARNING

Ratio of Learning	Ratios of Retention as Measured by the Savings Method					
	Intervals (days)					
	1	2	4	7	14	28
1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.33	1.30	1.26	1.08	1.19	1.22	1.22

verbal recall scores. By the same procedure we computed the ratios of retention for the scores derived by the 'saving method.' These ratios are found in Tables V and VII. To illustrate the relative efficacy of overlearning for the various intervals, we see that, as stated in Table IV, 50% overlearning increased retention 48% for the one-day interval, 100% for the two-day interval, 310% for the 4-day interval, 550% for the 7-day interval, etc. The infinity score for 150% learning with the 28-day interval was due to the zero record for 100% learning.

From Tables IV, V, VI, and VII we may conclude that

(1) as the degree of learning was increased from 100% to 150%, the corresponding increase in retention for the one-day interval was approximately the same, and that this ratio increased rapidly as the length of the interval between learning and recall was extended;

(2) as the degree of learning was increased from 150% to 200%, (or by an additional $33\frac{1}{3}\%$), the corresponding increase in retention was usually less, and this proportion did not vary consistently with the length of the interval.

Our results thus directly contradict those of Luh. This divergency of results may be due to the differences in the conditions,—difference in material, method of measurement

and length of the interval employed. Our results suggest that the third factor may be partly responsible.

A certain degree of overlearning, at least 50%, is highly economical from the standpoint of retention for intervals of 2 to 28 days, and the larger the interval the greater is the economy. Further increases of overlearning, however, proved to be uneconomical for most intervals.

(Manuscript received June 20, 1928)