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The effect of interpolated emotional reactions upon retention: A study of retroactive inhibition

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THE EFFECT OF INTERPOLATED EMOTIONAL REACTIONS UPON RETENTION: A STUDY OF RETROACTIVE INHIBITION

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INTRODUCTION

The concept of retroactive inhibition originated with Muller and Pilzecker, who found in their work on memory (1892-1900) that the interpolation of certain forms of activity between learning and recall may positively accelerate the forgetting process. Since their work a number of studies have been made dealing with different phases of the problem.

The purpose of the present paper is to review the work that has been done on the general problem of retroactive inhibition and to present some experimental work of a further problem: the effect of emotional reactions, as the interpolated activity, upon the retention of previously learned series of nonsense syllables.

HISTORICAL REVIEW

Studies of Retroactive Inhibition with Human Subjects

Muller and Pilzecker (8) conducted a series of experiments specifically designed to show that introduction of enforced mental activity immediately succeeding the learning of a list of nonsense syllables exerts an inhi-

bitory effect upon the later memory for that list.

Their apparatus consisted in a twelve-sided prism which revolved behind a metal screen in which was an adjustable slit. A strip of paper on which were written twelve syllables was placed around the revolving prism. The Hipp chronoscope and lip key, introduced into an electric circuit, were used to record reaction time for recall.

Both the Right Associates and the Saving methods were used. In the case of the five experiments with the former, in each experiment the results were compared for tests with two sets of lists, which differed only as to the manner in which the interval between learning and recall was used. For the one test the subject was left entirely free for the period, while in the other he engaged in some mental activity, "work", such as learning another list or studying pictures, the Aussage test.

The following tables, revised slightly from Tolman's summary, present exact conditions and results. Here "Exp." represents the number of the experiment as given by the authors, "n" refers to the number of syllable pairs used in each test; "R" indicates that part of the experiment in which the rest interval was used, "W", that in which the work interval was used. The column headed "RL" gives the number of repetitions given for the original learning; "%R" shows the percentage of correct replies given in the

test, and the "Time" column gives the reaction time of response. But one subject was used in each experiment. (These captions will be used in this manner throughout this paper where the Right Associates method was used in the original investigation. An attempt has been made to present the essential conditions and results in a uniform manner in all the tables, hence the tables are not in the original form.)

Exp.		n	Interpolated Interval	RL	%R	(Sigma) Time
31(a)	R	14	6 min. rest	8	48	2480
	W		34.4 sec. rest learn new series 68.8 sec.; 6 min. rest	8	23	3570
31(b)	R	72	24 hrs. Rest followed by usual activities	16	36	3460
			24 hrs. Rest 1 min.; learn new series 2 min. 17.6 sec.; usual activities	16	32	3660
32	R	162	8 min. rest	12	55	3070
	W		17.8 sec. rest; learn new series 1 min. 46.8 sec.; rest 8 min.	12	27	3230
33	R	72	8 min. rest	6	72	2090
	W		27 sec. rest; learn new series 1 min. 12 sec.; rest 8 min.	6	43	2260
34	W_1	144	6 min. rest; learn new series 1 min. 48 sec.; rest 10 min., followed by other activities	12	49	3000
	W_2		17.6 sec. rest; learn new series 1 min. 48 sec.; rest 10 min.	12	28	2760
35	R	108	8 min. rest	8	56	2490
	W		2 min. Aussage test; 6 min. rest	8	24	2950

In Experiment 34 it will be noted that both intervals are used for work, but for the first test (W_1) the work followed six minutes after the learning, while for the second (W_2) it followed immediately (in 17.6 seconds).

Using both time and percentage of correct replies as criteria, there is evidence of greater inhibition for the lists followed immediately by work than for those followed immediately by rest.

For the experiments in which the Savings method was used the following table shows conditions and results. The last column (R. Rel.) in this case shows the average number of repetitions for relearning. "n" here stands for the number of lists used.

Exp.	n	Interpolated Interval	RL	R. Rel.
36(a)R	8	4 min. rest; other lists; 10 min. rest (30 min. in all)	5	11.25
W		Learn new list; 4 min. rest; Other lists and rest; 10 min. rest (30 min. in all)	5	13.00
36(b)R	32	4 min. rest; other lists and rests; 5 min. rest	4	6.6
W		1 min. 20 sec. study new list; other lists and rests; 5 min. rest (15 min. in all)	4	7.8
37 R		4 min. rest; other lists and rests; 5 min. rest	5	4.9
W		Aussage test 2 min.; 4 min. rest; other lists and rest; 5 min. rest (15 min. in all)	5	8.0

Again the poorer records are made after the work intervals.

From these results a number of general conclusions were drawn. The more important ones are these:

1. The results seem to indicate the influence of retroactive inhibition.

2. Under ordinary circumstances the effect is weaker when the interpolated work is done after six minutes rest than when it is done immediately after the learning.

3. The results in the experiment where the Aussage test was used as the interpolated activity seem to indicate that similarity or dissimilarity of the original and interpolated activity is not an important factor in determining the degree of inhibition.

The second major study of the problem of retroactive inhibition was carried on by Rosa Heine (3), a student of Müller, in 1910. Her problem was to determine whether or not retroactive inhibition played a similar part for recognition memory that Müller and Pilzecker had found for recall memory; also to repeat the experiments of Müller and Pilzecker with recall memory and to discover new principles, if possible. In a series of nineteen experiments with recognition memory no evidence was found of inhibition.

Fourteen experiments were then conducted on recall memory, with results very like those of Müller and Pilzecker. Her methods were but slightly different from theirs: for the original learning series of sixteen syllables instead of twelve were used; and in Experiments 15 and 16 eight four-place numbers were used. The following table summarizes conditions and results for the first four of these experiments.

Exp.	n	Interpolated Interval	RL	%R	Time
13 R	126	8 min. rest	8	17.5	2445
W		2 min. Aussage test; rest 6 min.	8	6.4	3503
14 R	108	8 min. rest	10	57.4	1395
W		2 min. Aussage test; rest 6 min.	10	36.1	1557
15 R	72	90 min.: rest 6 min.; other activities	12	36.1	2450
W		90 min.: study new series 4 min.; other activities	12	9.7	2837
16 R		24 hrs.: 6 min. rest; other activities	15	37.7	2123
W		24 hrs.: 4 min. study new series; other activities	15	35.4	2987

Both the record of correct responses and the reaction time again give evidence of more inhibition for the work series.

Heine then turned her attention to the problem of discovering whether or not retroactive inhibition not only plays a part in association between successive syllables, but also in associations within the syllables. To test this she conducted a series of five experiments, using a procedure similar to that used before, except that the final test consisted in the presentation of two letters of each syllable, the subject being required to supply the third letter.

These are the results:

Exp.	n	Interpolated Interval	RL	%R	Time
17 R	216	9 min. rest	8	48.6	2799
W		3 min. study list of 8 4-place numbers; 6 min. rest	8	35.2	3443
18 R	216	9 min. rest	12	37.5	1993
		3 min. study list of 8 4-place numbers; 6 min. rest	12	27.6	2940
19 R	216	9 min. rest	8	73.6	1707
W		3 min. study list of 8 4-place numbers; 6 min. rest	8	56.9	1993
20 R	144	9 min. rest	10	32.7	3935
W		3 min. study list of 8 4-place numbers; 6 min. rest	10	15.9	5601
21 R	216	9 min. rest	12	47.7	3784
W		3 min. study list of 8 4-place numbers; 6 min. rest	12	38.0	4237

The last five of the fourteen experiments on recall memory dealt with the problem of whether or not strongly impressed associations are relatively less affected by retroactive inhibition than weaker ones. In this group of experiments four lists were learned each hour instead of two, designated R, W, and r and w, the R and W differing from the r and w only in that they were given a greater number of repetitions and were recalled after a greater interval of time.

For the three of these experiments in which the Right Associates method was used these are the results obtained:

Exp.		n	Interpolated Interval	RL	%R	Time
29	R	108	24 hrs.: 10 min. rest	30-20	62.0	2406
	W		3 min. study new series; 6-7 min. rest	30-20	36.2	3013
	r		9 min. rest	6-2	70.4	1939
	w		3 min. study new series; 6 min. rest	6-2	21.1	2683
32	R	144	30 min. rest	25	22.2	5055
	W		3 min. studying pictures; rest	25	20.2	5161
	r		8 min. rest	8	17.5	2445
	w		2 min. studying pictures; rest	8	6.4	3505
33	R	72	24 hrs. rest	25	11.1	2030
	W		3 min. studying pictures; rest	25	16.7	1946
	r	108	8 min. rest	10	57.4	1395
	w		2 min. studying pictures; rest	10	36.1	1557

Two experiments, in which the savings method was used, gave these results:

Exp.		n	Interpolated Interval	RL	R. Rel.
30	R	24	90 min.: rest and other activities	8	25.2
	W		90 min.: 3 min. studying new list; rest and other activities	8	25.2
	r		90 min.: rest and other activities	4	21.2
	w		90 min.: 3 min. studying new list; rest and other activities	4	22.2
31	R		90 min.: rest and other activities	12	24.2
	W		90 min.: 3 min. studying new list; rest and other activities	12	25.3

r	90 min.: rest and other activities	6	20.3
w	90 min.: 3 min. studying new list; rest and other activities	6	22.5

The results obtained by the use of both methods indicate greater inhibition for the more weakly impressed lists.

Heine's results may be summarized briefly thus:

1. In the nineteen experiments dealing with recognition memory there is no evidence of retroactive inhibition.

2. In the four experiments dealing with the problem of recall memory the findings of Müller and Pilzecker are substantiated.

3. The five experiments dealing with associations within the syllables show a like effect of inhibition.

4. The concluding five on the effect of the degree of impression indicate a lesser degree of inhibition for the more strongly impressed associations.

DeCamp(2) started to work on the problem before Heine's work had been reported in full. (Müller made a brief report of her work before the Fifth International Congress of Experimental Psychologists in 1912.) He began work on the assumption that the principle of retroactive inhibition had been definitely established, but obtained results which contradict the findings of Müller and Pilzecker and Heine.

DeCamp was primarily concerned with the determination of relative degrees of inhibition produced by various amounts and different distributions of work.

Seven trained subjects were used in Experiments 1 to 12, while 34 untrained subjects served in Experiment 13.

The Right Associates method was used except in the last experiment, where the Reconstruction method was employed. The subject was shown a series of seven pairs of nonsense syllables, the two members of the pair being exposed simultaneously. These were presented on a Wirth card exposure apparatus, timed with a metronome. In the case of the Reconstruction test the subject studied an arrangement of five men of the chess board for 15 seconds, and after a period of "rest" or "work" was required to reconstruct the arrangement. Errors in position and time were the criteria of recall in this experiment. Correct responses and time were recorded in the other experiments.

The interpolated period in all cases of the work interval were spent in mental multiplication, ergographic work, problem solving, or chess playing.

Seven experiments resemble those of Müller and Pilzecker rather closely in method, though the results do not indicate so clearly the influence of inhibition as do theirs. This is shown in the following summary.

Exp.	n	Interpolated Interval	RL	%R	Time
3 R	112	15 min. rest	10	48	2221
W		10 min. multiplication; 5 min. rest	10	33	2676
5 R	70	15 min. rest	10	34	5149
W		15 min. multiplication	10	30	5822
6 R	63	15 min. rest	10	79	2828
		10 min. multiplication; 5 min. rest	10	68	2955
7 R	70	15 min. rest	6	41	5127
W		10 min. multiplication; 5 min. rest	6	40	4286
8 R	63	15 min. rest	10	67	4862
W		1 min. adjusting ergograph; 10 min. work; 5 min. rest	10	43	4108
9 R	56	15 min. rest	10	53.6	5238
W		6 min. solving prolbems; 9 min. rest	10	46.4	5593
11	70	15 min. rest	8	40	2343
		10 min. chess; 5 min. rest	8	50	2392

In Experiments 3, 5, 6, and 8 both correct responses and time values indicate inhibition, but not so clearly as do those of the former investigators. In the other experiments the results are negative or doubtful.

Another group of four experiments examined a large number of different distributions of rest and work. In two the interpolated period was fifteen minutes in length, arranged thus: Rest 15, Work 0; Rest 14, Work 1; Rest 13, Work 2, etc., until the condition had become Rest 0, Work 15. In the other two experiments the last nine

minutes were given over to rest in each case, while the activity of the first six minutes was varied.

Since in only the case where there is no rest period does the work immediately follow the learning, the direct comparison will be made between this and the first condition, Rest 15, Work 0, in the case of the first two experiments.

Exp.		n	Interpolated Interval	RL	%R	Time
1	R	28	Rest 15 min.	16	18	2250
	W		15 min. work arithmetic	16	18	4250
2	R	51	15 min. rest	16	50	6700
	W		15 min. work arithmetic	16	55	6850
9	R	140	15 min. rest	10	41	6349
	W		6 min. arithmetic; 9 min. rest	10	31	4669
10	R	42	15 min. rest	10	33	2500
	W		6 min. arithmetic; 9 min. rest	10	36	2149

Slight indication of the influence of retroactive inhibition is found in the percentage of success record in Experiment 9 and in the time records of 1 and 2, but not nearly so conclusive as that found in the former studies.

In Experiment 4 DeCamp tested two distributions: Rest 6, Work 9, and Rest 2 and Work 13. Experiment 12 was the only test where a number of individuals was used. Experiment 13 was made with the Reconstruction method. Records were kept of errors in position and of time in

Experiment 13. The results of Experiments 4, 12, and 13 follow.

Exp.		n	Interpolated Interval	RL	%R	Time
4	W_1	70	6 min. rest; 9 min. work	10	29.	2675
	W_2		2 min. rest; 13 min. work	10	37	3328
12	R	14	15 min. rest	12	42.5	2047
	W		6 min. solving problems; 9 min. rest	12	42.0	2184
					Errors	
13	R	36	3 min. rest		10.4	67.4sec.
	W		2 min. arithmetic; 1 min. rest		11.7	66.2

Here again no evidence is shown of the influence of retroactive inhibition.

Before DeCamp's study was published Tolman (14), also working with the assumption that the principle of retroactive inhibition had been definitely established, began to work on a special phase of the problem, i.e., the effect of the conditions of learning . The conditions studied were these:

1. Pleasant vs. indifferent;
2. Normal vs. distracted attention;
3. With caffeine vs. with caffeine; and
4. Efficient vs. inefficient working periods.

In each pair of conditions he describes the conditions as "more stimulating" or "less stimulating."

Under the first conditions, in which the materials learned consisted of work lists or lists of words and numbers judged pleasant by the experimenter or by himself

and a few observers, four experiments were carried out. The materials all through were presented either on a revolving kymograph drum, or on the Rupp-Lipmann apparatus. Time was taken by a lip key and stop watch connected with an electric magnet. The Right Associates method was used throughout. The results follow:

Exp.		n	Interpolated Interval	Pleasant RL	Pleasant %R	Indifferent RL	Indifferent %R
1	R	40	9 min. rest	2.5	60	3.1	80
	W		3 min. study checker-board of consonants		40		35
2	R	48	9 min. rest	8.9	52.1	9.8	60
	W		3 min. study checker-board of consonants		64.6		47.9
3	R	40	6 min. rest	8.9	52.5	10.9	52.5
	W		3 min. study checker-board of consonants		57.5		42.5
4	R	40	6 min. rest	7.6	42.5	8.6	46.3
	W		3 min. studying checker board of consonants		55.0		47.5

It will be noted that the number of repetitions for the learning of the pleasant and indifferent lists varies throughout. This is to satisfy this condition: If it is to be proved conclusively that the work done under the "less stimulating conditions" is really more affected by retroactive inhibition than the work done under the "more stimulating conditions", the percentage of successful recalls for the "less stimulating" R lists must be greater than, or equal to, that of the W lists. Only then will

a greater difference of percentage of successes for the "less stimulating" R lists minus the percentage of successes for the "less stimulating" W lists than the percentage of successes for the "more stimulating" R lists minus the percentage of successes for the "more stimulating" W lists indicate conclusively that the "less stimulating" condition was affected by work.

In so far as the results of Experiments 2, 3, and 4 indicate no inhibition or even facilitation for the pleasant lists, and but slight inhibition for the indifferent lists, the negative findings of DeCamp are supported. However, in so far as when combined with Experiment 1, they present a uniform tendency for retroactive inhibition to appear more readily in the indifferent lists, they point to a possibility that in the case of two contrasted conditions of learning, one condition may be consistently more affected by retroactive inhibition than the other. The succeeding experiments were undertaken to test out this possibility.

The second group of experiments dealt with normal vs. distracted attention. Distracted attention was brought about by the tapping of a telegraph key on the revolving drum, which the subject was required to duplicate by striking a pencil on the table as he studied the syllables. These results were obtained:

Exp.	n	Interpolated Interval	Normal RL	Normal %R	Distracted RL	Distracted %R
5 R	72	6 min. rest	7.6	43.1	16.8	41.7
W		2 min. study checker-board of numbers; rest				

The evidence for inhibition in these results is so slight as to be negligible.

Two experiments followed on the comparison of the "with caffeine" and "without caffeine" condition:

Exp.	n	Interpolated Interval	With Caffeine RL	With Caffeine %R	Without Caffeine RL	Without Caffeine %R
6 R	48	7½ min. rest	9.5	37.5	10.5	50.0
W		2 min. study checker-board of numbers; rest		41.7		27.1
7 R	72	7½ min. rest	15.0	41.7	13.8	55.6
W		2 min. study checker-board of numbers; rest		29.2		30.6

The results of both show some evidence of greater inhibition on the non-caffeine days.

Experiments 8, 9, 10, 11, 12, and 13 made a comparison of the influence of retroactive inhibition under "efficient" and "inefficient" conditions, i.e., morning and evening, or morning and afternoon. The results follow:

Exp.		n	Interpolated Interval	Morning RL	Morning %R	Evening RL	Evening %R
8	R	50	8½ min. rest	9.5	44	21.8	52.0
	W		2 min. study checker-board of numbers; rest		42		34
9	R	30	8½ min. rest	9.3	36.7	12.5	43.3
	W		2 min. study checker-board of numbers; rest		26.7		26.7
				Morning		Afternoon	
10	R	30	8½ min. rest	9.7	50.0	14.8	50.0
	W		2 min. study checker-board of numbers; rest		36.7		23.3
11	R	30	8½ min. rest	9.0	56.7	14.0	56.7
	W		2 min. study checker-board of numbers; rest		43.3		26.7
12	R	30	8½ min. rest	7.2	66.7	9.0	66.7
	W		2 min. study checker-board of numbers; rest		60.0		50.0
13	R	50	8½ min. rest	4.5	54.0	8.4	68.0
	W		2 min. study checker-board of numbers; rest		56.0		48.0

Tolman's own conclusion for these six experiments is: "Without exception the lists learned in the inefficient hour of the day showed more inhibition, in terms of percentages of correct responses, than did those learned in the efficient hour of the day.

Briefly stated Tolman's results seem to indicate greater inhibition under what he calls "less stimulating conditions of learning", i.e., learning indifferent material, learning without caffeine, learning in an inefficient hour of the day, than under "more stimulating

conditions."

Robinson (10) concerned himself with the problems of the effect of similarity and dissimilarity of original and interpolated activity, temporal position, and the degree of learning.

Three experiments were made to study the first condition. In two of these the original problem was learning series of eight four-place numbers. The third was made with the Reconstruction method, a chess board and six chess men being used. The interpolated activities were (1)memorizing a second series of four-place numbers; (2) memorizing 20 consonants; (3)memorizing poetry; (4) solving four-place by four-place multiplication problems; and (5)reading simple narrative prose. In Experiment 2 a sixth activity was introduced, the study of pictures of nudes, which was intended to introduce the factor of affective tone.

Three criteria of recall were used: (1)Amount of recall; (2)Error of recall; and (3)Time, being the total time for reproduction divided by the number of digits given in the reproduction.

The results follow:

Exp.	Interpolated Interval (3 minutes)	Amount Recall (digits)	Error Recall	Time secs.
1	Studying numbers	15.4	27.5	5.73
	Consonants	22.4	17.4	3.07
	Poetry	21.9	19.3	3.57
	Multiplication	22.1	15.7	3.55
	Reading	22.8	16.5	
2	4-place numbers	15.3	33.8	5.50
	Digits	18.2	22.4	4.30
	Multiplication	20.6	21.5	4.08
	Pictures of nudes	20.6	22.3	3.15
	Reading	21.4	19.1	3.38

These results indicate a greater amount of inhibition in the case where work consisted in the learning of a second series of numbers than in any other condition. Reading produced the least deleterious effect.

Experiment 4 considered the effect of temporal position. Materials for original learning consisted of lists of ten three-place numbers, displayed on a hand operated drum. The twenty minutes of interpolated activity were used as is shown in this summary of conditions and results:

Exp.	Interpolated Interval	Amount Recall (digits)	Error Recall	Time secs.
4	20 min. reading	29.1	6.1	1.6
	5 min. study second list; 15 min. reading	18.6	31.9	5.9
	5 min. reading; 10 min. study second list; 5 min. reading	19.7	29.0	5.5

10 min. reading; 5 min. study second list; 5 min. reading	19.2	32.6	6.4
15 min. reading; 5 min. study second list	18.4	30.3	6.9

From these results it would seem that temporal position plays no important part in influencing the susceptibility to retroactive inhibition.

Individual records kept for the subjects seem to indicate that there is a tendency for practice to lower susceptibility to inhibition. This was also indicated in the chess experiment, where a practiced chess player showed much less inhibition than those who had played.

To study the effect of the degree of learning the conditions were the same as in Experiment 4, except that the number of repetitions was varied and the time kept constant. The results show the relative amount of loss under the various conditions. This is determined by dividing the difference in efficiency between Rest and Work conditions by the efficiency under the Rest condition.

Presentations	Amount of Inhibition	Time secs.	%Error
4	59.3	233	26
6	56.6	151	73
8	45.4	115	98
10	45.3	176	156
12	45.3	367	117

It is evident that within the limits here studied the results indicate that the number of repetitions, or the degree of learning, has no general tendency to increase or decrease the amount of inhibition.

The conclusions drawn from this study are these:

1. Similarity of contents, or processes, and of forms of presentation all play a part in determining the degree of retroactive inhibition.

2. The degree of retroactive inhibition is independent of the temporal position of the interpolation.

3. Practice in memorizing a particular kind of material may decrease one's susceptibility to retroactive inhibition.

4. Within the limits studied there is no single, continuous relationship between the number of presentations of a memorized material and its absolute susceptibility to retroactive inhibition.

Robinson, in two further studies, deals with the length of lists and susceptibility to retroactive inhibition, using in one (9) nonsense syllables, and in the other (11) numbers as original learning. In the first study ten subjects were used, each serving in ten different conditions three times. The conditions were those of the regular work and rest tests for five different lengths of series, 6, 9, 12, 15, and 18 syllables. Interpolated

work consisted in learning a new series of 12 syllables. The period was 15 minutes in length.

In the number test ten subjects were put through eight conditions four times. The lists were made up of 4, 6, 8 and 10 three-place numbers. Interpolated work consisted in learning a new series of 6 three-place numbers (15 minutes study). During the rest interval in each case the subject read the newspaper.

The average of the records for ten subjects with three repetitions for each condition are given here:

Nonsense Syllables

Repetitions	Inhibition	
	Absolute	Relative
6	25.2	33.3
9	21.6	27.2
12	16.9	24.7
15	13.8	17.2
18	16.1	18.6

Numbers

Repetitions	Inhibition	
	Absolute	Relative
4	30.8	51.3
6	45.0	68.1
8	34.1	52.0
10	23.9	32.8

Absolute inhibition is determined by subtracting the recall under the work condition from the recall under the rest condition. Relative inhibition is the percentage

which the absolute inhibition is of the recall under the rest condition.

The results of both studies show a decreasing susceptibility to retroaction as the lists increase in length, with some evidence of a lower limit of the law.

The most recently reported study of retroactive inhibition is that of Skaggs (13), who has dealt with several major problems:

1. The evidence for retroactive inhibition;
2. The effect of temporal position;
3. The effect of similarity and dissimilarity of original and interpolated activity; and
4. The effect of fatigue, which is a comparison of results of morning and evening studies.

Skaggs used as original learning activity the Reconstruction test, studying the arrangement of five chess men; series of disconnected sense words, and series of nonsense syllables, the latter dealt with both by simple recall and Right Associates methods.

His subjects were divided into three groups, trained, semi-trained, and untrained, according to their experience in introspecting.

In the reconstruction test the arrangement was exposed for 15 seconds. The sense words were exposed serially at the rate of one per 1.5 seconds by moving a long covering cardboard, containing a small lateral window cut in it, down a card on which the words were printed. The

exposure was timed by a silent pendulum.

The results will be presented here as they concern the problems in the order above stated, rather than grouped according to method used as in the report of the work.

Four experiments deal with the comparison of work and rest intervals.

Reconstruction Test

	n	Interpolated Interval	Errors	M.V.	Time secs.	M.V.
R	156	½ min. rest	4.21	.61	55.95	3.38
W		½ min. adding	8.55	.45	65.66	10.98
R		1 min. rest	5.95	1.27	55.55	17.53
W		1 min. adding	9.04	2.07	66.01	19.85
R		2 min. rest	6.88	2.24	57.05	20.20
W		2 min. adding	9.42	3.53	74.01	26.12

(M.V. refers to mean variation.)

Sense-Word Test

	n	Interpolated Interval	%R	Error	Time secs.
R	37	1 min. rest	6.2	0.63	65.0
W		1 min. adding	5.69	0.50	68.7

Nonsense Syllables: Recall Method

R	84	3 min. rest	4.10	0.64	77.4
W		3 min. mathematical test	3.39	0.52	74.9

Nonsense Syllables: Right Associates Method

				(sigma)
R	5 min. rest	3.54	1.43	5283
W	5 min. dissimilar work, or	3.89	0.98	5548
	5 min. similar work	3.39	1.44	5452

(The types of work described as similar and dissimilar will be explained in a later test.)

These tables show some evidence of inhibition, considering time, errors, and correct recalls. On the last, the Right Associates test with nonsense syllables, there is the least indication, in fact, so little as to be negligible. The method here was much like DeCamp's and fifteen repetitions were given for original learning. Probably the material was over-learned.

Tests taken in morning and evening, also the first and last of the series, were compared for comparison of work with and without fatigue. The reconstruction test alone was used in this group of experiments. The trained subjects showed no more tendency to retroaction in the evening than in the morning. Comparing first and last in the series seems to indicate some retroaction, but whether this is due to fatigue or lack of continued interest or interference of the learning immediately preceding could not be made clear.

The effect of practice was determined by a comparison of the averages of the first half of an entire series of twenty experiments for 5 trained subjects with the averages for the last half of the series. The results of the experiments using the reconstruction method are presented for individuals, but are too complicated to be reproduced here. Out of twenty-three possible comparisons eleven show greater retroaction for the first half, ten for the

latter half, and two are so close that they may be regarded as neutral. No definite conclusion can be drawn.

Comparing results obtained when using sense words shows a slight tendency for retroactive inhibition to increase with practice, but the work is too limited for any general conclusions to be drawn.

In studying the effect of varying temporal interpolation several methods were again employed. In the experiments involving the use of sense words as original learning but two subjects worked. The results were diametrically opposed, one showing less inhibition where rest follows learning, the other when work follows immediately.

Two experiments were made using nonsense syllables, one with simple recall, one with Right Associates method. These results were obtained; (Averages for five subjects)

n	Interpolated Interval	RL	%R	Error	Time secs.
162	3 min. rest; 3 min. work arithmetic or algebra	3	3.22	0.58	73.8
	1 min. rest; 3 work; 2 rest		3.75	0.38	62.6
	3 min. work; 3 rest		2.79	0.70	71.4

There results would tend to indicate that the temporal position of the work is important, work following immediately after learning produces greater inhibition. However, a control experiment with 13 untrained subjects

gave doubtful results:

n	Interpolated Interval	RL	%R	Error	Time secs.
52	2 min. rest; 3 work; 1 min. read magazine	3	2.95	0.85	67.3
	3 min. work; 2 rest; 1 min. read magazine		2.72	0.80	57.3

Time alone gives an indication worth mentioning that the effect is greater when work follows immediately. Of the individuals seven showed more retroaction for the immediate work interval, six showed more for the immediate rest interval.

The Right Associates method gave these results:

n	Interpolated Interval	RL	%R	Error	Time sigma
49	3 min. rest; 3 work; 1 min. looking at catalog	3	3.98	1.38	3184
	3 min. work; 3 min. rest; 1 min. looking at catalog		3.67	1.37	3309

The time record again indicates retroaction; the other records show too little to justify the drawing of any conclusions, although Skaggs does conclude that "a careful analysis of the above results justifies us in saying that the temporal position is important--with apparent individual exceptions."

The final question dealt with is the effect of similarity or dissimilarity of original and interpolated material. The reconstruction test and nonsense syllables were used.

The reconstruction test gave these results, with the conditions as indicated: (Averages for 5 subjects)

n	Interpolated Interval	Errors	Time secs.
50	1. New chess formation (similar work)	13.05	62.4
	2. Formation on white cardboard with black lines of large white button, black button, red checker, black checker, and a pawn (intermediate work)	9.24	60.2
	3. Multiplication (dissimilar)	9.75	64.5
	4. Study post card pictures (dissimilar)	7.10	34.5
	(Averages for 9 subjects)		
45	1. Similar (as above)	11.44	59.6
	2. Intermediate (as above)	8.7	51.7
	3. Dissimilar (as above)	6.1	42.5

Robinson's findings are confirmed. Apparently the effect varies with the degree of similarity.

The Right Associates method was used in one experiment with nonsense syllables, showing very little evidence of retroaction. Single syllables with the simple recall method showed retroaction in the records of correct recalls and errors, but not in time.

From this series of experiments Skaggs draws the following conclusions:

1. All the tests except the paired associates show

greater inhibition when work follows learning than when rest follows.

2. All tests (except reaction time for paired associates) show the importance of similarity and dissimilarity of original learning and interpolation in this relation:

A. When interpolation and learning are identical there is only reinforcement or repetition.

B. As the material is made (by degrees) more and more dissimilar the reinforcing factors gradually diminish in effectiveness and the interfering factors become more and more pronounced.

C. As the material of learning and work is made more dissimilar a point is reached where there is a maximum of interference or detrimental influence wrought upon the original learning.

D. Beyond this point the curve of interference goes downward, and then we can say that the more dissimilar the materials the less the detrimental influence.

E. However, the curve of detrimental influence never reaches zero because after the work and learning are as different as can possibly be made there is still a damaging influence exerted by the work.

3. The data accumulated indicate that the temporal position of the interpolated work is important.

4. On the basis of the data from the reconstruction experiments there seems evidence that as the subject becomes more and more fatigued in the course of the day's series the work activity acts relatively more detrimentally upon the original learning.

5. The data regarding the effect of practice are not clear.

Comparative Studies

Three other studies should be mentioned here: that of Webb with human subjects and rats, and those of Brockbank and Hunter with rats.

Webb (15) studied the effects of interpolated activities upon the retention of motor habits. Mazes were used for both original learning and interpolation, for the human subjects, pencil mazes, and for the rats the adjustable Hampton Court maze.

The subjects were divided into ten groups, five used as test groups and five as control groups. There were five in each group of human subjects and from seven to twelve in each group of rats. A test and a control group were trained to a variation of the maze (B, C, D, E, and F). The control group then rested, while the

test group in each case were trained to maze A. The retroactive effect was measured by the difference in the records of time, trials, and errors in relearning the original maze (B, C, D, E, or F).

A second experiment was the same, except that the mastery of maze A was the original learning, while the training of each group to another, (B, C, D, E, or F) served as interpolation. Thirty days after learning the new maze all were retrained for Maze A. The control groups in this case learned Maze A and then rested until the time for relearning.

Webb's conclusions from the results obtained from these experiments are:

1. The greater degree of disintegration occurred for the test groups.

2. The existence of retroaction is a function of the individual.

3. Human subjects are more susceptible than rats to the disintegrating effect of retroactive influences.

4. The degree of retroactive inhibition is the function of the interpolated maze actibity, varying with the difficulty of the interpolated maze learning.

Brockbank (1) used mazes as original learning, with the rope-ladder problem as interpolated activity. Comparison was again made between the records of a test and

a control group for relearning the maze. This comparison showed no evidence of inhibition for the test group. A comparison of the results of Webb and Brockbank seems to indicate that the similarity or dissimilarity of interpolated activity and original learning may also be an important factor with rats, as Robinson and Skaggs have shown it to be with humans.

Hunter (4) dealt with the interference of auditory-motor habits in the white rat. Twenty rats were trained to turn left in the ordinary T-shaped discrimination box for handclaps, and left for silence. All the rats learned the problem in from 210 to 710 trials.

The general plan of the work was as follows:

A. 20 rats trained to turn right for handclaps, left for silence.

B. 4 rats of Set A trained 30 days to turn right for a buzzer.

C. 4 rats of Set A trained 30 days to turn right for a tuning fork.

D. 4 rats of Set A trained 30 days to turn left for a tuning fork.

E. 4 rats of Set A trained 30 days on regular presentation of auditory stimulus.

F. 4 rats of Set A tested for retention after 30 days rest.

G. Rats of groups B, C, D, and E tested on handclaps.

Comparison was made of the records of the relative retention of the first problem for all groups,

There is no indication of the influence of retroactive inhibition, but rather a "forward reference", an interference of the first habit in the forming of the second. Hunter's own statement on the problem is this: "We have brought to light no evidence that learning the second habit as such interferes with the retention of the first habit. It seems clear that in some cases the lapse of time may be more effective than intervening training in disintegrating a habit."

Summary of Problems Investigated

An enumeration of the specific problems investigated and the results of their examination by the various experimenters follows:

1. The existence of the principle of retroactive inhibition in recall memory. All investigators except DeCamp have found definite indications of retroactive inhibition, i.e., poorer records are made after interpolated work than after interpolated rest. DeCamp used multiplication and physical work as interpolated activity with nonsense syllables as original learning. Robinson and Skaggs have clearly shown that dissimilar activities produce relatively little inhibition. Moreover, DeCamp was the only one who presented the members of the pairs of syllables simultaneously, and in most instances gave a greater number of

repetitions for learning than did others, except those studying the effect of the degree of learning. Skaggs, using the Right Associates method, found little evidence for inhibition where he gave fifteen repetitions. These differences in method may partially account for the differences in results. Individual differences may also be an important factor. In all investigations except those of Robinson and Skaggs, conclusions are based upon a number of experiments with one individual. When more than one was used the results often vary greatly between individuals.

In the case of recall memory it seems safe to conclude that there is such a factor as retroactive inhibition.

2. The existence of the principle of retroactive inhibition in recognition memory. Heine's experiments seem to show conclusively the absence of the influence of retroactive inhibition in recognition memory.

3. Factors influencing the degree of retroactive inhibition:

a. The effect of the temporal position of interpolation. On this question there is disagreement. Müller and Pilzecker, on the basis of the results of one experiment, concluded that memory was less affected if rest followed immediately than if work followed immediately after learning. DeCamp's results are doubtful. Robinson's

results lead him to conclude that the degree of inhibition is independent of the temporal position. Skaggs' results support those of Müller and Pilzecker in general, although I should say not conclusively: using the reconstruction test, both time and errors indicate greater inhibition for the "work at once" test, while for the two subjects using sense words, results are diametrically opposed and using nonsense syllables, 9 untrained subjects give doubtful results. This question seems to be undecided.

b. Similarity of original and interpolated activity. Müll and Pilzecker here again drew a general conclusion on the basis of results of one experiment, stating that the degree of inhibition was independent of this relationship between original and interpolated activity. Robinson investigated the problem more thoroughly and concluded that "the degree of retroactive inhibition present in a given situation is a function of the similarity between interpolated activity and original learning," although "where, on the face of things, interpolation and original learning are comparatively dissimilar there may still be an appreciable degree of retroactive inhibition." Skaggs' conclusions are very similar, showing that identical learning and interpolation gives only reinforcement, and the varying in degrees of similarity produces interference or inhibition to a certain high

point, after which further tendencies toward dissimilarity decrease inhibition, but never to zero.

A comparison of Brockbank's and Webb's results with animals indicate that this factor is also important in animal learning. Brockbank used different interpolation and found no inhibition, while Webb used similar interpolation and found indications of inhibition.

The point seems well established that the degree of retroaction varies with the degree of similarity or dissimilarity between original learning and interpolation.

c. Degree of learning. Heine and Robinson have investigated this factor. Their results are contradictory. Heine compared only two degrees of learning, while Robinson made a series of four comparison, where he found no general tendency either way.

d. The effect of practice. Apparently contradictory results have been obtained on this question by Robinson and Skaggs. Robinson found with a practiced chess player less inhibition than with subjects who did not play chess. Skaggs, on the other hand, compared records of trained subjects in the reconstruction test for the first and last five of twenty trials, a comparison which showed no effect of practice. However, it would seem that twenty "practices" in the reconstruction test is too different from long practice in playing chess to be classed in the

same category of practice. Skaggs' comparison of results of the first half and the last half of a series of twelve experiments with sense words shows a slight increase of inhibition.

e. Conditions of learning. Tolman found less inhibition under what he classed as "more stimulating" conditions than under his "less stimulating" conditions. Skaggs fails to substantiate his results so far as fatigue (measured by morning and evening conditions) is concerned, finding that if learning was as good in the evening as in the morning, the work interval was no more detrimental.

f. Length of series. Robinson's results on this question stand unquestioned: There is a decreasing susceptibility to retroactive inhibition as the material (number lists and nonsense syllable lists) increases in length. Although there is "good evidence of a lower limit to this law", as yet no work has been done to decide this.

g. Individual variation. This question has been touched upon only by Webb, although other results would tend to indicate that is is important.

h. Effect of difficulty of interpolation. Webb suggests that the degree of inhibition is the function of the relative difficulty of the interpolation. No one has definitely disputed this, although Robinson says that

the degree of inhibition is the function of the relative similarity between original learning and interpolation, thus implying that the difficulty of the interpolation is not the important factor.

i. Relative susceptibility of rats and humans to retroactive inhibition. Webb's conclusion that human subjects are more susceptible to retroactive inhibition than rats stands unquestioned thus far.

j. Forward reference vs. retroactive inhibition. Hunter's results with rats show that there is interference of the first habit in the formation of the second rather than a retroactive influence so far as his work with auditory-motor habits is concerned.

Theories of Retroactive Inhibition

Two general theories have been proposed to explain the phenomenon of retroactive inhibition: the Perservation Theory of Müller and Pilzecker, and the Transfer Theory, proposed by DeCamp and qualified by Webb and Robinson.

Müller and Pilzecker believed that the processes underlying retroactive inhibition and perservation were the same. Memorizing is followed by a period of gradually diminishing activity of the neural elements involved in the memorizing. Any mental activity immediately follow-

ing memorizing interferes with this so-called "setting-in" process. Since the neural activity diminishes gradually, the deleterious effect of the work would vary inversely as the time elapsing between the end of memorizing and the beginning of work.

The validity of this theory is based upon the influence of the factor of temporal position, which, as has been shown, is still under dispute.

DeCamp's Transfer Theory is also based upon the setting-in process. However, according to his theory, the emphasis is placed upon the identity of the neurological groups operating in learning and interpolation, the amount of inhibition varying "directly as the relative identity of the neurological groups involved." (2, p.62)

The difficulty with this is that it does not take account of the fact that a degree of identity must be reached where reinforcement or repetition occur.

Webb suggested a transfer theory without reference to a setting-in process. Certain elements in the original learning process may become transferred from the pattern of the original learning to the pattern of the interpolation, so that the recall of the original may be interfered with. Again there may be a transfer of elements from interpolation to recall, which would show deleterious effects.

Robinson considers these theories too limited. He says, "There is no need for so limiting one's conceptions of similarity and transfer.....The transfer causing retroaction, for instance, may in one case be a transfer from memorizing to interpolation and in another a transfer from interpolation to recall. All that one need assume, in order to explain any retroaction in terms of transfer, is that the situations, memorizing, interpolation, and recall, have enough in common, through content, form, process, or even temporal contiguity, to insure the reinstatement of a part of one of the situations in intimate connection with another." (10, pp. 56-57)

Nature of Retroactive Inhibition

So far as actual facts are concerned, it is only known that retention is weakened when certain forms of activity occur between learning and recall. Both the terms, "retroactive" and "inhibition", may be misnomers. "Retroactive" implies an action or influence of the second activity upon the first, a "working back." There is no evidence that such is actually the case. The general term "inhibition" is physiological, and refers to a blocking or interfering influence of one process upon another. Perhaps that is what happens in so-called retroactive inhibition, but there is no direct evidence that

such is the case. In fact, Hunter's results with rats indicate a forward reference, but show no evidence that the learning of the second habit interferes with the retention of the first. In human subjects there does seem to be some such interference, but just what is the nature of the process is not known.

Problems Needing Further Investigation

Because of contradictory and uncertain results further investigation should be made upon a number of questions:

1. Robinson's conclusion as to the possible lower limit of the law of decreasing susceptibility to retroactive inhibition as the material increases in length suggests the determination of maximum and minimum lengths.

2. Further work should be done to settle the contradictions in the matter of the importance of the temporal position of interpolation in affecting the degree of retroactive inhibition.

3. If the temporal position of interpolation is important, further work should show the most economical position.

4. The question of the effect of practice has nowhere received adequate investigation.

General Criticisms

Some general criticims may be made of the work reported in this historical review:

1. Conclusions are based upon results obtained from work with very few subjects, especially by the earlier experimenters. Where groups were used in the same test the individual differences are very great, so great, in fact, that Webb concludes that the factor of retroactive inhibition in learning is a function of the individual.

2. In both Müller and Pilzecker's and Heine's reports only averages are given for a number of tests for each individual rather than the records of each test. Are these means representative? What were the mean variations?

3. Great importance has been placed upon the introspective report, particularly in the evaluation of the rest interval, by all except Robinson, who in some of his later experiments had his subjects read the newspaper during that period. Skaggs, for instance, classified his subjects into groups according to their practice in introspection and implies that the data obtained from the trained group is relatively more important than that from the untrained or from the semi-trained groups. Some objective means of controlling the activity during this period should be used.

Some Experimental Studies of Emotion

Because of the methods used in arousing emotional reactions, the work of Landis and Totten should be mentioned here.

Landis (5,6) has carried on a group of experiments in his study of facial expression and general behavior during emotional disturbances, using such stimuli as these: classical music, jazz, music, painting of nudes, paintings of Christ, vulgar pictures of direct sex appear, illustrations in "Diseases of China", unexpected strong odors, feeling for frogs in a bucket, electric shock, and cutting off the head of a live rat.

Totten (14) was concerned with the consumption of oxygen during emotional stimulation. In all cases her subjects were tied in the chair because of the type of apparatus necessary for the records desired. Such situations as earthworms being placed on the face, snakes near the face, and the experiencing of an expected electric shock, preceded by the sound of a buzzer, were used in this experimental work.

EXPERIMENTAL

Statement of Problem

The experimental work presented in this section deals with the effect of interpolated emotional reactions upon the retention of previously learned nonsense syllables.

Although there has been no work done bearing directly on this phase of the probelm, reference is made by several writers to a phenomenon called retrograde amnesia, reported by psychiatrists. This refers to the effect of a physical shock or emotional disturbance which seems to blot out the possibility of recall of events just preceding the shock. Thus Skaggs speaks of such a condition as opposed to normal conditions where the interpolation of vigorous mental work "with or without emotional aspects" seems to interfere with associations previously set up. Skaggs considers both as retroactive inhibition. Robinson also mentions retrograde amnesia as a "pathological instance of positively accelerated forgetting," and says that he does not feel in a position to say how his theory of transfer can be used profitably therewith."

Perhaps the few experiments in which Robinson gave as interpolated activity the study of pictures of nudes corresponds more closely to this study than any other that has been made. Robinson's purpose was to furnish "an activity with some affective tone." Landis, in his study

of emotional expression, used a similar stimulus to arouse an "emotional reaction". At all events, an interpolation of such an activity introduces a factor supposedly not found in ordinary reading or learning of numbers or syllables. The term emotional reaction will be used in this paper to refer to a general bodily disturbance.

Description of Apparatus and General Method

The general plan was that followed by the former studies: comparison was made between the results of two tests, one in which the rest period followed the learning, the other in which the emotional stimulus was given between learning and test.

The material for original learning consisted in four series of fifteen nonsense syllables, a list for each test. These were presented on cards, $5\frac{1}{2}$ x 9 in., hinged at the bottom. The subject was seated across the table from the experimenter, who exposed the syllables by turning the cards, the time of each exposure being approximately 2 seconds, between 35 and 40 seconds for the series. For the rest condition the subject read for the three minutes of interpolation. Two methods were employed to arouse the emotional reaction. These will be described below.

The subjects were students from the elementary

psychology class, all freshmen but two, who were juniors. Five of the eighteen who were used served in both experiments. None had had any former experience in the laboratory, and none knew the purpose of the experiment. Each came at a stated hour when he was given the test with the rest condition, and was asked to return at the same hour one week later, when he was given the test with the work condition. The exceptions to this are subjects O, P, and R in Experiment II, who went through both conditions in one day, with approximately one-half an hour between the tests. Record was taken only of the correct recalls.

Experiment I

Reaction to Strong Odors

For the original learning the syllables were exposed five times, with written recall after each exposure, and again after interpolation. The subject was given these instructions: "I am going to show you a series of nonsense syllables, one at a time. Study them as I show them, for I want you to write as many of them as you can remember after each time I show them."

For the rest interval these instructions were given: "Read aloud from this book (handing him Well's "History of Philosophy") until I tell you to stop." This occurred at the end of three minutes.

For the work interval the subject was given a group of nine bottles containing odors, all agreeable but two, ammonia and ammonium bisulphide, numbers 7 and 9 in the series. These two served as the stimuli in this experiment. The subject was instructed to smell each, and if he knew what it was, to mention the name, but not to take time to identify those of which he was uncertain. The reaction was much the same in all cases. Odors 1 to 6 were jasmine, geranium, nutmeg, orange, caraway, and cassia, all rather weak, so that by the time bottle 7 was reached the subject was sniffing closely and carefully. The reaction was a sudden start, and a quick sidewise movement of the head. The reaction to the ammonium bisulphide, bottle 9, was not so strong, perhaps partly because the odor itself is not so violent, and partly because the subject was a bit wary because of his experience with the ammonia.

The results of this experiment are shown in Table I, which is given on the next page.

Table I

Subject	Condition	No. of Correct Recalls Before	After	%Loss
A	R	11	7	36.3
	W	11	6	45.4
B	R	11	11	0.0
	W	12	12	0.0
C	R	11	11	0.0
	W	9	9	0.0
D	R	8	6	25.0
	W	9	6	33.3
E	R	15	15	0.0
	W	15	15	0,0
F	R	7	7	0.0
	W	9	9	0.0
G	R	13	13	0.0
	W	15	15	0.0
H	R	11	9	18.1
	W	12	11	8.3
I	R	14	14	0.0
	W	14	12	14.3
J	R	8	4	50.0
	W	9	8	11.1
K	R	7	7	0.0
	W	11	6	45.4
L	R	12	9	25.0
	W	14	13	7.0

Mean %Loss for the group: R.....12.08 M.V. 4.2
W.....13.70 M.V. 3.7

Length of interpolated interval was 3 minutes. "Before" refers to the recall before interpolation, "After" refers to the recall after interpolation. The %Loss is found by dividing the difference between the number recalled "Before" and the number recalled "After" interpola-

tion by the total number correct in the "Before" recall.

Mean of the total number of correct recalls "Before" for the 12 subjects..... R.....10.67 W.....11.67

Mean of the total number of correct recalls "After" for the 12 subjects..... R..... 9.41 W.....10.13

The averages show no general tendency, and the individual records vary very very greatly, from 0 to 50% in the percentage of loss. Of the individuals five show no loss for either the rest or the work interval. Four show more loss after the work interval, while three show more loss after the rest interval.

A comparison of the means of total correct responses before interpolation indicates that learning was approximately equal in both the rest and work tests. A similar comparison of means for the after interpolation recall records shows a small absolute loss in the work test as compared with the rest test.

Experiment II

Reaction to Loss of Support, Flash, and Noise

The syllables in this experiment were exposed six times, with written recall after the sixth and again after interpolation. The instructions to the subject were the same as those in Experiment I, except that he was asked for written recall only after the sixth exposure during

the original learning period.

During the rest period in this experiment the subject was asked to read silently from W. S. Franklin's "Bill's School and Mine" for the three minutes. Subjects I, D, H, G, and E served in both experiments.

The emotional stimulus was the sudden loss of support, caused by the falling of the back of the chair, together with the reaction caused by a light flash produced by the explosion of an Eastman flash cartridge, and the noise produced by falling weights. The apparatus and procedure were arranged in this way: The subject was seated in his usual chair, a morris chair, and instructed to lean back, close his eyes, and relax, while he repeated the alphabet as rapidly as possible. (Subject H read instead.) The back of the chair was held in position by a rod which lay in grooves on the backward extensions of the arms. A wire was fastened around this rod, passed up over a horizontal round in the back of the chair, and fastened at the other end to a weight, which lay upon a small platform which was screwed on the backward extension of the arm. A string was tied on the weight and passed across a table to the opposite side of the room. By pulling the weights off the chair arm by the string, the experimenter could cause the chair back to fall. The wire connecting the rod and the weights

was of sufficient length to allow the weights to strike the floor, thus producing a considerable crash. While the string was pulled with the right hand, the fuse of the flash cartridge was lit with the left by means of a candle which stood back of a screen. The cartridge was placed on a shelf to the side of the subject because of the danger of injury to the eyes produced by such an intense and sudden flash if it should be in direct view. The experimenter was protected by a small cardboard or tin screen, in which a hole had been cut to expose the fuse from the back.

The results of the experiment are presented in Table II.

Table II

Subject	Condition	No. of Correct Recalls Before	After	%Loss
I	R	9	9	0.0
	W	10	9	10.0
D	R	5	5	0.0
	W	6	6	0.0
M	R	3	3	0.0
	W	7	7	0.0
N	R	12	11	8.3
	W	6	5	16.6
H	R	11	9	18.1
	W	12	9	25.0
G	R	13	11	15.4
	W	13	12	7.7
O	R	5	2	60.0
	W	5	2	60.0
E	R	15	14	6.6
	W	11	8	27.3
P	R	9	6	33.3
	W	13	11	15.4
Q	R	9	7	22.2
	W	8	6	25.0
R	R	9	8	11.1
	W	11	10	9.1

Mean %Loss for the group: R.....15.9 M.V. 5.4
W.....17.8 M.V. 5.4

Mean of the total number of correct recalls "Before" for the 11 subjects..... R.....10.27
W.....9.11

Mean of the total number of correct recalls "After" for the 11 subjects..... R..... 8.45
W..... 8.45

In this experiment two subjects show no loss in either the rest or the work test, one shows the same loss in both, four show more loss in the rest test, and five show more in the work test. The average shows so little greater loss for the work period as to be negligible so far as evidence of retroactive inhibition is concerned.

The mean of recalls before interpolation shows again that original learning was approximately equal in the rest and work tests. The means of the recalls after interpolation for both conditions were equal, showing that there was no more loss following the emotional disturbance than following the reading.

Although the results show no more influence of retroactive inhibition than those of the former experiment, the reaction was more pronounced in all cases. In two cases quite a decided reaction occurred: When the cartridge exploded in the test with subject O the cardboard screen caught on fire. The experimenter, in attempting to remove the flaming card, accidentally passed it in front of the electric fan, and dropped it on the floor as the flames increased. The subject was called upon to put the fire out. Not more than the three minutes was taken in this procedure. The effect of this on O's total correct recalls was not greater than the three minutes interpolated reading.

In the test with subject Q the experimenter burned her hand on the tin screen (heated by the flash) and also was momentarily blinded by the flash. The two combined to call forth an exclamation, which apparently made Q think that something serious had happened. He jumped up from the chair (after catching himself as the back of the chair fell) and came around the table. When the experimenter explained that everything was all right, and asked him to go back and write the syllables again, he said, "Oh, I can't remember one of them now." As he sat down and tried to recall, however, they seemed to come back to him, and as the record of correct recalls shows, the loss was but very slightly greater than for the reading period. If a time record had been taken, in this case at least, there is no doubt that it would have indicated loss.

Discussion of Methods

The Effect of Practice

A statement may be made concerning the effect which practice in the learning of nonsense syllables may have had in this work. A comparison of the means of total correct recalls before interpolation under the rest and work conditions shows in both experiments that the influence of the little practice obtained was unimportant:

Experiment	Condition	Mean number of recalls before interpolation (12 subjects)
I	R	10.67
	W	11.67
		(11 subjects)
II	R	10.27
	W	9.11

A further comparison of the records of the five subjects who served in both experiments and thus learned four lists follows:

Experiment	Condition	Mean number of recalls before interpolation
I	R	12.2
	W	11.4
II	R	10.6
	W	10.4

This comparison indicates a slight decrease in the amount of recall with each succeeding trial. Whether this is due to interference of former lists, or decreasing interest and effort, or to chance variation cannot be determined. However, the variation is so slight that we may conclude that the effect of practice in these experiments was unimportant.

Reliability of the Recall Method

An attempt was made in connection with the experimental work described in this paper to determine the relia-

bility of the recall method as used in the study. Only recently has there been any attempt to evaluate methods used in the study of the learning process, although in the fields of mental testing and education the evaluation and standardization of tests has been an important problem since about 1900.

Heron (16), Hunter (17), and Randolph (18) have made studies on the reliability of the maze as a method of studying the learning process both with human and animal subjects. Hunter also made a study using nonsense syllables with the Right Associates method.

The general method used has been to give the same test twice to a group of subjects under as nearly the same conditions as possible. In order to eliminate as far as possible the effects of retention, the second test is given from 30 to 180 days after the first. Correlations are then determined between the individual records made in the two tests. A correlation of 0.70 or better is said to indicate a satisfactory reliability, while a lower correlation indicates the contrary. A test which shows a low reliability is in need of revision before it is used for scientific purposes.

Using the method described above, a group of 52 elementary history students were given two recall tests with nonsense syllables, one February 9, the other May 4,

84 days apart. The same list of 15 nonsense syllables were used each time, and conditions and instructions were the same. The syllables were exposed in the manner that has been described in connection with the main experiments of this study. Three exposures were given with written recall after each. These instructions were given: "I am going to show you a series of nonsense syllables. Study them as I show them, for I will ask you to write as many as you can recall after each exposure. Write them in order if possible, but write all you can remember, whether in order or not."

The trials were scored by giving one point for each syllable correct in kind. Correctness of position was not scored. No partial credit was given.

The total recall scores on the first three tests were correlated by the Pearson formula with the total recall scores in the second three tests. The coefficient so obtained was 0.84 0.025. This high correlation indicates that the recall method as used here is a reliable method for the study of the learning process.

Some General Criticisms

Several defects in the method used in this study of retroactive inhibition and the possible effect on the results may be mentioned here:

1. The subjects knew that recall would follow the interpolated interval in the second condition, i.e., the work condition, in each case, but had no way of knowing that such would be the case under the rest condition.

2. The written recall which was made before interpolation really served as an extra trial, and might easily have been used to good advantage, expecially where the subject knew that he would be called upon to reproduce the material again, i.e., in the work period.

3. The number of subjects was too small to justify the drawing of general conclusions, and individual differences were very great.

4. Time records were not taken.

CONCLUSIONS

The results obtained under the conditions of this experimental work indicate that the reactions here described as emotional have no more inhibitory effect than reading, which has previously been shown to have a very slight effect.

BIBLIOGRAPHY

1. Brockbank, T. W. Redintegration in the Albino Rat. Behav. Monog., 1919, 4.

2. DeCamp, J. E. A Study of Retroactive Inhibition. Psychol. Monog., 1919, 19, No. 84.

3. Heine, Rosa. Über Wiedererkennen und Rückwirkende Hemmung. Zsch. f. Psychol., 1914, 68, 161-236.

4. Hunter, W. S., and Yarbrough, J. U. The Interference of Auditory Habits in the White Rat. J. Anim. Behav., 1917, 7, 49-65.

5. Landis, Carney. Studies of Emotional Reaction: A Preliminary Study of Facial Expression. J. Exper. Psychol., 1924, 7, 325-341.

6. Landis, Carney. Studies of Emotional Reaction: General Behavior and Facial Expression. J. Comp. Psychol., 1924, 4, 447-501.

7. Müller, G. E., and Pilzecker, A. Die Rückwirkende Hemmung. Zsch. F. Psychol., Erg. I, 1900.

8. Robinson, E. S. Results of Variation in Length of Memorized Material. J. Exper. Psychol., 1922, 5, No. 6.

9. Robinson, E. S. Some Factors in Retroactive Inhibition. Psychol. Monog., 1920, 28, No. 128.

10. Robinson, E. S. Effect of Length of Lists upon Memory for Numbers. Amer. J. Psychol., 1924, 35, 235-243.

11. Skaggs, E. B. Further Studies in Retroactive Inhibition. Psychol. Monog., 1925, 34, No. 161.

12. Skaggs, E. B. The Concept of Retroactive Inhibition. Psychol. Rev., 1926, 33, 237-244.

13. Tolman, E. C. Retroactive Inhibition as Affected by Conditions of Learning. Psychol. Monog., 1917-1918, 25, No. 107.

14. Totten, Edith. Oxygen Consumption during Emotional Stimulation. Comp. Psychol. Monog., 1925, 3, No. 13.

15. Webb, L. W. Transfer of Training and Retroaction. Psychol. Monog., 1917, 24, No. 104.

References on the Reliability of Methods

16. Heron, W. T. The Reliability of the Inclined Plane Problem Box as a Method of Measuring the Learning Ability of the Rat. Comp. Psychol. Monog., 1922, 1, No. 1.

17. Hunter, W. S. Correlation Studies with the Maze in Rats and Humans. Comp. Psychol. Monog., 1924, 2, No. 8.

18. Randolph, V., and Hunter, W. S. A Note on the Reliability of the Maze as a Method of Studying Learning in the Angora Goat. Ped. Sem., 1926, 33, 3-9.