INTERACTION BETWEEN PROACTION AND RETROACTION IN SHORT-TERM RETENTION[1]

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WHEN A PERSON learns something and some time later is given a retention test on this material, his performance can be shown to depend on a large number of variables. Two important classes of these variables are proaction and retroaction. Proaction refers to the material or tasks learned or performed prior to the learning of the task whose retention is measured; retroaction is the material or tasks learned or performed between the learning of a given task and the test of its retention.

Experiments in the area of verbal learning and retention, such as those by Whitely and Blankenship (11), Twining (7), Melton and Von Lackum (4), McGeoch and Underwood (3), Thune and Underwood (6), and Underwood (8), have shown that under a variety of experimental conditions both proaction and retroaction lower performance on the retention test. The three experiments reported by Underwood (8) constitute a particularly clear demonstration that performance on the retention test is inversely related to the amount of proaction and amount of retroaction. He found that the greater the number of lists of words learned prior to the learning of a given list, the less the recall score for that list, and the greater the number of lists learned between the learning and retention test of a given list or the greater the number of practice trials on one such interpolated list, the less the recall of that list.

From Underwood's and other related experiments it would seem to follow that if the retention of a task is subject to *both* proaction and retroaction at the same time, then the two effects should summate in some fashion. In fact, the retention of any task, whether learned in the laboratory or outside, is subject to interference or facilitation by both proaction and retroaction. In typical experiments conducted to date, however, one of these classes of variables has usually been held constant while the effects of changes in the other are studied. Thus, if an investigator is interested in the effects of different amounts of retroaction on retention of some material, he may use different groups of subjects,

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each learning a different amount of interpolated material, but all being presumably equal on variables classified as proaction. For the so-called unpractised or naïve subjects the amount of experimentally manipulated proaction is zero in such an experiment, for practised subjects the amount of experimentally manipulated proaction may be defined in terms of the practice tasks that they all are required to do prior to the experiment proper or in terms of prior similar experimental experience. The essential point is that the class of variables called proaction in a typical retroaction experiment is controlled either statistically or experimentally, but not varied systematically, and so is the class of variables called retroaction in a typical proaction experiment.

If now, under certain conditions at least, learning a list of words prior to another lowers the recall of the second list (proactive inhibition), and if learning a list of words between the learning and recall of another also lowers the recall of the first (retroactive interference), then what would happen if the retention of a given list of words is subject to *both* proaction and retroaction? Consider, for instance, the following paradigm:

Group I	Learn A	Learn B		Recall B
Group II		Learn B	Learn C	Recall B
Group III		Learn B		Recall B
Group IV	Learn A	Learn B	Learn C	Recall B

If tasks A, B, and C consist of learning comparable lists of words we could predict that the recall of the critical list B is less for Group I than for Group III (proactive inhibition) and that it is less for Group II than for Group III (retroactive inhibition). Following Melton and von Lackum (**4**) we could also predict that for a short retention period recall of List B is less for Group II than for Group I or that proactive inhibition is smaller than retroactive inhibition.

The question that to the best of our knowledge has not been asked by any previous experimenters and the one that was of primary interest to us in this experiment is this: How does recall of B by Group IV compare with that by Groups I and II? Are the two effects, proactive and retroactive inhibition, additive, and if so, how are the effects combined? In other words, although it produces a real tongue-twister, what is the interaction between proaction and retroaction in short-term retention? The question can, of course, be asked about different lengths of retention periods. In fact, Underwood (**9**) has shown that there may be some interaction between amount of proaction and amount of retroaction on the one hand and the length of retention period on the other hand in determining recall performance, and hence it is quite possible that the kind of interaction found between proaction and retroaction itself changes with retention interval. In the present experiment, however, we limited our original question to a very short-term retention only.

We used a rather novel design to get at this problem. It is not completely free of defects, but it permits at least a rough answer to the question we asked. The design is a straightforward extension of the paradigm presented above, combined with a relatively seldom used method of learning verbal material and the method of free recall.

Method

Apparatus and Materials

Five lists of 16 words each were constructed. All words were 5- to 7-letter dissyllabic English nouns. For reasons not pertinent to this experiment the words in each list were selected from Thorndike's and Lorge's dictionary (**5**) according to their frequency of usage in printed English as follows: four words from among the thousand most frequently used words, four words from among the fifth thousand, four words from among the tenth thousand, and four words from the thirtieth thousand. A further restriction was that no two words in the same list should start with the same letter. The lists were varied in content on the basis of a pilot study so that all five lists were of approximately equal difficulty. The final lists are shown in Table I.

TABLE I

Lists of Words Used in the Experiment

List I	List II	List III	List IV	List V
action	buyer	accent	canard	amice
bandage	crumpet	barrack	daddy	bridle
crater	dipper	drumlin	flower	cherub
dinner	equine	finding	gambler	doctor
express	farrow	garden	hermit	ether
fiber	granite	hoyden	island	famine
gable	kitty	issue	letter	hamlet
hormone	linden	jungle	miser	lactose
legion	midden	lagoon	noodle	nature
octroi	novice	maxim	person	object
pustule	ocean	office	rumour	pilgrim
quinsy	picture	pomade	surtout	reason
satin	quarter	quillet	trochee	stamen
travel	result	treason	voter	trollop
viceroy	talker	valley	wafer	vulture
wallow	virgin	walker	zenith	waiver

For each list 16 different word orders were constructed in a systematic fashion such that each word appeared in each serial position just once and followed each other word in the list just once.

Two Gerbrands memory drums were used to present words at the rate of one word per 1½ sec. The drums and the *E* were separated from the *S* by a cardboard shield, with 2 by ½ in. slots cut to allow S to see the words appearing on the drums.

Subjects

Ss were 60 University of Toronto first year undergraduates enrolled in the Introductory Psychology course. Their age range was 18 to 30 years, with a median age of 20 years. They were randomly assigned to 5 experimental groups of 12 Ss each.

Procedure and Design

Each S learned 1, 2, 3, 4, or 5 lists consecutively, depending upon the experimental group to which he was assigned, and after a 10 min. interpolated activity attempted to recall all words from all previously learned lists. The detailed procedure was as follows: The first list of 16 words was presented to S 8 times in succession, in a different order on each trial, and with 5 sec. between trials. S then attempted to write down as many words as he remembered from the list. He was given 90 sec. to do this. No restrictions were placed on the order of words in recall. S's performance in this test for immediate recall, measured in terms of the number of words correctly recalled, was regarded as his learning (L) score for that list. The second list (if given) was then presented in the same way and the L-score obtained, then the third list, and so on until the number of lists prescribed for the S's group had been learned. S was then given 10 min. to complete the Shipley-Hartford Abstraction Test, and finally was instructed to write down as many words as possible from all of the previously learned lists. The time allowed for this final recall varied according to the experimental group; for each previously learned list 90 sec. were given to S for recall. Again no restrictions were imposed on the order of words in recall nor were Ss themselves asked to identify recalled words by the ordered number of the list from which each word came. All the words recalled by each S were inspected by *E* and assigned to various ordered lists for that S. The number of words correctly recalled by S from each previously learned list constituted his retention (R) score for that list. In a few cases words were recorded by S in the final recall which were not among those previously learned by S. These were disregarded in scoring.

In the original learning 6 of the 12 Ss in each experimental group were presented with 8 of the 16 different word orders of each list, and the other half of each group were shown the remaining 8 word orders of each list. The lists were assigned to individual Ss in a semi-systematic fashion so that different Ss learned different lists and different orders of lists.

The design is illustrated in Table II. From the table it can be seen, to consider Group D as an example, that the R-score for ordered list No. 3 is subject to 2 lists as proaction (ordered lists 1 and 2) and 1 list as retroaction (ordered list 4). Similarly, Group E's recall of the second list is subject to the proactive influence of 1 list and the retroactive influence of 3 lists, and so on. The final recall of the sole list in Group A, of course, is free from experimentally controlled proaction and retroaction.

TABLE II

EXPERIMENTAL DESIGN

Group	Original learning (ordered lists)					10 min. retention interval	Final recall
A					1	Standard activity	Free recall of
B				1	2	(Shipley-Hartford)	words in all
C			1	2	3		previously
D		1	2	3	4		learned lists
E	1	2	3	4	5		

The independent variables, proaction and retroaction, are thus measured in terms of the number of comparable lists learned prior to and following any given list. This design makes it possible to obtain measures of retention that are subject to various combinations of amounts of proaction and retroaction. Table III shows the categories of treatment combinations into which fall the data from final recall, and indicates which of the 5 groups contribute the data for each combination.

TABLE III

GROUPS CONTRIBUTING DATA FOR EACH COMBINATION OF AMOUNTS OF RETROACTION AND PROACTION

Amount of proaction (number of lists)	Amount of retroaction (number of lists) 0	1	2	3	4
0	A_1*	B_1	C_1	D_1	E_1
1	B_2	C_2	D_2	E_2	
2	C_3	D_3	E_3		
3	D_4	E_4			
4	E_5				

*Capital letters denote experimental groups, subscripts refer to the number of ordered lists.

RESULTS

The data included the number of words recalled immediately after the eight learning trials for a list (Learning or L), and the number of words from each list in final recall (Retention or R). These data are summarized in Table IV and Figures 1 and 2.

Table IV shows means and standard deviations of L-scores for each ordered list for each group. It is clear from the column means that there are no systematic differences between L-scores for different ordered lists.

TABLE IV

NUMBER OF WORDS RECALLED IMMEDIATELY AFTER EIGHT LEARNING TRIALS (L-SCORES): MEANS AND STANDARD DEVIATIONS

Group		Ordered lists 1	2	3	4	5
A	M	12.9				
	S.D.	1.8				
B	M	11.5	11.7			
	S.D.	2.3	3.0			
C	M	11.6	11.3	12.8		
	S.D.	1.5	0.96	1.9		
D	M	10.4	11.3	10.9	11.7	
	S.D.	2.2	2.6	2.8	2.1	
E	M	11.3	11.7	11.6	11.4	11.7
	S.D.	1.3	2.1	1.9	2.8	1.9
Column means		11.5	11.5	11.8	11.6	11.7

That is, there are no resultant effects due to warm-up, practice, or transfer. It is also evident that there are no substantial differences between L-scores for different groups.

The retention data were of primary interest in the experiment. Figure 1 shows mean R-scores as a function of retroaction for various amounts of proaction, and Figure 2 illustrates the same data with proaction on the abscissa and retroaction as the parameter. The analysis of these data was complicated by the facts that (1) the effects of the two independent

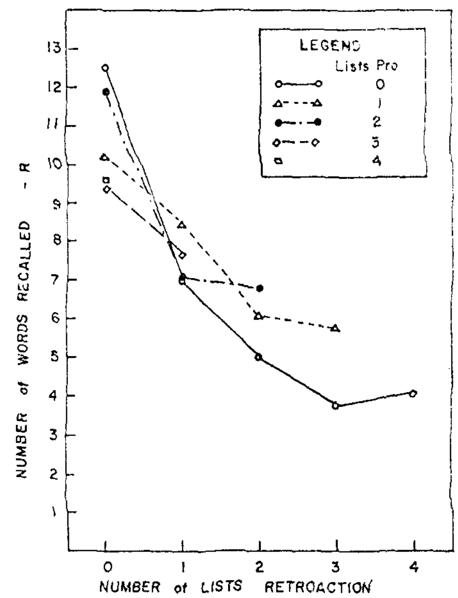

FIGURE 1. Ten-minute recall as a function of amount of retroaction. Each point represents the mean number of words recalled by 12 Ss under different amounts of retroaction (abscissa) and different amounts of proaction (parameter).

variables and their interaction are partially confounded with differences between subjects, and (2) the 5 × 5 proaction-retroaction table is incomplete. These difficulties are evident upon examination of Table III.

A preliminary analysis was performed upon the 3 × 3 table composed of the data from the combinations of zero, one, and two lists proaction and retroaction, assuming a completely orthogonal design. Under this assumption, the statistical model is not quite correct for the design used, but the tests are conservative. An analysis of covariance was used on

R with L as a covariant. The test for parallelism of individual regression lines indicated that it was reasonable to assume no interaction between L and the experimental treatments ($F = 1.72$, 8 and 90 df, $p > 0.10$). The covariance analysis showed that the interaction between proaction and retroaction was not significant ($F = 1.81$, 4 and 98 df, $p > 0.10$). Proaction was also not significant ($F = 0.73$, 2 and 98 df), but the hypothesis of no retroactive effect could not be rejected ($F = 36.4$, 2 and 98 df).

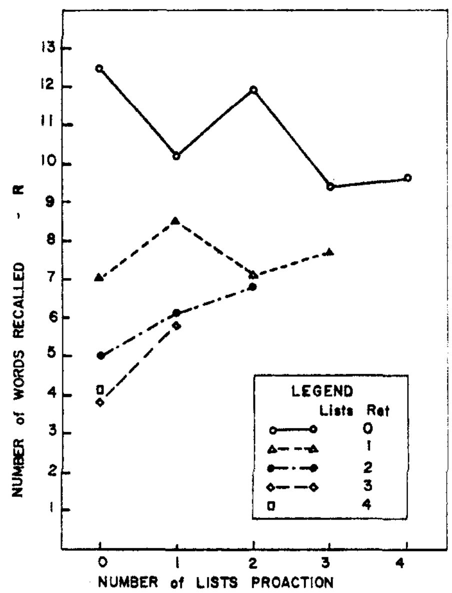

FIGURE 2. Ten-minute recall as a function of amount of proaction. Each point represents the mean number of words recalled by 12 Ss under different amounts of proaction (abscissa) and different amounts of retroaction (parameter).

The graph of Figure 2 suggests that the inclusion of the data missing from the preliminary analysis might result in the rejection of the null hypothesis of no interaction between proaction and retroaction. That is, for the sample used in this experiment, R decreases with increasing proaction for zero retroaction, but for one and two lists retroaction, proaction actually facilitates recall. However, individual analyses of covariance of R with L as covariant for zero, one, two, and three lists retroaction resulted in acceptance of the null hypothesis in each case

($F = 2.14$, 4 and 54, df, $p > 0.05$; $F = 0.932$, and 43 df; $F = 1.63$, 2 and 32 df, $p > 0.10$; $F = 1.30$, 1 and 21 df, $p > 0.25$; respectively). This means that there is not sufficient evidence to reject the hypothesis that all curves in Figure 2 are parallel to one another and to the abscissa.

Thus it can be concluded that increasing retroaction produces increasing decrement in 10 min. recall, whereas increasing proaction has no demonstrable effect.

Discussion

If we interpreted our results strictly in keeping with the practices of statistical zealots we would be forced to the conclusion that under the conditions of this experiment retroaction has a pronounced effect on 10 min. retention and that proaction has no effect. This would mean then that what affects retention is what has been learned after the learning of the list whose retention is measured, but not what has been learned prior to the learning of the designated list. We doubt whether anyone would have much quarrel with the statement that retroactive inhibition is a phenomenon which can be demonstrated under a wide range of experimental conditions, including those of the experiment reported here. For three reasons, however, we are somewhat reluctant to make a strong statement about proactive effects in this experiment. First, our statistical model, for reasons that we pointed out above, permits only conservative tests of the null hypothesis. In any case, when accepting the null hypothesis we might have made a Type II error. Second, the top curve in Figure 2, showing R as a function of proaction with retroaction absent, strongly suggests proactive inhibition. The computed F for this curve ($F = 2.14$, 4 and 54 df) is significant at the "Oh Shucks!"[2] level, and the interaction F in the preliminary analysis mentioned above also approached significance at the same level, suggesting interaction between proaction and retroaction. Third, other experimenters have clearly demonstrated proactive inhibition under somewhat different experimental conditions (1, 4, 8) and we like to believe in empirical evidence. Indeed, Underwood (**10**) has recently suggested that proaction plays a much more important role in forgetting than is commonly believed. It is possible, of course, that the absence of any proactive effects in the present experiment is related to the differences between the procedures used by previous experimenters and the design used in this experiment. If this is the case it becomes important to isolate and specify the variable or variables responsible for such differences. In view of the state of theories in this field at present such a problem would seem to be primarily an empirical one.

[2]Term used by G. A. Kelly, *Ann. Rev. Psychol.*, 1958, 9, p. 325.

From a look at the data in Figure 2, it is tempting to suggest that there is interaction between proaction and retroaction and that our failure to obtain a significant F for such interaction is related to large variability between the subjects. If we discard, at least for the present, the somewhat improbable possibility that proaction actually facilitates recall when combined with relatively greater amounts of retroaction, although it seems to be suggested by the sample curves for two and three lists of retroaction in Figure 2, then it would seem that proactive inhibition decreases with increasing amounts of retroaction. In such a case it would also follow logically that relative retroactive inhibition should be greatest with minimum amounts of proaction and that it decreases with increasing amounts of proaction. An evaluation of these hypotheses has to wait for further experimental work, since the evidence for them in this study was insufficient. If these hypotheses are supported by empirical evidence it would provide the theorists in this area with another whetstone on which to sharpen their tools.

There is relatively little that we would like to say about the effects of retroaction on retention found in this experiment. Our findings simply confirm the results from many previous studies that have demonstrated retroactive inhibition. The curve for zero amount of proaction in Figure 1 seems to be flattening off and approaching an asymptote, corroborating findings by Underwood (8) and Briggs (2).

The design that we have used in this experiment is not free from defects, but it has permitted us to look at the combined effects of proaction and retroaction and it can be considered a useful tool for extending our understanding of the phenomenon of retention and forgetting. An essential element in this design is the learning task given to the subject where he is required to learn to make individual responses without many restrictions upon stimuli to which these responses are appropriate. This makes it possible to ask for "free" recall of previously learned responses in the subsequent retention test and permits responses to be emitted in the order of their relative strengths. Although it is possible that the subject's earlier responses in the retention test may interfere with other, yet-to-be-made responses and thus introduce another source of error, the difficulty is not as serious with the method used here as it would be with the more traditional methods of serial anticipation and paired associates which have been used almost exclusively by previous investigators in studying proactive and retroactive effects on retention. The order in which responses are made by the subject in free recall is probably influenced by prior experimental conditions and by the independent variables used in the experiment. The order of recalled words in the first relearning trial with the method of serial anticipation or paired associates is, however, also influenced by the order in which the experimenter presents appropriate stimuli to the subject, which may constitute another source of variability. With these more orthodox methods another difficulty arises in connection with intra-list and inter-list intrusions. How should these be treated? Is an intrusion comparable to no response, indicating subliminal strength of that response? In what sense is an intrusion retained or forgotten? The method used in this experiment sidesteps these problems.

The main difficulty inherent in the design used has already been pointed out above: statistical analysis is difficult because of lack of an appropriate model. It is possible, of course, to eliminate partial confounding between subjects and the effects of the two independent variables by using data for one ordered list only from each group of subjects. Thus there should be two groups of subjects instead of a single Group B, three groups instead of Group C, and so on, in the present type of experiment. Eventually this may have to be done. At present, however, there are many more important sources of error to worry about and hence such a "pure" design may seem wasteful of experimenters' and subjects' time. In this experiment we should have used three times as many subjects as we did to get the same amount of data and a "pure" design.

Summary

In this experiment Ss learned lists of disparate English nouns by a modified method of serial presentation. The learning of each list was preceded and followed by the learning of other comparable lists. After a 10 min. period of interpolated activity retention scores for previously learned lists were obtained. The results showed that the number of lists learned prior to the learning of any particular list (amount of proaction) did not affect retention. Recall scores, however, were found to be inversely related to the number of lists that had been learned after a particular list (amount of retroaction), thus demonstrating retroactive inhibition. There was not sufficient evidence for accepting the hypothesis of interaction effects between proaction and retroaction although such interaction was suggested by the data.

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