DOCUMENT RESUME

ED 085 672 CS 000 864

AUTHOR	Underwood, Benton J.; And Others
TITLE	Associative Interference and Recognition Memory.
INSTITUTION	Northwestern Univ., Evanston, Ill.
SPONS AGENCY	Office of Naval Research, Washington, D.C. Personnel and Training Research Programs Office.
PUB DATE	Nov 73
NOTE	36p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Associative Learning; *Cognitive Processes; *Educational Research; Learning Processes; *Learning Theories; *Paired Associate Learning; Recall (Psychological)

ABSTRACT

Three experiments tested the generality of the conclusion that associative unlearning is minimal in the A-B, A-D paradigm. In Experiment 1, single-trial study of A-D, following single-trial study of A-B, did not produce retroactive inhibition in the recognition of A-B. In Experiment 2, A-B was acquired by associative matching. The interpolated learning was by the paired-associate anticipation method and included A-D and C-B pairs. There was no evidence for losses in A-B on a recall test. In Experiment 3, A-B was learned by a paced, multiple-choice procedure, and A-D and A-Br pairs in an interpolated list were learned under the same procedure. There was a small amount of associative unlearning following A-D, and heavy associative unlearning following A-Br. The possibility was offered that little associative unlearning is detected by recognition measures in A-B, A-D because recognition decisions are not commonly based on associative information. (Author)

ASSOCIATIVE INTERFERENCE AND RECOGNITION MEMORY

Benton J. Underwood, Joel Zimmerman, and Alan S. Brown

Northwestern University

November 1973

Project NR 154-321
Sponsored by
Personnel & Training Research Programs
Psychological Sciences Division
Office of Naval Research
Arlington, Virginia
Contract No. N00014-67-A-0356-0010

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Northwestern University Evanston, Illinois	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP -----
3. REPORT TITLE ASSOCIATIVE INTERFERENCE AND RECOGNITION MEMORY	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Technical Report	
5. AUTHOR(S) (First name, middle initial, last name) Benton J. Underwood, Joel Zimmerman, and Alan S. Brown	

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November, 1973	25	7

8a. CONTRACT OR GRANT NO. N00014-67-A-0356-0010	9a. ORIGINATOR'S REPORT NUMBER(S) ------
b. PROJECT NO. NR No. 154-321	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) ------
d.	
10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited	
11. SUPPLEMENTARY NOTES --------	12. SPONSORING MILITARY ACTIVITY Code 458 Personnel & Training Research Program, Office of Naval Research

13. ABSTRACT

Three experiments tested the generality of the conclusion that associative unlearning is minimal in the A-B, A-D paradigm. In Experiment 1, single-trial study of A-B did not produce retroactive inhibition in the recognition of A-B. In Experiment 2, A-B was acquired by associative matching. The interpolated learning was by the paired-associate anticipation method and included A-D and C-B pairs. There was no evidence for losses in A-B on a recall test. In Experiment 3, A-B was learned by a paced, multiple-choice procedure, and A-D and A-Br pairs in an interpolated list were learned under the same procedure. There was a small amount of associative unlearning following A-D, and heavy associative unlearning following A-Br. The possibility was offered that little associative unlearning is detected by recognition measures in A-B, A-D because recognition decisions are not commonly based on associative information.

DD FORM 1473 (PAGE 1)
NOV 65

S/N 0101-807-6801

Unclassified
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
RECOGNITION						
INTERFERENCE						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

ASSOCIATIVE INTERFERENCE AND RECOGNITION MEMORY

Benton J. Underwood, Joel Zimmerman, and Alan S. Brown

Northwestern University

November 1973

Project NR 154-321
Sponsored by
Personnel & Training Research Programs
Psychological Sciences Division
Office of Naval Research
Arlington, Virginia
Contract No. N00014-67-A-0356-0010

ASSOCIATIVE INTERFERENCE AND RECOGNITION MEMORY

Benton J. Underwood, Joel Zimmerman, and Alan S. Brown

Abstract

Three experiments tested the generality of the conclusion that associative unlearning is minimal in the A-B, A-D paradigm. In Experiment 1, single-trial study of A-D, following single-trial study of A-B, did not produce retroactive inhibition in the recognition of A-B. In Experiment 2, A-B was acquired by associative matching. The interpolated learning was by the paired-associate anticipation method and included A-D and C-B pairs. There was no evidence for losses in A-B on a recall test. In Experiment 3, A-B was learned by a paced, multiple-choice procedure, and A-D and A-Br pairs in an interpolated list were learned under the same procedure. There was a small amount of associative unlearning following A-D, and heavy associative unlearning following A-Br. The possibility was offered that little associative unlearning is detected by recognition measures in A-B, A-D because recognition decisions are not commonly based on associative information.

ASSOCIATIVE INTERFERENCE AND RECOGNITION MEMORY

Benton J. Underwood, Joel Zimmerman[1], and Alan S. Brown

Northwestern University

A recent article summarized the present status of unlearning as an empirical phenomenon, and as a theoretical component in accounts of forgetting produced by retroactive inhibition (Postman & Underwood, 1973). The fact of particular relevance to the present experiments is that unlearning of the association between A and B in the A-B, A-D paradigm is small in amount, and frequently is not found at all. This conclusion is based on studies in which recognition measures have been used to test the integrity of the A-B association. If the interpolated learning weakens the association between A and B, this weakening is insufficient to prevent the subject from correctly pairing A and B on a recognition test. In addition, it has been shown that the development of proactive interference as successive lists are learned and recalled does not occur if recognition rather than recall measures are used (Underwood, Broder, & Zimmerman, 1973). More generally, therefore, the conclusion seems to be that associative interference does not occur in recognition memory. There is one consistent exception, namely, the A-Br paradigm. Even with recognition tests, this paradigm produces appreciable decrements (e.g., Postman & Stark, 1969).

The conclusion that associative interference and unlearning are not found in recognition memory, or if found, are of very small magnitude, has important theoretical implications. Among other possibilities, it may suggest that the associative relationship within a pair of words is not fundamentally involved in recognition memory. Thus, the A-B

[1]Presently at Social Research, Inc., Chicago, Illinois.

association may have been weakened by A-D learning but if the association is not critical for recognition decisions, unlearning would not be found by recognition measures. However, before proceeding on such a possibility, it seemed worthwhile to obtain some evidence concerning the generality of the conclusion that there is a lack of interference in recognition memory produced by the A-B, A-D paradigm. Most of the analytical work on the issue has made use of the traditional two-list situation and paired-associate learning. In the experiments reported here, a deliberate attempt has been made to use somewhat different tasks and procedures from those commonly employed.

Experiment 1

A study by Bower and Bostrom (1968) represented a break with the classical methodology. Their results gave no evidence for interference in recognition memory. Since a null result is important in the theoretical context noted above, a replication of the Bower-Bostrom study is reported here as Experiment 1. In Experiments 2 and 3, other types of tasks and procedures were introduced.

The Ss in the Bower-Bostrom (1968) procedure were presented a series of pairs, one time each, and then tested on a YES-NO recognition list. Within the list presented were pairs which formed A-B, A-D paradigms. The results showed that hits for both A-B and A-D did not differ from the number of hits for control pairs. Thus, there was no evidence for either retroactive or proactive interference in recognition memory. That this was true was even more surprising in view of the fact that each S was given 15 successive lists in all of which the stimulus terms were bigrams and the response terms were single-digit numbers. Therefore, not only would successive lists form a series of A-B, C-B paradigms, but many letters of the stimulus terms would be repeated across lists. Given such a design, the study would seem to represent an impressive documentation of the complete lack of associative interference in recognition memory. Not only did the within-list paradigms fail to influence recognition, but the authors reported that there were no differences in performance across lists, thus indicating no systematic changes due to between-list interference paradigms.

The aim was to replicate the essentials of Bower-Bostrom study using words to contruct the lists. Each S was given four successive lists, with recognition memory being measured after each. Each list used different words for the stimulus terms, but the same words were the response terms in all four lists. Within lists, therefore, there were pairs fitting the A-B, A-D paradigm, and between lists, pairs fitting the A-B, C-B paradigm. As a parallel condition, other Ss learned four successive lists in which no word was used in more than one list. Presumably, this should eliminate the between-list interference which might result from the A-B, C-B paradigm.

Method

The S was presented 30 pairs of words on a single trial. Within the list, some of the pairs formed an A-B, A-D paradigm. For some of these sets the S was tested on A-B (retroactive inhibition, RI), and for others he was tested on A-D (proactive inhibition, PI). There were also control pairs, nominally A-B or A-D only. Immediately after the list was presented, a YES-NO recognition test was given on pairs. By re-pairing certain of the study items, wrong or NO pairs were formed along with the intact pairs used to measure RI and PI. In the two parallel conditions, all Ss were given four successive lists, all with the same structure as will be described in detail later. In one condition, the response terms remained the same across all four lists (Cond. S), with the stimulus terms differing from list to list. In the other, both the response terms and the stimulus terms differed for each list (Cond. D).

Study lists. The 30 pairs in each list consisted of 10 buffer pairs (five at the beginning and five at the end), and 20 pairs of critical interest in the body of the list. Among the first 10 in the body of the list were four A-B pairs which were followed in the second 10 by four corresponding A-D pairs (RI and PI pairs). Two additional A-B pairs among the first 10 served as control pairs for RI, and two additional A-D pairs in the second 10 served as PI controls. The remaining positions were occupied by additional A-B, A-D pairs and unique pairs which were used in producing re-paired pairs for the test to serve as incorrect or NO pairs. For all lists the stimulus terms were five-letter nouns, the response terms three-letter words of varying form class. All pairings for both Cond. S and Cond. D were made randomly, and the words used in a particular list resulted from random selection. The first list for both conditions was identical.

Test lists. There were 22 pairs on a test list. Eight of these came from buffer pairs of the study list and consisted of five correct pairings and three incorrect pairings. Four of the eight were tested in positions 1-4, four in positions 19-22. The 14 critical pairs occupied positions 5-18. These included two RI pairs (A-B, A-D on the study list with only A-B being tested), two PI pairs (A-B, A-D, with only A-D being tested), two RI control pairs, and two PI control pairs. One of each of the above four types occurred within positions 5-11, one within positions 12-18. All of these required a YES response to be correct. The remaining six positions were occupied by re-paired words for which a NO response would be correct. It should be noted that all words occurring on the test list had also appeared on the study list. There were no true new words involved.

Procedure and subjects. The study lists were presented at a 4-sec. rate on a memory drum. Eight sec. after the last pair was removed, the word "TEST" appeared followed by the test series. Each test pair was presented for 4 sec. during which time the S responded YES or NO to indicate his decision. The Ss had been instructed that a YES represented two words which had appeared together on the study list, with NO representing two words which had not appeared together on the study list. The S was further instructed that he must respond to each pair, guessing if necessary. After the recognition test on the first list was completed, the second study list was presented, and so on, so that all lists were completed in a single session.

A total of 60 undergraduate students served as Ss, 30 being assigned to each condition from a block-randomized schedule.

Results and Discussion

Initially, the number of correct YES responses and the number of correct rejections (NO) were summed for each S for each list. A mean percentage correct was then determined. The values for the four lists in order for Cond. S were 73.0, 71.8, 72.1, and 75.3. It may be seen that for this condition there were no appreciable changes across lists. This confirms the finding of Bower and Bostrom (1968). For Cond. D, the successive values were 73.9, 70.3, 77.6, and 82.6. At least after the second list, performance improved. An analysis of variance with the two conditions as one variable and the four lists as the other, showed that, overall, conditions did not differ ($F = 1.11$), although the main effects of lists was significant, $F(3, 174) = 9.22$, $p < .01$, as was the interaction between lists and conditions, $F(3, 174) = 3.46$, $p < .05$. These data seem to indicate that a small amount of interference may have resulted from the use of the same response terms in the four lists in Cond. S. Across all item types for all lists combined, there were 75.8% hits and 31.5% false alarms for Cond. S, with the corresponding values for Cond. D being 79.4% and 28.5%.

The critical data are concerned with RI and PI. It will be remembered that there were only two items of each type in each list. Therefore, the data have been combined across the four lists and the mean number of correct recognitions shown in Table 1 are out of a possible eight correct. For RI or PI to be demonstrated, performance on the control items must be higher than performance on the experimental items. For RI, it is apparent that there was no consistent difference

Table 1

Mean Number of Correct Recognitions for RI and PI Pairs (E) and for Control Pairs (C) for Conditions S and D

(Standard Deviations in Parenthesis)

	RI-E	RI-C	PI-E	PI-C
Condition S	5.97 (1.15)	6.13 (1.22)	5.83 (1.38)	6.13 (1.25)
Condition D	6.73 (1.36)	6.63 (1.24)	5.67 (1.71)	6.37 (1.46)

Table 1

Mean Number of Correct Recognitions for RI and PI Pairs (E) and for Control Pairs (C) for Conditions S and D

(Standard Deviations in Parenthesis)

	RI-E	RI-C	PI-E	PI-C
Condition S	5.97 (1.15)	6.13 (1.22)	5.83 (1.38)	6.13 (1.25)
Condition D	6.73 (1.36)	6.63 (1.24)	5.67 (1.71)	6.37 (1.46)

between the E and C pairs. Under Cond. S the performance on the C items is slightly better than on the E items, while this is reversed for Cond. D. For PI, the direction of the differences for both conditions is appropriate to infer interference. Summed across both experiments, the mean difference between the E and C items for PI reaches a borderline level of reliability, t (59) = 2.00, $p < .05$.

In summary, there was no evidence for RI in the recognition data, hence there was no possibility for unlearning. This confirms the report of Bower and Bostrom (1968). There is a suggestion of a small amount of interference resulting from the PI procedures. But, however one views the data, the general conclusion must be that there is minimal associative interference in recognition memory under the present procedures.

Experiment 2

The intent of this study was to provide a within-list interference potential during recognition learning followed by a between-list potential resulting from a paired-associate list learned by the anticipation method. The question is whether on a test for the first list following interpolated learning there will be evidence for retroactive inhibition.

Method

The general design of the conditions of the experiment will be described first, followed by details. There were three stages to the experiment, with the critical variable introduced during the second stage.

Stage 1: All Ss were given five study-test cycles on a list of

24 pairs. The five test trials always consisted of the S pairing the left-hand or stimulus terms with the right-hand or response terms, both of which were provided for him. The 24-pair list consisted of four unique pairs, four sets of two pairs forming A-B, A-D, and A-E paradigms, and four sets of three pairs each forming A-B, A-D, A-E paradigms. This list, therefore, had 12 different stimulus terms and 24 different response terms.

Stage 2: All Ss were transferred to a paired-associate list of 12 pairs which was presented for anticipation learning until one errorless trial was achieved. This list was identical for all groups, but by using different lists for Stage 1, the between-list relationships differed as follows for four groups:

Group P. Pairs from the first list were transferred intact to the paired-associate list. The 12 pairs consisted of the four unique pairs, one pair from each of the four sets forming A-B, A-D paradigms, and one pair from each of the four sets forming A-B, A-D, A-E paradigms.

Group S. The 12 stimulus terms were transferred but the response terms were entirely new. This produced an A-B, A-D paradigm between lists, but the number of potential interfering associations represented by A-B differed among subsets of items. The associations for the unique pairs in the first list would constitute a single interfering association for each of the four pairs in paired-associate learning. For the four pairs derived from the four sets forming A-B, A-D within the first list, there would be two interfering associations for each of the four pairs. For the four pairs derived from the four sets forming A-B, A-D, A-E within the first list, there would be three interfering associations.

Group R. The response terms were from the first list and were identical to those for Group P. New stimulus words were used for these response terms. Thus, the four response terms (right-hand terms) from the O Items (unique pairs) occurred in the paired-associate list, each with a new stimulus term. Likewise, one response term from each of the four sets of two pairs with common stimulus terms were carried over, as was one response term from each of the four sets of three pairs with common stimulus terms. In all eight cases, new stimulus terms were used.

Group C. The first list was entirely unrelated to the interpolated paired-associate list.

<u>Stage 3</u>. Following paired-associate learning, all <u>S</u>s were given a form of an MMFR test for the first list. In this test, the <u>S</u>s were given the 24 response terms and were asked to recall and pair the stimulus terms appropriately or, were given the stimulus terms (with repeated stimuli occurring the appropriate number of times) and were asked to recall and pair the response terms. It should be noted that recall was required in this third stage for a list in which associative matching had been used for learning.

<u>Lists</u>. All words were five-letter words. Assignment to function was done on a random basis subject only to the restriction that the initial letters of the words in a pair not be the same. By the nature of the design, the four lists used in the first stage were different in part at least, since the paired-associate list was identical for all groups.

Procedure and subjects. The first lists were presented for study at a 4-sec. rate prior to each matching trial. For the matching test, the S was given a sheet with the 24 stimuli listed on the left, and with a blank to the right of each. The 24 response terms were listed to the right of the blanks. Both lists were in alphabetical order. The Ss were given an unlimited amount of time to write in the appropriate response terms in the blanks. The order of presenting the pairs on the study trials differed from trial to trial.

The paired-associate list was presented at a 1.5:1.5-sec. rate, in four different orders. Trials were continued until one errorless recitation was given. Immediately after learning the paired-associate list, the MMFR test was given. As noted earlier, half the Ss were given the stimulus terms and half given the response terms, in each case being requested to recall and pair the other terms. The direction of recall had no influence on performance so the results for this variable will not be reported.

A total of 120 introductory-psychology students participated. There were 30 Ss in each of the four groups identified earlier as Groups P, S, R, and C. The Ss were assigned to conditions by a block-randomized schedule.

Results and Discussion

Associative matching. The four groups did not differ across the five matching trials combined ($F < 1$), nor did they differ on the fifth trial ($F < 1$). It will be remembered that there were four unique pairs, four sets of two pairs forming A-B, A-D paradigms, and four sets of three pairs forming A-B, A-D, A-E paradigms. In terms of the number of potential interfering items within a set these may be identified as 0 Items, 1 Items, and 2 Items. Across the five trials the 0 Items were given correctly with greater frequency than were the 1 and 2 Items. This was consistent on every trial and was statistically reliable when summed across trials, $\underline{F}$ (2, 232) = 49.85, $\underline{p}$ < .01. Combined across all groups the percentages correct were 82, 75, and 76, for 0, 1, and 2 Items, respectively. The differences were still present on the fifth trial, the percentages being 97, 93, and 95.

Paired-associate learning. The mean numbers of trials to the criterion for the four groups were as follows: Group P, 7.70; Group R, 10.97, Group S, 13.20, and Group C, 10.57. The differences among the groups were reliable overall, $\underline{F}$ (3, 116) = 3.27, $\underline{p}$ < .05. Essentially, the same relative differences were present on the first two trials of paired associate learning. That Group P leared most rapidly might be expected on the grounds that all pairs had been a part of the associative-matching task, but it might be surprising that an average of 7 trials were required to learn. However, it should be remembered that only one pair from the sets of 1 Items and 2 Items were used in the paired-associate list. Thus, the $\underline{S}$ had to learn which of the response terms was carried over for a set having the same stimulus term. Indeed, 26 intrusions of these response items from the matching task occurred during paired-associate learning. Another factor which would probably retard performance for Group P on the paired-associate task was that the task was paced at a fairly rapid rate, as opposed to completely unpaced performance used for the matching task.

Group S might be expected to require more trials to learn than Group R on the basis of the fact that response learning was required for Group S and not for Group R. That Group S took more trials than Group C probably indicated some interference from the associations acquired on the matching task. There were 12 intrusions from the matching list.

Differences in learning of item types in the paired-associate list were confounded by differences in the level of learning in the matching task and by the fact that the items carried over to the paired-associate list from the matching list in the different types were not equivalent in difficulty. Differences in item difficulty in the three classes were evident in the performance of Group C, the group which had no items in common for the two lists.

MMFR. Table 2 shows the percentages of items correctly produced and correctly paired in each item class (0, 1, 2) for the four groups. The critical fact to be obtained from an examination of Table 2 is that there is no evidence at all for retroactive interference. It can be seen that for no item type for any of the three experimental groups was performance poorer than for Group C. Statistically speaking, however, there was no evidence that the learning of the paired-associate list had any influence on the recall of the task originally learned by a matching procedure. The fact that the 0 Items were generally better recalled than the 1 Items and 2 Items would be expected because of the differences existing at the end of original

Table 2

Correct Pairings (Percentages) on MMFR as a Function of Group and Item Type

(The data for Group P are broken down in terms of pairs transferred intact to paired-associate learning and for pairs not transferred, and for Group R in terms of pairs in paired-associate learning in which the response terms were and were not transferred from the matching task)

	Item Type		
	0	1	2
Group P			
Transferred pairs	97.5	92.5	98.3
Non transferred Pairs	--	86.7	90.0
Group R			
Transferred pairs	92.5	90.8	92.5
Non transferred pairs	--	91.7	88.8
Group S	95.8	87.5	87.2
Group C	92.5	82.1	86.1

learning of the matching task.

In summary, this experiment has shown that a task learned by associative matching (procedurally a recognition task) was quite unaffected by the learning of a paired-associate list which involved pairs that formed interference paradigms with the associations learned in the matching task. This was true in spite of the fact that the Ss were required to recall the responses on the retention test.

Experiment 3

In this study a multiple-choice procedure was used for the learning of the original and the interpolated list. This procedure has been used by other investigators (e.g., Postman & Stark, 1969) when the interest was in assessing associative unlearning. However, as will be seen, the particular way of handling the multiple-choice items differs from earlier studies and, as was true in Experiment 2, the initial tests for associative unlearning were made by recall procedures.

Method

Paradigms. The first list was common to all paradigms. It consisted of eight pairs, and during the multiple-choice learning the S always had to choose between two response terms. The wrong word in a pair was a correct word for another stimulus term in the list. The same wrong word always served that function for a given stimulus on all trials. For example, shabby was the correct response word for the stimulus deny. The wrong word appearing with shabby was escort and these two words formed the two-alternative set for deny on all learning trials. It should be noted that this task requires associative learning if mastery is to occur. Since the wrong word in each set is a correct word in another set, the Ss must learn to give the particular response term only in the presence of a particular stimulus term. Neither this task, nor the tasks used in the first two experiments, were presumed in any way to eliminate associative learning between words.

Three different paradigms were formed by varying the interpolated lists. Two of these were variants on the A-Br paradigm in that the eight response terms used in the first list were also used in the second. In Cond. 2D, both of the words paired with a stimulus term were different from the two appearing with that stimulus in the first list. For example, for the interpolated list, victor and inland replaced shabby and escort as the two-alternative set to the stimulus deny. Of course, victor and inland had occurred as response terms in the first list; however, they had not been used together as a two-alternative set in the first list. Thus, in Cond. 2D, both the right and the wrong word for each stimulus term differed from the right and wrong word appearing with a stimulus in the first list.

In Cond. 1D, the wrong word paired with a given stimulus in the first list became the right word for that stimulus in the interpolated list. To continue the illustration, in Cond. 1D, escort became the correct response term for deny in the second list, and inland the wrong word. The reason for the use of this paradigm needs some explanation. As noted above, the wrong word in a two-alternative set remained as the wrong word in this set on all trials. For a given stimulus term, the S always made his choice between the same two response alternatives. In the first list, escort was always the wrong word to the stimulus deny. Assume that as a result of the consistent pairing of escort and deny some associative relationship developed between them, even though escort was nominally wrong for that stimulus. This would mean, in effect, that during original learning two different response terms (one right, one wrong) became associated with the same stimulus term. If this occurred, the learning of the interpolated list should proceed more rapidly under Cond. 1D than under Cond. 2D. Given this possibility, unlearning differences between the two conditions might also emerge.

The third paradigm parallels the A-B, A-D paradigm in paired-associate learning, but will be called Cond. N. A completely new set of eight words was used during the interpolated learning, with the stimulus terms remaining the same in both lists. Finally, a fourth condition, a control without interpolated learning (Cond. C), was used.

The stimulus terms for all of the lists were four-letter words, printed in capital letters. The response terms were two-syllable words printed in lower case on the memory-drum tapes. The item sets (stimulus term, two response terms) were presented in four different orders, and the positions of the right and wrong words in a set were varied from trial to trial.

Procedure and subjects. The lists were presented at a 2:2-sec. rate. During the initial 2 sec. the S made his choice, and the correct word in the pair was shown alone for the following 2 sec.

The criterion of learning for both lists was two successive errorless trials. For the three experimental groups, the retention tests came immediately after interpolated learning. As the first step, the Ss were given a sheet with the eight stimulus terms listed on the left, with two blanks after each labelled "first list" and "second list". The usual instructions for MMFR were given, namely, to fill in the blanks with the correct words for each stimulus, one from the first list learned, one from the second. This test was unpaced. When the S indicated he could not remember any more of the words, a sheet was given him on which 32 words were listed alphabetically. These included the eight words from the first list, the eight words from the interpolated list learned under Cond. N, and 16 words which had not occurred on either list. The S was told that the appropriate response terms were in the list of 32 and he was urged to pair as many more as he could. A red pencil was used to write the additional words for this recognition test.

Initially, the three experimental groups were run, 35 undergraduate students being assigned randomly to each of the three conditions. After these groups had been completed, an average was computed for the time required to learn the interpolated lists under all three conditions. Then, 35 additional Ss were tested under Cond. C (no interpolated learning), using the average time calculated above (10 min.) between original learning and the retention test as a rest interval. During this interval the Ss worked on a pyramid puzzle.

Results and Discussion

Learning. All four groups learned the same first list. The mean numbers of trials required to reach two successive errorless trials varied between 6.31 and 8.17 ($F = 1.01$). Thus, the four groups did not differ in learning the common list.

The mean numbers of trials to learn the interpolated list were 4.83, 6.14, and 6.23, for Cond. 2D, 1D, and N, respectively. These means did not differ, $F(2, 102) = 2.24$, $p > .05$. There is no evidence, therefore, that if the wrong word became associated with the stimulus term in original learning for Cond. 1D that it influenced interpolated learning. Overall, the learning of the second list was more rapid than the first. An analysis which included both lists for the three conditions showed that the second lists were learned in fewer trials than the first, $F(1, 102) = 8.58$, $p < .01$, but that neither conditions nor the conditions by lists interaction was reliable statistically. For the three conditions combined, the mean number of trials required to learn the first list was 7.23, for the second or interpolated list, 5.73. The positive transfer may be due to a number of factors (e.g., warm up, learning-to-learn) which were sufficient in magnitude to overcome any interference produced by these paradigms.

Retention. The retention data for the first list are shown in Fig. 1. The data include only correct pairings, with the MMFR to the left, and MMFR plus the additional correct responses produced in recognition on the right. Looking first at the MMFR, it can be seen that very severe losses were produced by the interpolated list for all experimental conditons, with the 50% loss (compared with the control) for Cond. N being the maximum loss. That this loss is to a

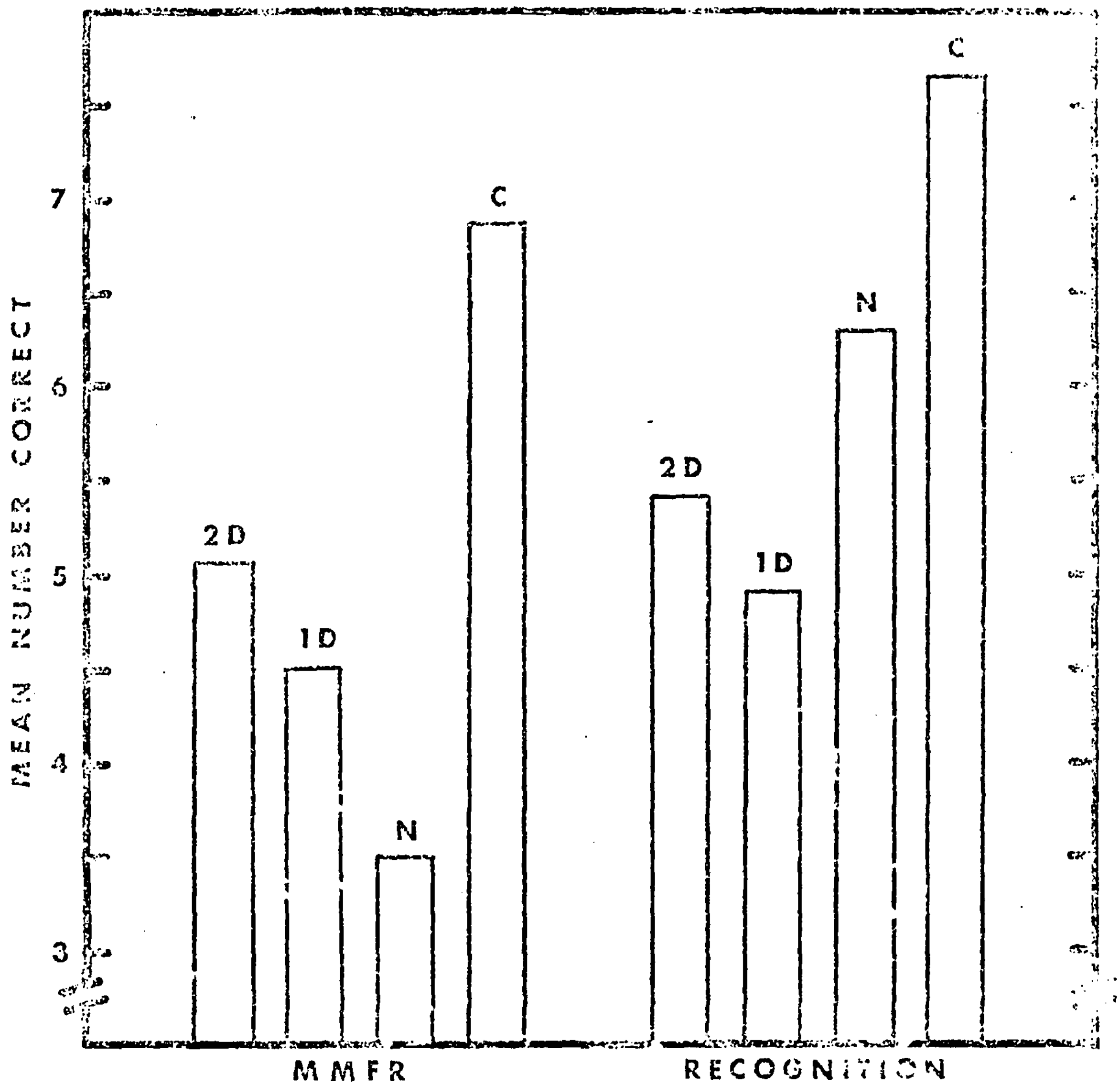

Fig. 1. Mean number correct on MMFR for the four conditions and mean number correct on a subsequent test of associative recognition.

large extent due to lack of availability in memory of the response terms is indicated by the additions produced under the recognition procedures. For Cond. N, nearly three correct pairings were added, while for the other two experimental conditions, less than half an item was added on the average. All of the differences which have been pointed out were reliable statistically. An analysis of variance showed that conditions differed, $\underline{F}$ (3, 136) = 12.45,$\underline{p}$ < .01, that recognition added significantly to the number correct over the number produced in MMFR (F=141.69), but that the amount added differed for the conditions ($\underline{F}$=39.56). This differential increase is to be attributed primarily to the increase between MMFR and recognition for Cond. N. Nevertheless, a difference between Cond. N and Cond. C is still present following recognition (18%) and is reliable statistically, the mean difference being 1.37 items, $\underline{t}$ (68) = 3.61, $\underline{p}$ < .01. The inference is that this represents a true associative loss in recognition memory. The magnitude of this loss is probably overestimated. The $\underline{S}$s in Group C had nearly seven correct on MMFR on the average. Thus, on the recognition test the $\underline{S}$ may have had only one or two stimuli to which a response had not already been assigned. If the $\underline{S}$ eliminated the new words from the recognition task, which seems likely, guessing from the remaining one or two response terms would be likely to produce a greater increase than would guessing for Group N, where four stimuli without responses assigned (on the average) were available. Nevertheless, scores were higher for Cond. C for MMFR than for Cond. N following recognition (Fig. 1), so it would still seem proper to conclude that a small associative loss was present in Cond. N. Finally it should be mentioned that recall of the second list was very high and did not differ for conditions.

In summary, using a two-alternative recognition task, two paradigms approximating the A-B, A-Br paradigm as defined in paired-associate learning, showed heavy associative losses in unlearning. A paradigm approximating the A-B, A-D paradigm showed a small associative loss.

General Discussion

In the first experiment the results confirmed those reported by Bower and Bostrom (1968) in showing no retroactive inhibition in recognition memory when A-B and A-D pairs were represented within the same study list. There was evidence for proactive inhibition of small magnitude. This finding could be produced by assuming a small learning deficit for A-D as a consequence of having studied A-B earlier in the list. Other work indicates that such deficits will occur (Brown & Underwood, 1974), although the exact nature of the deficit (item learning; associative learning) is not clear.

The second experiment gave no evidence for either a loss of response availability or of an associative loss. These results were surprising for a number of reasons. The original learning occurred by associative matching, but the retention test was recall. It is highly probable that recall processes were heavily used in the so-called assciative-matching task. When a multiple-choice task with many alternatives is given, the S may well turn to recall rather than to recognition in mastering the task. It is presumed that a great deal of learning took place on the unpaced matching trials, so that the fact that the response terms (or stimulus terms) could be recalled may not have been unexpected in retrospect. Given that the Ss did use or develop recall capacities during associative matching, however, it would seem that learning a paired-associate list with A-D pairings as the interpolated task would have produced unlearning of the first task. This was not the case. During associative matching it was probable that bidirectional associations were formed. It might be possible, therefore, for unidirectional unlearning to have occurred with recall being produced by the association not unlearned. This seems quite unlikely in view of the fact that recall direction (nominal stimulus terms to nominal response terms or vice versa) did not influence recall in any of the conditions. The extraordinarily high performance on MMFR should be noted again; the 12 stimulus terms and the 24 response terms were highly available in recall and the S could pair them correctly. It was as if the associative-matching task and the paired-associate task were functionally two different tasks in spite of the overlap of words in the two. Yet, there was some evidence for interference in interpolated learning as indicated by instrusions and by the relatively poor performance of the Ss in Group S where A-B, A-C interference would be maximal. All in all, the very high performance on the recall of the 24-pair list learned by associative matching poses problems for conceptions of unlearning.

The third experiment produced evidence for considerable associative unlearning in the A-Br paradigms (Cond. 2D and 1D). This supports the typical finding for paired-associate learning. There was also some evidence for associative unlearning in the A-B, A-D paradigm.

In this paradigm, recall of A-B was severely depressed, indicating a loss of response terms. This confirms a recent report by Lehr and Netti (1973) who also used a two-choice task. Providing the response terms increased A-B performance considerably in Experiment 3, although pairing performance was not as high as that shown by the control group. In paired-associate learning, evidence concerning associative loss in the A-B, A-D paradigm shows either no decrement, or a small decrement. It would seem that the small loss found in Experiment 3 can fit into this conclusion. Any exact value or percentage figure cannot be carried over easily from one task to another. The critical comparison is to be found in the increase in performance from recall to recognition and in this comparison the task used here and the typical paired-associate task produced the same functional relationships. Again, although original learning occurred by a recognition procedure in Experiment 3, the capacity to recall in the control group was quite high (nearly seven out of the eight possible response terms).

In the introduction to this paper the possibility was advanced that the lack of associative unlearning in recognition tests for the A-B, A-D paradigm may be due to the fact that recognition memory is not commonly based on associative information. The data from Experiment 1 would not deny this possibility. Experiment 2 did not produce evidence of unlearning. Although the results of that experiment clearly pose problems for unlearning theory, they are not directly relevant to the issue of whether recognition decisions are or are not based on associative information. The findings for Experiment 3 ply confirm those for previous studies with traditional paired-associate lists, namely, loss of response terms in A-B, A-D, with a small amount of associative loss, and heavy associative loss in A-Br.

Certain experiments (from the Northwestern laboratory) which are not as yet published produced results which argue that the association between a pair of words is not directly related to recognition performance. For example, a pair of words which are strongly associated by cultural usage (e.g., table-chair) is no better recognized after a single study trial than is a pair of nonassociated words. As a result of such evidence, it was proposed that frequency information about the components of a pair (each word in the pair) as well as about the pair as an integrated unit mediated the recognition decisions. Perhaps this line of thinking may be applied to A-B recognition following A-D learning. Given that D is recalled to A or recognized as going with A, there is no first-list response term which has occurred as frequently with A as has B. This is to say that as a unit, A-B has higher frequency than A and any other response term in the first list. It seems quite possible that such frequency information could mediate the recognition decisions. To advance this proposal also requires the assumption, as has been proposed earlier (Underwood, 1969), that frequency information per se acts only to discriminate among memories, not to retrieve them. The implication is that the unit frequency of two associated words can be developed from an association but is independent from it.

References

Brown, A.S., & Underwood, B. J. Verbal-context shifts and free recall. Journal of Experimental Psychology, in press.

Bower, G. H., & Bostrom, A. Absence of within-list PI and RI in short-term recognition memory. Psychonomic Science, 1968, 10, 211-212.

Lehr, D. J., & Netti, J. F. Retroactive inhibition and spontaneous recovery in a contingent verbal discrimination task. Psychological Reports, 1973, 32, 443-450.

Postman, L., & Stark, K. Role of response availability in transfer and interference. Journal of Experimental Psychology, 1969, 79, 168-177.

Postman, L., & Underwood, B. J. Critical issues in interference theory. Memory and Cognition, 1973, 1, 19-40.

Underwood, B. J. Attributes of memory. Psychological Review, 1969, 76, 559-573.

Underwood, B. J., Broder, P. K., & Zimmerman, J. Associative matching and cumulative proactive inhibition. Bulletin of the Psychonomic Society, 1973, 1, 48.

DISTRIBUTION LIST

Navy

4 Dr. Marshall J. Farr, Director
Personnel & Training Research Programs
Office of Naval Research
Arlington, VA 22217

1 Director
ONR Branch Office
495 Summer Street
Boston, MA 02210
ATTN: C.M. Harsh

1 Director
ONR Branch Office
1030 East Green Street
Pasadena, CA 91101
ATTN: E.E. Gloye

1 Director
ONR Branch Office
536 South Clark St.
Chicago, IL 60605
ATTN: M.A. Bertin

6 Director
Naval Research Laboratory
Code 2627
Washington, DC 20390

12 Defense Documentation Center
Cameron Station, Bldg. 5
5010 Duke St.
Alexandria, VA 22314

1 Chief of Naval Technical Training
Naval Air Station Memphis (75)
Millington, TN 38054
ATTN: Dr. G.D. Mayo

1 LCDR Charles J. Theisen, Jr., MSC, USN
4024
Naval Air Development Center
Warminster, PA 18974

1 Mr. Lee Miller (AIR 413E)
Naval Air Systems Command
5600 Columbia Pike
Falls Church, VA 22042

1 Dr. Harold Booher
NAVAIR 415C
Naval Air Systems Command
5600 Columbia Pike
Falls Church, VA 22042

1 Commanding Officer
Naval Medical Neuropsychiatric Research
San Diego, CA 92152

1 Technical Reference Library
Naval Medical Research Institute
National Naval Medical Center
Bethesda, MD 20014

1 Dr. John J. Collins
Chief of Naval Operations (OP-987F)
Dept. of the Navy
Washington, DC 20350

1 Technical Library
Bureau of Naval Personnel
Dept. of the Navy
Washington, DC 20360

1 Dr. James J. Regan, Technical Director
Navy Personnel Research & Development Center
San Diego, CA 92152

1 Special Asst. to Chief of Naval Personnel
Bureau of Naval Personnel (Pers Oe)
Arlington Annex, Room 2403
Washington, DC 20370

1 Commanding Officer
Navy Personnel Research & Development Center
San Diego, CA 92152

1 Superintendent
Naval Postgraduate School
Monterey, CA 92940
ATTN: Library (Code 2124)

1 Technical Library
Naval Ship Systems Command
National Center, Bldg. 3
Room 3S08
Washington, DC 20360

1 Chief of Naval Training Support
Code N-21
Bldg. 45
Naval Air Station
Pensacola, FL 32508

1 Dr. William L. Maloy
Principal Civilian Advisor for
Education & Training
Naval Training Command, Code 01A
Pensacola, FL 32508

1 Mr. Arnold Rubinstein
Naval Material Command (NMAT-03424)
Room 820, Crystal Plaza #6
Washington, DC 20360

1 Dr. Martin F. Wiskoff
Navy Personnel Research & Development
Center
San Diego, CA 92152

1 Dr. John Ford, Jr.
Navy Personnel Research & Development
Center
San Diego, CA 92152

1 Director of Research
U.S. Army Armor Human Research Unit
ATTN: Library
Bldg. 2422 Morade St.
Fort Knox, KY 40121

1 U.S. Army Research Institute for the
Behavioral & Social Sciences
1300 Wilson Blvd.
Arlington, VA 22209

1 Mr. Edmund F. Fuchs
U.S. Army Research Institute
1300 Wilson Blvd.
Arlington, VA 22209

1 Chief, Unit Training & Educational
Technology Systems
U.S. Army Research Institute for the
Behavioral & Social Sciences
1300 Wilson Blvd.
Arlington, VA 22209

1 Dr. Stanley L. Cohen
Work Unit Area Leader
Organizational Development Work Unit
Army Research Inst. for Behavioral &
Social Science
1300 Wilson Blvd.
Arlington, VA 22209

1 Dr. Leon H. Nawrocki
U.S. Army Research Inst.
Rosslyn Commonwealth Bldg.
1300 Wilson Blvd.
Arlington, VA 22209

Air Force

1 Dr. Martin Rockway
Technical Training Division
Lowry Air Force Base
Denver, CO 80230

1 Maj. P.J. DeLeo
Instructional Technology Branch
AF Human Resources Laboratory
Lowry AFB, CO 80230

1 Headquarters, U.S. Air Force
Chief, Personnel Research & Analysis
Division (AF/DPSY)
Washington, DC 20330

1 AFHRL/AS (Dr. G.A. Eckstrand)
Wright-Patterson AFB
Ohio 45433

1 AFHRL (AST/Dr. Ross L. Morgan)
Wright Patterson Air Force Base
Ohio 45433

1 AFHRL/MD
701 Prince St. Room 200
Alexandria, VA 22314

1 AFOSR(NL)
1400 Wilson Blvd.
Arlington, VA 22209

1 Headquarters Electronic Systems Division
ATTN: Dr. Sylvia R. Mayer/MCIT
L.G. Hanscom Field
Bedford, MA 01730

Marine Corps

1 Mr. E. A. Dover
Manpower Measurement Unit (Code A01M-2)
Arlington Annex, Room 2413
Arlington, VA 20370

Coast Guard

1 Mr. Joseph J. Cowan, Chief
Psychological Research Branch (P-1)
U.S. Coast Guard Headquarters
400 Seventh St., SW
Washington, DC 20590

Other DOD

1 Lt. Col. Austin W. Kibler, Director
Human Resources Research Office
Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, VA 22209

1 Dr. Ralph R. Canter
Director for Manpower Research
Office of Secretary of Defense
The Pentagon, Room 3C980
Washington, DC 20301

Miscellaneous

1 Dr. Scarvia Anderson
Executive Director for Special Devpt.
Educational Testing Service
Princeton, NJ 08540

1 Dr. Richard C. Atkinson
Stanford University
Dept. of Psychology
Stanford, CA 94305

1 Dr. Ronald P. Carver
American Institutes for Research
8555 Sixteenth St.
Silver Spring, MD 20910

1 Century Research Corporation
4113 Lee Highway
Arlington, VA 22207

1 Dr. Kenneth E. Clark
University of Rochester
College of Arts and Sciences
River Campus Station
Rochester, NY 14627

1 Dr. Allan M. Collins
Bolt Beranek & Newman
50 Moulton St.
Cambridge, MA 02138

2 ERIC
Processing & Reference Facility
4833 Rugby Ave.
Bethesda, MD 20014

1 Dr. Victor Fields
Dept. of Psychology
Montgomery College
Rockville, MD 20850

1 Dr. Edwin A. Fleishman
American Institutes for Research
8555 Sixteenth St.
Silver Spring, MD 20910

1 Dr. Robert Glaser, Director
University of Pittsburgh
Learning Research & Development Center
Pittsburgh, PA 15213

1 Dr. Robert Tenneyson
Florida State University
Center for Computer-Assisted Instruction
Tallahassee, FL 32306

1 Dr. Henry J. Hamburger
University of California
School of Social Sciences
Irvine, CA 92664

1 Human Resources Research Organization
Division #3
P.O. Box 5787
Presidio of Monterey, CA 93940

1 Human Resources Research Organization
Division #4, Infantry
P.O. Box 2086
Fort Benning, GA 31905

1 Human Resources Research Organization
Division #5, Air Defense
P.O. Box 6057
Fort Bliss, TX 79916

1 Human Resources Research Organization
Division #6, Library
P.O. Box 428
Fort Rucker, AL 36360

1 Dr. Lawrence B. Johnson
Lawrence Johnson & Associates, Inc.
200 S Street, N.W., Suite 502
Washington, DC 20009

1 Dr. David Klahr
Carnegie-Mellon University
Graduate School of Industrial Admin.
Pittsburgh, PA 15213

1 Dr. Robert R. Mackie
Human Factors Research, Inc.
6780 Cortona Dr.
Santa Barbara Research Park
Goleta, CA 93017

1 Dr. Andrew R. Molnar
Technological Innovations in Education
National Science Foundation
Washington, DC 20550

1 Dr. Leo Munday, Vice President
American College Testing Program
P.O. Box 168
Iowa City, IA 52240

1 Dr. Donald A. Norman
University of California, San Diego
Center for Human Information Processing
La Jolla, CA 92037

1 Mr. Luigi Petrullo
2431 N. Edgewood St.
Arlington, VA 22207

1 Dr. Diane M. Ramsey-Klee
R-K Research & System Design
3947 Ridgemont Dr.
Malibu, CA 90265

1 Dr. Joseph W. Rigney
Behavioral Technology Laboratories
University of Southern California
3717 South Grand
Los Angeles, CA 90007

1 Dr. George E. Rowland
Rowland & Company, Inc.
P.O. Box 61
Haddonfield, NJ 08033

1 Dr. David J. Weiss
Dept. of Psychology
University of Minnesota
Minneapolis, MN 55455

1 Dr. Anita West
Denver Research Institute
University of Denver
Denver, CO 80210

1 Dr. Kenneth Wexler
University of California
School of Social Sciences
Irvine, CA 92664

1 Dr. John Annett
The Open University
Milton Keynes
Buckinghamshire ENGLAND

1 Dr. Charles A. Ullmann
Director, Behavioral Sciences Studies
Information Concepts Incorporated
1701 No. Ft. Myer Dr.
Arlington, VA 22209

1 Mr. Dexter Fletcher
Dept. of Psychology
Univ. of Illinois at Chicago Circle
Box 4348
Chicago, IL 60680