EFFECTS OF ORGANIZATION ON RECOGNITION MEMORY

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The effect of organization on recognition memory was investigated in two experiments. In both experiments, a categorized list was presented for study with instances of a given category being either blocked or distributed randomly throughout the list. The order of items in the recognition test was of varied similarity to their order within the blocked study list. Results indicated that the effect of blocked versus random presentation tended to be dependent on the order of recognition test items. In the first experiment, blocked presentation enhanced recognition only when test items were grouped on the basis of category membership and the order of old items within a category was the same as it had been in the study list. A similar trend was observed in the second experiment. Results were discussed with reference to the role of retrieval in recognition memory.

Tulving and Thomson (1971) have suggested that retention of an event, regardless of the type of test, is dependent on the storage of appropriate mnemonic information and the retrievability of that information at the time of test. In contrast, Kintsch (1970b) has suggested that a portion of the retrieval process, search, is involved only in tests of recall. The effect on recall of relationships between study items is attributed to an effect on search; interitem relationships are employed to aid in locating an item in memory. То support the claim that recognition does not involve a search process, recognition memory must be shown to be independent of interitem relationships.

Differences in the effects of organizational variables on recall and on recognition have been observed. Cofer, Bruce, and Reicher (1966) found that free recall performance following presentation of a categorized list was enhanced if instances of the same category were presented in a blocked manner rather than distributed randomly throughout the study list. In contrast, Kintsch (1968) found that recognition performance following blocked pre-

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sentation did not differ from that produced by random presentation of category instances. In the Kintsch study, the manipulation of blocked versus random presentation was confounded with a manipulation of the normative frequency with which category instances were given as responses to the category name. In an unconfounded comparison, D'Agostino (1969) found a small, but significant, recognition advantage for blocked presentation. It would appear that blocking the presentation of category instances enhances free recall performance but has either no effect or a relatively small effect on recognition memory.

Tulving and Thomson (1971) found an effect of interitem relationships on recognition memory. Following the presentation of pairs of associatively related words, recognition was superior when words were tested in the same pairs rather than alone or in the presence of new associatively related words. The results of other investigations (Light & Carter-Sobell, 1970; Thomson, 1971) agree that increasing the difference between the contexts in which a word occurs for study and for test impairs recognition. On the basis of these data, presentation of a word for recognition test does not insure that S can retrieve mnemonic information that is relevant for the recognition judgment. Providing a studylist associate, at the time of test, aids in the retrieval of mnemonic information concerned with the study-list occurrence of the test word.

An effect of blocked versus random presentation might be dependent on the form of the recognition test employed. It is likely that the order in which items are presented for test is important. If studylist associations are primarily formed between contiguously presented instances of the same category, a facilitative effect of blocked presentation might be observed only when old category members are presented for recognition test in an order that is identical to that in which they were presented for study. Furthermore, the probability of obtaining a facilitative effect of blocked presentation might be inversely related to the number of test items intervening between the recognition tests of items that were presented contiguously during study. Neither Kintsch (1968) nor D'Agostino (1969) employed a recognition test that would be expected to be sensitive to associative differences produced by varying study-list organization. In both investigations, the test list was constructed by randomly ordering the old words and an equal number of new words that were selected from the same categories. D'Agostino added the restriction that not over two words from the same category could occur in adjacent test positions. The purpose of the experiments to be reported was to assess the dependence of the effect of blocked versus random presentation on the order of items in the recognition test list.

Method

EXPERIMENT I

Design and subjects.—Two levels of study-list organization (blocked and random) were factorially combined with two levels of test order constraint (uncategorized and categorized) to form four between-Ss experimental conditions. The Ss were 60 students in an introductory psychology class who participated for course credit; 15 Ss were assigned to each of the four experimental conditions. The Ss were tested in small groups that ranged in size from 3 to 5; all Ss tested in a given session received the same level of study-list organization. Assignment of incoming groups to type of study list was random with the restriction that both levels of study organization must be represented by N groups before either could be represented by N + 1. Within the limits imposed by group size, the two test conditions were equally represented in each experimental session.

Materials.—The stimulus words were the 12 most frequently reported instances from each of 12 conceptual categories drawn from the norms of Battig and Montague (1969). Words that held an evennumbered frequency rank in the category norms, i.e., Category Frequency Ranks 2, 4, 6, 8, 10, and 12, were employed as study items, and words with oddnumbered frequency ranks were employed as new, distractor items for the recognition test. Thus, a study list consisted of 72 words, 6 instances each of 12 different conceptual categories. As dictated by the experimental design, instances of a given category were either presented in contiguous study list positions (blocked) or randomly distributed throughout the study list.

The uncategorized test list was similar to the test list employed by Kintsch (1968) and by D'Agostino (1969); old and new items were randomly ordered with the restriction that two items from the same category could not occur in adjacent test list positions. The same words were employed to construct the categorized test list, but the order of the words differed; words from the same category, both old and new, were grouped so that they occurred in adjacent serial positions in the test list. Although new words might intervene between the tests of old words, the order of old test words from a given category was the same as it had been in the study With these added restrictions, words were list. randomly assigned to test positions.

Test lists were prepared as mimeographed test booklets. The first page of the test booklet was blank with the exception of a sentence that informed Ss that they were not to turn that page until they were instructed to do so. The second page contained instructions for the recognition test. These instructions stated that each of the following pages of the test booklet would contain a list of words, a portion of which had occurred in the study list. The Ss were instructed to respond to each item in the order in which it was listed in the test booklet, circling those items that they believed had occurred in the study list. Each of the last six pages of the test booklet contained a single column of 24 words, one-half of which had occurred in the study list.

Procedure.—Study lists were shown to Ss on a closed-circuit television screen as a list of individual study items at a rate of 2 sec/item. After the study list had been shown, Ss were instructed to turn the first page of the test booklet. Prior to reading the test booklet instructions, Ss were not informed about the nature of the retention test. There was no time limit on the recognition test.

Analyses.—The number of hits, correct recognitions of old words, and false alarms, incorrect recognitions of new words, were computed for each S. The procedure for correcting recognition performance, for response bias, is dependent on the choice of underlying models of decision processes. In the present investigation, two measures of recognition performance were employed. A difference

Test	Study									
		Blo	cked	Random						
	Hits	FA	D	d'	Hits	FA	D	ď		
Uncategorized Categorized	49.3 58.8	6.5 6.6	42.8 52.2	2.0 2.4	49.7 46.7	3.9 3.7	45.8 43.0	2.3 2.2		

 TABLE 1

 Measures of Recognition from Experiment I

Note.—A difference between mean difference scores of at least 5.1 was required to produce a *t* value that was significant at the .05 level. A difference of 6.8 was demanded for significance at the .01 level.

measure was obtained, for each S, by subtracting the number of false alarms from the number of hits. The signal detection model was employed to obtain a second measure of corrected recognition; a sensitivity measure, d', was computed for each S. Kintsch (1970a, pp. 226-237) describes the assumptions underlying these models and computational techniques for obtaining d'.

Results

Table 1 shows the mean number of hits and false alarms (FA) for each of the experimental conditions, together with difference scores (D) and the signal detection measure of recognition (d'). Blocked presentation produced a larger number of false alarms than did random presentation, regardless of the type of recognition test employed. Hits occurred most frequently in the condition that received a categorized test list following blocked presentation of the study list.

The Type of Study \times Type of Test interaction, F (1, 56) = 5.77, p < .025, was the only significant effect revealed by the analysis of difference scores. Blocked study presentation followed by a categorized test list produced recognition performance that was significantly superior to that produced by any other combination of study and test condition. None of the other comparisons between experimental conditions were significant.

The d' analysis failed to reveal either significant main effects or a significant interaction between study condition and test condition, F(1, 56) = 1.18, p > .10.

For the categorized test conditions, proportions of hits as a function of number of new items intervening between an old test item and the immediately preceding old test item from the same category were computed. A comparison of these proportions should reflect the effect of increasing the test separation of items that were presented contiguously in the blocked study list. Parallel proportions from the condition receiving random presentation of the study list can be employed to assess nonassociative effects of test separation.

Twenty-two old items immediately followed an old item from the same category in the categorized test list, 21 were separated by one intervening new item, and 17 were separated by two or more intervening new items. The proportion of these old test items that were correctly recognized following blocked presentation was .78, .76, and .85 for 0, 1, and 2 or more intervening new items, respectively. With the same ordering of number of intervening items, the proportions of hits following random presentation were .61, .63, and .62. Thus, the effect of increasing the number of new test items intervening between the tests of old items was small. Within a limited range, increasing the test separation of old items that were contiguous in the blocked presentation study list does not result in a decrease in the probability of a correct recognition response.

Experiment II

The lack of agreement between recognition measures makes it difficult to interpret the results of the first experiment. The choice of a procedure for correcting recognition performance, for response bias, depends on assumptions about the decision

processes underlying recognition memory. The appropriate procedure to be employed in the first experiment is undetermined. The second experiment includes a third measure of recognition that was derived from a forced-choice procedure. The Ss in all conditions were instructed to indicate exactly the same number of words as being old. If Ss follow instructions, the resulting measure of recognition need not be corrected for response bias; differences in number of hits cannot be produced by differences in response bias if the total number of old responses is not allowed to vary. Comparisons between the three recognition measures employed in Exp. II might aid in choosing between the measures employed in the first experiment.

If the difference analysis in the first experiment is accepted, the results lend support to suggestions made in the introduction. Blocked study presentation produced better recognition performance than random study presentation when old items from a category appeared close to one another in the test list and were in the same order as they had been in the study list. When an uncategorized test list was employed, recognition performance following blocked presentation did not differ significantly from that following random study presentation, replicating the results of Kintsch (1968).

The second experiment was designed to determine the importance of the correspondence between order of instances within a category at the time of study and at the time of test. In the first experiment, the grouping of category instances, irrespective of the order within the group of old category instances, might have been responsible for the observed results. To check this possibility, a third test condition was included in the second experiment. This categorized-unordered test condition changed the order of items within a category between the study list and the test list. Comparisons of the two categorized test conditions provide an indication of the importance of immediate forward associations formed between category members. A difference between a categorized-unordered test condition and an uncategorized test condition might either reflect the influence on recognition of backward and remote associations or suggest that grouping category instances has a nonassociative effect on recognition performance.

Method

Design and subjects.—The second experiment was a $2 \times 3 \times 2$ factorial with 2 levels of organization of the study list (blocked and random), 3 levels of test order (uncategorized, categorized-unordered and categorized-ordered), and 2 replications. All variables were manipulated between Ss. The Ss were 120 students in an introductory psychology class who participated for course credit. Ten Ss were assigned to each of the 12 experimental conditions. The method of assigning Ss to conditions was similar to that employed in Exp. I.

Materials .- With the exception that different categories were employed, words were selected in the same manner as in the first experiment. Again, a study list consisted of 72 words, 6 instances each of 12 different categories. Two basic replications of the design were formed by interchanging the test roles of particular items. Words that held an oddnumbered frequency rank in the category norms were employed as study items in the first replication and as distractor items for the recognition test in the second replication. Distractor items in the first replication and study items in the second replication were words that held an even-numbered rank in the category norms. The mean total frequency, in the category norms, was higher for odd-numbered items (222.3) than for even-numbered items (189.7). Instances of a given category were either blocked or distributed randomly throughout the study list as dictated by the experimental design.

The uncategorized test list and the categorizedordered test list were identical in form to those conditions in the first experiment. The categorizedunordered test list was identical to the categorizedordered test list with the exception that the order of old instances within a category group was different than it had been in the study list. If Items i and j were consecutive instances of a category on the study trial, either other old instances intervened between the tests of Items i and j or Item j was tested prior to the test of Item i in the categorizedunordered test list. Test lists were prepared as mimeographed test booklets. The first page of the test booklet contained a sentence informing S that he was not to open the test booklet until he was instructed to do so. Instructions printed at the top of the second page informed S that he was to circle those items that he thought had occurred on the study list. The second and third pages of the test booklet each contained 72 test items, 3 columns of 24 items each.

Procedure.—The procedure was identical to that of Exp. I, except that after Ss had had 5 min. to

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	Study									
Test	Blocked					Random				
	Hits	FA	D	d'	FC	Hits	FA	D	d'	FC
Uncategorized Categorized-Ordered Categorized-Unordered	51,1 58,2 53,8	6.8 3.6 6.9	44.3 54.6 46.9	2.0 2.7 2.1	56.0 62.5 57.0	50.4 50.0 47.2	8.5 2.8 4.2	41.9 47.2 43.0	1.9 2.7 2.3	55.0 57.6 55.0

TABLE 2 Mean Recognition Measures from Experiment II

complete the test booklet, they were stopped and instructed to count the words they had circled. They were then informed that the study list had contained 72 words. If S had circled fewer than 72 words, he was instructed to place an X beside additional words that he felt might have occurred on the study list until the number of circled plus the number of X'ed words totaled 72. If more than 72 words had been circled initially, S was instructed to place an X beside circled words that he was least confident of until the number of circled words minus the number of circled and X'ed words equaled 72. This procedure was adopted to provide a measure of recognition performance that was unaffected by response bias. No time limit was imposed on the second portion of the recognition test.

Analyses.—The number of hits and number of false alarms, made prior to instruction, restricting the total number of old responses, were totaled for each S. These scores were employed to compute difference scores and d' measures of recognition.

The number of hits and number of false alarms which S made when asked to give a recognition response to 72 words were computed. Instructions were effective in restricting the number of old responses; only five Ss failed to give exactly 72 old responses. Three of these Ss were in error by only 1 response and the others were in error by 2 responses. Not over one S in any one condition was in error. In view of the success of instructions, total number of hits was treated as a forced-choice measure of recognition; as such, it was unnecessary to correct for response bias.

Results

Forced-choice analysis.—The main effect of replications was significant, F (1, 108) = 6.95, p < .01, and the interaction of replication with study list organization approached significance, F (1,108) = 3.68, p < .10. Recognition performance was highest in the first replication, the replication with the higher mean frequency of old items in the category norms. Studylist organization tended to have a larger effect in the second replication.

The results of the second experiment, collapsed across the replications factor, are summarized in Table 2; mean hits and mean false alarms (FA) are presented for each of the experimental conditions, together with difference scores (D), d', and forced-choice (FC) recognition scores. Both the main effect of study list organization, F(1, 108) = 7.69, and the main effect of test condition, F(2, 108) = 8.70, both $p_{\rm S} < .01$, were significant in the analysis of forced-choice scores. Blocked study presentation (58.5) produced higher recognition performance than did random study presentation (55.8). Recognition performance on the categorized-ordered test list (60.0) was higher than that on either the categorizedunordered (56.0) or uncategorized (55.5) test list; the difference between the latter two conditions did not approach significance, t (108) < 1. Although the ordering of means suggests the presence of an interaction between study and test, the analysis failed to provide evidence that the interaction effect obtained in Exp. I had been replicated. The interaction of study and test did not attain significance, either when all three test conditions were included in the analysis, F(2, 108) = 1.41, p > .10,or when only the two test conditions employed in Exp. I, categorized-ordered and uncategorized, were included in the analysis F(1, 108) = 2.60, p > .10.

Comparisons between measures and experiments.—The significant effects revealed by the difference analysis were in nearly complete agreement with the results of the forced-choice analysis. The only discrepancy was that the Study List Organization \times Replications interaction attained

significance in the difference analysis, while only approaching significance in the analysis of the forced-choice measure. The d'analysis also revealed a significant Study List Organization × Replications interaction. In addition, the results of the d' analysis were discrepant from those of the forced-choice analysis in that they failed to reveal a significant main effect of study-list organization, F < 1. In general, the results of the difference and forced-choice analyses were in closer agreement than were the results of the d' and forced-choice analyses.

In contrast to the results of the first experiment, when category instances were randomly presented, the categorizedordered test produced better recognition performance, regardless of recognition measure, than did the uncategorized test. The smaller number of false alarms in the categorized-ordered condition appears to be completely responsible for this effect on corrected recognition scores. Two effects on the number of false alarms were not in agreement with results obtained in Exp. I. First, a categorized-ordered test list in the second experiment produced fewer false alarms than did an uncategorized test list; there was no difference between test lists with respect to the number of false alarms in the first experiment. Second, on the uncategorized test, the number of false alarms following random presentation was larger than the number following blocked presentation. In agreement with the results for both test conditions employed in Exp. I, blocked presentation resulted in a larger number of false alarms than did random presentation in the categorized test conditions.

DISCUSSION

The results of the forced-choice analysis, in Exp. II, were in closest agreement with those from the analysis of difference scores. Consequently, more confidence was placed in the difference analysis of Exp. I, and discussion of the first experiment will be centered around the results of this analysis rather than the results of the d' analysis.

In the introduction, it was suggested that an earlier failure to find an effect of blocked versus random presentation (Kintsch, 1968) could be attributed to the type of recognition test that was employed. Study-list organization was expected to have no effect when the test list was of the type employed by Kintsch, uncategorized, but was expected to have an effect when a categorized-ordered test was employed. It was suggested that differences between recognition performance on the two types of tests would be dependent on the degree of study-list organization; the difference was expected to be larger following blocked, rather than random, presentation. The results of Exp. I provided complete support for the above predictions. However, the results of the second experiment failed to replicate those of the first. Although the difference was numerically larger when a categorized-ordered test was employed, the interaction of study list organization and type of test was not significant in Exp. II. Blocked study presentation produced recognition performance that was superior to that produced by random presentation, regardless of the type of recognition test employed. Recognition performance on a categorized-ordered test was superior to that produced by an uncategorized test.

Organization variables do have an effect on recognition memory. The conditions under which an effect should be expected, however, have not been completely determined. In conflict with the finding of the first experiment, the results of Exp. II agree with those of D'Agostino (1969) in demonstrating that an effect of study organization is not necessarily contingent on the employment of a categorized-ordered test. The superiority of the categorized-ordered test in Exp. II was not dependent on the level of study list organization. As evidenced by the difference between categorized test conditions, the superiority of the categorized-ordered test cannot be easily attributed to the influence of a nonassociative factor such as increased guessing efficiency. If the test effect was produced by differences in the ease with which study associations were employed, study associations must have been formed between randomly presented category instances in Exp. II. A finding that associations had been formed during random presentation should not be surprising; clustering of items on the basis of category membership following random presentation has frequently been observed in studies of free recall (e.g., Cofer, Bruce, & Reicher, 1966). Conflicting results from investigations of organization effects on recognition may be partially due to differences in degree and ease of organization.

Degree of organization probably depends on category size, the particular categories employed, the normative frequency of study words as category instances, S's strategy, and a number of other unspecified variables. Organization of randomly presented category instances would be expected to depend on all of the above variables plus the distance between instances of a given category in the study list. Differences, between experiments, in the particular categories employed may have been responsible for the conflicting results observed in the present investigation.

Following Tulving and Thomson (1971), the probability of recognition is viewed as being dependent on the similarity of the encoding of a test word and information stored in memory. A portion of the encoded version of a given study item may include other items that were in the study list. When this occurs, recognition of an item can be enhanced by preceding its test with the presentation of an item with which it was associated during study. Thus, an ordered test list produces an encoding that is more similar to the representation that was encoded on the study trial and enhances recognition. In the present experiments, it appears that immediate forward associations were formed between category instances. There was no evidence of an effect of either backward or remote associations; recognition performance on the categorizedunordered test did not differ from that produced by the uncategorized test. In general, recognition can be influenced by interitem relationships, and varying the order of items

in a recognition test appears to be a reasonable means of determining the nature of interitem dependencies in storage.

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