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Imagery and recognition memory: The effects of relational organization

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Begg (1978), among others, has recently argued that recognition performance is independent of the size and number of units stored in memory, that is, the degree of interitem organization. In four experiments, interactive imagery was contrasted with separation imagery on recognition memory. In the first two studies, the recognition of single words was better under separation instructions; in the final studies, in which recognition of pairs of words was required, performance was better following interactive imagery. Rather than being independent of the size of memory units, recognition depends upon the relationship between the size of the units encoded at learning and the nature of the test items themselves.

A number of studies have suggested that instructional manipulations that induce subjects to form strong interitem associations during list learning affect recall performance but do not influence recognition memory. For example, Bower, Lesgold, and Tieman (1969) presented subjects the same or rearranged word triplets for two learning-recall trials. All subjects were asked to use mental imagery to link the items within each triplet. Free recall increased across trials for both the same and the rearranged word groupings, but the increase was significantly greater with invariant triplets. In contrast, however, there was no effect due to changing word groupings on recognition. Bower et al. concluded that variables affecting the stability of interitem associations will influence the success of retrieval operations, but not recognition. In a later paper, Bower (1970) compared paired associate recall following instructions for subjects to use relational imagery linking items together, separation imagery with no mediating link between items, or rote repetition of the word pair. Recall was clearly superior with relational imagery, but there were no differences between any of the conditions on the recognition of the stimulus words. Schwartz and Humphreys (1974) compared relational imagery and control instructions on the recall and recognition of single words. Once again, relational imagery produced better recall, but there was no effect of instructions on recognition. Finally, Begg (1978) has replicated the earlier finding that relational and separation imagery produce equivalent recognition memory. Cued recall and the level of organization in free recall, however, were clearly higher with relational imagery.

While the general conclusion of the above experiments has been that interitem organization is of little or no importance for recognition memory, some conflicting results may be noted. Sneed, Brunts, and Mueller (1977) obtained evidence that rearranging word groupings over learning trials results in poorer recognition than does leaving groupings unchanged. This conflicts with the earlier finding of Bower et al. (1969). Second, Peterson and Murray (1973) reported that relational imagery produced significantly better recognition performance than did rote repetition, in contradiction of Bower's (1970) study. Third, Groninger (1974) contrasted separation imagery with neutral control instructions on the recognition of singly presented words and found better performance with the former. The Schwartz and Humphreys (1974) study, on the other hand, obtained no difference between relational imagery and control instructions. If the outcomes of these two experiments are taken together, they suggest that separation imagery may produce better recognition of single test items than does interactive imagery when list words are originally presented one at a time. As yet, such a comparison does not appear to have been carried out in the same experiment. It would seem, therefore, that the relationship between interitem associations and recognition memory is by no means clear.

At a more theoretical level, it has been proposed that the encoding of words involves two relatively independent processes (Anderson & Bower, 1972). First, items are tagged as having occurred in the context of a specific list, and second, associations or pathways are tagged between the list items themselves. This reflects the Bower et al. (1969) distinction between "occurrence information" and retrieval schemes. The tagging of associations or pathways is of particular importance when retrieval of items is required, but not for item recognition. The storage of occurrence information, on the other hand, is of prime importance in the recognition process. The findings of the first-mentioned set of studies fit neatly into this explanatory framework. Relation and separation imagery do not differ in terms of the storage of occurrence information and, consequently, do not differ on recognition tests. They do differ, however, in the degree to which interitem associa-

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tions are tagged, hence the differences in cued recall and degree of item organization in free recall. Begg (1978) has recently put forward much the same argument. Interactive imagery results in information being stored as fewer but larger memory traces or units than does separation imagery, but the amount of item information preserved is equivalent for both types of imagery. If cued recall is considered, the higher performance levels with interactive imagery are explicable in terms of the size and integration of units contacted during retrieval. Recognition, however, depending solely upon stored item information, is independent of the size and number of units in memory.

In the comparison of the two types of imagery instructions and their effects on recognition, a different prediction derives from research investigating context changes between list presentation and testing. Thomson (1972), for example, has shown that when an individual item is encoded in the presence of a context word, the absence of that context word during the test phase lowers the probability that the item will be correctly recognized. This is the case whether the context word is semantically related to the list word or not. Thomson proposed that, at recognition, the encoding of the test item is matched against the trace encoded at original presentation. If these two encodings differ because of the addition or deletion of a context item, then there is a reduced probability of correctly recognizing an old test word. This implies that the context in which a word is encoded determines the nature of the stored occurrence information and that changes in context at testing lead to access problems in retrieving this stored information (Tulving, 1976). On the basis of this argument, relational imagery should decrease the probability of correctly recognizing old, singly presented words relative to separation imagery. In the memory units formed by relational imagery, the way a particular item is encoded will depend to some degree upon the other items in that unit. A recognition test involving single words should disrupt these units in a manner analogous to the deletion of context words in Thomson's (1972) experiments. That is, there will be encoding variability between the input and test phases for old items. Under separation imagery instructions, on the other hand, single words are encoded as memory units at both presentation and testing, so there should be a reduction in encoding variability between these phases and, consequently, higher recognition. Such a prediction runs counter to that based on the argument that recognition is independent of the size and number of traces or units in memory. While memory units of different sizes may contain the same levels of occurrence information, test words will differ in the degree to which they act as cues to provide access to this occurrence information.

EXPERIMENT 1

The aim of the first experiment was to examine recognition performance following instructions to rehearse items by rote to form separate images or to form interactive images linking items together. In effect, this combines the Groninger (1974) and Schwartz and Humphreys (1974) studies into a single experiment. From earlier findings, it would be expected that rote rehearsal would lead to poorer recognition memory than would either of the two types of imagery instructions. If, as Begg (1978) and others have proposed, interitem organization does not affect recognition, then the two imagery instructions should not differ in performance. If, on the other hand, the analysis in terms of encoding variability between input and test phases is correct, relational imagery should produce poorer recognition than should separation imagery.

Method

Design. Instructions to rehearse words by rote, to form separate images, and to form interactive images were varied in a 3 by 2 factorial design, with repeated measures on the second factor. This second variable refers to the type of distractor on the recognition test. Half of the list words had a corresponding unrelated test distractor; half had a corresponding synonym distractor. This was designed to attenuate ceiling effects in recognition performance, since such effects are often present in this type of study. There were 16 subjects in each of the three conditions. All were volunteers from the first-year course in psychology at the University of New South Wales.

Materials. Two sets of 30 pairs of words were constructed, with the pairs in each set being made up of either unrelated or synonymous nouns. The criteria used by the experimenter for placement in a particular set were as follows. Items were classed as unrelated if the items within the pair bore no obvious relationship to each other (e.g., window-pencil, match-rattle). Words were classed as synonyms when the items shared substantially the same meaning; one source for these items was *Webster's Synonyms, Antonyms and Homonyms* (1962) (e.g., shovel-spade, house-home). Imageability (I) ratings were available for 87 of the words; all had mean ratings of 6.00 or above (Paivio, Yuille, & Madigan, 1968). The remaining items all had concrete referents and appeared to readily evoke images.

Two lists of 60 words were constructed, with the items in each pair going into one or the other of the lists. They were then placed on slides. The recognition list consisted of a single random arrangement of all 120 words placed on three separate pages.

Procedure. All subjects were told that they would be given a list of 60 common nouns. Those in the rehearsal condition were asked to repeat the words silently to themselves as they appeared on the screen. Subjects in the separate imagery group were told to form a single image or mental picture for each item and were specifically asked not to link their images together. Finally, those in the relational imagery condition were told to form their images around consecutive groups of three words. It was stressed that after each triad of items, they should commence a new interactive image. Such instructions are known to produce pronounced effects on the organization of recall (Begg, 1978), and it was hoped that they would result in the formation of cohesive memory units.

Subjects were tested either individually or in small groups, depending upon attendance at the experimental session. All subjects received six practice words prior to list presentation; they were not informed how their memory for the material would be tested, although they were told to expect a test. The words were then presented via a Kodak Carousel projector with an automatic timer set for an exposure duration of 5 sec. In each group of 16 subjects, half received one list and half received the other. The recognition list was then distributed with instructions to cross out those items that had not been shown. A 10-min period was set for recognition testing.

Results and Discussion

Each subject's recognition protocol was scored for the number of hits and false alarms made on the unrelated and synonymous sets of words. The hit and false alarm rates for each instructional condition are shown in Table 1. Recognition performance was analyzed using d′ values. Because ceiling effects were apparent in the unrelated item sets under imagery instructions, the d′ values were calculated using the total numbers of hits and false alarms for each subject. The mean d′ values in the rote rehearsal, separate imagery, and relational imagery conditions were 1.79, 3.56, and 2.90, respectively. They were analyzed using orthogonal planned contrasts (Hays, 1969), with the rejection region for each contrast set at $p < .05$.

The first contrast compared the overall performance in the rote rehearsal conditions with the average of the two imagery conditions. This contrast was significant [$F(1,45) = 36.63$, $MSe = .61$]; recognition was clearly poorer in the rehearsal group. The second contrast, which compared the separate imagery condition with the relational condition, was also significant [$F(1,45) = 5.68$, $MSe = .61$]. Recognition performance following separate imagery was better than that following relational imagery.

The finding that rote rehearsal leads to poorer recognition than do instructions to form either separate or relational images is in agreement with the findings of Groninger (1974) and Peterson and Murray (1973). In addition, inspection of the hit and false alarm rates indicates a similar pattern of recognition confusions in the rehearsal and imagery conditions, with synonymous set errors predominating over unrelated set errors. This is evidence that semantic encoding resulted from both rehearsal and imagery instructions (cf. Elias & Perfetti, 1973). More important, however, is the finding that relational imagery produced poorer recognition performance than did separate imagery. This supports the hypothesis of encoding variability between input and testing with relational imagery and runs counter to the argument that interitem organization has no effect on recognition.

Table 1
Mean Hit and False Alarm Probabilities as a Function of Instructions in Experiment 1

Item Set	Instructions: Rehearsal	SI	II
	Hit Probabilities		
Unrelated	.76	.97	.94
Synonymous	.74	.94	.84
	False Alarm Probabilities		
Unrelated	.10	.01	.05
Synonymous	.22	.09	.13

Note–SI = separate imagery; II = interactive imagery.

EXPERIMENT 2

The second study again contrasted separate and relational imagery instructions in order to confirm the results of Experiment 1. Subjects in the relational imagery condition were asked to form their images around successive pairs of words rather than triplets. This in effect makes the instructions formally similar to those of Begg (1978) and Bower (1970). Second, the study list length was increased to 80 words in an attempt to avoid the ceiling effects present under separate imagery instructions. The predictions remain the same. The change of context or encoding variability hypothesis predicts a significant difference between the two types of imagery. If recognition is independent of the size and number of stored memory units, there should be no effect of instructions.

Method

Design. Separation and relational imagery instructions were compared in a 2 by 2 factorial design with repeated measures on the second factor, type of word set. There were 16 subjects in each instructional condition, all from the first-year psychology course at the University of New South Wales.

Materials and Procedure. Two sets of 40 pairs of words were constructed in a manner similar to that in Experiment 1. The recognition list consisted of all 160 items arranged in a random fashion. The experimental procedure was the same as in the first study, except that subjects in the relational imagery condition were required to form their images around pairs of words.

Results and Discussion

Each subject's recognition sheets were scored for the hit and false alarm rates on the unrelated and synonymous sets of words. The mean hit and false alarm rates in the separate imagery condition were .97 and .02 (unrelated set) and .95 and .09 (synonymous set). In the relational imagery condition, the respective means were .93 and .05 (unrelated set) and .87 and .16 (synonymous set). Each subject's overall hit and false alarm probabilities were converted into d′ values, as in Experiment 1. The mean d′ (with standard deviation in parentheses) for the separate imagery condition was 3.71 (.84), whereas that of the relational imagery condition was 2.68 (.71). This difference was statistically significant [$t(30) = 3.72$, $p < .05$].

The results of this study confirm the finding in Experiment 1 of poorer recognition following relational imagery instructions. Contrary to Begg (1978), Bower (1970), and Schwartz and Humphreys (1974), interitem associations can clearly influence recognition processes. The most reasonable explanation appears to be one in terms of context changes between presentation and testing, with consequent encoding variability producing difficulties in retrieving stored occurrence or item information (Tulving, 1976).

While the first two studies demonstrate that item organization hinders the recognition of individually presented list words, it is possible to think of instances

in which such associations should aid recognition. Consider an experiment in which subjects are asked to learn a list of paired associates with either separation or relational imagery. They are then presented a recognition test of pairs of words on which the stimulus terms are always old but the response-term test items may be old, new words not on the original list, or rearranged so that they occur with a different stimulus term. For example, if the original list contained the pairs ship-tree, toast-cottage, and fork-chair, the recognition list could contain ship-tree (old response term), toast-chair (rearranged response term), and fork-radio (new test item). In such a recognition test, the subject needs to decide whether the response term occurred at all on the original list and whether it occurred in the context provided by the stimulus term. Clearly, relational information should play an important role in recognition decisions. Interactive imagery, in contrast to the first two experiments, should now produce better performance than separation imagery because it results in the storage of interitem associations needed for recognition.

EXPERIMENT 3

The aim of the third study was to examine recognition memory in the manner outlined above following rote rehearsal, separation imagery, and relational imagery instructions. Again, it was expected that rote rehearsal would produce the poorest overall levels of performance, whereas separation imagery would be worse than interactive imagery.

Method

Design. Instructions to rehearse paired associates, to form separate images, or to form interactive images to each pair were varied in a 3 by 2 factorial design, with repeated measures on the second factor. The latter was the type of item on the recognition test (new or rearranged response terms). There were 10 subjects in each of the three conditions. All were student volunteers from the first-year psychology course at the University of Newcastle.

Materials. A pool of 130 pairs of nouns, for the most part selected from the Paivio et al. (1968) norms, was constructed with the proviso that items in each pair not be related to each other in any obvious way. Two lists of 100 pairs were then formed by random selection from the word pool. For each list, a recognition set was made up, consisting of all 100 first members of the pairs matched with 50 of the second items (intact pairs), 25 extralist items (new pairs), and 25 re-paired response terms (rearranged pairs).

Procedure. The list pairs, numbered 1 to 100, were arranged on typed sheets, with 20 pairs to a page. These sheets were then presented to the subjects in a manilla folder. Subjects were tested either individually or in pairs. In each group of 10 subjects, half received one list and half received the other. Subjects in the rote rehearsal condition were asked to simply repeat the pair of words silently to themselves. Those in the separate imagery condition were instructed to form an image for each word but to keep the images noninteracting. Finally, subjects in the relational imagery group were asked to incorporate the two images into a single image. All were informed that the experimenter would pace them through the list by reading out the numbers associated with each pair at the rate of one every 10 sec, in numerical order. Five practice pairs were given before actual list presentation. After list learning, the recognition sheets were distributed, with instructions to cross out those pairs that were not identical to the ones just viewed. A 15-min period was set for recognition testing.

Results and Discussion

Each subject's recognition sheet was scored for the probability of a hit and the probabilities of making false alarms on new test pairs and on re-paired test items. The mean hit and false alarm rates, together with the d′ values, are shown in Table 2. The d′ values were analyzed with the same orthogonal planned contrasts used in the first study. The rejection region for each contrast was set at $p < .05$.

The first contrast, comparing overall recognition in the rehearsal condition with the average of the imagery conditions, was significant [$F(1,27) = 6.98, MSe = 1.56$]. Performance was generally poorer following rehearsal. The comparison of the two imagery conditions was also significant [$F(1,27) = 10.17$, $MSe = 1.56$], with overall discrimination being lower in the separate imagery group. There was a significant effect due to type of test item [$F(1,27) = 52.78$, $MSe = .17$], indicating poorer discrimination of re-paired items than of new items from the old pairs. This effect, however, was relatively small in the interactive imagery condition and strongest in the separate imagery condition. This was reflected in the interaction between the type of test item and type of imagery instruction [$F(1,27) = 17.68, MSe = .17$].

Once again, rote rehearsal led to the poorest overall recognition performance. The rehearsal group had the lowest hit rate, as well as an elevated false alarm rate on new test items. It is of note, however, that the false alarm rate of .24 on re-paired items was lower than that of the separate imagery group (.42). More important, the results of this study indicate that relational information can play an important role in recognition decisions. In contrast to the first two experiments, in which interitem associations interfered with the recognition

Table 2
Mean Hit Probabilities, False Alarm Probabilities, and d′ Values as a Function of Instructions in Experiment 3

	Instructions		
Distractor	Rehearsal	SI	II
		Hit Probabilities	
Overall	.69	.81	.91
		False Alarm Probabilities	
New	.14	.06	.03
Re-Paired	.24	.42	.08
		d′ Values	
Old-New	1.82	2.67	3.38
Old/Re-Paired	1.45	1.14	2.95

Note—*SI = separate imagery; II = interactive imagery.*

of single test words, such associations enhanced performance when the recognition of pairs of test words was involved. This enhancement was most notable in the discrimination of re-paired items.

EXPERIMENT 4

The aim of the fourth study was to further compare the recognition of pairs of words following separation and interactive imagery instructions. A methodological change was introduced in this study by allowing subjects to pace themselves through the list at their own rate. This was done because of the informal comments of some of the subjects in the previous study that they would have liked a little more time to form their images. It is possible, for example, that differences between the relational and separate imagery conditions reflect differences in the time required to form the appropriate images.

Method

Design. Separation and relational imagery instructions were contrasted in a 2 by 2 factorial design, with repeated measures on the second factor, type of test item. There were 10 subjects in each imagery condition. All were volunteers from the first-year psychology course at the University of Newcastle.

Materials and Procedure. The study and recognition lists constructed for the previous experiments were used in this study. Instructions to subjects in the two imagery groups also remained the same. The only change in procedure was that subjects were told that they could work their way through the list at their own pace. The lists were presented on typed sheets face down in a manilla folder, and subjects were asked to turn over a new page when they had finished with the previous one. All subjects were tested individually and timed by the experimenter with a stopwatch.

Results and Discussion

Each subject's recognition protocol was scored in the same way as in the previous experiments. The mean hit rate in the interactive imagery condition was .96; that in the separate imagery condition was .84. The mean false alarm rates for new and rearranged test items were .02 and .04, respectively, in the interactive imagery group and .03 and .29 in the separate condition. The mean d' values were 3.20 (old-new) and 1.72 (old/re-paired) in the separation condition and 3.87 and 3.63, respectively, in the interactive condition.

A 2 by 2 analysis of variance performed on the d' scores revealed a significant main effect for instructions [$F(1,18) = 21.96$, $MSe = .75$]. Type of test item was also significant [$F(1,18) = 39.56$, $MSe = .19$]. As was the case in Experiment 3, there was a significant interaction between these two main effects [$F(1,18) = 20.34$, $MSe = .19$]. In the separate imagery condition, recognition of re-paired items was substantially reduced relative to new items, whereas in the interactive condition the recognition of both types of items was virtually equivalent.

Finally, each subject's total time spent in learning the study pairs was divided by 100 to obtain an approximate estimate of the amount of time spent on each pair. In the separate imagery conditon, the mean time was 9.36 sec/pair; in the interactive group, the mean time was 9.59 sec/pair. This difference was not statistically significant [$t(18) = .14$, $p > .05$].

The results of this experiment confirm those of the previous one. Separation imagery instructions produced poorer recognition performance as measured by d' than did interactive imagery instructions. The source of this difference is in terms of hit rate and the correct rejection of re-paired test items. False alarms made on new pairs were close to ceiling level in both imagery groups. The obtained effects did not appear to be attributable to the time required to form separate or interactive images. The most reasonable explanation is that, in the cases of old study pairs and rearranged test pairs recognition decisions need to be based on occurrence information and also on relational information that is not encoded under separate imagery instructions. The recognition of new test pairs appears to be based on occurrence information alone, hence the absence of an effect due to type of imagery.

GENERAL DISCUSSION

The present series of experiments investigated recognition performance following rehearsal, separation imagery, and interactive imagery. The findings of generally poorer performance with rehearsal replicate earlier studies and will not be discussed further. As a whole, the results of these four experiments are not consistent with the view that the tagging of associative pathways between items has no effect on recognition of those items. While Begg (1978) has argued in somewhat different terms that recognition is independent of the number and size of units stored in memory, the present results do not support such a hypothesis. Experiments 1 and 2 showed that recognition of single words was poorer when subjects had originally formed strong interitem associations than when they had encoded the words separately. In Experiments 3 and 4, on the other hand, such associations were shown to benefit performance when the recognition of list pairs, and particularly, rearranged pairs was required. Clearly, a fuller account of the relationship between organization and recognition memory needs to make reference to the nature and size of the units constituting the recognition test items and the relationship between the test units and those encoded at initial presentation.

The results may best be accounted for by assuming, along with Anderson and Bower (1972), Begg (1978), and others, that at the time of list presentation, subjects may encode occurrence or item information and relational information. Separation imagery instructions emphasize the encoding of the former, whereas interactive imagery instructions lead to the encoding of both types of information. At the time of recognition, a subject's level of performance will depend upon the infor-

mation encoded at study and the nature of the test items. If individual items are to be recognized, the presence of associative links between words worsens performance because of context changes between study and test phases (Thomson, 1972; Tulving, 1976). The context change makes it difficult to retrieve the stored item information that allows correct identification of items. If pairs of items are to be recognized, then the encoding of relational information is a necessary precondition for recognizing which items go with which.

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