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Conceivably, the differences among conditions are attributable solely to differences in response availability. If so, then differences among the conditions in recall performance would disappear in tests of recognition memory.

METHOD

Three paired-associate lists of 30 items each were constructed using unrelated concrete nouns. Each S learned and recalled all lists. Study times and test times were 5 sec per item. After one study trial on each list, an "immediate" test followed for the items of that list. The test stimuli were presented in the same order as that in which the pairs had been studied, thus assuring a constant lag of 30 items between studying and testing each pair. After the three lists had been studied and tested once each, a final test was given to all 90 pairs. On both immediate and final tests, half the items were tested for cued recall and half by multiple-choice recognition. The recognition test presented the cue word followed by five response words from the appropriate list; S was to select and say aloud the correct response that had been paired with the cue word. No feedback was given on test trials.

Each S was assigned randomly to one of four groups, received general paired-association instructions, and then was instructed specifically on how to memorize the S-R pairs. In the repetition condition, S was asked to repeat or rehearse each pair silently to himself during the study time. In the sentence-reading condition, S saw each pair as capitalized subject and object nouns in a simple declarative sentence, was told to read the sentence aloud and use it to associate the two critical nouns. In the sentence-generation condition, S was shown each pair and asked to make up and say aloud a meaningful sentence or phrase using and relating the two words in a sensible way. In the imagery condition, S was asked to visualize a mental picture or image in which the two referents (denoted by the words) were in some kind of vivid interaction. He was encouraged to make his image as elaborate, vivid, or bizarre as he wished. The Ss were 40 undergraduates fulfilling a service requirement for their introductory psychology course, with 10 Ss assigned to each of the four learning conditions.

RESULTS

The average number of correct responses per list (15 recall and 15 recognition items) is given in Table 1 for the four types of learning conditions. "Immediate" in Table 1 denotes tests given just after each set of 30 items had been studied. "Final" denotes the test of all items at the end of the session after the three lists had been

Comparison of associative learning strategies

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Ss learned paired-associate lists of nouns using one of four learning strategies: repetition of the pair, reading the pair as subject and object nouns in a meaningful sentence, generation of a meaningful sentence linking the two nouns, or visualization of a mental image in which the word referents were in vivid interaction. Half of the pairs were tested for recall of the response member given the stimulus and half were tested for multiple-choice recognition of the response. Significant differences in recall and recognition occurred with conditions ranking in the order: imagery (best), sentence generation, sentence reading, and rote repetition (worst). The results are interpreted in terms of associative consequences of relational organization: S's memory benefits from actively searching out, discovering, and generating (or depicting) predicative or actor-action-object relations between the words or referents of a pair.

This experiment is concerned with the effect of various learning strategies upon paired-associate learning by college Ss. Ss spontaneously use many different techniques to learn paired associates; with noun pairs, the techniques may range from simple repetition to the construction of catchy phrases or elaborate narratives woven around the word pair. Rohwer (1966) reported that reading young children a declarative sentence linking the S-R pair as subject and object nouns produced better recall than having the children simply study the pair without a sentence context. Further, Bobrow & Bower (1969) found that college students

remembered a noun pair much better if they generated their own sentence linking the word pair rather than just studying the pair embedded in a sentence constructed by E. Finally, Bower (in press) cites evidence that having S form a mental picture of the words' referents in vivid interaction produces somewhat better learning than does having S generate a sentence linking the word pair. Comparing across these several studies, there seems to be a progressive improvement in recall going from rote repetition to studying the word pair in a sentence, to generating a sentence linking the pair, to forming an interactive mental image. The following experiment compares these several learning strategies within one experiment and one S population, using both recall and recognition tests of associative learning.

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Table 1
Average Correct Responses Per List for Four Study Conditions (Out of 15)

Test Type		Repetition	Sentence-Reading	Sentence-Generation	Imagery
Immediate	Recall	5.57	8.17	11.50	13.10
	Recognition	12.03	13.10	14.80	14.67
Final	Recall	5.23	8.03	10.93	12.67
	Recognition	11.73	13.13	14.70	14.87

studied and tested once each. The pattern of results and the outcome of statistical analysis were much the same for the immediate and the final test results.

There were significant differences in immediate recall among the four mediation conditions, $F(3,36) = 32.24$, $p < .001$; all ordered pairwise t tests were significant at or beyond the .05 level. The recognition data also showed significant differences among conditions, $F(3,36) = 7.68$, $p < .01$; however, ordered t tests revealed that the only significant pairwise gap was that between the sentence-reading vs the sentence-generation conditions, $t(18) = 3.64$, $p < .01$.

DISCUSSION

In general, the comparative results on recall are much as conjectured from the prior pieces of evidence: Visualization of interactive scenes produced best recall, followed by sentence generation, then sentence reading, and finally rote repetition of the pair. We may suppose, with Asch (1969), that associative learning is largely determined by the person finding and remembering some sort of relation among the two items. Rote repetition of two words insures the relation of temporal contiguity between the two phonotographic units, but few relations other than contiguity are aroused, activated, or used for storing the S-R pair. Declarative sentences, embedding the critical words as subject and object nouns, assert predicative relations among the words, usually treating them as "actor" and "object of action." Bobrow & Bower (1969) conjectured that the advantage in recall of sentence-generating Ss over sentence-reading Ss is due to differences in probability or amount of "comprehension"

of the relationship between the critical nouns in the two cases. Ss who must search out and construct a linking (predicative) relationship among two nouns are more likely to activate and thereby associate the two full semantic concepts than are Ss who merely read a large number of similar sentences.

The recall difference between the imaging and sentence-generation conditions is interesting, and its significance is open for speculation. Paivio (1969) and Bower (in press) have conjectured that imaging Ss benefit because they may establish a dual memory code, with both verbal and imaginal memory traces. Bower proposed that the code in the verbal memory system corresponds to an "actor-action-object" relational bonding between the semantic concepts, while the code in the pictorial-imaginal memory system depicts the visual schema or scene corresponding to the semantic relations found. Later presentation of the cue word may reinstate either the sentence memory code (from which the other main noun can be selected for recall) or the code for visualizing the constructed scene (from which S will "recognize" the main objects and thus "recall" the name of the desired object). Imaging Ss exceed sentence-generation Ss, by hypothesis, because the former Ss have both memory codes available whereas the latter Ss predominantly have only the verbal code available. A relevant bit of evidence is that Ss instructed to visualize or mentally image the scene described by a declarative sentence give associative recall of the main nouns at a level significantly higher than that of Ss who simply read the sentence.

The discussion above applies to the

recall results. The pattern of results is quite similar with the multiple-choice recognition tests except that an obvious ceiling is apparent in the better learning conditions. Recognition even on the final test was 98% and 99% for the sentence-generation and imaging conditions, respectively. The significant gap in recognition is between the sentence-reading vs sentence-generation Ss, which suggests an "active-idiosyncratic vs passive-prescribed" dimension to the Ss' associative strategies. It may be noted that this was also the largest gap between conditions in recall probability. The recognition data will be interpreted as disconfirming the response-availability account of mnemonic differences: Even with response-availability factors equated by recognition tests, performance following the various learning strategies still differs. Without strong arguments to the contrary, the recognition data will be interpreted as showing the same differences among conditions as were shown by the recall tests. Depending on one's theory, this may imply that the mediation conditions differ in the amount or quality of information that is stored about each pair rather than differing in terms of retrieval efficiency of a constant amount of stored information.

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