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Notes, Comments, and New Findings

The Representation of Pictures in Memory

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The two experiments presented in this article examined the memory representation of pictorial information. The technique used to investigate structure was priming in item recognition. Subjects studied a list of pictures and then were tested for recognition of parts of pictures. In Experiment 1, the time to recognize a target part of a picture was speeded (primed) if the immediately preceding part in the test list was from the same picture. This priming effect was larger if the two parts were interacting with each other in the picture than if they were not interacting. Experiment 2 showed more priming between the interacting, foreground parts of a picture than between one of the interacting parts and a background part. For noninteracting parts, priming between foreground parts was equal to priming between foreground and background parts. It is suggested that priming may prove a useful technique for investigating other aspects of the representation of pictorial information.

In recent years, there has been considerable discussion about the representation of pictorial information in memory. The discussion has focused on the form of the representation—whether it is a pictorial, imagelike representation or a propositional representation. In this article, the issues addressed concern not the form of the representation but rather its content. Specifically, the experiments are designed to investigate the relationships between the different parts of the representation of a picture in memory. The experiments also illustrate a new methodology for the study of memory for pictures.

Figure 1 shows examples of the pictures used in the experiments. In the first picture, the policewoman and the pig are interacting with each other, whereas in the second picture, the two people standing by the bus stop are not interacting with each other. Thus, the relationships between the parts of the two pictures are different. This difference may lead to differences in the memory representations of the two pictures. The policewoman and the pig may be more closely (or more strongly or more probably) connected in the memory representation of their picture than the man and the woman are in the memory representation of their picture. This is the hypothesis tested in Experiment 1. In Experiment 2, the question of interest was whether the background parts of a picture are as closely connected to the foreground parts of the picture as the foreground parts are to each other.

These two experiments were designed to investigate the effect of the meaningful relations between parts of pictures on memory for pictorial information. The experiments were also designed with a second goal, namely, to test a new method of investigating memory for pictures. The method is priming in item recognition, a method that has worked well for investigating memory for sentences and paragraphs. McKoon and Ratcliff (1980; Ratcliff & McKoon, 1978) have used priming to measure the relative distances between propositions in the memory representations of paragraphs. They used a study–test procedure, with paragraphs as the study items and individual words as the test items. For each test word, the subject was instructed to respond according to whether it had appeared in a studied paragraph. If a test word was immediately preceded in the test list by a word that was close to it in the propositional representation of the paragraph, then response time to the test word was speeded (primed) relative to a control condition in which the immediately preceding test word was farther away in the propositional representation.

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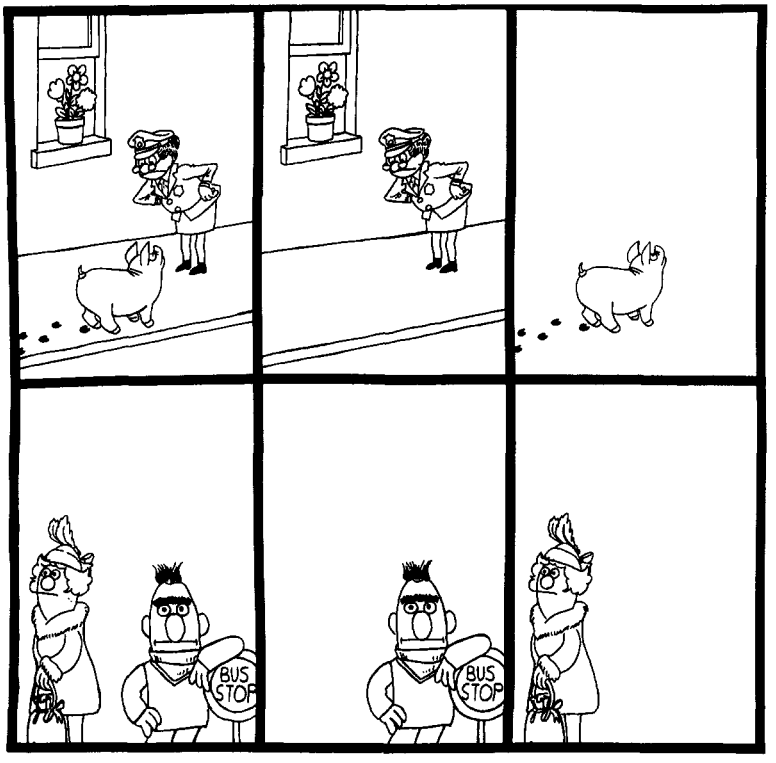

Figure 1. Examples of the pictures used in Experiment 1.

An analogous method was used in the experiments presented in this article. Subjects studied a list of pictures such as those in Figure 1. Then they were tested on parts of pictures (as shown in Figure 1). For each part, they were instructed to respond according to whether it was a part of a picture they had studied. It was expected that when one part was immediately preceded in the test list by another part of the same picture, then response time would be speeded relative to a condition in which the part was preceded by a part from another picture. The amount of speedup (or priming) was expected to depend on how closely the two parts were connected in the memory representation of the picture.

Experiment 1

The first picture in Figure 1 is an example of one of the sets of pictures used in Experiment 1 and the second picture is an example of the other set. In every picture there were two foreground characters, but in one set of pictures (such as the policewoman and the pig) the two characters were interacting and in the other set (such as the two people at the bus stop) they were not. The hypothesis tested in Experiment 1 was whether the difference in the relationships among the parts of the pictures would be reflected in the memory representations of the pictures. Would the interacting characters be more closely (or more strongly or more probably) connected than the noninteracting characters? If so, this difference in the connections between the characters should be revealed by a difference in the amount of priming between them. The policewoman should prime the pig more than the two people at the bus stop prime each other.

Method

Subjects. The subjects were 18 Dartmouth undergraduates who participated in the experiment for extra credit in an introductory psychology course.

Materials. For the experimental design there were 80 pictures, each of which had two foreground characters; for 40 of these pictures the characters were interacting and for 40 they were not interacting. The foreground parts of a picture were always parts that appeared to be as close or closer to the observer of the picture than any other

parts of the picture. Interacting characters were, for example, participating in conversation, exchanging some object, or looking at each other. Noninteracting characters were simply present in the same scene. Foreground characters in the interacting pictures were, on average, about the same size and about the same distance from each other as the foreground characters in the noninteracting pictures. There were also 40 filler pictures. All pictures were adapted from pictures in children's coloring books. The same characters did not appear in more than one picture.

For each of these 120 pictures, two test items were constructed. For the 80 pictures used in the experimental design, one test item, designated as the target, showed one of the foreground characters and the other test item showed the other foreground character. For none of the 120 pictures did the two test parts overlap in any way. There were also 120 test items that were parts of pictures not used in the experiment; these were the negative test items.

Procedure. A study–test procedure was used. All study and test items were presented with a Kodak slide projector controlled by a microcomputer interfaced to Dartmouth's time-sharing computer. Responses were recorded on the keyboard of a cathode ray tube (CRT) terminal, which was also interfaced to the time-sharing system by the microcomputer.

Each trial of the experiment consisted of a study list of "whole" pictures and a test list of "parts" of pictures (see Figure 1). On the practice trial, there were 5 pictures to study and 12 test parts. There were four experimental trials, each with 30 study pictures and 90 test parts. For the 30 study pictures, 10 pictures were chosen randomly without replacement from the interacting picture set, 10 from the noninteracting picture set, and 10 from the filler set. These were presented in random order in the study list. The test list was constructed in the following way: First, the target part of each of the interacting and the noninteracting pictures was placed in a randomly chosen position in the test list, but not in positions 1 or 2. Then, if a target part was to be primed, the other part of the same picture was placed in the immediately preceding test position. If the target was not to be primed, then a part of some other studied picture was placed in the immediately preceding test position. Finally, the remaining parts of the interacting, the noninteracting, and the filler study pictures, and 30 of the negative test parts were placed in the remaining test positions in random order. The restrictions on construction of the test list were that a part of one of the interacting or noninteracting pictures could not precede the unprimed target of that picture by fewer than three test positions and that no test item could be used more than once.

Each picture in the study list was displayed for 4 sec. The time interval between each picture was the time required for the projector to advance to the next slide. After the study list, there was a blank interval of 4 sec to cue the subject that the test list was about to begin. The parts of the test list were then displayed one at a time. Each remained in view until the subject made a response, then the projector advanced to the next test item. The subject was instructed to respond "yes" or "no" according to whether the part had appeared in any of the pictures in the study list. The "/" and "Z" keys on the CRT keyboard were used for yes and no responses, respectively. Subjects were instructed to respond quickly and accurately.

Design. There were two factors in the experiment: A picture showed either interacting or noninteracting characters, and the target part of a picture was either primed by the other part of the picture or unprimed (preceded in the test list by a part from another studied picture). The interacting pictures were divided into two sets (20 per set); these were combined with the two priming conditions and two groups of subjects (nine per group) in a Latin square design. The noninteracting pictures were treated in the same manner. Order of presentation of study and test items was rerandomized for every three subjects.

Results and Discussion

Responses slower than 3.0 standard deviations from a subject's mean were eliminated from the analyses. Only correct responses preceded by correct responses were included in the analyses to be as sure as possible that both the priming and the target items were in memory. All analyses were based on means for each subject or test item in each condition. Means of these means are shown in Table 1.

There were two factors in the experiment:

Table 1
Response Times and Error Rates: Experiment 1

Condition	Test part	
	Primed	Unprimed
Interacting parts	1,636 (14)	1,756 (26)
Noninteracting parts	1,675 (14)	1,720 (18)
Other positive test items	1,781 (18)	
Negative test items	1,894 (13)	

Note. Numbers given in parentheses are percentages. Response times are in msec.

whether a picture showed interacting characters or noninteracting characters and whether the target part was primed or unprimed. Response times for the targets of interacting and noninteracting pictures did not differ ($F < 1$) either when the analysis treated subjects as a random variable or when the analysis treated materials as a random variable. Response times for primed targets were faster than response times for unprimed targets; this effect was significant with subjects as the random variable, $F(1, 12) = 33.5$, $p < .001$, but not with materials as the random variable, $F(1, 76) = 1.5$, $p = .22$.

The question of interest in the experiment was whether the priming effect would be larger for the interacting pictures than for the noninteracting pictures. This interaction is shown in the data of Table 1. For interacting pictures, primed responses were 120 msec faster than unprimed responses; for noninteracting pictures, primed responses were only 45 msec faster than unprimed responses. This interaction was significant in the subjects analysis, $F(1, 12) = 5.7$, $p < .04$, and marginally significant in the materials analysis, $F(1, 76) = 2.9$, $p < .09$. With subjects as a random variable, primed and unprimed responses differed significantly for interacting pictures, $F(1, 12) = 35.2$, $p < .001$, and for noninteracting pictures, $F(1, 12) = 4.9$, $p < .05$. With materials as a random variable, primed and unprimed responses differed significantly for interacting pictures, $F(1, 76) = 4.3$, $p < .04$, but not for noninteracting pictures ($F < 1$). Average standard error of the means was 23 msec. An interaction also appeared to be present in the error data; however, it was not significant in analyses of variance.

Thus it appears that the priming effect was larger for the interacting pictures than for the noninteracting pictures. In other words, when the two characters shown in a picture interacted with each other, then they primed each other more in the test list than characters that did not interact with each other. This result is interpreted to reflect the relationships between the characters in the memory representations of the pictures. Interacting characters are more closely (or strongly or probably) connected than noninteracting characters. Note that the result of this experiment cannot be attributed to differences in physical distance in the pictures between the characters; noninteracting characters were as close together as interacting characters.

Experiment 2

Experiment 2 was designed to investigate the closeness of connections between two foreground parts of a picture relative to the closeness of connections between a foreground part and a background part. The experiment was also designed to compare these relative distances for pictures in which the foreground parts were interacting and pictures in which the foreground parts were not interacting.

Figure 2 shows two of the pictures used in the experiment. In the first picture, the two foreground parts, the character with three heads and the Count, are interacting, and the woods are the background part. The Count was designated the target part, and it was primed either by the other foreground part, the three-headed character, or by the background part—the woods (see Figure 2). In the second picture of Figure 2, the foreground parts are not interacting. The man was designated the target, and it was primed either by the other foreground part, the woman and the girl, or by the background part.

Method

Subjects. There were 24 subjects from the same population as in Experiment 1.

Materials. There were 20 pictures with two foreground characters interacting and a background part, 20 pictures with two foreground parts not interacting and a background part, and 20 filler pictures. For each of the 20 interacting and 20 noninteracting pictures, there were three test items: the two foreground characters, one designated the target, and the background. In general, foreground parts were parts that appeared to be as close or closer to the observer of the picture than background parts. Background parts were generally scenery, including scenes of buildings, trees, mountains, farms, gardens, and so forth. The distance between the target and the other foreground part of a picture was, on average, slightly less than the distance between the target and the background part. The sizes (areas of the pictures covered) of the background and foreground parts were, on average, the same. For the fillers, there were two test parts. None of the test parts overlapped each other in any way. There were also 60 test items that were parts of pictures that had not appeared in the experiment.

Procedure. In general, the procedure was the same as that used in Experiment 1. In Experiment 2, there were only three trials, with 20 study pictures and 60 test items per trial. On each trial, the study pictures included 6 or 7 interacting pictures, 6 or 7 noninteracting pictures, and 6 or 7 fillers. Forty of the test items were positive and 20 were negative.

Design. There were two factors in the experiment; a picture was either interacting or noninteracting, and the target part of the picture was

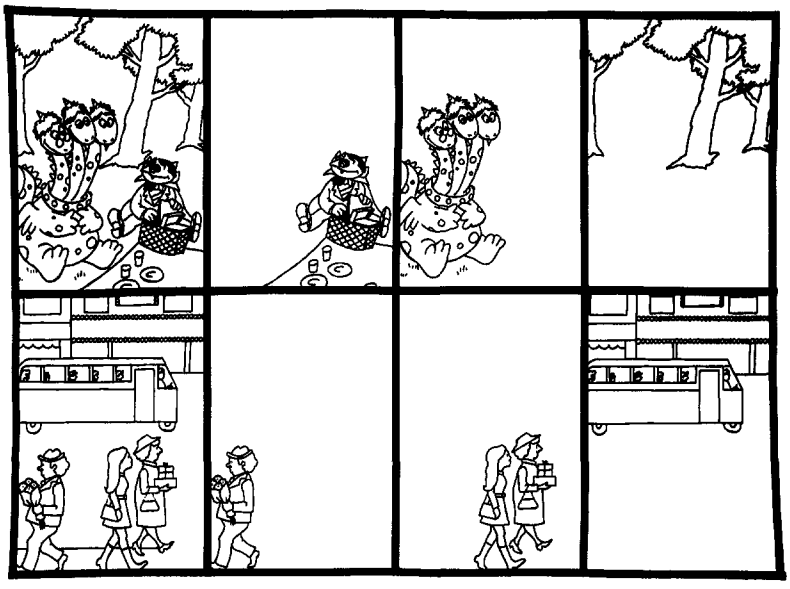

Figure 2. Examples of the pictures used in Experiment 2.

primed either by the other foreground part of the picture or by the background part of the picture. For the interacting pictures, the two priming conditions were combined with two sets of pictures (10 per set) and two groups of subjects (12 per group) in a Latin square design. The noninteracting pictures were treated similarly. Order of presentation of materials was rerandomized after every sixth subject.

Results and Discussion

The data were analyzed as in Experiment 1 and are shown in Table 2. Response times to targets of interacting and noninteracting pictures differed marginally in the subjects analysis, $F(1, 20) = 3.5$, $p < .08$, but not in the materials analysis ($F < 1$). The main effect of priming the target with a background part versus priming with a foreground part was marginally significant, $F(1, 20) = 4.6$, $p < .05$ (subjects analysis), and $F(1, 36) = 3.4$, $p < .07$ (materials analysis).

The interesting result in this experiment concerns the interaction of these two factors, marginally significant by subjects analysis, $F(1, 20) = 3.6$, $p = .07$, and by materials analysis, $F(1, 36) = 3.9$, $p = .05$. For pictures in which the foreground parts did not interact, response times for the foreground targets did not differ according to whether the priming part was the other foreground part or the background part ($F < 1$) in both subjects and materials analyses. In contrast, for pictures in which the foreground parts were interacting, response times for the targets were faster when the prime was the other foreground part than when the prime was the background part, $F(1, 20) = 6.7$, $p < .02$ (subjects analysis) and $F(1, 36) = 14.4$, $p < .001$ (materials analysis). Average standard error of the means was 39 msec. The data also appear to show an interaction in error rates, but this was not significant.

These results show that when two characters in a picture are interacting, they are more closely connected to each other in the memory representation than they are to the background of the picture. However, when two characters are not interacting, they are as closely connected to the background as they are to each other. It should be noted that the result for interacting pictures

Table 2
Response Times and Error Rates: Experiment 2

Condition	Test part	
	Primed by foreground	Primed by background
Interacting parts	1,603 (15)	1,710 (24)
Noninteracting parts	1,721 (21)	1,717 (28)
Other positive test items	1,701 (24)	
Negative test items	1,797 (14)	

Note. Numbers in parentheses are percentages. Response times are in msec.

cannot be due to differential priming of the target by character versus scenery parts because there is no differential priming for the noninteracting pictures. Rather, the result for the interacting pictures reflects the amount of interaction between the foreground characters relative to the amount of interaction between the foreground characters and the background.

General Discussion

The experiments presented in this article investigated two questions about the representation in memory of pictures. The first question was whether two parts of a picture would prime each other more if they were interacting with each other than if they were not interacting. The results of Experiment 1 showed this to be the case. The second question concerned priming between foreground parts and background parts. In Experiment 2, it was found that a foreground part was primed more by another foreground part than by a background part if the two foreground parts were interacting. When the two foreground parts were not interacting, then priming appeared to be equal for foreground and background parts. Thus, the first conclusion to be drawn from the experiments presented in this article is that the meaningful relationships between the parts of a picture are incorporated into the memory representation of the picture.

The questions addressed by Experiments 1 and 2 illustrate the application to picture memory of questions usually associated with memory for linguistic information. Investigating the relative closeness of parts of pictures parallels recent investigations of the organization of ideas in memory for texts (cf. Anderson & Bower, 1973; Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975; McKoon & Ratcliff, 1980; Ratcliff & McKoon, 1978). Investigating the differences between relatively important (foreground or topic) parts of pictures and relatively unimportant (background or detail) parts of pictures parallels investigations of the role of topicality in memory for texts (cf. Kintsch, 1974; Kintsch et al., 1975; McKoon, 1977). Thus, a second conclusion to be drawn from the experiments of this article is that the study of memory for pictures may profit from consideration of issues and data in the study of memory for texts.

The third conclusion concerns the technique of priming in item recognition. This technique has worked well for examining the structure of the representation in memory of textual information (McKoon & Ratcliff, 1980; Ratcliff & McKoon, 1978). The experiments presented here show that the technique has the potential to be equally useful in the study of the structure of the representation of pictorial information.

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