Journal of Experimental Psychology:
Learning, Memory, and Cognition
1989, Vol. 15, No. 2, 179–187

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0278-7393/89/$00.75

Wide-Angle Memories of Close-Up Scenes

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We report a picture-memory phenomenon in which subjects' recall and recognition of photographed scenes reveal a pronounced extension of the pictures' boundaries. After viewing 20 pictures for 15 s each, 37 undergraduates exhibited this striking distortion; 95% of their drawings included information that had not been physically present but that would have been likely to have existed just outside the camera's field of view (Experiment 1). To determine if boundary extension is limited to recall and drawing ability, Experiment 2 tested recognition memory for boundaries. Eighty-five undergraduates rated targets and distractors on a boundary-placement scale. Subjects rated target pictures as being closer up than before and frequently mistook extended-boundary distractors as targets. Results are discussed in terms of picture comprehension and memory. In addition to its theoretical value, discovery of the phenomenon demonstrates the importance of more widespread use of open-ended tests in picture-memory methodology.

A picture depicts a part of the visual world and contains this information within its boundaries—usually the four sides of a rectangle. In a portrait, this rectangle may be filled with the smiling face of a friend. Although only the face is shown, the viewer understands that this is not a depiction of a disembodied head, but that the rest of the friend and the rest of the scene "exist" just beyond the picture's boundaries.

Research on memory for pictures has focused on the recognition of visual information within picture boundaries (e.g. J. C. Bartlett, Till, & Levy, 1980; Intraub, 1980; Mandler & Johnson, 1976; Pezdek et al., 1988). Memory for the boundaries themselves has not received attention. This may be due to the types of memory tests typically used to study picture memory (e.g., recognition tests and verbal recall), which are not open-ended with respect to remembered pictorial details. In contrast, observation of drawings of remembered pictures suggests that an assessment of subjects' memory for picture boundaries may provide important information about pictorial representation.

Picture-drawing tasks have not been prevalent in the picture-memory literature. With relatively few exceptions (e.g., F. Bartlett, 1932; Carmichael, Hogan, & Walter, 1932; Schooler, Gerhard, & Loftus, 1986), recognition tests and recall tasks using verbal descriptions have played the major role in picture-memory research. It may be that reliance on these tasks alone has seriously limited our insights into pictorial representation in ways that careful observation of drawings might help to reveal. This indifference to what would seem to be a direct means of studying picture memory stems, at least in part, from the difficulties that drawings pose as data. One prefers a dependent measure to be objective and uncomplicated. Drawings require judgments to be assessed. These judgments are complicated by at least two serious problems: (a) how to distinguish true memory errors from the subjects' lack of artistic ability to depict clearly what is remembered, and (b) how to distinguish memory effects from the conventions of drawing used by the subject.

Such problems have helped to make recognition tests the preferred means for studying picture memory, but of course these, too, have their limitations. Although "old/new" responses are objective and can be submitted to signal-detection analysis or guessing correction, thereby eliminating any need for rater judgment, the limitation here has been on the choice of the distractors and on the subjects' free expression of what they remember. The hidden paradox is that in a traditional recognition paradigm, to test memory for a particular aspect of a picture, a distractor must be selected that would be likely to mimic a possible memory error (e.g., a deletion, addition, or distortion). Because the experimenter does not know in advance exactly how the subject's memory may fall short of the "ideal" eidetic image, the distractors selected may often lack the sensitivity to provide an adequate test of a particular hypothesis. Subjects' performance in this case might yield an inflated view of the accuracy of picture memory, or as demonstrated by McCloskey and Zaragoza (1985), under some conditions, a limited distractor set can lead to an overestimation of picture-memory errors.

Concern that restrictive test procedures may be limiting the study of pictorial representation led the first author to conduct exploratory class experiments over several years. Students in each class were presented with photographs of scenes and were asked to draw them 30 to 40 min later. In observing the drawings, distortion along one dimension became apparent. Viewers tended to overextend the pictures' boundaries dramatically, so that their drawings included more spatial area than had actually been presented in the pictures. They tended to draw parts of the visual world that would have been likely to have existed just outside of the camera's view. For example, objects cropped by the edges of the photograph were depicted

Experiment 1 and part of Experiment 2 were presented in November 1987 at the 28th annual meeting of the Psychonomic Society, in Seattle, WA. We thank Douglas Nelson, Jennifer Freyd, and Geoffrey Loftus for their valuable comments on this article. We also thank Jeff Edwards and Kathy Wooley for their assistance during data analysis.
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as whole, and objects that were whole in the photograph were depicted as having had more background between them and the picture's edge than had actually been the case. Viewers never seemed to draw veridical boundaries. But more important, their errors were strikingly unidirectional and never seemed to include distortion in the other direction (i.e., a restriction of the boundaries). A comparison of their drawn recollections with the stimuli generally resulted in surprise on the part of the viewers at the degree of the distortion.

If one's recollection of pictures does not contain veridical information regarding picture boundaries but, instead, consistently contains additional surrounding information (that had not been presented), it would suggest that observers comprehend a picture within the structure of its *expected* surrounding space. Restricting the notion of a picture schema to visual information *within* the physical boundaries of the picture (e.g., Friedman, 1979; Goodman, 1980; Mandler & Johnson, 1976) may overlook this important concept. Comprehension of a picture may be understood in much the same way as comprehension of a single fixation upon the visual environment: a single fixation that cannot with any acuity take in an entire scene. Picture comprehension may use the same mental structures that underlie the perception of a visual environment composed of successive, temporally distinct eye fixations (e.g., Hochberg, 1978, 1986). Memory may reflect this aspect of picture perception such that the expectation of what is just beyond the current fixation becomes a part of the internal representation of a remembered scene.

The present experiments tested memory for pictures by using a combination of picture-drawing and picture-recognition tests that was intended to minimize the problems associated with each. The primary goal was to study the mental representation of the boundaries of pictured scenes. Another goal was methodological: to expand the standard repertoire of picture-memory tests to allow a more open-ended assessment of what observers remember.

Experiment 1

Experiment 1 formally tested the observation that subjects extend the boundaries of remembered photographs of scenes when they draw them. All stimuli in this experiment were close-up photographs of common objects in natural settings. The close-ups were taken such that the main object (or object cluster) in each scene was cropped by at least one of the four picture boundaries. In other words, the main object(s) ran off the edge of the picture on at least one side, but in such a way that the identity of the object was not compromised. For example, see the close-up photograph of the garbage cans against the fence used in Experiment 2 (Figure 1, Panel A).

Subjects were presented with 20 such pictures for 15 s each and were later required to draw four of them. We considered the experiment to be a conservative test of the initial observation because the close-up composition (which always included cropped objects) was present in each of the pictures and was therefore more likely to be salient. In contrast, in Experiment 2, close-up and relatively wide-angle photographs were intermixed in the presentation sequence.

Method

Subjects. The subjects were 37 undergraduates, all of whom were enrolled in a psychology course at the University of Delaware. All were tested together as a group during a scheduled class period.

Apparatus. A Kodak Carousel slide projector was used to present the slides on a screen at the front of a classroom that seated approximately 40 people. The size of the projected image was 2 × 3 feet (.6 × .9 m). The approximate visual angle experienced by a subject in the front-row center and the rear-row center was 20° × 30° and 10° × 14°, respectively.

Stimuli. The stimuli were 20 scenes, each of which consisted of a main object or cluster of objects situated in a natural background. A close-up photograph of each scene was taken such that the main object or object cluster could be clearly identified even though the outer edges of the object or object cluster were cropped by at least one of the photograph's four edges. All photographs were 35-mm slides. (See Appendix A for picture list and associated number of edges occluding the main object[s].)

Design and procedure. The subjects were presented with the 20 slides for 15 s each. They were instructed to try to remember each scene in as much detail as possible. The experimenter stressed that the background was just as important to remember as the main object(s). This was done to avoid a possible misinterpretation on the part of the subjects that might bias them to focus on the main object and ignore the layout of the background.

After a 35-min delay, during which time the subjects listened to a normally scheduled lecture by their instructor, they were given a response booklet. The pictures had been divided into five sets of four pictures. Subjects were randomly assigned one of these sets to draw. Each two-page booklet contained the names of the four relevant pictures and four rectangles with sides drawn in the ratio 1:1.5 (which is the same as a standard 35-mm slide). Subjects were told to consider the edges of the rectangle to be the edges of the photograph they saw and to draw their picture accordingly, filling in the space as it had been filled in the photograph. The importance of the edges was also stressed in the response booklet by means of an arrow and a note, "edge of slide," placed next to each rectangle. Subjects were told not to be concerned with their artistic ability but to do their best to represent the picture. They were told that they could make changes in the drawing if something looked wrong when they were done, and they were encouraged to add any verbal comments on the drawing itself if they wanted to clarify something. Because the picture label provided in the booklet referred only to the main object(s), subjects were reminded that the label was only a shorthand title that actually referred to the entire picture.

Results and Discussion

Subjects consistently extended the pictures' boundaries, including more of the scene than had been presented in the stimulus. They completed objects that had not been complete in the photograph and added more background between objects and the edges of their drawings. See Figure 1 (Panels A, C, and E) for a concrete example of the effect. (The drawings in the figure were obtained from subjects in Experiment 2, but the effect and the scoring procedure were the same as in the present experiment.)

To score the degree and the direction of any distortion of the boundaries, the experimenter and a naive judge rated the drawings on a 7-point scale. A rating of 4 (center scale) indicated that the subject had correctly cropped the appropriate edges. A rating of 3 indicated that the subject had overextended the boundaries but that at least one edge was cropped or was drawn right up against the boundary. A rating of 2 indicated that the subject had extended all four boundaries and had included a small amount of space around the main object(s), and a rating of 1 indicated the same, except that a relatively large amount of space was added. If the drawing represented the picture as being more close-up than it actually had been, it was rated as a 5, 6, or 7, depending on whether the distortion was small or great.

After a training session, the judges independently rated each picture. On 11 occasions, when the judges disagreed, a third opinion was consulted. This judge (the first author) independently rated the pictures in question. The two primary judges never differed by more than a single level of the rating scale, and the third judges' rating always coincided with one of those two, thus breaking the tie. Table 1 shows the number of pictures falling into each category. The total number of drawings made by the subjects was 133 because subjects could not recall the specified drawing on 10% of the trials. As may be seen in the table, after a 35-min delay, although all 133 pictures were easily recognizable as specific scenes from the set, subjects drew only 4 pictures correctly with respect to the boundaries. Subjects' errors did not fluctuate between extension and restriction of boundaries. On 95% of the trials, they extended the boundaries of the pictures they drew.

Experiment 2

Boundary extension may reflect a fundamental aspect of pictorial representation, or it may be more limited in scope, reflecting instead aspects of recall in general or drawing per se. Carmichael, Hogan, and Walter's (1932) classic experiment in which drawings of simple ambiguous pictures showed distortion in the direction of a verbal label provided during presentation was not replicated when Prentice (1954) tested memory for the same stimuli using a recognition test. Earlier, Hanawalt and Demarest (1939) had demonstrated that the same distortions could be obtained if the disambiguating labels were presented at the time of the test instead of during presentation, implicating a drawing bias.

In addition, many models of memory and a history of empirical results make the point that what is consciously available during recall by no means exhausts what is stored in memory. Subjects may recognize what they previously could not recall. For example, Johnson's (1983) modular model of memory (MEM) makes a distinction among three types of memory systems that can be tapped by different retrieval tasks. Two of these, the reflective and the perceptual systems, are relevant here. The reflective system contains inferences that the observer draws about a stimulus; these are readily retrieved during recall. The perceptual system contains more specific information about the physical appearance of the stimulus that can be most readily retrieved during recognition. This applies well to the current data if we consider that the subjects' drawings (recall) reflect inferences made during comprehension of the picture, whereas a recognition test tests the subjects' perceptual memory of the stimulus.

Table 1
Number of Drawings That Correctly Depicted the Picture Boundaries, Overextended Them, or Restricted Them

Rated placement of the boundaries						
Overextension			Correct	Restriction		
1	2	3	4	5	6	7
28	79	19	4	2	1	0

Note. $N = 133$ drawings.

The main question addressed in Experiment 2 was whether any evidence of boundary extension would be obtained if the subject was presented with the same picture again in a recognition test. A relatively long retention interval (2 days) was used to provide a sensitive test. The recognition test was designed to minimize or eliminate the problems discussed previously regarding the choice of distractors in two ways: (a) The difference between the targets and the distractors was based on the boundary-placement errors observed in Experiment 1 (i.e., these were "informed" distractors), and (b) a boundary-rating scale instead of a yes–no response was used. Subjects were required to rate each picture on a 5-point scale, indicating whether it was the same picture, more of a close-up than before, or more of a wide-angle. In this way, if the distractors were not sensitive enough to detect a slight distortion in the subjects' memory for the boundaries, rating of the actual stimulus itself might be. The test therefore provided two measures of memory for boundaries: one, a measure of the subjects' ability to discriminate a target from a changed-boundary distractor, and the other, a rating indicating the degree to which a test picture's boundaries differed from remembered boundaries.

A second issue addressed in Experiment 2 involved the effect of recall on recognition memory. The motivating question was, "If the boundary effect does not occur in a recognition test, would it occur if the recognition test was preceded by recall?" Loftus and Loftus (1980) have suggested that the "blending" or integration of memory traces that differ with respect to a particular detail can lead to errors in recognition. To test this, one group of subjects participated in a drawing task and an imagery task in which they were required to recall each picture on the basis of a verbal cue just prior to the recognition test. In addition to testing the effects of recall on recognition, inclusion of the drawing task allowed us to test the replicability of the results of Experiment 1 under conditions in which (a) there was a longer retention interval, (b) wide-angle and close-up pictures were mixed in the presentation sequence, and (c) subjects selected for themselves which pictures to draw in a free-recall paradigm (in Experiment 1, drawings were assigned in a verbally-cued recall task).

Method

Subjects. The subjects were 85 University of Delaware undergraduates (47 females) taking introductory psychology. All had elected to enroll in the departmental subject pool. There were 44 subjects in the recognition group and 41 subjects in the recall/recognition group.

Apparatus. An Olympus OM-2 35-mm camera, a tripod, and a zoom lens were used to create the slides. A Kodak Carousel projector was used to present them on a screen in front of a large (250-seat) auditorium. Image size was 6 × 9 feet (1.8 × 2.7 m). The approximate visual angle subtended for a subject seated in the front-center seat and one seated in the rear-center seat (row 10 of the auditorium) was 30° × 44° and 14° × 22°, respectively.

Stimuli. Stimuli were 40 slides (35 mm), consisting of two versions of the same 20 scenes. A close-up version and a relatively wide-angle version were created by changing the setting on the zoom lens. The relatively wide-angle pictures included the entire main object (or object cluster), whereas this part of the scene was cropped on at least one of the four sides in the close-up. Figure 1 shows one of the scene pairs in Panels A and B. (See Appendix B for a list of all the scenes used in the experiment.) The difference between the two versions was based on a conservative estimate of the distortions observed in

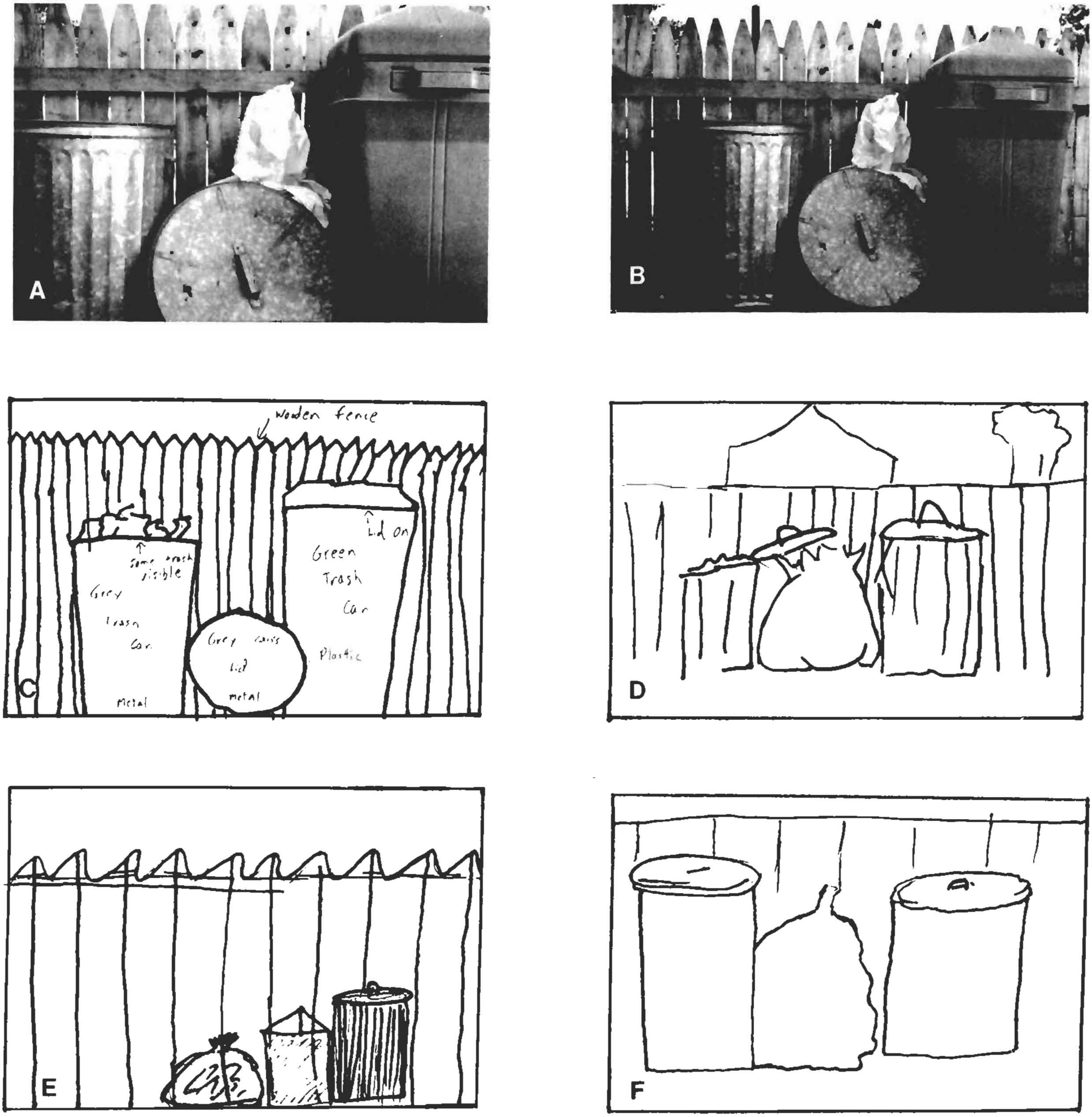

Figure 1. Scene pair and drawings. (The top panels show one pair of scenes used in Experiment 2: A is the close-up and B is the wide-angle. Panels C and E are two subjects' drawings of Panel A showing boundary extension, rated as 2 and 1, respectively. Panels D and F are two subjects' drawings of Panel B; D shows a boundary extension of 2; F is an example of no boundary extension, rated as 4. The photographs in the experiment were in color. The subjects' original drawings were in pencil; these were photocopied, and all pencil marks were darkened with ink for this figure.)

Experiment 1. Of the 20 scenes used in Experiment 1, 9 were replaced because of drawing difficulties or because of their potential confusability with new scenes.

Design and procedure. Subjects were usually tested in small groups of 2 to 5 persons although occasionally an individual was tested alone, and on one occasion a group of 8 subjects was tested. The subjects were seated in the first 10 rows of the auditorium, separated from one another by at least 2 seats. During the presentation phase of the experiment, all subjects were presented with 20 different scenes: 10 were close-ups and 10 were wide-angles. Those pictures that were close-ups for half the subjects were wide-angles for the other half and vice versa. Each picture was shown for 15 s. The subjects were told to focus their full attention on each picture and to remember it in as much detail as possible. They were also told that the background in the scene was as important to remember as the main object(s). Approximately 48 hr later, subjects returned to be tested. Although both groups received the same recognition test, in the recall/recognition group the test was preceded by two types of recall tasks. These will be described next, followed by a description of the recognition test.

In the recall/recognition group, the subjects were asked to draw the 6 pictures that they remembered best. Test booklets and instructions were otherwise the same as in Experiment 1. After drawing, subjects were required to generate each of the 20 pictures they had seen during presentation. The generation response sheet contained the name of the main object in each scene. Subjects were instructed to rate their image of each main object on a 5-point scale ranging from *vague* to *vivid*. If they could not remember the scene, they were given the option of indicating so. After completing that task, they were given the recognition test.

All 20 scenes were included in the recognition test. For 10 of the scenes (5 close-ups and 5 wide-angles), the test version was the same as the presentation version. For the remaining 10 scenes (5 close-ups and 5 wide-angles), the test version was the opposite of the presentation version. There were four variants of the recognition test so that pictures were counterbalanced across the four presentation/test conditions. That is, each scene was a close-up tested by a close-up (CC), a wide-angle tested by a wide-angle (WW), a close-up tested by a wide-angle (CW), and wide-angle tested by a close-up (WC) equally often. In all variants of the test, the order of the scenes (irrespective of the boundary placement) was the same. Subjects were randomly assigned to one of the four variations.

Subjects were told that they would see a set of slides in which some of the pictures would be identical to ones they had seen before, and some would be different. What was meant by "different" was illustrated with four versions of a sample scene showing how that scene would look as the camera was moved further away from it or closer up to it. They were told that each time they saw a scene in the test, they were to indicate on their response-sheet scale whether the test picture was the *same as the presentation picture* (0), or whether the camera was *a little further away* (1), *a lot further away* (2), *a little closer-up* (-1), or *a lot closer-up* (-2) than it had been when the presentation stimulus had been photographed. The demonstration provided visual as well as verbal reminders that when the camera is closer up, one sees less of the scene, and when it is further away, one sees more of the scene. Subjects gave a confidence rating of *sure*, *pretty sure*, *not sure*, or *guess* for each response.

Results and Discussion

Boundary extension was evident in both the subjects' drawings and in their recognition-memory responses. Clearly this phenomenon did not exhibit the type of modularity discussed in Johnson's (1983) MEM model. The results may be summarized as follows: (a) A pronounced boundary-extension effect was evident in the drawings of both the close-up and the wide-angle scenes; (b) in the recognition test, subjects' ratings of boundary placement and their pattern of "same" responses showed boundary extension; and (c) preceding the recognition test with a drawing/image-generation task had no effect on performance.

Recall. There was a total of 222 drawings[1] — 92 close-ups and 130 wide-angles (on average, subjects drew 5.4 pictures, usually because they ran out of time or, less frequently, because they couldn't recall 6 pictures). These drawings were judged at the same time and by the same panel as those in Experiment 1.[2] Once again, judges never differed in their decision by more than a single rating. The third judge's opinion was required for 25 of the drawings. The results, collapsing over picture type, are presented in Table 2. Once again, even though the pictures were drawn well enough to be readily identified, subjects rarely drew the correct boundaries and rarely erred by restricting them. Boundary extension was evident in 96% of the close-up drawings and 87% of the wide-angle drawings. The modal response for both picture types was a boundary extension of 2. As can be seen in Figure 1, the modal drawing of the close-up (Panel C) looks very much like the wide-angle stimulus, and the modal drawing of the wide-angle stimulus (Panel D) shows additional boundary extension. (To evaluate the drawings in the figure, it is important to study each of the four edges of both the drawing and its associated stimulus.)

Recognition. Overall, subjects were confident of their responses. In the recognition group, 82% of the responses fell in the top two confidence categories, and only 2% were described as guesses. In the recall/recognition group, 78% fell in the top two confidence categories, and 5% were described as guesses. For clarity, the recognition results will be presented in two sections. The first section will focus on boundary ratings obtained when the stimulus and test items were the same (i.e., Target Conditions CC and WW). The second section will focus on a comparison of performance in the target and distractor conditions.

Boundary ratings when presentation and test pictures were the same. The mean number of responses indicating "this picture is closer-up than before" and "this picture is further away than before" in the CC and WW conditions is presented in Table 3 for both recognition groups. Wilcoxon tests, performed on the number of responses falling into each category, showed that subjects tended to call target pictures "closer-up" rather than "further away" in both recognition groups, for

[1] There were actually 224 drawings. Two of these were made by a single subject and represented two large objects from the same picture as being in two different pictures (a wheel-barrow picture and a lawn-mower picture). This was the only such case. The two drawings were not included in the analysis.

[2] The procedure was the same as that described in Experiment 1 except that the ratings that had been based on "number of occluded sides" were changed when the drawings of wide-angle pictures were rated so that they now reflected the judges' subjective judgment of how accurately the subjects had placed the objects with respect to the boundaries. This was done because, by definition, the wide-angle scenes did not contain main objects that were occluded.

both close-ups and wide-angle pictures ($p < .01$, two-tailed for all four comparisons).[3] The effect was particularly striking for the close-up pictures; not one of the 85 subjects in the two groups showed a bias in the opposite direction.

The mean boundary ratings obtained for the CC and WW conditions are shown in Table 4. The mean ratings were analyzed in a 2 × 2 mixed analysis of variance (ANOVA; Group: Recognition vs. Recall/Recognition × Picture Type: Close-up vs. Wide-Angle). No effect of group was obtained (F = 1.14); requiring subjects to draw or generate images prior to the recognition test had no effect on their ratings. There was, therefore, no evidence that the relatively extreme errors in recall had "blended" with subjects' picture memory in the sense used by Loftus and Loftus (1980). There was a main effect of picture type in that close-up pictures yielded a greater magnitude of distortion than did wide-angle pictures, $F(1, 83) = 92.60$, $p < .001$ $MS_e = .135$. Recall that this tendency was also reflected in the drawings. This difference will be addressed in the General Discussion section.

Recognition performance when the presentation picture and the test picture were different. There were two types of distractor conditions: CW (close-up presentation, wide-angle test picture) and WC (wide-angle presentation, close-up test picture). If the presentation pictures are represented in memory with extended boundaries, then subjects should show an asymmetrical pattern when they rate the distractors. Subjects should rate WC distractors as being relatively far from "same" because (a) they really are closer up, and (b) the memory for the presentation picture contains extended boundaries, thus exaggerating the difference. Subjects should not show as strong an effect in the opposite direction in the CW condition because although the test picture really is more wide-angle, memory for the presentation picture contains extended boundaries, thus minimizing the difference between this type of distractor and the target.

Referring to Table 4 (columns CW and WC), this predicted asymmetry is apparent. The difference in magnitude in the boundary ratings for the CW and WC conditions (i.e., the size of the deviation from 0) was analyzed by changing the signs in the WC condition and performing a dependent t test including all the subjects in both groups. The degree of deviation from 0 was much greater for the WC distractors, and this difference was highly significant, $t(84) = 16.63$, $p < .0001$, two-tailed.

To determine if there was also an asymmetry in the number of *same* responses (0 on the rating scale), a 2 × 2 repeated measures ANOVA (Test Condition: Same vs. different × Presentation-Picture Type: Close-Up vs. Wide-Angle) was performed. The mean number of *same* responses in the CC, WW, CW, and WC conditions was 2.2 (SD = 1.3), 3.2 (SD = 1.4), 2.2 (SD = 1.4), and 0.8 (SD = 0.8), respectively. (Note that the total number of responses possible in each condition was five.) Consistent with the asymmetry prediction, there was a highly significant interaction between test condition (same or different) and presentation-picture type (wide-angle or close-up), $F(1, 84) = 71.73$, $p < .001$, $MS_e = 124.81$. The interaction shows that whereas subjects made the same number of *same* responses to CC and CW test items (2.2, or 44% of the time), they were quite good at discriminating WW and WC test items.

Table 2
Number of Drawings in Experiment 2 That Correctly Depicted the Picture Boundaries, Overextended Them, or Restricted Them

Rated placement of the boundaries						
Overextension			Correct	Restriction		
1	2	3	4	5	6	7
60	88	53	11	6	2	0

Note. N = 222 drawings.

Table 3
The Mean Number of "Closer-Up" Responses (−) and "Further-Away" Responses (+) to Test Items When the Presentation and Test Items Were the Same, as a Function of Group (Recognition or Recall/Recognition) and Picture Type (Close-Up or Wide-Angle)

	Close-up		Wide-angle	
Group	−	+	−	+
Recognition	2.5	0.1	1.2	0.6
Recall/Recognition	2.7	0.2	1.2	0.6

Note. The total number of responses possible for each picture type in each group was five.

Object completion. In considering the cause of this nonveridical representation of a picture in memory, the Gestalt principles related to object completion (Ellis, 1955) come to mind. Although the wide-angle versions of the pictures did not crop any part of the main object or main object cluster, extraneous parts of the background often contained partially cropped objects. The boundary extension obtained in both the wide-angle and close-up scenes could therefore be attributed to a tendency for object completion in memory.

Two observations suggest that it would be a mistake to conclude at this point that the completion of individual objects is the only contributing factor to this distortion in memory and that boundary extension may also be related to spatial expectations during scene comprehension. One observation is the large number of cases in which boundaries were clearly extended, yet the extension did not yield object completion (e.g., a rating of 3 for close-up pictures drawn in Experiments 1 and 2). The other observation is of boundary extension when the object was complete (wide-angle view) and the background was a textured surface. For example, one picture included a French horn supported by red string on a wooden wall. In the wide-angle case, the horn and nail and string were completely visible, centered on the wall. In the drawings, however, subjects included more of the background surface, although the textured background was in no obvious

[3] For close-up and wide-angle pictures, respectively, $T = 0$ (6 ties) and $T = 69$ (16 ties) for the recognition group, and $T = 0$ (2 ties) and $T = 85$ (11 ties) for the recall recognition group.

Table 4
Mean Boundary-Placement Scores for Test Items in Each Group When the Presentation and Test Items Were the Same (CC and WW) and When They Were Different (CW and WC)

Group	CC	WW	CW	WC
Recognition				
M	−.62	−.12	.23	−1.28
SD	.39	.44	.43	.36
Recall/recognition				
M	−.73	−.15	.24	−1.31
SD	.40	.36	.47	.34

Note. A score of 0 indicates that the subject rated the test item as being identical to the presentation item, scores of −1 and −2 indicate the degree to which subjects rated the test item as "closer-up," and scores of 1 and 2 indicate the degree to which they rated it as further away.

sense made complete. Future research will have to disentangle these issues, but at present it seems clear that object completion cannot fully account for the phenomenon.

General Discussion

These experiments demonstrate a pronounced unidirectional distortion in memory for picture boundaries. The distortion was evident in subjects' drawings of remembered photographs and in a recognition test designed to be sensitive to boundary placement. In their drawings, subjects tended to depict the photographs as having had more expansive boundaries than they actually did. They included in their drawings information that had not been present in the photograph but that would have been likely to have existed just outside the camera's view. Subjects usually completed cropped objects and added space between the edges of the completed object and the edges of their drawing.

In Experiment 1, under conditions in which every picture in the study set contained a cropped view of the main object cluster, subjects extended picture boundaries 95% of the time. Experiment 2 showed that boundary extension was also pervasive in drawings of photographs in which the main objects had not been occluded by the edges of the picture. The backgrounds in these pictures, however, often contained occluded objects, leaving open the possibility that boundary extension is the result of object completion in memory. Although object completion may turn out to be a contributing factor, it is important to note that there were numerous cases of extension without object completion and extension when the picture contained a nonoccluded object against a homogenous background (see "Object completion" in Results and Discussion, Experiment 2).

Experiment 2 demonstrated that boundary extension is not due to the schematic nature of recall or to drawing per se, because it was evident in a picture-recognition-memory test. In addition, preceding the recognition test with tasks requiring subjects to draw and generate images of the stimuli in no way affected recognition performance. Subjects tended to rate old pictures as being closer up than before, rather than further away. A large asymmetry emerged in the magnitude of the ratings that the subjects made to the two types of distractors. Close-up distractors were rated as being much more distorted than were wide-angle distractors. Furthermore, subjects were more likely to accept wide-angle distractors than close-up distractors as old, and they could not discriminate between old pictures and wide-angle versions of the same pictures. In sum, cued-recall, free-recall, and picture-recognition tests all indicated that memory for the pictures contained an area that had actually been outside the scope of the pictures' physical boundaries.

We believe that the important point about boundary extension is not that memory for pictures is nonveridical. There are many studies indicating a schematic, reconstructive aspect to memory for pictures, just as is the case for prose (e.g., F. Bartlett, 1932; Kraft & Jenkins, 1977; Pezdek, 1977). The boundary-extension effect is consistent with this general view of memory. The interesting aspect of the boundary effect, however, is its unidirectionality.

One explanation of the phenomenon is that picture memory reflects the cognitive processes that underlie initial comprehension of scenes during visual scanning. Consider the proposal of a mental structure or schema into which successive views are fitted during scanning (Hochberg, 1978). If a bounded picture can be thought of as analogous to the information contained in a single fixation made during visual scanning, then comprehension of that picture may include the implicit schematic expectation that the next fixation will bring more of the fixated object or scene into view. Just as observers seem to readily comprehend the implied space beyond the boundaries of a video or movie screen when moving objects pass in and out of their explicit view (Hochberg, 1986), observers may understand the implied space (and completed object) that exists beyond the boundaries of the picture. This dynamic view of memory, which involves expectations during initial comprehension, is expressed in Freyd's (1987) review of research in which static representations of motion show expectancy effects and in research by Kraft (1987) showing the effects of camera angle (and, thus, observer's viewpoint) on picture comprehension and memory.

An alternate interpretation of unidirectional boundary extension is based on the concept of prototypic representation. According to this position, the memory distortion occurred because the views presented in the current experiments tended to bring the observer closer up to the main object(s) than they would normally expect to be. Boundary extension in this case would be interpreted as distortion toward the prototype. These two hypotheses provide different interpretations of the observation in Experiment 2 that boundary extension is more extreme for the more close-up versions of the scenes. They also provide divergent predictions about what would happen if increasingly wide-angle pictures were presented under our experimental conditions.

According to the schematic view, the smaller and more centrally located the object of interest is with respect to the picture's boundaries, the more likely the expected area surrounding the object will be contained within the picture. The closer the object of interest is to the boundary, the more likely the expected space will not be contained within the picture itself but will be inferred (resulting in boundary extension). This leads to the prediction that the degree of boundary extension should decrease, finally reaching asymptote as more extreme wide-angle pictures are used. In contrast, the prototypic memory view holds that less boundary distortion occurred with the wider angle pictures because the former more closely approximated the prototypic representational distance. This position yields the prediction that as increasingly wide-angle views are presented, boundary extension should decrease and then change to boundary restriction.

Several other possible lines of inquiry are raised by these results—for example, the time course of the distortion, the effect of intentional boundary-storage instructions on the distortion, and the generality of the effect to other types of pictorial occlusion that do not involve what could be called the "artificial" occlusion caused by the edges of the photograph (e.g., object occlusion by another object in the scene both when there is a strong conceptual component to the relation, as when a person sitting in a chair occludes part of the chair, or a weak one, as when a cup on the table occludes the edge of another object on the table). Related to the intentional strategy issue, pilot evidence suggests that prior knowledge alone (without practice) has little if any impact. When individuals received feedback on their drawings and then did the task again (with different stimuli) or did the task after having the effect described to them in a research presentation, they surprisingly showed large boundary extensions in their new drawings. This occurred in spite of their professed attempts to guard against the effect during encoding. Our experience is that it is very difficult to recall the boundaries of our own stimuli correctly after repeated viewing.

In conclusion, boundary extension is a strong, highly replicable picture-memory phenomenon with interesting theoretical implications for a general model of picture comprehension and memory. No less important is the methodological issue raised by these experiments. A pronounced memory distortion that seems to be the rule rather than the exception has gone unnoticed in a research environment in which picture memory has typically been tested with old/new recognition tests that contain either highly dissimilar distractors or distractors that in the experimenter's best guess will be sensitive enough to test the detail and quality of the subjects' memorial representation. More open-ended test methods (e.g., drawing) would provide a vital addition to the tests traditionally used to study memory for pictures. Observations made under these conditions may serve to redirect and extend the nature of our inquiries. Recognition tests with "informed" distractors and a means for assessing remembered aspects of the target stimulus itself (in this case a rating scale) can determine whether a given phenomenon observed in recall/drawing is generalizable. Recall tasks have been of major importance in tests of memory for words and prose passages; we propose that they are equally important in attempts to understand the organizational principles of pictorial representation.

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Appendix A

Picture Names and the Number of Edges Occluding Part of the Main Object or Object Cluster in Experiment 1

Picture name	No. edges	Picture name	No. edges
Flowers	2	Telephone	2
Chainsaw and ax	2	Lawn mower	3
Fan	2	Bicycle	4
Pizza	3	Car	2
Laundry	3	Television	3
Typewriter	4	Globe	2
Woman	2	Beer	2
Blender	2	Wine rack	2
Trumpet on chair	1	Tennis shoes	4
Lamp	2	Trash Can	2

Appendix B

Picture Names and the Number of Edges Occluding Part of the Main Object or Object Cluster in the Close-Up Versions of Scenes in Experiment 2

Picture name	No. edges	Picture name	No. edges
Trash cans	4	Woman	2
Globe	2	Blender	2
Beer	2	Flowers	2
Tennis shoes	4	Bananas	2
Pizza	3	Typewriter	4
Laundry	3	Door	2
Lawn mower	3	Fan	2
Horn	2	Television	3
Candlestick	2	Lamp	2
Car	1	Telephone	2

Received January 26, 1988
Revision received May 24, 1988
Accepted June 8, 1988 ■