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Looking at Pictures But Remembering Scenes

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Ss tend to remember close-up photographs as having had extended boundaries (Intraub & Richardson, 1989). Three alternate explanations were tested: object completion, distortion toward a perceptual schema, and normalization toward a prototypic view. In three experiments, 55–130 undergraduates viewed 16 close-up, prototypic, or wide-angle views of objects for 15 s each. Immediately or 48 hr later, they rated test pictures on a 5-point scale as "same," "closer up," or "farther away." Results ruled out object completion because boundary extension occurred when the picture contained no incomplete objects. Immediate tests supported the perceptual schema hypothesis because all unidirectional distortions involved boundary *extension*. Delayed tests were more suggestive of a memory schema effect because wide-angle pictures yielded boundary *restriction*. A two-component model of picture processing is proposed.

Strictly speaking, a portrait of a friend contains a disembodied head and some background information. Yet the viewer does not wince. It is understood that the rest of the friend and the rest of the background "exist" just beyond the picture's boundaries. The viewer apparently perceives the depicted information within this larger context. Picture memory research, however, has usually focused on recognition memory for the specific contents of a picture (e.g., Bartlett, Till, & Levy, 1980; Goodman, 1980; Intraub, 1980; Mandler & Johnson, 1976; Pezdek, Maki, Valencia-Laver, Whetstone, Stoeckert, & Dougherty, 1988). This, of course, is necessary if we are to understand the principles that guide recollection of objects, their details, and their placement in a scene. Limiting inquiry to these questions, however, may cause us to overlook important characteristics of pictorial representation. To address this possibility, instead of explicitly testing memory for the objects in a picture, Intraub and Richardson (1989) tested the observer's recollection of a picture's boundaries. What they discovered was a striking tendency for viewers to remember photographic close-ups as having depicted more of a scene than had actually been displayed. They called this memory distortion *boundary extension*.

In one type of task, Intraub and Richardson (1989) presented subjects with 20 close-up photographs of common scenes for 15 s each. Either 35 min or 2 days later, they drew a subset of the pictures. Analysis of hundreds of drawings showed that regardless of the delay, boundary extension was observed between 87% to 96% of the time. These drawings included information that was not in the picture, but that was likely to have existed just outside the camera's field of view. Main objects that were cropped by the edges of the photograph tended to be depicted as whole, and main objects that were not cropped by the edges tended to be depicted as having had more background between them and the picture's edges than had actually been the case. Boundary extension was the rule rather than the exception.

Intraub and Richardson (1989) demonstrated that this unidirectional distortion was not an artifact of the drawing task. The same distortion was evident in a recognition test in which subjects rated test pictures (targets and distractors) in terms of how similar in depicted area each was to a stimulus. Subjects tended to rate target pictures as "closer up" than before (less area). This response to seeing the same picture again indicated that the subject's representation of that picture contained extended boundaries. The pattern of responses elicited by the distractors also supported this conclusion.

Given two versions of the same scene, an asymmetry was observed depending on whether the closer version was the stimulus and the slightly wider version was the distractor or vice versa. When the wider angle version was the distractor, it was rated as closer to *same* than when the closer version was the distractor. This asymmetry is the logical result of a unidirectional distortion. If the presentation picture is remembered with extended boundaries, a wider angle distractor would be expected to more closely match the subject's recollection than a distractor showing a closer view. Finally, it is important to note that both versions of the scenes used in these experiments were close-ups and that both versions yielded boundary extension. The closer version, however, yielded a greater *degree* of extension than did the wider version. This was true in both the drawing task and the recognition test.

What is interesting about these observations is the unidirectionality of the distortion. If subjects simply had a vague recollection of the pictures' boundaries, they should have sometimes extended them and sometimes restricted them. What was interesting was that virtually all subjects were making the same unidirectional error in memory for boundaries. The discovery of a common representational error has

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the potential of providing new insight into the nature of pictorial representation. The purpose of the present experiments was to test three alternate explanations of boundary extension: the object completion hypothesis, the perceptual schema hypothesis, and the memory schema hypothesis.

Alternate Explanations of Boundary Extension

Object Completion

The boundaries in Intraub and Richardson's (1989) photographs usually cropped either the main objects or background objects. For this reason, the Gestalt principle of object completion (see Ellis, 1955) was considered as a possible explanation of boundary extension. Intraub and Richardson (1989) tentatively argued against object completion as the primary cause of boundary extension on the basis of some characteristics of subjects' drawings (e.g., subjects frequently extended boundaries without completing the cropped objects—they simply drew more of the object than had appeared in the original picture). The present experiments were designed to provide a direct test of the object-completion hypothesis. New stimuli were created in which all objects were photographed against a homogeneous background (e.g., grass, asphalt, carpeting, tile). If boundary extension is caused by a tendency to complete background objects, then no boundary extension should be obtained with these stimuli.

Schema-Based Models

The concept of a schema or mental framework that guides perception and influences memory is a fundamental concept in cognition (e.g., Bartlett, 1932; Gibson, 1969; Hochberg, 1978). Schema theories focus on the dynamic nature of mental representation. In applying the concept to pictorial representation, we are offering two functionally distinct schematic structures as possible explanations of boundary extension. Each structure serves a different purpose and thus affects the memory representation according to a different set of principles. In the sections that follow, we will describe a *perceptual schema hypothesis*, which focuses on how the subject's initial perception or comprehension of a picture may yield boundary errors, and a *memory schema hypothesis*, which focuses on how normalization processes in memory may yield boundary errors. Both hypotheses can account for the data reported by Intraub and Richardson (1989), but each yields different predictions about the pattern of boundary errors that would be expected as increasingly wide-angle views of a scene are presented to the observer.

Perceptual Schema Hypothesis

The perceptual schema hypothesis is predicated on two basic assumptions: (a) that picture perception includes the activation of a mental scene schema that provides observers with an immediate understanding of what is likely to exist just outside the picture's boundaries and (b) that information contained in the schema is likely to become incorporated in the observer's mental representation of that picture. Earlier we pointed out that when viewing a close-up picture, such as the portrait of a friend, the observer's perception does not seem to be limited to the visual contents of the display. The observer can be said to *perceive* that the rest of the friend and the rest of the depicted information continue just outside the picture's boundaries. The scene that exists just outside the picture's boundaries may be as tangible to the perceiver as the scene that exists just outside the boundaries of a window frame when the observer looks out a window.

This hypothesis is consistent with Hochberg's (1978, 1986) proposal of a mental schema that guides the integration of successive glimpses of the visual world. The schema is an abstract representation containing memory for previously fixated information and expectations about the contents of future fixations. Hochberg argues that it is this schema that allows us to perceive an object that is never seen in its entirety but instead is viewed piecemeal through a moving aperture (Hochberg, 1986). If a bounded picture can be thought of as analogous to information contained within a single eye fixation on a scene, then picture comprehension may include the schematic expectation of what the next eye fixation would bring into view if one were actually viewing a scene.

According to this view, the perceptual schema is automatically activated when the subject perceives the picture. Without the schema, the subject would misunderstand what the picture represents (particularly in the case of a close-up). Because it is such an integral part of the subject's perception, elements contained in the schema may become incorporated in the subject's pictorial representation in memory. The result of this incorporation is boundary extension: unidirectional distortion of the picture's boundaries. Subjects remember having seen more of the scene than had actually been presented in the picture.

Intraub and Richardson's (1989) observation that the wider angle pictures yielded a smaller degree of extension than the closer views can be explained by this hypothesis. With centrally located objects, when the object of interest is very small (as in a very wide-angle picture), the expected information surrounding it is contained both in the perceptual schema and in the picture itself. When the object fills the picture space (as in a close-up), much of the expected surrounding area will not be contained within the picture itself, but will be contained in the perceptual schema that extends beyond the boundaries. This view leads to a prediction about what should happen to boundary extension as increasingly wide-angle views of a scene are presented. The degree of boundary extension should decrease as more wide-angle views of an object are presented, until with very wide-angle views no directional bias will be observed. If boundary extension is caused by memory for the perceptual schema, under no conditions should boundary *restriction* be observed.

Memory Schema Hypothesis

According to the memory schema hypothesis, boundary extension reflects a process of normalization in memory that can be thought of as *regression to the prototype* (cf. Bartlett, 1932; Gibson, 1969). Subjects may have an expectation about a standard view of an object. When a picture provides something other than the standard or prototypic view, memory for that picture will distort toward the prototype. The close-ups used in Intraub and Richardson's experiments were by definition closer than the standard view. Over time, the subject's representation of these pictures may have begun to normalize, thus yielding boundary extension.

This hypothesis offers a different explanation of why the wider versions of Intraub and Richardson's (1989) scenes yielded a smaller degree of extension than did the closer versions: The wider versions were more like the prototype to begin with and thus underwent less dramatic change as they normalized. Following this logic, a different pattern of results is expected as increasingly wide-angle views are presented. As the picture view widens from a close-up view to a prototypic view, boundary extension should decrease and finally disappear. Prototypic pictures should yield no directional distortion. As the picture view widens from prototypic to wide-angle, the distortion should reverse to boundary *restriction*. The degree of restriction would be expected to increase with increasingly wide-angle views.

To summarize, the object completion hypothesis attributes boundary extension to the completion of objects cropped by a picture's edges. This hypothesis will be tested by presenting pictures in which no cropped objects are depicted. The perceptual schema hypothesis attributes boundary extension to the initial comprehension of a picture that includes schematic expectations about information just outside the picture's boundaries. Alternatively, the memory schema hypothesis attributes the phenomenon to normalization of the pictorial representation toward a prototypic view in memory. Both of the latter hypotheses can account for the results of Intraub and Richardson (1989), but each predicts a very different pattern of results regarding memory for prototypic and wide-angle pictures. The following experiments tested these alternate predictions. Because each of the three experiments used different subsets of pictures from a new stimulus set, we will begin with a general section on stimulus selection.

Stimulus Selection

Stimuli

The stimuli were 66 slides (35 mm), consisting of what we subjectively termed *close-up*, *medium*, and *wide-angle* versions of the same 22 scenes. Each scene consisted of a main object or small cluster of objects against a homogeneous natural background (e.g., carpeting, asphalt, brick, tile, grass). Stimuli were photographed using an Olympus OM 2 35-mm camera equipped with a viewing grid, a tripod, and a zoom lens. The main object was photographed from the same angle in all three versions. The zoom lens was used to create closer or wider views. Sometimes the tripod had to be moved to bring the camera closer or farther from the object than the zoom would allow. In this case, the viewing grid was used to maintain the object's location in the scene, and the height of the tripod was adjusted to ensure that the view of the object was preserved.

Procedure and Results

Fifty-eight University of Delaware undergraduate students were divided into three groups, with each group viewing a different presentation set of 22 pictures. Each presentation set contained the 22 scenes in the same order but showed a different version of each scene. Each subject therefore saw only one version of each scene in a sequence containing all three types of views. (See Experiment 1 for a description of the apparatus.)

We asked subjects to rate each picture with respect to their conception of what a standard photograph of that particular object would be. A 5-point rating scale ranging from −2 (*much too close*) to +2 (*much too far*), with 0 being *standard view*, was used. We then selected 16 scenes whose close-up versions were rated as closer than standard and whose wide-angle versions were rated as farther than standard. Descriptive information about these scenes is presented in the Appendix. The mean ratings for the close-up and wide-angle versions in this set were −.42 and 1.53, respectively. Contrary to our expectation, medium versions were not rated as standard, but instead were rated as slightly too far ($M = 0.41$). Therefore, we selected the "prototype" pictures for Experiments 2 and 3 from both the close and medium versions, depending on which version was rated closer to 0. The mean rating for these pictures was −0.02. Examples of close, medium, and wide versions of two of the stimulus pictures are presented in Figure 1.

Experiment 1

The first experiment in this series was designed to replicate Intraub and Richardson's (1989) recognition test results with the new set of pictures. To most closely approximate the conditions of the previous research, we selected the close and medium versions of the pictures described in the Stimulus Selection section and listed in the Appendix. The procedure was the same as in Intraub and Richardson's (1989) Experiment 2 recognition condition, except that there were 18 pictures at presentation instead of 20.

Method

Subjects. The subjects were 55 University of Delaware undergraduates (24 female) who had agreed to participate in the departmental subject pool for a general psychology course.

Apparatus. Subjects were seated in a small classroom (approximately 30 seats). In this and the following experiments, subjects were assigned seats, so that when they returned for the memory test, they would view the pictures from the same location. The slides were presented on a white plasterboard screen using a Kodak Carousel projector. The projector was situated squarely in front of the screen to provide an undistorted rectangular image. Image size was 17 in. × 26 in. (43.6 cm × 66.7 cm). The approximate visual angles experienced by a subject in the front row center seat and rear row center seat were 8.0° × 11.4° and 4.0° × 6.0°, respectively.

Stimuli. The close and medium versions of the 16 selected scenes were used in this experiment (for a listing, see the Appendix).

Design and procedure. Subjects were shown 16 pictures for 15 s each. Eight were presented in their close-up version and 8 were

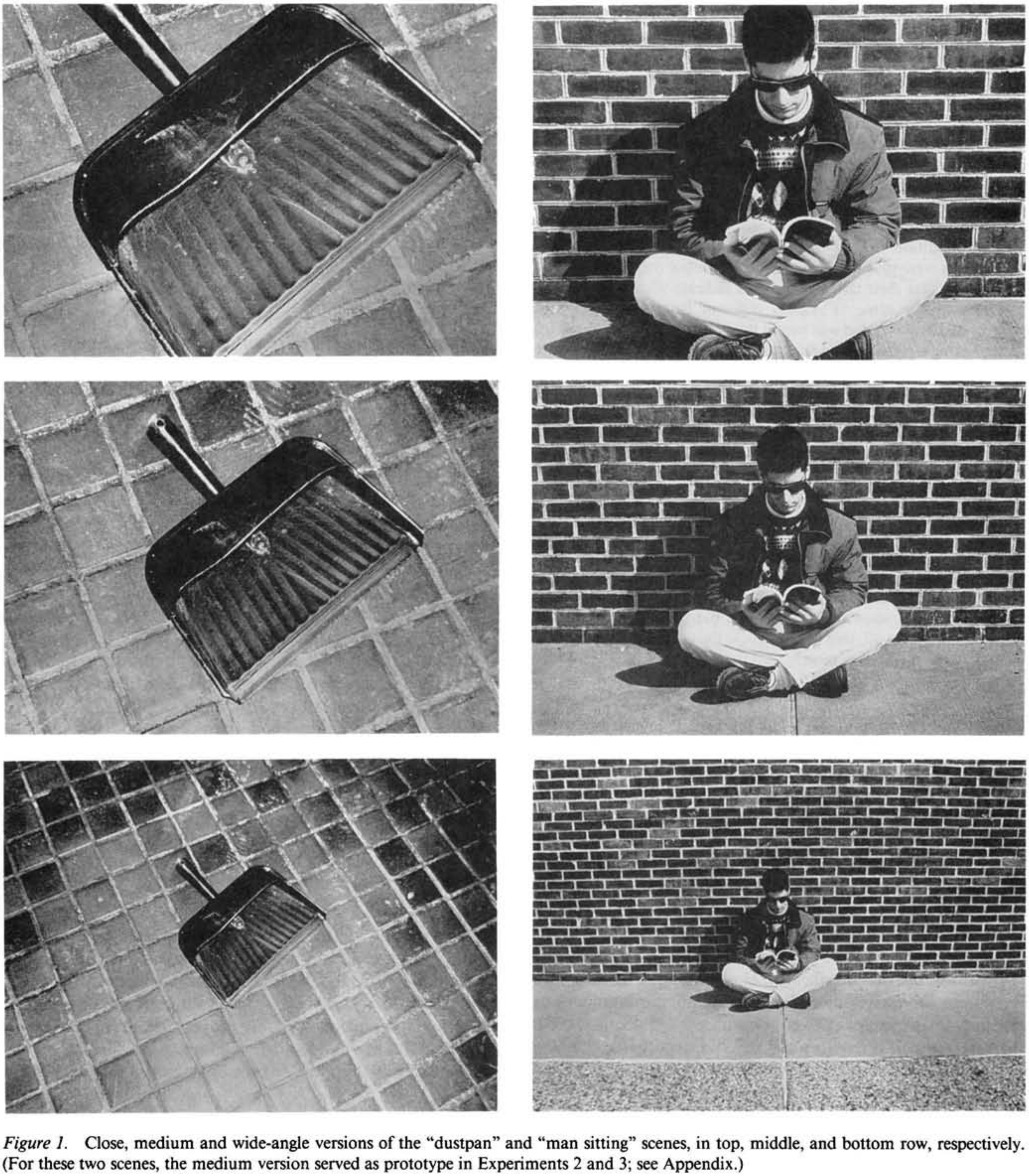

Figure 1. Close, medium and wide-angle versions of the "dustpan" and "man sitting" scenes, in top, middle, and bottom row, respectively. (For these two scenes, the medium version served as prototype in Experiments 2 and 3; see Appendix.)

presented in their medium version. No more than 2 close-ups or 2 medium pictures were presented in a row. The scenes were presented in the same order to all subjects regardless of which version of the scene was presented. An additional slide was added at the beginning of the sequence and at the end to guard against primacy and recency effects. Subjects were instructed to focus their full attention on all slides and to remember each in as much detail as possible. They were told that the background information was just as important to remember as the main object.

Approximately 48 hr later, subjects returned for the recognition test. The 16 scenes (excluding the 2 buffer pictures) were shown in the same order as in the presentation phase for 10 s each. The same order was used so that the subjects would experience the same viewing context during presentation and test. This was done to enhance subject's accuracy and thus bias *against* the phenomenon. Eight of the scenes were shown in the same version as in presentation (target condition), and 8 were shown in the other version (distractor condition). There were therefore four conditions at test: close-up version at presentation and test (CC), medium version at presentation and test (MM), close-up version at presentation and medium version at test (CM), and medium version at presentation and close-up version at test (MC). Pictures were counterbalanced across these four presentation/recognition conditions so that they appeared equally often in each condition.

Subjects were told that they would be shown the same scenes as before and that their task would be to indicate whether each scene was exactly the same or slightly different from the presentation picture. To explain what was meant by *different*, we pointed out that when taking a picture of a scene, the camera can be moved closer to the main object, thereby showing less of the surrounding scene, or farther away, thereby showing more of the surrounding scene. Subjects were presented with four versions of a sample scene to illustrate how that object would look as the camera was moved closer or farther away. They were then instructed that for each scene they were shown, they should indicate on their response sheet whether the camera was in the same location as in the presentation picture (rating of 0), or whether the camera was slightly closer (−1), much too close (−2), slightly farther away (+1), or much too far away (+2) from where it had been when the presentation picture was photographed. Subjects were instructed to give a confidence rating of *sure*, *pretty sure*, or *not sure* for each picture. Finally, they were told that although all the scenes had been shown before, if they didn't remember seeing a particular scene at all, they should circle the *don't remember picture* option on their response sheet.

Results and Discussion

The mean number of hits (correctly identifying a target as *same*) did not differ as a function of picture type, $t(54) = .96$. The percentage of hits was 57% in the CC condition and 62% in the MM condition. Although the hit rate was the same, the pattern of errors differed between the two conditions and replicated Intraub and Richardson's (1989) boundary extension effect for the close-ups. The percentage of responses indicating that the test picture looked "closer up" than the presentation picture and the percentage indicating that it looked farther away are shown in Table 1. A Wilcoxon test performed on the number of closer up and farther away responses for each subject revealed significant boundary extension for close-ups (CC condition: $z = -5.43$, $p < .001$). Consistent with the perceptual schema hypothesis, the same Wilcoxon analysis performed on the wider angle pictures yielded no directional distortion (MM condition: $z = -.55$, *ns*).

Unlike the close-ups, the medium pictures yielded no directional distortion. This can be interpreted as an extension of Intraub and Richardson's (1989) observation that boundary extension decreased when slightly more wide-angle pictures were presented. The medium pictures used in the present experiment were considerably more wide-angle than either of the picture types used by Intraub and Richardson (1989).[1] A direct test of the tendency for wider angle pictures to show less boundary extension was made in Experiment 3, when memory for close, prototypic, and wide-angle pictures was tested in the same experiment.

Table 1
Percentage of Responses Indicating That the Same Picture Looked "Closer Up" or "Farther Away" Than Before for Close (CC) and Medium (MM) Pictures (Experiment 1)

Condition	Response: Closer up %	Response: Farther away %	Wilcoxon
CC	35	3	$p < .001$
MM	15	20	*ns*

Note. Wilcoxon tests were performed on the number of responses in each category.

In the present experiment, subjects were rather confident of their responses. They reported being sure, pretty sure, or not sure on 36%, 51%, and 11% of the trials, respectively. They reported no memory for a picture on 2% of the trials. The same pattern of results was obtained (i.e., extension for CC pictures and no directional distortion for MM pictures) when *sure* responses alone were analyzed.

The mean boundary score for each of the four test conditions is shown in Table 2. Comparison of the two distractor conditions (CM and MC) yielded the same asymmetrical pattern as found in Intraub and Richardson (1989). The magnitude of the response (deviation from 0) was greater in the MC condition than in the CM condition, $t(54) = 3.19$, $p < .005$, indicating that subjects tended to extend the boundaries of the presentation picture.

Finally, the results of the close condition suggest that boundary extension cannot be attributed to object completion. Half of the pictures had main objects that were not cropped by the pictures' boundaries (see the Appendix), yet boundary extension apparently occurred for those pictures. In Experiment 3, the design allows for a more stringent test of extension for pictures without cropped objects at the boundaries, and we will return to this issue in our discussion of Experiment 3.

Experiment 2

Experiment 2 tested the predictions of the memory schema and perceptual schema hypotheses for pictures rated in the prototypic range and those rated as wide angles. According to the memory schema hypothesis, subjects should show no directional distortion of prototypic pictures and should restrict the boundaries of wide-angle pictures. According to the perceptual schema hypothesis, prototypic pictures would be likely

[1] We obtained boundary ratings for the Intraub and Richardson (1989) pictures, using the procedure described under Stimulus Selection. The pictures were included at the end of a series of close, medium, and wide-angle versions of scenes similar to those in the current stimulus set. Each Intraub and Richardson version was rated by 40 subjects. Consistent with our subjective impression, these pictures were considered to be close-ups (mean ratings for the closer and wider versions were −1.05 and −.21, respectively) and overall were significantly more close-up than the new pictures used in Experiment 1, $F(1, 34) = 200.55$, $MS_e = .06$, $p < .001$; 2 × 2 mixed ANOVA (Picture Set × Picture Version [closer version vs. wider version]).

Table 2
Boundary Score for Each Test Condition (Experiment 1)

Score	CC	MM	CM	MC
M	−0.42	0.07	0.65	−0.93
SD	0.37	0.43	0.52	0.48

Note. CC = close version at presentation and test; MM = medium version at presentation and test; CM = close version at presentation and medium version at test; MC = medium version at presentation and close version at test.

to show boundary extension, and wide-angle pictures should show less extension or no directional distortion. Boundary restriction of pictures should not be observed for any picture type.

Because the perceptual schema and the memory schema might both affect picture memory, but follow different time courses, memory was tested following two different retention intervals: immediate and 48-hr delay. We considered that distortion toward the prototypic viewing distance in memory might be more readily observable with a longer retention interval, whereas a distortion reflecting the perceptual schema might be more immediately apparent. The immediate condition was interesting in and of itself in that boundary memory had never before been tested following less than a 35-min delay.

Method

Subjects. Subjects were obtained from the same pool as in Experiment 1. There were 44 undergraduates (25 female) in the delay condition and 53 subjects (32 female) in the immediate condition.

Apparatus. The apparatus was the same as in Experiment 1.

Stimuli. Prototypic and wide-angle versions of the 16 selected scenes were used in Experiment 2. Prototype versions were selected from both close-up and medium versions depending on which was rated closer to standard (for a listing, see the Appendix).

Design and procedure. Subjects participated in either the immediate condition or the delay condition (48-hr delay). During the presentation phase of the experiment, subjects were shown 16 pictures: 8 were prototypic versions and 8 were wide-angle versions. No more than 2 prototypes or wide-angles were presented in a row. The scenes were presented in the same order to all subjects regardless of which version of the scene was presented. The slides were shown for 15 s each. As in Experiment 1, one slide was added at the beginning and one at the end of the presentation sequence to guard against primacy and recency effects. Subjects were read the same instructions as in Experiment 1.

Either 48 hr later or immediately after the presentation, subjects participated in the recognition phase of the experiment. The test instruction took approximately 3 min so that in the immediate condition there was a 3-min delay before testing began. The 16 scenes, excluding the 2 buffer pictures, were shown in the same order as in the presentation phase. As in Experiment 1 there were four test conditions, which in this case corresponded to a prototype tested by a prototype (PP), a prototype tested by a wide angle (PW), a wide angle tested by a prototype (WP), and a wide angle tested by a wide angle (WW).

Subjects were told that they would be shown the same scenes as in the presentation phase and that their task would be to indicate whether these scenes were exactly the same or slightly different from the ones they had seen before. The instructions and the rating scale were identical to those described in Experiment 1.

Table 3
Percentage of Hits for Prototypic (PP) and Wide-Angle (WW) Pictures as a Function of Retention Interval (Experiment 2)

	Picture type	
Retention interval	PP	WW
Immediate	79	68
Delay	60	60

Results

The percentages of hits for the PP and WW pictures in each retention condition are shown in Table 3. A two-way mixed ANOVA (Time × Picture Type) was performed on the number of hits in each condition. As would be expected, subjects were better at remembering picture boundaries in the immediate condition than in the delay condition, $F(1, 95) = 10.41$, $p < .01$, $MS_e = 1.36$. There was no effect of picture type and no interaction between picture type and retention interval: $F(1, 95) = 2.06$ and 1.62, respectively ($MS_e = .934$).

Picture type, however, had a pronounced effect on subjects' recollection of picture boundaries. Table 4 shows the percentage of closer up and farther away responses for each condition. Consistent with the perceptual schema hypothesis, within minutes of presentation, boundary extension was evident for the PP pictures (Wilcoxon, $z = -2.84$, $p < .002$), whereas no directional distortion was obtained for the WW pictures (Wilcoxon, $z = -.49$, *ns*). It is important to note that the lack of a directional distortion could not be attributed to a superior overall memory in the WW condition (i.e., a ceiling effect) because, if anything, the hit rate was a little lower than in the PP condition (see Table 3). Errors in the WW condition indicated no directional bias whatsoever. Following a 48-hr delay, however, the pattern of results changed. Whereas the PP condition again yielded boundary extension (Wilcoxon, $z = -3.86$, $p < .001$), the WW condition yielded boundary restriction (Wilcoxon, $z = -4.25$, $p < .001$). The mean boundary scores for the PP and WW conditions for both retention intervals are presented in Table 5.

As in Experiment 1, subjects were confident about their responses. In the immediate condition they reported being

Table 4
Percentage of Responses Indicating That the Same Picture Looked Closer Up or Farther Away Than Before for the Prototypic and Wide-Angle Pictures as a Function of Retention Interval (Experiment 2)

	Response		
Picture type	Closer up %	Farther away %	Wilcoxon
		Immediate	
Prototype	15	5	$p < .002$
Wide angle	15	15	*ns*
		Delay	
Prototype	30	8	$p < .001$
Wide angle	5	33	$p < .001$

Table 5
Mean Boundary Score for Each Test Condition for Immediate and Delay Groups (Experiment 2)

Test condition	Group	
	Immediate	Delay
PP		
M	−0.13	−0.25
SD	0.28	0.37
WW		
M	−0.03	0.32
SD	0.36	0.38
PW		
M	1.60	1.41
SD	0.31	0.38
WP		
M	−1.70	−1.18
SD	0.37	0.47

Note. PP = prototype tested by a prototype; WW = wide angle tested by a wide angle; PW = prototype tested by a wide angle; WP = wide angle tested by a prototype.

sure, pretty sure, or not sure on 65%, 30%, and 4% of the trials, respectively. Subjects reported no memory for a picture on 1% of the trials. In the delay condition, the percentages were 44%, 46%, and 8%, respectively, with subjects reporting no memory for a picture on 4% of the trials. Once again, the same pattern of results was obtained for the *sure* responses alone.

Mean boundary-placement scores for the PW and WP conditions are presented in Table 5. A priori predictions about asymmetry in the two distractor conditions can be made only when a unidirectional distortion is expected. In the immediate condition, where a unidirectional distortion was obtained, a significant asymmetry was not found, although consistent with prior research the WP condition did yield a higher rating than the PW condition. A significant difference may have been obscured by a ceiling effect for the ratings. In the delay condition, the pattern was not unidirectional. A significant asymmetry was obtained, however, $t(43) = 3.26$, $p < .005$, indicating that restriction was more pronounced than extension.

Discussion

The results of the immediate condition were consistent with the perceptual schema hypothesis. The closer views yielded boundary extension, and the wider views yielded no directional distortion. Delaying the test by 48 hr, however, yielded a different pattern of results that was suggestive of the memory schema hypothesis. The closer views were remembered with extended boundaries, whereas the wider views were remembered with restricted boundaries. Although this pattern is consistent with the major prediction of the memory schema hypothesis, the results were not fully consistent with that model.

According to the memory schema hypothesis, over time, the representation of a picture normalizes toward its prototypic viewing distance. Therefore, pictures rated in the prototypic range should not have yielded boundary extension and certainly should not have yielded a greater degree of extension in the delay condition than the immediate condition. As prototypes, although they may have initially been affected by the perceptual schema (yielding extension), with an increase in delay they should have shown less extension as they normalized, eventually reaching a point of no directional distortion. Of course one could argue that the ratings we obtained might not have provided a good indication of the prototypic distance and that, in fact, these pictures fell short of being true prototypes. If this criticism turns out to be true, this apparently anomalous observation would be explained, and the memory schema hypothesis could account for performance in the delay condition.

An alternate hypothesis, however, is suggested by the symmetry of the extension and restriction responses obtained in the delay condition. The pattern suggests that the representation of each picture type was normalizing to a picture type falling between the two. According to this view, although initially affected by the perceptual schema, over time, the remembered pictures normalize toward the average of the picture types presented in the set. Extension and restriction would therefore be attributed to the *mixed* presentation of very different picture types, not to a general prototypic viewing distance stored in memory. Although accounting for the present results, this hypothesis is less successful in accounting for the results of the Intraub and Richardson (1989) recognition tests, in which the wider of the two pictures did not yield restriction of boundaries. Recall that both versions yielded boundary extension to varying degrees.

This, however, may be explained in terms of how different the presentation pictures are. In Intraub and Richardson (1989) the picture types were very similar, so that the pull to normalize toward the average of the set (and thus restrict) was small relative to the pull to agree with the perceptual schema (and thus extend). In the current experiment, where the difference between picture types was relatively large, after 2 days the tendency to normalize may have been stronger than the tendency to reflect the perceptual schema. The next experiment was designed to determine whether the memory schema hypothesis or the alternate hypothesis (normalization to the average of the set) can account for performance in the delay condition.

Experiment 3

The main purpose of Experiment 3 was to replicate Experiment 2 using a completely independent design with respect to picture type. If the extension and restriction observed in the delay condition is due to normalization toward a general prototypic viewing distance, then the same results should be obtained when picture types are not mixed. Specifically, wide-angle and close-up pictures should again normalize toward this prototype. If, however, the restriction results are due to a more transient prototype created during presentation, then the pattern observed in Experiment 2 should not be replicated when picture types are not mixed. Instead, as predicted by the perceptual schema hypothesis, we should observe decreasing extension, as more wide-angle pictures are presented.

Method

Subjects. The subjects were 130 (60 female) University of Delaware undergraduates enrolled in introductory psychology who were participants in the departmental subject pool. Subjects were tested in groups of no more than 6 subjects each. In the delay group, the close-up, prototypic, and wide-angle conditions had 23, 21, and 21 subjects, respectively. In the immediate group, these conditions contained 23, 20, and 22 subjects, respectively.

Apparatus. The apparatus was the same as in Experiment 1 except that there were two rows of three chairs each. Image size was the same. The visual angle for a subject in the front row center was approximately 13° × 20°, and for the back row center, appoximately 10° × 15°.

Stimuli. Close-up, prototypic (consisting of close and medium versions), and wide-angle pictures from the set of 16 scenes were used. (For a listing, see the Appendix.)

Design and procedure. During the presentation phase of the experiment, subjects were shown 16 scenes, all of which were either close-ups, prototypes, or wide angles. As in the previous experiments, a buffer slide was added to the beginning and end of the order to guard against primacy and recency effects. Each slide appeared on the screen for 15 s. Subjects were given the same memory instructions as in the previous two experiments.

The recognition test was administered either immediately following presentation or after a 48-hr delay. As in Experiment 2, the instruction required approximately 3 min so that the first test picture in the immediate condition was presented about 3 min after the last presentation picture. The recognition test differed from the previous ones in that there were no distractor versions. In this way, throughout the entire experiment subjects viewed only close-up, prototypic, or wide-angle pictures. At test, subjects were presented with the same sequence of 16 stimuli they had seen during the presentation phase. Subjects were not aware that the same slide tray was being used. In the immediate condition, in which subjects saw the slides 3 min before the test phase, the experimenter staged a fake slide switch while the subjects filled out some information on the response sheet. The delayed group was just instructed to return in 48 hr for the second part of the experiment.

Subjects were told that they would see the same scenes they had seen during the presentation phase and that their task would be to indicate whether they were exactly the same or slightly different from the ones they had seen before. The instructions and the rating sheet were the same as in Experiments 1 and 2.

Results and Discussion

Table 6 shows the percentage of hits in each condition. A 2 × 3 independent ANOVA (Time × Picture Type) conducted on the number of hits for each subject showed that neither time, $F(1, 124) = 1.71$, nor picture type ($F < 1$) had any effect on the hit rate; on average, across all conditions, subjects were correct 58% of the time. This differs from Experiment 2 in which the increase in delay, from immediate to 2 days, resulted in approximately a 14% decrease in the hit rate. Apparently, eliminating the mixture of different picture types during presentation and test spared the subject's ability to recognize many of the pictures as "the same" over a 48-hr retention interval. The pattern of boundary errors, however, was greatly affected by time and picture type. First we will address the effects of picture type.

Boundary extension and picture type. The boundary scores for all three picture types for the two retention intervals are shown in Table 7. As indicated by the negative boundary scores in the table, errors tended to reflect extension of boundaries in memory. A 2 × 3 independent ANOVA (Time × Picture Type) conducted on the boundary scores showed that this tendency decreased as more wide-angle scenes were presented, $F(2, 124) = 17.05$, $p < .001$, $MS_e = .063$. Recall that this relationship between picture type and boundary memory was observed in Intraub and Richardson (1989) and in Experiment 1 of the current paper.

Table 6
Percentage of Hits for Close, Prototypic, and Wide-Angle Pictures as a Function of Retention Interval (Experiment 3)

	Picture type		
Retention interval	Close	Prototype	Wide
Immediate	53	57	57
Delay	60	58	61

The percentage of subjects reporting more extension than restriction responses, more restriction than extension responses, or no bias (i.e., ties) is presented in Table 8. Wilcoxon tests performed on the number of extension and restriction responses made by each subject revealed significant boundary extension for all conditions except the delayed wide-angle condition, which yielded boundary restriction ($T^+ = 0$, 4, and 17.5, for the close, prototype, and wide angle immediate conditions, respectively, and $T^+ = 6$, 12, and 52, for the close, prototype, and wide-angle delay conditions, respectively, $p < .01$ for all cases of extension, and $p < .05$ for restriction). As in the previous experiments, subjects were rather confident of their responses. Collapsing over picture type, in the immediate condition, subjects were sure, pretty sure, or not sure, on 41%, 50%, and 8% of the trials, respectively. They gave no responses on .2% of the trials. In the delay condition the percentages were 32%, 53%, and 13%, respectively, with subjects offering no response on 2% of the trials.

An analysis of the responses by picture (collapsing over subjects) showed that extension was not due to a small subset of pictures. When tested immediately, of the 16 stimuli in the close, prototype, and wide-angle conditions, 15, 15, and 12 yielded more extension than restriction responses, respectively. In the delayed condition, the number of pictures was 14, 11, and 5 for the close, prototype, and wide-angle conditions, respectively.

As in Experiment 2, the results of the immediate condition clearly followed the predictions of the perceptual schema hypothesis. Wide-angle pictures did not yield boundary restriction. Instead, all three picture types were remembered as having wider boundaries then they actually did, with the

Table 7
Mean Boundary Scores for Close, Prototypic, and Wide-Angle Pictures as a Function of Retention Interval (Experiment 3)

	Picture type		
Retention interval	Close	Prototype	Wide
Immediate			
M	−0.45	−0.34	−0.17
SD	0.25	0.22	0.17
Delay			
M	−0.28	−0.20	0.07
SD	0.29	0.24	0.30

Table 8
Percentage of Subjects Reporting More Extension Responses Than Restriction Responses, More Restriction Than Extension Responses, or No Bias (Ties)

	Picture type		
Majority response	Close-up	Prototype	Wide angle
	Immediate		
Extension	100	85	77
Restriction	0	10	14
No bias	0	5	9
Total *N*	23	20	22
	Delay		
Extension	74	76	24
Restriction	9	14	52
No bias	17	10	24
Total *N*	23	21	21

degree of extension decreasing as picture type changed from close to wide angle.

The delay condition did not yield the same pattern as in Experiment 2. As may be seen in Table 7, all picture types showed a reduction in the degree of extension after a 2-day delay, $F(1, 124) = 17.05$, $p < .001$, $MS_e = 1.07$. There was no interaction of time and picture type ($F < 1$). Instead of a strong symmetrical pattern of extension and restriction, extension decreased over time for the two closer sets, and a small but significant amount of restriction was observed in the wide-angle condition. One way to describe the data is that after a 48-hr delay, all conditions yielded more restrictive responses compared with the immediate condition.

The fact that any restriction was obtained indicates that the perceptual schema hypothesis alone cannot account for distortions in memory for boundaries and that some type of transformation in memory is also taking place. This transformation, however, does not seem to be due to normalization toward a prototypic viewing distance. It may be due instead to local interactions among pictures in the presentation sequence, with pictures normalizing toward the average of that particular picture set. Additional evidence for this view was obtained in the following analysis.

The design of the present experiment allowed us to directly study local picture effects. Recall that the prototype pictures included eight close-up pictures and eight medium pictures (see Stimulus Selection Section). This meant that a set of the same eight pictures appeared in the close condition and in the prototype condition of the present experiment. The remaining eight scenes appeared in their close version in the close condition and in their medium version in the prototype condition. The order of the scenes in both conditions was the same. The mean boundary scores for the same eight pictures when they were mixed with eight close scenes (close condition) and when they were mixed with eight medium scenes (prototype condition) are shown in Table 9. A 2 × 2 (Time × Condition) independent ANOVA was performed on the mean boundary score for the eight pictures that were the same. Consistent with the local picture averaging hypothesis, there was a main effect of condition, $F(1, 83) = 11.0$, $p < .01$, $MS_e = .091$. The same pictures were rated as more wide-angle when they were presented with pictures that were slightly wider than themselves than when they were presented with pictures that were slightly closer up. A 48-hr delay again yielded less extension, $F(1, 83) = 5.79$, $p < .05$, $MS_e = .091$, and there was no interaction of time and condition ($F < 1$).

Overall, subjects were fairly confident of their responses. In the immediate condition, subjects indicated that they were sure or pretty sure on 90% to 93% of the trials, with an average miss rate (not remembering a picture) of .2%. In the delay condition, they reported being sure or pretty sure on 82% to 89% of the trials, with an average miss rate of 1.7%. As in the previous experiments, the pattern of results was the same when subjects were sure as when the data were collapsed across confidence levels.

Object completion. In the close condition 8 pictures (50%) contained no incomplete objects, and in the prototype condition 15 pictures (94%) fell into this category. The objects were centered on a natural textured background (e.g., carpet, asphalt, tile, brick, grass). The boundary scores for these pictures in the close condition were −.31 and −.13 for immediate and delay, respectively, and for the prototype condition were −.32 and −.19 for immediate and delay, respectively. The extension was significant by Wilcoxon tests ($p < .01$) for all but the close-ups in the delay condition. There were no cropped edges in the wide-angle pictures; yet, as described earlier, significant boundary extension was obtained in the immediate wide-angle condition. These results are consistent with two observations about subjects' drawings reported by Intraub and Richardson: (a) Subjects frequently extended boundaries by showing more of an occluded object than was presented without completing it, and (b) subjects extended the boundaries of a picture that happened to have a homogeneous background with no occluded objects. In conjunction with the recognition results obtained with the current stimulus set, these observations demonstrate that boundary extension is not simply a case of object completion. It is better described in terms of recalling more of the scene than was actually presented (i.e., recalling more area).

General Discussion

These experiments replicated the boundary extension effect first reported by Intraub and Richardson (1989) and provided new information about the conditions under which it will occur. We will summarize four new empirical observations, followed by a discussion of their theoretical implications.

Table 9
Boundary Scores for the Subset of Eight Pictures Appearing in Both the Close and Prototype Conditions at Each Retention Interval (Experiment 3)

	Picture condition			
	Close		Prototype	
Retention interval	*M*	*SD*	*M*	*SD*
Immediate	−0.31	0.26	−0.50	0.27
Delay	−0.13	0.29	−0.37	0.38

The first observation is that boundary extension, as measured in a recognition task, does not require a 48-hr retention interval. Boundary extension was obtained within minutes of presentation in Experiments 2 and 3. The second is that boundary extension is not limited to close-up views of scenes, but occurs reliably for prototypic and wide-angle views of the same scenes when tested within minutes. The third is that the degree of extension decreases as increasingly wide-angle views are presented. The fourth is that boundary *restriction* can be observed for wide-angle views following a delay of 48 hr.

Three theoretical accounts of boundary distortion were tested. Results provided no support for the object completion hypothesis, strong support for the perceptual schema hypothesis when memory was tested immediately, and mixed support for the memory schema hypothesis after a delay.

Object Completion

Like most photographs of scenes, photographs in the Intraub and Richardson (1989) stimulus set often included cropped objects in the background (e.g., part of a window or part of a tree), raising the possibility that the extension of picture boundaries in memory may have been caused by the subject's tendency to complete incomplete forms. The present research demonstrates that the Gestalt principle of object completion (see Ellis, 1955) cannot account for this error in recollection.

The stimulus set used in these experiments included no cropped background objects. All backgrounds were homogeneous or textured natural backgrounds. Nonetheless, boundary extension was clearly evident. In the immediate condition of Experiment 3, memory for wide-angle, prototypic, and close-up pictures (excluding all close-ups in which the main object was cropped) yielded significant degrees of boundary extension. Subjects simply remembered having seen more of the background than had actually been displayed.

It remains to be seen whether incomplete background objects can influence the *degree* of extension. This can be tested by creating a stimulus set in which the same main object is photographed from the same distance, once with a cropped background object and once with the same background object shifted so that it is not cropped. The point of the present research, however, is that regardless of whether object completion has an influence or not, it certainly cannot account for the basic phenomenon.

Perceptual Schema

When memory was tested immediately, the pattern of results strongly supported the perceptual schema hypothesis. The results of Experiments 2 and 3 suggest a two-component model of pictorial representation. One component is the influence of the perceptual schema and the other is the influence of normalization processes in memory. The relative strengths of these components varies over time. Immediately following presentation, the effects of the perceptual schema are stronger, but over time these may lessen and the effects of normalization become stronger.

The perceptual schema hypothesis focuses on the fact that a picture always depicts only part of a scene, with its edges serving as arbitrary boundaries. The basic premise is that picture perception includes an understanding that the scene continues outside these boundaries. This continuation of the scene is represented in the schema—perhaps the same mental structure that has been hypothesized to play a role in the integration of successive views (Hochberg, 1978, 1986). Consistent with this hypothesis, recognition tests yielded boundary extension within minutes of presentation, regardless of whether picture types were mixed (Experiment 2) or unmixed (Experiment 3). In both cases, when subjects saw the same pictures again, their responses indicated that they remembered those pictures as having had wider boundaries. In addition, as predicted, the *degree* of extension decreased as increasingly wide-angle pictures were presented.

This prediction was based on the assumption that the most predictive part of the schema is that area immediately surrounding an attended object. In the case of a close-up, much of the predictive portion of the schema extends beyond the picture's boundaries. As more wide-angle views of the object are presented, more of the schema is represented within the picture itself. We proposed that the subject's pictorial representation in memory includes information that was actually depicted, as well as schematic information that was understood. Accordingly, close-ups were expected to show the greatest degree of extension, and extension was expected to decrease as more wide-angle views were presented. Theoretically, as the picture view widens, at some point this decrease should asymptote, with pictures yielding no directional distortion. This prediction was borne out in the immediate conditions of Experiments 2 and 3. Boundary extension decreased as increasingly wide-angle views of the same object were presented. Wide-angle pictures showed a small degree of extension or no directional distortion. This observation cannot be attributed to wide-angle pictures' being more distinctive or more memorable than other picture types. Subjects were no more accurate in recognizing the boundaries for wide-angle pictures than for other pictures; they simply showed less of a *directional* distortion.

Also consistent with the perceptual schema hypothesis was the observation that pictures that had been rated in the prototypic range were not immune to distortion, but instead yielded extension. This observation and the lack of restriction for wide-angle views run counter to the predictions of the memory schema hypothesis.

Memory Schema

The pattern of responses changed dramatically in both Experiments 2 and 3, when a two-day delay was introduced between presentation and test. Over time, the representation of the picture space apparently undergoes a transformation. One possible account of this transformation, proposed at the outset of the paper, is the memory schema hypothesis. Two basic assumptions of this hypothesis are (a) that subjects' general knowledge about pictures includes the prototypic viewing distances associated with the depicted object and (b) that the pictorial representation in memory normalizes toward this prototype over time (e.g., Bartlett, 1932). As normalization takes place, close-ups should show boundary extension, wide angles should show boundary restriction, and pictures that were rated as prototypic should show no directional distortion.

As described in the previous section, when memory was tested immediately, no evidence for these predictions was obtained; all picture types were remembered with extended boundaries. After a delay of 48 hr, however, the pattern of results changed, yielding boundary restriction for wide-angle pictures in both Experiments 2 and 3. This outcome is consistent with the memory schema hypothesis. On the other hand, the tendency for pictures rated in the prototypic range to be remembered with *extended* boundaries is not consistent with the memory schema hypothesis. One could argue that the prototypic ratings did not actually capture the true dimensions of the internal prototype; however, even if this were the case, comparison of the results of Experiments 2 and 3 shows additional problems for the memory schema hypothesis.

In Experiment 2, the normalization assumption was supported in that the pictures that immediately showed extension showed increased extension over time, and the pictures that showed no directional distortion immediately, showed restriction over time. In Experiment 3, however, when the same pictures were presented in a blocked design, without picture types being mixed, this normalization pattern was not obtained. Close-ups, prototypes, and wide-angle pictures all showed more restriction after 48 hr than they had shown immediately. The same wide-angle pictures showed considerably more restriction when they were presented with prototypes (Experiment 2) than when they were presented in isolation (Experiment 3). These observations in conjunction with the analysis of the eight repeated pictures in Experiment 3 (i.e., the same pictures presented with slightly closer pictures in one condition and slightly more wide-angle pictures in another) suggest that subjects are affected by the average viewing distance depicted in a particular set of pictures and suggest that normalization toward this episodic prototype may be taking place. Contrary to the memory schema hypothesis, normalization toward a preexperimental expectation about depicted viewing distances apparently was not taking place.

The results suggest that the pictorial representation is influenced both by perceptual expectations that tend to push the boundaries out and by a memory transformation (e.g., normalization to the average picture of the presentation series) that may exert a counterinfluence. Initially, the perceptual influence may be the stronger of the two, but over time the memory transformation may gain in strength. The nature of this transformation is not clear at this point, except to say that it is not simply a normalization to preexperimental expectations about depicted viewing distances. It may be that these different tendencies interacted with the different picture types to yield the *restrictive drift* obtained in the delay condition of Experiment 3, but the current research does not allow more than speculation about this possibility. Future research that will test memory following several different retention intervals should help to elucidate the characteristics of temporal changes in the remembered picture space.

Boundary Distortion and Other Memory Phenomena

Boundary extension has strong potential theoretical significance because it appears to be the rule rather than the exception in memory for photographs. Extension of boundaries has now been observed in drawings and in two types of recognition tests. We have demonstrated the phenomenon with a picture set in which the background contained occluded objects (Intraub and Richardson, 1989) and one in which it did not (present experiments). Unlike other well-known picture memory errors in which verbally presented information becomes integrated into the subject's memory for a related picture (e.g., Loftus & Palmer, 1974; Pezdek, 1977), boundary extension occurs spontaneously, without the experimenter providing any misleading information.

We have proposed that boundary distortion occurs in two phases. In the first phase it is unidirectional: Subjects tend to remember pictures as showing more of a scene than had actually been presented. If, as we suggest, boundary extension in the immediate conditions is caused by the activation of a perceptual schema during the initial comprehension of the stimulus, then it may be closely related to the phenomenon of *representational momentum* (e.g., Finke & Freyd, 1985; Freyd, 1987; Kelly & Freyd, 1987). In these experiments (reviewed in Freyd, 1987) it has been demonstrated that perceptual expectations about physical changes in a stimulus (e.g., movement of a visual stimulus or changes in the pitch of an auditory stimulus) result in predictable directional distortions in memory. For example, if a geometric form is moving in a particular direction and the display is terminated, subjects will tend to remember the form as being farther along in its path than it actually was when they last saw it (Finke & Freyd, 1985).

In boundary extension, the expectation is not about a physical change in the stimulus, but about the expected continuation of the scene outside of a picture's arbitrary boundaries. The expectation concerns what the next eye fixation would be likely to bring into view, were the boundary not present. Just as subjects in the representational momentum experiments remember seeing a form where it was likely to have traveled next, subjects remember seeing parts of the scene that are likely to have existed just outside the camera's field of view. In a sense, subjects are looking at pictures but are remembering scenes.

Over time, the pictorial representation apparently undergoes further transformation, of a different type. This is reflected in the qualitatively different pattern of results we obtained following a 2-day delay. Instead of all pictures yielding boundary extension, wide-angle pictures yielded boundary restriction. The distortion during this phase appeared to involve a type of normalization. If further research shows that normalization to the average of the picture set is a good characterization of the phenomenon, then boundary distortion over time may be similar to the normalization functions reported for simple geometric shapes and for maps in a variety of research paradigms (Kemp, 1988; Moyer, Bradley, Sorensen, Whiting, & Mansfield, 1978; Tversky, 1981).

In conclusion, memory for pictures includes a distortion of the picture space that is apparently the rule rather than the exception. It is a highly robust phenomenon. It provides another example of the dynamic nature of mental representation. The phenomenon of boundary extension also raises interesting issues about the nature of pictorial representation and the relation of the physical picture to the subject's mental schema of the scene that the picture represents.

References

Bartlett, F. (1932). *Remembering: A study of experimental and social psychology.* Cambridge, England: Cambridge University Press.

Bartlett, J. C., Till, R. E., & Levy, J. C. (1980). Retrieval characteristics of complex pictures: Effects of verbal encoding. *Journal of Verbal Learning and Verbal Behavior, 19,* 430–449.

Ellis, W. D. (Ed. and Trans.). (1955). *A source book of Gestalt psychology.* London: Routledge & Kegan Paul.

Finke, R. A., & Freyd, J. J. (1985). Transformations of visual memory induced by implied motions of pattern elements. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 11,* 780–794.

Freyd, J. J. (1987). Dynamic mental representations. *Psychological Review, 94,* 427–438.

Gibson, E. (1969). *Principles of perceptual learning and development.* New York: Appleton-Century-Crofts.

Goodman, G. S. (1980). Picture memory: How the action schema affects retention. *Cognitive Psychology, 12,* 473–495.

Hochberg, J. (1978). *Perception* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Hochberg, J. (1986). Representation of motion and space in video and cinematic displays. In K. J. Boff, L. Kaufman, & J. P. Thomas (Eds.), *Handbook of perception and human performance* (Vol. 1, pp. 22:1–22:64). New York: Wiley.

Intraub, H. (1980). Presentation rate and the representation of briefly glimpsed pictures in memory. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 1–12.

Intraub, H., & Richardson, M. (1989). Wide-angle memories of close-up scenes. *Journal of Experimental Psychology: Learning, Memory and Cognition, 15,* 179–187.

Kelly, M., & Freyd, J. J. (1987). Explorations of representational momentum. *Cognitive Psychology, 19,* 369–401.

Kemp, S. (1988). Memorial psychophysics for visual area: The effect of retention interval. *Memory and Cognition, 16,* 431–436.

Loftus, E. F., & Palmer, J. C. (1974). Reconstruction of automobile destruction: An example of the interaction between language and memory. *Journal of Verbal Learning and Verbal Behavior, 13,* 585–589.

Mandler, J. M., & Johnson, N. S. (1976). Some of the thousand words a picture is worth. *Journal of Experimental Psychology: Human Learning and Memory, 2,* 529–540.

Moyer, R. S., Bradley, D. R., Sorensen, M. H., Whiting, J. C., & Mansfield, D. P. (1978). Psychophysical functions for perceived and remembered size. *Science, 200,* 330–332.

Pezdek, K. (1977). Cross-modality semantic integration of sentences and picture memory. *Journal of Experimental Psychology: Human Learning and Memory, 3,* 515–524.

Pezdek, K., Maki, R., Valencia-Laver, D., Whetstone, T., Stoeckert, J., & Dougherty, T. (1988). Picture memory: Recognizing added and deleted details. *Journal of Experimental Psychology: Learning, Memory and Cognition, 14,* 468–476.

Tversky, B. (1981). Distortion in memory for maps. *Cognitive Psychology, 13,* 407–433.

Appendix

Mean Rating for the Close, Medium, and Wide-Angle Version Scenes Based on a 5-Point Scale Where 0 Indicates *Standard View*, Negative Ratings Indicate *More Close-Up Than Standard*, and Positive Ratings Indicate *Farther Away Than Standard.*

Scene	Version			No. of cropped edges in close version
	Close	Medium	Wide	
Movie reels	0.11[a]	0.55	1.50	0
Lantern	0.10[a]	1.33	1.74	0
Telephone	−1.00	−0.30[a]	1.72	1
Racquet	−0.35[a]	0.39	1.34	0
Dust pan	−1.17	−0.25[a]	1.40	2
Brownie	0.00[a]	1.60	1.70	0
Backpack	0.22[a]	0.45	1.85	0
Man sitting	−0.45	0.25[a]	1.11	2
Book and glasses	−0.28[a]	0.45	1.95	0
Compact discs	−0.20[a]	0.40	1.83	2
Hat	0.20[a]	1.06	1.65	0
Traffic cone	−0.40	0.35[a]	1.11	0
Sneakers	−1.10	0.00[a]	1.35	2
Hanger	−0.50	0.05[a]	1.25	2
Oranges	−0.80	0.40[a]	1.56	2
Blender	−0.67	−0.15[a]	1.60	2

[a] Indicates version used as prototype (the version closest to 0).

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