Beyond the edges of a picture

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Viewers remember having seen a greater expanse of a scene than was shown in a photograph: an error called *boundary extension.* Two experiments examined the cause of the distortion by presenting 303 undergraduates with close-up, prototypic, wide-angle, or inverted-close-up views of seven scenes. Stimulus durations of 4 or 15 s were tested. Results showed that boundary estension decreased with increasingly wide-angle views and that inverted pictures yielded as great a distortion as did pictures with a normal orientation. Results support the hypothesis that boundary extension is mediated by the activation of a perceptual schema during picture perception and does not simply reflect a tendency for subjects to remember having seen a prototypic view.

Boundary extension refers to the viewer's tendency to remember seeing information that was not in a photograph but that was likely to have existed just outside the camera's field of view (Intraub & Richardson, 1989). This distortion of the remembered picture space has been observed in subjects' drawings (Intraub & Richardson, 1989; Intraub, 1992; Intraub & Bodamer, 1993; Legault & Standing, 1992) and in their recognition test performance (Intraub & Richardson, 1989; Intraub, Bender, & Mangels, 1992; Intraub, 1992; Intraub & Bodamer, 1993). The phenomenon is so robust that even when subjects were informed about it and tried to prevent it, they were unsuccessful. Forewarning served to reduce, but not to eliminate, the distortion (Intraub & Bodamer, 1993).

Intraub et al. (1992) tested three different explanations of boundary extension. The first hypothesis attributed the distortion to object completion (see Ellis, 1955). In Intraub and Richardson's (1989) original study, all the pictures depicted relatively close-up views of common scenes. In almost all cases, the edges of the picture cropped an object, frequently a background object, such as a tree or a window. According to the object completion hypothesis, boundary extension occurs when these cropped objects are completed (i.e., made whole) in memory. Intraub et al. (1992) demonstrated that object completion could not account for the phenomenon because the same distortion of the picture space occurred when an object was centered on a natural background (e.g., sand, grass, carpeting, and so forth) that contained no

AMERICAN JOURNAL OF PSYCHOLOGY
Winter 1996, Vol. 109, No. 4, pp. 581–598

cropped objects. Subjects persisted in remembering the picture as depicting a more wide-angle view than had actually been the case.

The second hypothesis, referred to as the *memory schema hypothesis*, attributed Intraub and Richardson's (1989) results to normalization toward a prototypical view of each scene. According to this hypothesis, for any scene that can be described, there exists a *prototypic* viewing distance. For example, in imagining a snapshot of a bicycle against a fence, there is some viewing distance that is likely to be considered prototypic, with a certain amount of background showing and the bicycle therefore taking up a certain area of the picture space. A picture showing much more of the background (and thus diminishing the area of the picture devoted to the bicycle) would be considered a wide-angle view, and one showing much less background (and thus enlarging the area devoted to the bicycle) would be considered a close-up. Indeed, by definition, the term *a close-up* indicates a view that shows less of the scene than is expected.

If the subject's memory for a picture normalizes toward the prototypic (expected) view (c.f. Bartlett, 1932; E. Gibson, 1969), then close-ups should be remembered with extended boundaries. Tighter close-ups should show more extension than less extreme close-ups because the latter are closer to the prototypic view to begin with and therefore have less potential for distortion. This pattern was in fact obtained by Intraub and Richardson (1989), who used two versions of their close-ups as stimuli. Related to the notion of a prototypic viewing distance in a picture is research by Palmer, Rosch, and Chase (1981) that demonstrated the existence of canonical viewing angles in the pictorial representation of objects.

The third hypothesis is the *perceptual schema hypothesis*. According to this model, when the viewer sees a partial view of a scene (as in the case of a photograph), general expectations about the spatial layout of the scene are activated and the viewer understands this partial view within the context of these expectations. These scene expectations constitute what we've called a perceptual schema. This schema is similar to Hochberg's (1978, 1986) proposed "mental schema"—a visual-spatial representation that he argues may mediate the integration of successive views during visual scanning and during perception of movies and video displays. According to the perceptual schema hypothesis, regardless of the source of a partial view, (e.g., an eye fixation, a slide presentation, or a cinematic sequence), comprehension includes the activation of the perceptual schema. It is such an integral part of perception (particularly in the case of a close-up, where very little of the scene is actually depicted) that it becomes incorporated in the viewer's representation—thus yielding boundary extension.

The perceptual schema hypothesis can also account for Intraub and Richardson's (1989) observation that tighter close-ups yielded a greater degree of extension than did close-ups with a slightly more wide-angle view. This is because in a close-up of an object, very little of the scene is actually shown in the picture, whereas prototypic and wide-angle views show increasingly more information, respectively. Close-ups therefore have the greatest potential for boundary extension because the subject must rely more on the perceptual schema to interpret the picture. In increasingly wide-angle views, more of the highly predicted information surrounding the attended object is already contained within the picture. In a sense, it is redundant with the schema. As a result, as the picture view widens, boundary extension (the addition of scene information that is not present in the picture) should decrease, until at some point no overall directional distortion can be detected.

Although the two hypotheses make the same prediction for close-up views, they diverge where it comes to predicting memory performance for increasingly wide-angle views. According to the memory schema hypothesis, close-ups should yield boundary extension, prototypic views should yield no directional distortion, and wide-angle views should yield *boundary restriction* as they normalize. According to the perceptual schema hypothesis, all picture types should yield boundary extension, with the degree of distortion decreasing with increasingly wide-angle views. At very wide-angle views, the effect may no longer be detectable, thus yielding no directional distortion. Contrary to the memory schema prediction, unidirectional boundary restriction should never occur for any picture-type because perceptual expectations are always outside the picture's boundaries.

Intraub, Bender, and Mangels (1992) tested the contrasting predictions of the memory schema and perceptual schema hypotheses using boundary recognition tests. In one experiment, 130 subjects were divided into three groups. Each group was presented with either the close-up, prototypic, or wide-angle versions of the same 16 scenes for 15 s each. Half of the subjects were tested immediately, and half were tested after a two-day delay. To avoid any contamination of memory through the introduction of other versions of a scene at any point in the experiment, the recognition test contained the same 16 pictures as the presentation sequence with no distractor items. Subjects were told that the same scenes would be presented but that sometimes they might be shown in a more close-up or more wide-angle version. They were instructed to rate each picture on a 5-point scale to indicate if it was the same or showed more or less of the scene.

The immediate condition supported the perceptual schema hypothesis; within minutes of presentation, boundary extension was obtained for close-ups, prototypes, and wide-angle views. Furthermore, the degree of extension decreased as increasingly wide-angle views were presented. A different pattern was observed after a delay. As in the immediate condition, close-ups and prototypes both yielded boundary extension, although, somewhat counter-intuitively, the degree of the effect was less after two days than after a few minutes (a point we will return to later). Wide-angle pictures, on the other hand, yielded a small, but significant, amount of boundary restriction. They determined that the extent to which restriction occurred in the delay condition depended on the heterogeneity of the stimulus set. For example, when only wide-angle pictures were presented, less boundary restriction was obtained than when wide-angles were mixed with prototypes. But in the immediate condition, the boundary extension was obtained regardless of the composition of the memory set.

Intraub et al. (1992) proposed a two-component model, the *Extension-Normalization Model*, to account for these results. The first component involves activation of the perceptual schema, which yields boundary extension. The strength of the perceptual schema effect depends on picture view, with close-ups yielding the greatest effect. Legault and Standing (1992) provided additional support for the perceptual schema hypothesis by demonstrating that whereas pictures of scenes yield overall boundary extension, when the main objects alone were traced and presented to another group of subjects, no directional distortion was obtained. This supports the assumption that the activation of knowledge about scene structure is an important component of boundary extension. It also argues against the notion that boundary extension occurs because objects are remembered as being smaller in memory, and subjects must then "fill in" the background to complete the picture space. If this were true, then boundary extension should have also been obtained in the object-alone condition.

The second component involves normalization, not toward the expected view of each scene (as in the memory schema hypothesis), but toward the average view depicted in the stimulus set. The strength of normalization is determined by the heterogeneity of the set. A less heterogeneous set of picture views would result in a smaller normalization effect than would a more heterogeneous set. The relative influence of the perceptual schema and normalization changes over time: the perceptual schema exerting greater influence immediately, and normalization increasing in strength over time. The decrease in the degree of boundary extension that occurred over time for close-ups and prototypic views apparently does not reflect an improvement in memory with the passage of days. Instead, it reflects the interaction of two different types of distortions: boundary extension, moving all boundary outward, and normalization, pulling some of them back inward, over time.

The Extension-Normalization Model has interesting implications for pictorial representation, but, before these can be explored, it is very important to address the generality of its predictions. The purpose of the present research was to determine if the predictions of the first component (the perceptual schema hypothesis) would be replicated under a different set of conditions. In Intraub et al. (1992), memory for close-up, prototypic, and wide-angle views was tested using two different types of recognition tests. The primary purpose of the current research was to determine if the same pattern of errors would be obtained if memory were tested by having subjects draw the pictures (recall).

It is well-known that recall and recognition do not always yield the same results (e.g., Flexser & Tulving, 1978; Johnson, 1983). The tasks may tap different types of information or may activate different systems of representation. For example, Johnson (1982) suggested in her modular model of memory (MEM) that, because recognition tests involve a re-presentation of the stimulus, they may activate perceptual memory, which is more sensitive to visual detail and layout, whereas free recall may tend to activate referential memory, which is more inferential in nature, and would include subject's "filling in" information based on prototypic expectations. That is, recognition memory tests might yield results that support the perceptual schema hypothesis, whereas recall might support the memory schema hypothesis.

In Intraub and Richardson (1989), both recall and recognition tests yielded boundary extension. In that research, however, only close-up views were presented. As described earlier, in the case of close-ups, both the perceptual schema and memory schema hypotheses are consistent with this outcome. In Experiment 1, memory for close-up, prototypic, and wide-angle views was tested using a recall (drawing) task. If boundary extension is a fundamental aspect of pictorial representation in memory, then we would expect the results of a recall task to parallel that obtained with recognition tests. If the pattern of errors obtained using recognition is modular in nature, then the pattern of errors may change, depending upon how memory is tested: that is, a recognition test would support the perceptual schema predictions, and a recall task would support the memory schema predictions. Another reason for using drawings is that, in addition to subjectively evaluating them and noting when additional background is added to a picture, along with the requisite minimization of the main object within the picture space, one can measure the area covered by the object in the drawing as compared with its area in the stimulus, thus providing a quantitative assessment of the degree of the distortion.

In addition to testing the generalizability of the effect to recall, these experiments tested its generality across set size, stimulus duration, and stimulus orientation (upright or inverted). Specific rationales and predictions will be presented in the introduction to each experiment.

EXPERIMENT 1

This experiment followed Intraub et al. (1992, Experiment 3), in which subjects studied either close-up, prototypic, or wide-angle views of the same scenes followed by a memory test, except that the number of stimuli was reduced from 18 to 7, and presentation was followed immediately by a recall (drawing) task, instead of a recognition test. Following the drawing task, a recognition test was administered as a secondary test. This was done because it was a "no-cost" addition to the design that would allow us to determine, regardless of the results of the recall test, if we could replicate Intraub et al. (1992) with the new picture set when using the same type of recognition test that they had used. Intraub and Richardson (1989) reported that an interpolated drawing task had no effect on recognition performance for their pictures, so the secondary test was thought to be a useful addition.

Another issue addressed in this experiment was whether boundary extension could be eliminated (or minimized) by making the pictures more difficult to encode, thus inducing more effortful processing. It has been demonstrated that inverting pictures makes them more difficult to recognize in a subsequent test (e.g., Diamond & Carey, 1986; Yin, 1969; for a similar effect of inversion on dot patterns see Tanaka & Farah, 1991). For example, Diamond & Carey (1986) reported that recognition memory for landscapes decreased from 88% correct to 79% correct when the pictures were inverted (both at presentation and test). By inverting the pictures and requiring subjects to memorize their details and layout, we expected to cause subjects to conduct a more deliberate scan of the picture than in the normal viewing condition. Indeed, subjectively, observers reported that studying an inverted scene seemed more difficult than studying one in an upright orientation. We reasoned, based in part on Johnson and Raye's (1981) discussion of reality monitoring, that the subjects who made this more deliberate scan would be less likely to confuse the externally presented pictorial information with the internally generated information that came from the perceptual schema. This more effortful scan might lead to a reduction or elimination of boundary extension if the phenomenon was due to attentional factors during encoding. If, on the other hand, boundary extension is more fundamental, reflecting picture perception/comprehension, inversion should have no effect on boundary extension.

METHOD

Subjects

The subjects were 206 (109 female) University of Delaware undergraduates who elected to take part in the department's subject pool to complete a research requirement in a general psychology course.

Stimuli

The stimuli were close-up, prototypic, and wide-angle views (35-mm color slides) of seven scenes similar to those used in Intraub et al. (1992). Each included a main object, or object cluster, against a natural background (e.g., wood floor, cement steps, carpeting). The object(s) was in the central portion of the field so that no object was cropped by the picture's boundaries. Figure 1 shows all three versions of one of the stimulus scenes (the pail and shovel on a pebbled sidewalk). Pictures were selected from a set (described in Bender, 1992) that had been rated by subjects (N = 60) on a 5-point scale as to whether they were *very close-up* (−2), *slightly close-up* (−1), *standard views* (0), *slightly wide-angle* (1) or *very wide-angle* (2). The mean ratings for the seven pictures in this study were −1.2 for close-ups, 0.0 for prototypes, and 1.1 for wide-angle views. Although Intraub et al. (1992) were able to photograph close-up and wide-angle views that yielded high subject agreement, they were not as successful in photographing views that most subjects could agree were prototypic. In this set, although on average the prototypic views yielded a mean score of 0, they were rated as prototypic by only 68% of the respondents. For the current experiment, using the new set, we were able to improve upon this. The seven pictures selected as depicting prototypic views in this experiment had a subject agreement rate of 81%.

Apparatus

A Kodak Carousel slide projector was used to project an image onto a projection screen. The visual image measured .38 m × .58 m. Two rows of three chairs each were set up in front of the screen in a dimly lit room. The distance from the screen to the front of the middle seat in the front row and the middle seat in the back row was 1.83 m and 2.48 m, respectively. This yielded visual angles of approximately 12° × 18° and 9° × 14° respectively.

Design and procedure

Subjects were assigned to one of four groups. Each group saw only one type of picture view: close-up (N = 51), prototypic (N = 51), wide-angle (N = 52), or inverted close-up (N = 52). In all four groups, subjects were told,

> Your task will be to focus your full attention on each picture and to remember it in as much detail as possible. The pictures consist of a main object against a background. The background is just as important to re-

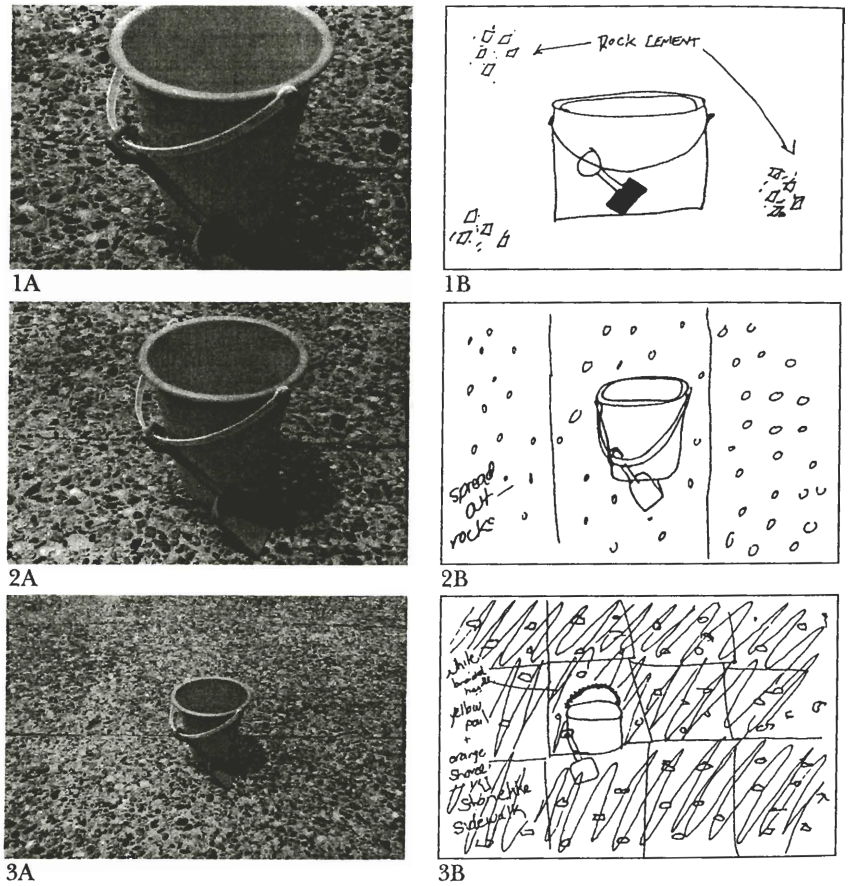

Figure 1. The first column shows the close-up, prototypic, and wide-angle views of one stimulus (the pail), and the second column shows a typical drawing of each view (proportion of the area drawn in each example is .35, .37. and .69, for the close-up, prototype, and wide-angle picture, respectively). Original stimuli were color photographs; subjects' original pencil drawings were traced in black ink for the figure

> member as the main object. In other words, please try to retain an exact copy of each slide in your memory.

Subjects then viewed the seven slides for 15 s each. The only time between pictures consisted of the time necessary for the carousel to turn. There were two orders of presentation, one the reverse of the other. Approximately half the subjects in each condition viewed each order. Following presentation, subjects took part in a drawing task, followed by a recognition test.

Drawing task

Immediately following presentation, the subjects were issued response booklets. Each page contained two rectangles, which measured .10 m × .15 m, so that they had the same aspect ratio (1:1.5) as the stimuli (35-mm slides). An unambiguous one-word title next to each rectangle indicated which picture the subject should draw in that space. Pictures were listed in the same order as they had been initially presented. Subjects were asked to draw each of the pictures in as much detail as possible. They were told,

> Don't worry if you're not a great artist; just do your best to represent the object and its background. Consider the edges of the rectangle to be the edges of the photograph you saw and draw the picture accordingly, filling in the space on your page as it had been filled in the photograph on the screen. After you draw each picture, make any changes that your think are necessary. If you want to clarify any part of your drawings, feel free to add words.

Drawings took about 20 min to complete.

Recognition test

The drawing booklets were collected upon completion, and the recognition response sheets were distributed. The subjects were told they would be seeing the same scenes again, but this time their task was to rate each slide on a 5-point scale as to whether each picture was exactly the same or slightly different than the one they had seen during presentation: *same* (0), *slightly too close* (−1), *much too close* (−2), *slightly too far* (1), or *much too far* (2). If they could not remember a picture at all they were instructed to circle "Don't remember picture" (DRP). Subjects circled a confidence rating of "sure," "pretty sure," or "not sure," for each response. The test slides were presented in the same order, orientation, and duration (15 s) as in their original presentation. As in prior research, to make sure that subjects understood the ratings they were to make, we showed them four views of the same scene (a bicycle against a fence), that ranged from close-up to wide-angle. It was pointed out that when the camera is closer, less of the scene is visible than when it is farther away.

Area measurement

To allow for a quantitative assessment of the representation of the picture space, the area of the main object in the subject's drawing was compared to the area of the main object in the stimulus. Areas were measured in the following way. The main object in each drawing was traced onto graph paper (10 squares/in.). The area of the main object in the drawing was then estimated by counting the number of boxes within the space covered by the object. To obtain the area of the stimulus object we projected the 35-mm slide onto a .10-m × .15-m rectangle on the graph paper (the same size rectangle that surrounded the drawings), traced the main object, and then estimated area using the same counting procedure described above.

RESULTS AND DISCUSSION

Recall

Using the procedure described in the "area measurement" section, the area of the main object in each drawing was divided by the area of the main object in the stimulus. This proportion, referred to as the *proportion drawn,* indicates boundary extension when the mean proportion is less than 1.00 and boundary restriction when it is greater than 1.00. A proportion of 1.00, of course, indicates an accurate drawing. Six subjects were deleted from the drawing analysis because they did not complete all the drawings. For the close-up, prototypic, wide-angle and inverted-close-up conditions, this included 2, 1, 2, 1, subjects, respectively.

As predicted by the perceptual schema hypothesis, but contrary to the memory schema hypothesis, subjects' drawings revealed striking degrees of boundary extension for the close-ups and prototypes and no directional distortion for the wide-angle pictures. The mean proportion drawn in the close-up, prototypic, and wide-angle conditions was, .35 ($SD = .13$), .43 ($SD = .18$), and 1.03 ($SD = .44$), respectively (see Figure 1 for samples of subjects' drawings). The .95-confidence intervals were constructed around each mean. The interval did not include 1.00 for the close-ups and prototypes, indicating significant boundary extension. The interval did include 1.00 for the wide-angles, indicating no directional distortion of picture boundaries across the set. A one-way ANOVA showed that the proportion drawn increased as increasingly wide-angle views were presented, $F(2, 146) = 85.81$, $MSE = .08$, $p < .0001$. (Neuman-Keuls yielded a significant difference between the prototypic and wide-angle conditions, $p < .001$).

Collapsing over subjects, boundary extension was obtained for each of the seven pictures in the close-up and prototypic conditions (see Table 1). In the wide-angle condition, where on average no directional distortion was obtained, it is clear that this was not the case for all the pictures. Some pictures yielded extension and others yielded restriction. A determining factor in the direction of the distortion appears to have been the size of the object in the picture space relative to the size of the other objects in the set—a critical factor in normalization. In Table 1, the wide-angle pictures are presented in size order, from the picture in which the main object covered the smallest area to the picture in which the main object covered the largest area. As may be seen in the Table, with the exception of one reversal, the proportion drawn decreased dramatically as the size of the main object increased. In other words, large objects got smaller (yielding boundary extension) and small objects got bigger (yielding boundary restriction). Consistent with the Extension-Normalization Model, given a condition in which the in-

Table 1. Mean proportion of the main object that was drawn in each condition

	Scene						
Picture type	Basketball	Bear	Bananas	Tire	Sneakers	Pail	Crayons
Close-up	.43	.34	.26	.44	.36	.41	.22
Prototype	.66	.29	.30	.44	.39	.37	.42
Wide-angle	1.98	1.24	.78	1.20	.81	.68	.53

Note. Picture names are listed in size order for the wide-angle pictures, beginning with the smallest (basketball). For close-ups, this list puts the pictures in the following size order: 4, 2, 5, 7, 3, 1, and 6. For prototypes, the order is: 1, 6, 3, 7, 4, 5, and 2.

fluence of the perceptual schema was expected to be small, a normalization pattern emerged.

Inverting a picture had no effect on subjects' drawings. The proportion drawn was .39. The .95-confidence interval did not include 1.00, showing once again a significant unidirectional distortion of the picture-space. The proportion drawn did not differ between the close-up and inverted-close-up conditions, $t(98) = 1.39$.

Recognition

Recognition ratings yielded the same pattern of results as the recognition tests in Intraub et al. (1992, Experiment 3). As may be seen in Table 2, all picture types showed significant boundary extension, with the degree of extension decreasing as increasingly wide-angle views were presented, $F(2, 151) = 14.35$, $p < .001$, $MSE = 1.75$. (Neuman-Keuls yielded a significant decrease between the close-up and prototypic conditions.) As a point of comparison, boundary scores in Intraub et al. (1992) for the close-up, prototypic, and wide-angle views were –.45, –.34, and –.17, respectively.

Table 2. Mean boundary rating (*M*) and upper (UL) and lower (LL) limits of the .99-confidence interval for each picture type

Picture type	*M*	UL	LL
Close-up	–.66	–.53	–.79
Prototype	–.40	–.27	–.52
Wide-angle	–.30	–.17	–.42
Inverted close-up	–.50	–.35	–.65

Note. Negative mean boundary ratings and confidence intervals that do not include 0 indicate significant boundary extension.

In each condition, the percentage of responses indicating that the test picture depicted a closer view than the stimulus, the same view as the stimulus, and a more wide-angle view (farther away) than the stimulus is shown in Table 3. Extension responses were made much more frequently than restriction responses, and Wilcoxon tests showed this tendency to be highly significant across subjects for all four picture types (close-up: $T = 7.5$, $N = 50$, $z = -6.08$; prototype: $T = 37.5$, $N = 44$, $z = -5.34$; wide-angle: $T = 73$, $N = 44$, $z = -4.92$; and inverted close-up: $T = 24$, $N = 47$, $z = -5.71$; $p < .001$ in all cases). The hit rate (correctly recognizing a picture as "same"), was the same in the prototypic and wide-angle conditions but decreased in the close-up condition. A one-way ANOVA on the number of same responses indicated that this decrease was significant, $F(2, 151) = 6.95$, $MSE = 48$, $p < .001$.

The percentage of times subjects rated their responses as "sure," "pretty sure," and "not sure," was 11.8%, 57.5%, and 29.1%, respectively. Subjects either did not recognize a picture, or failed to provide a confidence rating on 1.7% of the trials. Inspection of the cases where subjects were "sure" of their responses showed that the same pattern of errors occurred for these responses.

As was the case in recall, each picture in the close-up and prototype conditions tended to be remembered with extended boundaries. The mean boundary scores for individual pictures ranged from –.35 to –.92 for the close-ups, and –.10 to –.73 for the prototypes. Unlike the drawings, recognition responses to the wide-angle pictures yielded a small degree of boundary extension. This could be seen for all but one picture (which yielded no directional distortion). In no case was boundary restriction obtained, and there was no indication of normalization. From smallest to largest, the scores were –.14, –.27, –.35, –.41, 0, –.31, and –.69.

Why the same wide-angle pictures yielded no directional distortion in the drawings and a small significant degree of boundary extension in the recognition test is open to speculation. It may be that in present-

Table 3. Percentage of responses calling the test picture "too close" (–), "same" 0, or "too wide-angle" (+)

	Response		
Picture type	–	0	+
Close-up	58%	37%	5%
Prototype	42%	52%	7%
Wide-angle	38%	52%	10%
Inverted close-up	50%	43%	7%

Note. Percentages are rounded to the nearest whole number.

ing the same stimulus again, recognition tests are more sensitive to traces of processes that took place during perception than are recall tasks (Johnson, 1983). This could explain why, in the case of a weak perceptual schema effect, recognition test results would yield boundary extension and the drawings would yield normalization.

As was the case with the drawings, recognition results revealed boundary extension in both close-ups and inverted close-ups (see Table 2). However, unlike the drawings, a small, significant difference in the degree of the distortion was obtained. The degree of extension was slightly less pronounced for the inverted close-ups than for the upright close-ups, $t(101) = 1.99$, $p = .05$. The hit rates, however, did not differ significantly, $t(101) = 1.38$, (see Table 3). This small, marginally significant decrease in the degree of the distortion for inverted pictures was explored further in Experiment 2.

EXPERIMENT 2

The purpose of inverting the pictures in the previous experiment was to cause subjects to make a more deliberate scan of the pictures, thus increasing their ability to remember the layout more accurately. Clearly, inversion did not eliminate boundary extension either in the drawings or the recognition test. However, the slight reduction in the magnitude of boundary extension, seen in the boundary recognition scores, raised the possibility that the long stimulus duration (15 s) made the identification of pictures so easy that the difference between inverted and normally oriented pictures was minimized. Therefore, we attempted to replicate this difference under conditions in which stimulus duration was shortened to 4 s/picture. We reasoned that if there is an inversion effect, then it should be even more pronounced if the subject is allowed less time to view each picture. As in the previous experiment, memory was tested with a drawing task followed by a recognition test.

METHOD

Subjects

The subjects were 97 undergraduates (46 female) from the same subject pool described in Experiment 1. There were 49 subjects in the close-up condition and 48 in the inverted close-up condition.

Stimuli

The same seven close-ups views were used as in Experiment 1.

Apparatus

The apparatus was the same as in Experiment 1.

Design and procedure

Approximately half the subjects were presented with seven close-ups in a normal orientation and the other half with the same seven pictures in an inverted orientation. The instructions, picture orders, and presentation and test (including the 15-s duration for each test picture) were the same as in Experiment 1 except that the slides were presented for 4 s each, with the time between slides determined by the slide change time of the carousel.

RESULTS AND DISCUSSION

Recall

In both conditions, subjects extended picture boundaries in their drawings. The mean proportion drawn was .34 (*SD* = .14) in the close-up condition and .35 (*SD* = .16) in the inverted-close-up condition. (One subject's data was deleted from the close-up condition because of the failure to complete all drawings.) Both conditions yielded unidirectional boundary extension: The .95-confidence interval in both cases showed that the proportion drawn differed from 1.00. These proportions were comparable to those obtained with the 15-s stimulus durations in Experiment 1 and did not differ from each other, $t(94) = .44$.

Recognition

Overall, confidence was high in both conditions. Subjects reported being "sure," "pretty sure," or "not sure," on 25%, 58%, and 14% of the trials, respectively, for the close-up condition. These scores were 30%, 58% and 10%, respectively, for the inverted-close-up condition. Subjects either did not recognize a picture or failed to provide a confidence rating on 1.5% of the trials in each condition. Table 4 shows the mean number of "closer-up" and "farther away" responses for normal and inverted pictures. Wilcoxon tests again showed that boundary extension

Table 4. Percentage of responses calling the test picture "too close" (–), "same" (0), or "too wide-angle" (+)

	Response		
Picture type	–	0	+
Close-up	53%	42%	5%
Inverted close-up	58%	37%	5%

Note. Percentages are rounded to the nearest whole number.

responses were more prevalent in both conditions (close: $T = 22$, $N = 45$, $z = -5.59$; inverted: $T = 18.5$, $N = 47$, $z = -5.77$, both $p < .001$).

The mean boundary score for the close-ups and the inverted close-ups was –.62 ($SD = .45$) and –.66 ($SD = .40$), respectively, There was no significant difference, $t(95) = .42$. The mean number of hits (correctly recognizing the picture as same) for the close and inverted pictures was 2.9 ($SD = 1.84$) and 2.5 ($SD = 1.52$), respectively. As was the case in Experiment 1, this difference was not significant, $t(95) = 1.09$. There was absolutely no indication in this experiment that inverting a picture results in the elimination or reduction of boundary extension.

A comparison of the results of Experiments 1 and 2, for the close-up and inverted-close-up conditions, allowed us to examine the effect of stimulus duration on boundary extension. A reduction in stimulus duration from 15 s to 4 s, (which also included an increase in the presentation rate), had no effect on the degree of the distortion. A 2 × 2 independent ANOVA was performed (presentation duration × picture type) on subjects' boundary scores. Neither picture type, $F(1, 196) = 1.05$, nor stimulus duration, $F(1, 196) = 1.02$, were significant, and there was no interaction, $F(1, 196) = 2.72$ ($MSE = .17$ in each case). Table 5 shows the boundary score for each picture in each condition. As in Experiment 1, negative boundary scores were obtained for each of the seven pictures.

GENERAL DISCUSSION

This research provided an opportunity to study subjects' recall of close-up, prototypic and wide-angle views of the same seven scenes. The overall pattern of errors in subjects' drawings paralleled the recognition memory errors obtained by Intraub et al. (1992): Subjects experienced boundary extension, and the degree of the distortion tended to de-

Table 5. Mean boundary score for each picture in the close-up and inverted close-up conditions (Experiment 2)

	Version	
Scene	Close	Inverted
Basketball	–.48	– .46
Bananas	–.98	–1.08
Pail	–.47	– .67
Tire	–.67	– .31
Crayons	–.85	–1.13
Bear	–.49	– .62
Sneakers	–.47	– .38

crease as picture-view widened, thus supporting the perceptual schema hypothesis. The pattern of results refute the memory schema hypothesis in two ways. First, whereas the memory schema hypothesis predicts no directional distortion for prototypes, these pictures yielded a significant degree of boundary extension in both recall and recognition. Second, whereas the memory schema hypothesis predicts boundary restriction for wide-angle pictures, these yielded either no directional distortion (in recall) or boundary extension (in recognition).

In addition to replicating Intraub et al. (1992) using a recall test, the results showed that boundary extension does not require a large stimulus set to occur. Although set size fell within the traditional short-term memory stricture of seven plus or minus two, within minutes, boundary extension was so great that in close-up and prototypic views, main objects were reduced to about 35% and 43% of their actual size, respectively. On average, drawings of wide-angle pictures revealed no directional distortion of the boundaries.

Boundary extension has always been found to be greatest for close-up views (Intraub et al., 1992; Intraub & Richardson, 1989). This was true in the present experiments. Furthermore, we found that the degree of boundary extension for close-ups was not affected by a reduction of stimulus duration from 15 s to 4 s and that there was little, if any, effect of inverting the pictures. Although an inverted orientation has been associated with a decrement in recognition memory for pictures (e.g., Diamond & Carey, 1986; Yin, 1969) and was expected to result in more effortful encoding of the stimulus, it had no effect on subjects' drawings and little or no effect on their recognition responses. These results are consistent with the view that boundary extension is caused by the activation of expectancies during perception of the picture. Irrespective of differences in duration or orientation, unseen information from the area just outside the pictures' boundaries was incorporated in memory.

According to the Extension-Normalization Model, in memory, both activation of the perceptual schema and normalization exert influence on the mental representation of the picture, with their relative importance changing over time. The perceptual schema immediately effects memory. Normalization exerts a greater effect over time. When the perceptual schema effect is very strong, it will overshadow any early effects of normalization. If the influence of the perceptual schema is very weak, then a normalization pattern may be observed immediately.

Although both recall and recognition results support the perceptual schema hypothesis and refute the memory schema hypothesis, with wide-angle pictures there is a difference in the results of those tests that is worthy of mention. The recall test yielded no directional distortion for wide-angle pictures, and the pictures yielded evidence of a normalization pattern. The delayed recognition test that followed recall yielded a small degree of boundary extension for the wide-angle pictures, with no suggestion of a normalization pattern (as was the case in the immediate recognition test for similar stimuli in Intraub et al., 1992). This difference between recognition and recall of the wide-angle pictures has also been reported by Intraub, Gottesman, Willey, and Zuk (1996). A possible explanation is that as Johnson (1982) argued, recall may be more subject to inferential processes and recognition tests may be more sensitive to perceptual information. In a case where the effect of the perceptual schema is weak (as in the case of wide-angle views), a recall test might be more sensitive to the influence of normalization than a recognition test. This possibility, while speculative, raises some new questions for future research.

The contribution of the present research to our understanding of picture memory is twofold. In terms of a theoretical perspective, it provides converging evidence for the perceptual schema component of the Extension-Normalization Model. It supports the contention that partial views of scenes are perceived within the context of their expected surroundings. People remember having seen not only what was actually presented, but what they understood to have existed just outside the picture's boundaries. In terms of empirical information, it shows new conditions under which boundary extension occurs. Neither inverting pictures nor reducing their presentation duration from 15 s per picture to 4 s per picture compromised the phenomenon. Subjects remembered having seen more of the scene than was actually shown in the picture minutes after viewing only seven scenes. Regardless of whether the current model is upheld in future research, it is increasingly clear that any model of pictorial representation will have to account for this remarkably robust distortion.

Notes

This research was supported by National Science Foundation Grant BNS 9011015 to Helene Intraub and was presented at the Thirty-second Annual Meeting of the Psychonomic Society, San Francisco, CA, November, 1991.

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