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BOUNDARY EXTENSION AND MEMORY FOR AREA AND DISTANCE

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Abstract

Memory for a previously viewed picture of a scene often includes details that might have been present just beyond the boundaries of that picture. This is known as boundary extension *(Intraub & Richardson, 1989) and has been proposed to reflect the anticipatory nature of representation (Intraub, 2002). Another possible explanation of boundary extension involves changes in remembered distance or size (Hubbard, 1996). To examine whether boundary extension is due to changes in remembered distance, participants judged distances to objects in 3-D scenes. Results were consistent with previous research in memory psychophysics. To examine whether boundary extension is due to changes in remembered size, participants recalled boundaries of scenes while object size remained unchanged. Results were consistent with previous research in boundary extension. The data suggest boundary extension is not due to changes in memory for distance or size.*

When observers view a picture of a scene, their subsequent memory for that scene often includes details that were not present in the picture, but that might have been present just outside the boundaries of the viewed scene (see Figure 1). This is referred to as *boundary extension* (Intraub & Richardson, 1989), and it has been suggested to reflect the

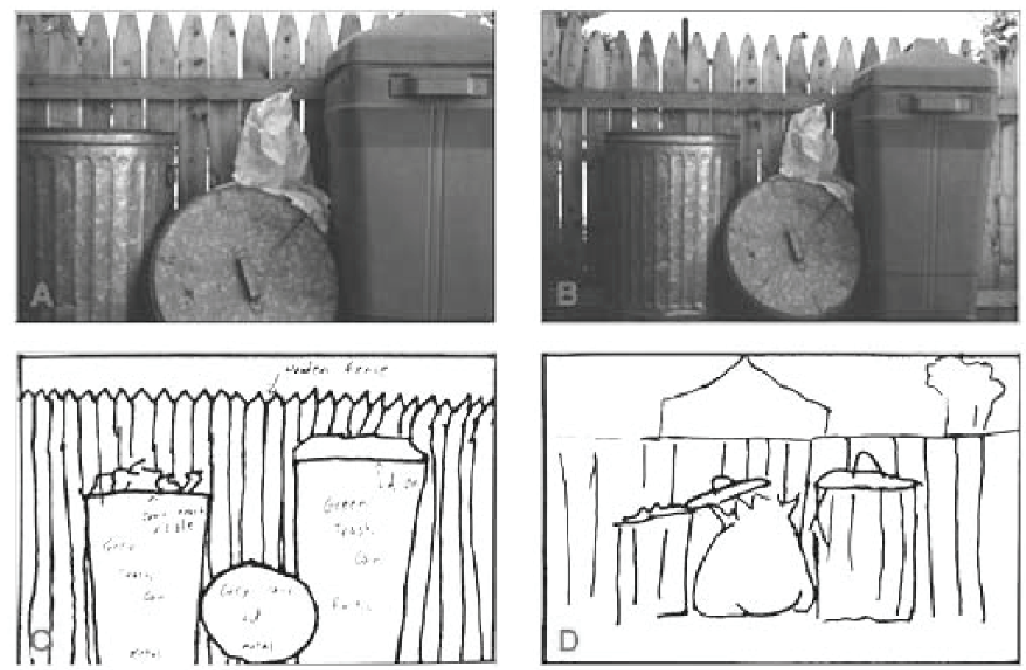

Figure 1. Examples of boundary extension. A typical drawing of an observer who viewed the picture in Panel A is shown in Panel C, and a typical drawing of an observer who viewed the picture in Panel B is shown in Panel D. Adapted from Intraub and Richardson (1989).

internalization of spatial continuity (Intraub, 2001). In experiments on boundary extension, observers typically view a photograph of a scene, and then draw the scene from memory or choose which photograph from a set of photographs corresponds to the previously viewed scene. Participants are more likely to draw a picture or accept a photograph in which objects in the scene subsume a slightly smaller visual angle (i.e., appear slightly smaller).

There is a literature within memory psychophysics on remembered size and remembered distance that is relevant to boundary extension. These studies have consistently found remembered objects subsume a slightly smaller visual angle than those objects subsume during perception (reviewed in Algom, 1992; Hubbard, 1994). The findings on remembered size appear consistent with boundary extension. However, a smaller remembered visual angle suggests an object should also be remembered as more distant. Psychophysical studies on remembered distance suggest that people actually remember objects at the correct distance or closer, and not as more distant. The findings on remembered distance appear inconsistent with boundary extension. The experiments described here examined the relationship between boundary extension and remembered size and distance of objects.

Experiment 1

Experiment 1 examined whether boundary extension could be due to a displacement in depth and whether boundary extension occurred for a partial view of a 3-D scene. The remembered distance to a 3-D scene was assessed by having participants initially view a scene, and then subsequently placing them back in front of the same scene and asking them to stand where they stood when they initially viewed that scene.

Method

Participants. Fifty-nine undergraduates (thirty-one in the 45 cm condition and twenty-eight in the 90 cm condition) naïve to the hypothesis were recruited from the participant pool in the Department of Psychology at Texas Christian University and received partial course credit.

Stimuli. Four scenes previously shown to result in boundary extension in a typical 2-D boundary extension recognition test were used (see Figure 2): North (a computer monitor on a cart), East (a large stuffed animal on a desk), South (a set of books on a bookshelf), and West (a pine cone and a candle on a bookshelf).

Procedure. Participants viewed each scene from a distance of either 45 cm or 90 cm. All participants viewed the scenes in a different random order. Scenes were viewed through a set of goggles with a 25 mm x 17 mm (width x height) viewing window for each eye (the same 3:2 ratio used in boundary extension experiments). At the beginning of each trial, a cardboard flap on the window of the goggles occluded the participant's view. The participant was led to a predetermined position in front of the scene. The experimenter then raised the cardboard flap. The participant was asked to look straight ahead and to remember in detail the characteristics of the scene. After viewing the scene for 15 seconds (a time typically used in studies examining boundary extension), the experimenter lowered the cardboard flap, once again occluding vision, and led the participant to the next scene. After viewing all four scenes, the participant was led back to each scene in the order in which the scenes were initially viewed. At each scene, the participant was positioned at the same distance at which he or she had initially viewed the scene. The experimenter then raised the occluding flap, and the participant was instructed to adjust his or her position by moving forward or backward to indicate the original position from which he or she first viewed the scene. After the participant

Figure 2. Photographs of scenes used in Experiments 1 and 2. Views depicted are 45 cm from the main object(s) in the scene.

made a judgment by stepping forward or backward, the judged position was measured in reference to the original starting position.

Results and Discussion

If a participant underestimated distance to the scene, then a positive number was assigned to his or her adjusted position; if a participant overestimated distance to the scene, then a negative number was assigned to his or her adjusted position. Thus, a mean positive score indicates a result consistent with memory psychophysics (participants remember being closer to an object), whereas a mean negative score indicates a result consistent with boundary extension (participants remember being further away from an object).

Participants remembered being closer to the scene than they actually were, $t(58) = 5.9$, $p < .001$. Significant displacements in remembered distance toward each scene were found: North, $t(58) = 5.7$, $p < .001$, South, $t(58) = 2.8$, $p < .01$, East, $t(58) = 4.5$, $p < .001$, West, $t(58) = 4.7$, $p < .001$. Viewing distance (45 cm vs. 90 cm) was not significant, $F(1, 57) = .01$, $MSE = 112.4$, $p < .919$. These results are consistent with previous studies examining memory for distance in 3-D scenes in memory psychophysics (e.g. Algom, 1992; Hubbard, 1994), but not with the only previous study of close-up views of 3-D scenes and boundary extension (i.e., Intraub, 2004).

Experiment 2

Experiment 2 examined memory for close-up views of 3-D scenes, and used a verbal response measure previously shown to provide evidence of boundary extension in 2-D scenes.

Participants viewed a scene, and upon subsequent viewing, used a rating scale to indicate whether the subsequent viewpoint was closer or more distant from the scene than the initial viewpoint.

Method

Participants. Twenty-eight undergraduates from the same participant pool used in Experiment 1 participated, and none had participated in the previous experiment.

Stimuli. The scene stimuli were the same as in Experiment 1.

Procedure. The procedure in Experiment 2 was identical to Experiment 1, with the following exceptions: All participants viewed scenes from a distance of 45 cm. After viewing all four scenes, participants were led back to each scene and positioned at the distance of the initial viewing. They rated on a 5-point scale whether their view of that scene was the same as or slightly different from their initial view of that scene (-2 = "much too close", -1 = "slightly too close", 0 = "same", +1 = "slightly too far", +2 = "much too far"), and this scale was modeled on those used by Intraub and colleagues.

Results and Discussion

The mean ratings for each scene were compared to zero; a significant positive rating indicates overestimation of distance, and a significant negative rating indicates underestimation of distance. Participants showed no significant differences in ratings for the scenes when data were collapsed across scene, $t(27) = 1.02$, $p < .318$, and ratings for none of the scenes were significantly different from zero: North, $t(27) = 0.00$, $p < 1.00$, South, $t(27) = 0.420$, $p < .678$, East, $t(27) = 1.03$, $p < .312$, West, $t(27) = 0.682$, $p < .501$.

Experiment 2 examined remembered distance using the same visual angles and the same views as in the 45 cm distance condition of Experiment 1. The distance ratings used in Experiment 2 had previously been successful in demonstrating boundary extension for 2-D scenes; however, there was no significant boundary extension for 3-D scenes in Experiment 2. In conjunction with Experiment 1, Experiment 2 suggests that whether apparent boundary extension occurs is dependent upon specific characteristics of the scene and response method and not due to a general bias in remembered size or distance.

Experiment 3

Results from previous studies examining boundary extension in 2-D scenes suggested an object is remembered as subsuming a slightly smaller visual angle relative to when that object was perceived. However, previous studies examining boundary extension for 2-D scenes have generally kept the boundaries constant and asked participants to draw the scene within the boundaries of a blank rectangle. It is not clear if boundary extension for a 2-D scene reflects changes in the boundaries of a scene or reflects changes in remembered distance or size of objects in the scene.

Method

Participants. Thirty-four undergraduates from the same participant pool used in Experiment 1 participated, and none had participated in the previous experiments.

Stimuli. Scene stimuli consisted of four pictures previously found to exhibit boundary extension in tests of recognition and recall, and each picture consisted of a single central figural object. The central object in each picture was a close-up view of a lamp, a

Figure 3. Photographs of scenes used in Experiment 3.

basketball, a horse, or a cup, and the aspect ratio of each picture (horizontal: vertical) was 3:2 (see Figure 3). Cut-outs were made of the central object in each scene (see Figure 4), and these cut-outs were placed on an otherwise blank sheet of paper (one cut-out per sheet).

Procedure. Pictures were displayed in a classroom setting using an IBM laptop computer connected to a ceiling mounted computer video projector (NEC Model NT 1050), and were projected on a screen measuring 82" x 32". Participants sat near the center of each of the first three rows directly in front of the screen on which the pictures were projected. Participants were told to pay attention to each picture and to remember the main object and the background including layout, size and location of everything in the picture space. The pictures were presented sequentially; each picture was visible for 15 seconds, and there was no pause between successive pictures. Immediately following presentation of the last picture, participants completed a recall task. Cut-outs of each object were presented on separate 8.5" x 11" sheets. Participants were told to complete the scene around the cut-out of each object, and to draw the boundaries that surrounded the scene. Immediately following the recall task, participants completed a recognition task in which they

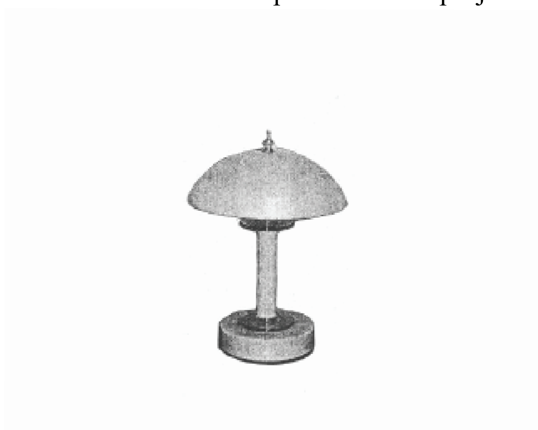

Figure 4. An example of a cut-out used in Experiment 3.

viewed the same scenes again in the same order and duration as previously. Participants rated each picture on the same 5-point scale used in Experiment 2.

Results and Discussion

Recall. The area of the scenes in participants' drawings were compared to estimates of the area the scenes should have subsumed (relative to object size) if participants' drawings were veridical reproductions of the scenes. In general, remembered area was significantly larger than actual area, $t(33) = 6.71$, $p < .001$; remembered area was significantly larger than actual area for the pictures of the lamp, $t(33) = 5.27$, $p < .001$, basketball, $t(33) = 6.06$, $p < .001$, horse, $t(33) = 8.09$, $p < .001$, and cup, $t(33) = 5.63$, $p < .001$.

Recognition. The mean rating ($M = -.50$) across objects was significantly less than zero, $t(33) = -6.63$, $p < .001$. Each picture showed significant boundary extension: lamp, $t(33) = -5.27$, $p < .001$, basketball, $t(33) = -6.06$, $p < .001$, horse, $t(33) = -8.09$, $p < .001$, and cup, $t(33) = -5.63$, $p < .001$.

Negative ratings in the recognition task are consistent with previous reports of boundary extension. A possible reason for the smaller remembered size is that in the recognition task, as well as in previous studies of boundary extension, the perimeter length of the boundary was kept constant (and object size allowed to vary). The incorporation of additional likely information from beyond the boundaries of the original scene necessitated a decrease in subsumed size of the central object. However, when object size was kept constant (and boundary location allowed to vary) in the recall task, remembered area increased, and this is consistent with an extension of the boundaries outward.

General Discussion

The experiments described here examined whether results typical of experiments on boundary extension could result from changes in remembered distances of 3-D objects (Experiments 1-2) and remembered size (Experiment 3). The data suggest (a) boundary extension is not due to changes in remembered distance or size, (b) memory for distance and size might be task dependent, and (c) boundary extension occurs when object size is constant in 2-D scenes.

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PHOTOGRAPHS OF MOUNTAINS TAKEN FROM A HIGHER ALTITUDE APPEAR TO MAKE THEM LOOK TALLER THAN PHOTOGRAPHS OF MOUNTAINS TAKEN FROM A LOWER ALTITUDE

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Abstract

We found that a mountain appears taller when observed from a position that is higher than the mountain's height. Observers were first asked to look at photographs of mountains taken from various heights. They are then made to compare each of the photographs (standard stimuli) with the comparison stimuli, which comprised of images that had been digitally expanded or reduced in height as compared to the original photograph taken from a certain height. Subsequently, the observers selected one of the comparison stimuli where the height of the mountain in the standard stimulus appeared to be the same as that of the processed image. The results indicated that mountains appeared the tallest when they were observed from a height that was 1.4 to 1.7 times higher than their altitudes.

Although there are many studies on the perception of height, few studies have investigated how the perceived height of objects varies depending on the viewing height. In Bingham (1993), the participants were presented with photographs of trees, which measured 3 m to 27 m in height and which were taken from various heights. The participants were required to estimate the height of the trees. The results revealed that the perceived height of the trees was 2.7 m lower when viewed from a height of 4 m than when viewed from a height of 1.7 m. Can such an effect of viewing height on the perceived height of objects be observed even when the objects or other conditions of observation are different? Many a times, the impression of the same mountain in different photographs varies. Further, the perceived height of the mountain varies depending on the conditions surrounding the taking of the photographs, such as the position from which the photograph was taken, the direction from which sunlight fell on the mountain, and whether the mountain was covered with snow. Why do these factors affect the perceived height of the mountain? This study investigates the effect of viewing height on the perceived height of mountains by using images of mountains constructed using computer graphics.

In addition to the observation height, the 3D shape of the mountains was another factor manipulated in this study. Depth perception cues are crucial for the perception of 3D shape from a 2D display of objects. To investigate this point, we used two types of mountains (the mountains differed in terms of their shape). One was a cone-shaped mountain; the other, a barrel-shaped one. The cone-shaped mountain was almost the shape of a mathematical cone, while the barrel-shaped mountain resembled a laid barrel split into two. With respect to depth perception, the cone-shaped mountain sloped uniformly in all directions such that the observer could estimate, fairly precisely, the depth as well as the 3D shape of the mountain, from the ridgeline of its side. On the other hand, in the barrel-shaped mountain, the ridgeline was a poor indicator of the 3D shape of the mountain. We predicted that this difference in the ability to estimate the 3D shape would influence the perceived height of mountains in 2D images.