Effect of Region Information on Perception of Partially Occluded Figures

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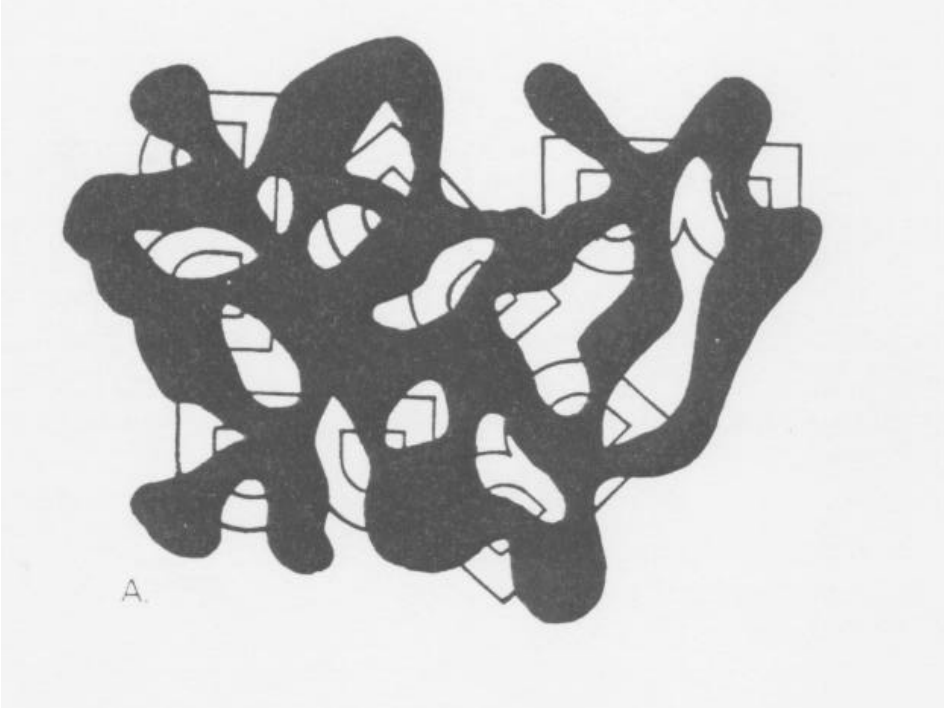
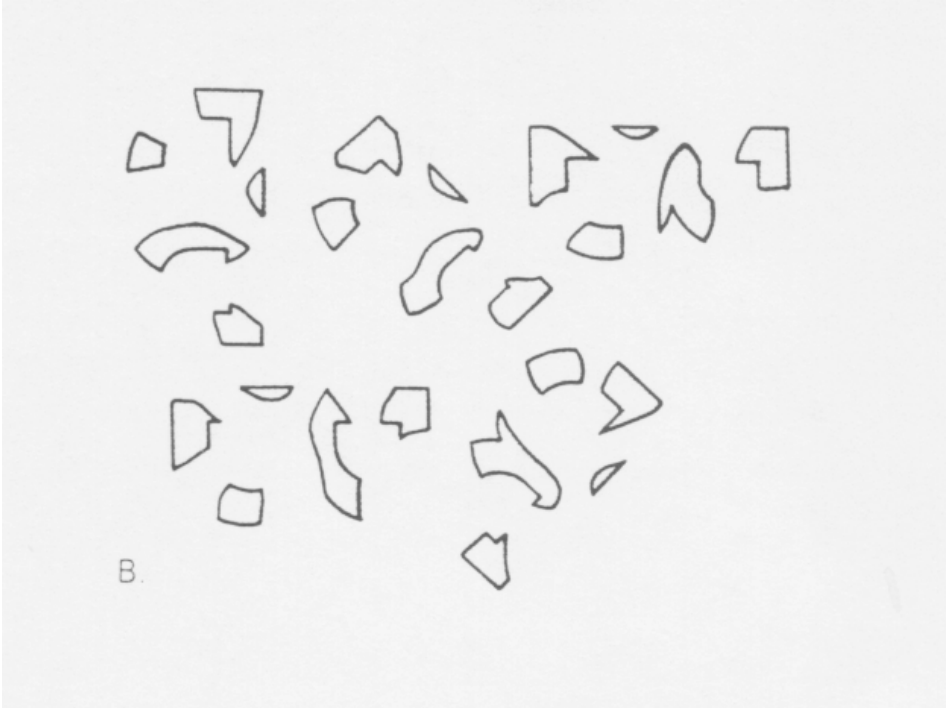
Prior theories of the perception of partially occluded figures have tended to be contour-based. For example:

Here, it is clear which contours belong to the Bs and which do not.

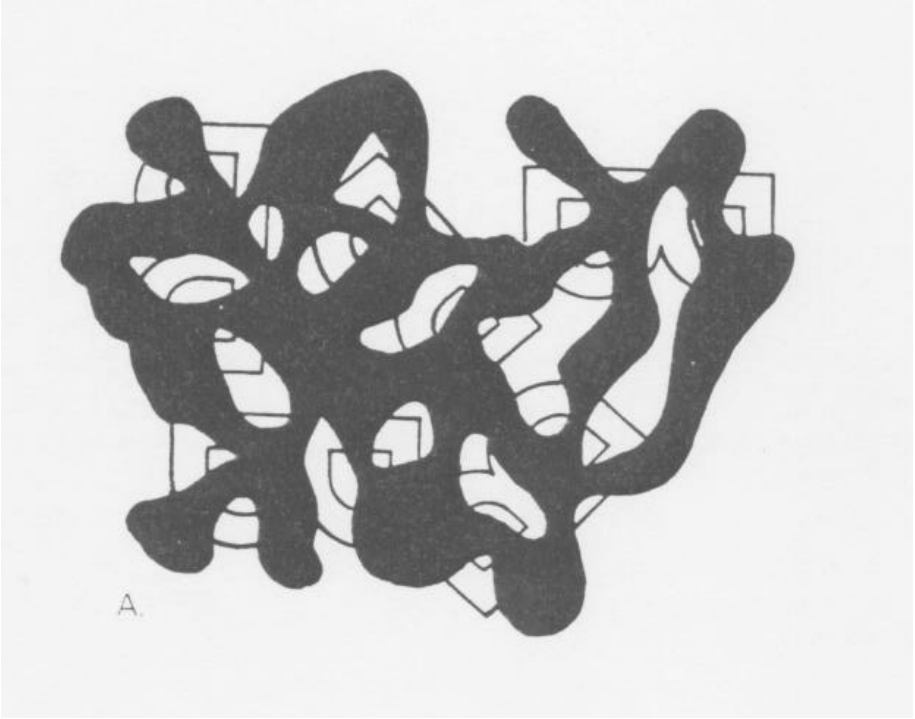
Here, contours not belonging to the Bs seem to prevent us from perceiving the Bs.

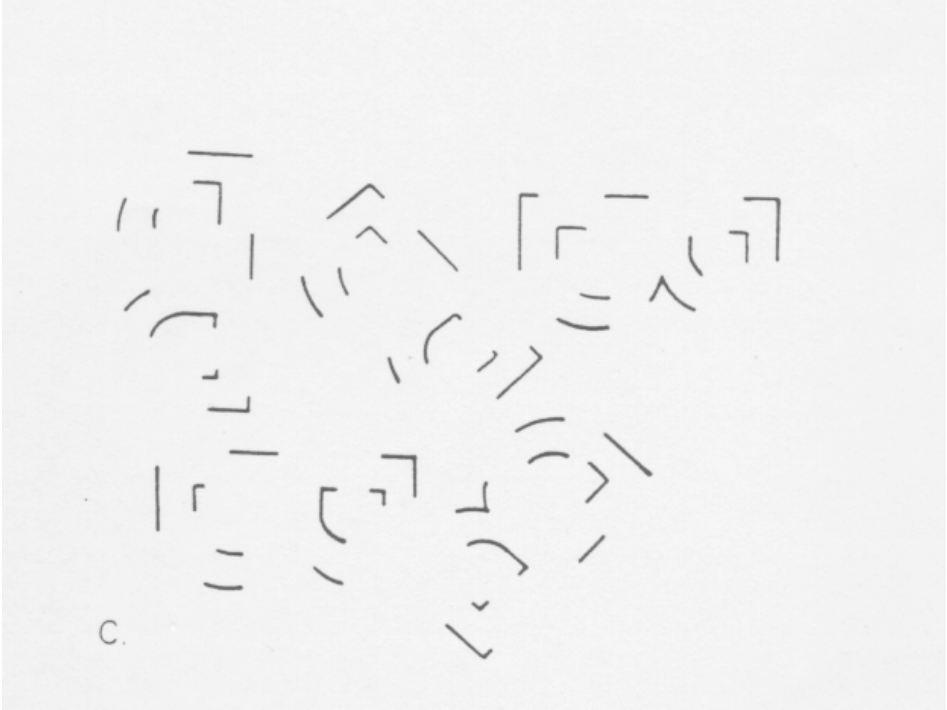




(after Bregman, 1981)

T-junctions can be used to identify and remove the contours belonging to the black occluder. Image segmentation then becomes almost trivial (e.g., see Nakayama, Shimojo, & Silverman, 1989).





(right: after Brown & Koch, 1993)

However, the images below demonstrate that depth cues may <u>not</u> be necessary in disregarding contours "extrinsic" to a figure of interest…

(from Street, 1931)

How do fragments fit together?

Which fragments belong to the figure?

How do fragments fit together?

Using stimuli similar to the Dalmatian, Scheessele & Pizlo (VSS, 2002) showed that other properties of contours – such as orientation, length, and curvature – may be used to classify contours as "intrinsic" or "extrinsic" to a figure.

Contour information appears to be a primary factor in the perception of "partially visible" figures.

But… is it the only factor?

What role, if any, does region information play in the perception of partially visible figures?

We tested this in a series of experiments.

EXPERIMENT 1

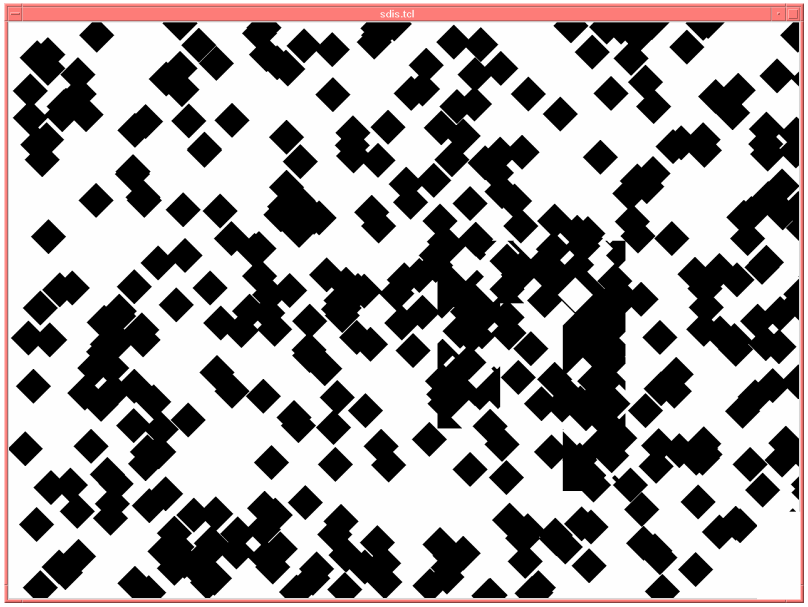
region present vs. region absent (contour-only)

Stimuli

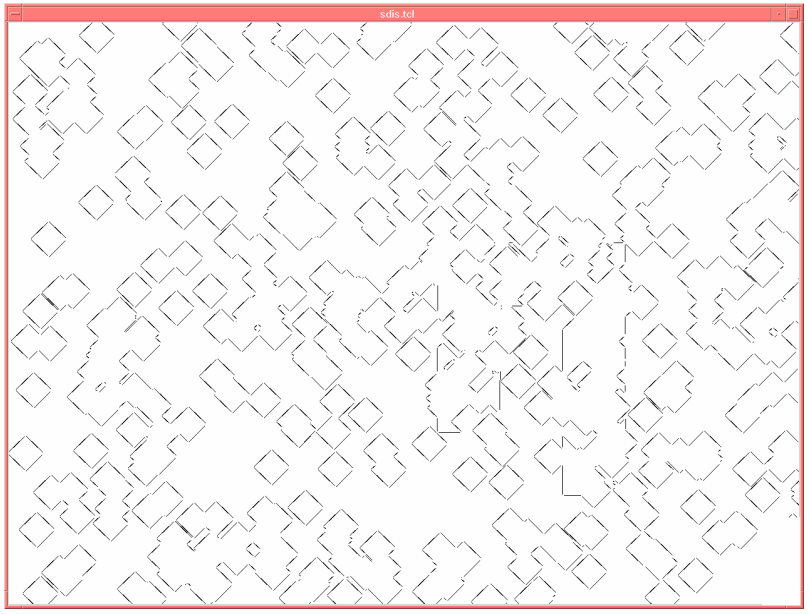
In the lab, you want the ability to generate hundreds of random stimuli for which all aspects are under the experimenter's control. So, instead of Dalmatians, we used geometrical target figures…

In each stimulus, one of these targets was presented either in its 'normal' orientation (as shown above) or rotated by 180^{o}. An equal number of white and black diamonds were randomly placed in the image, with some occluding the target figure. In Experiment 1, there were 2 factors manipulated: region (present vs. absent) and diamond distractor size (small vs. large). Thus, there were four experimental conditions.

Stimuli in the region absent (contour-only) conditions were identical to those in the corresponding region present conditions, except that region information was removed using Sobel edge detection. An example stimulus from each condition is presented below.

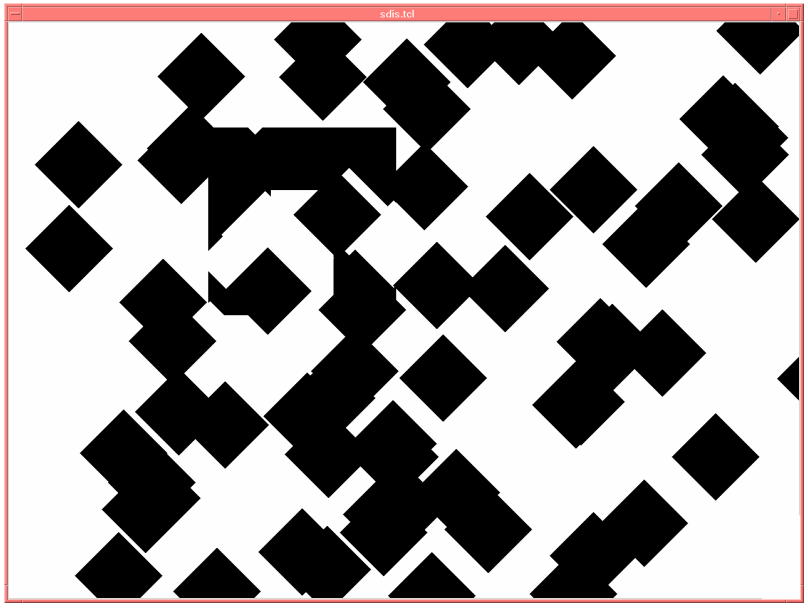


region present/small diamonds

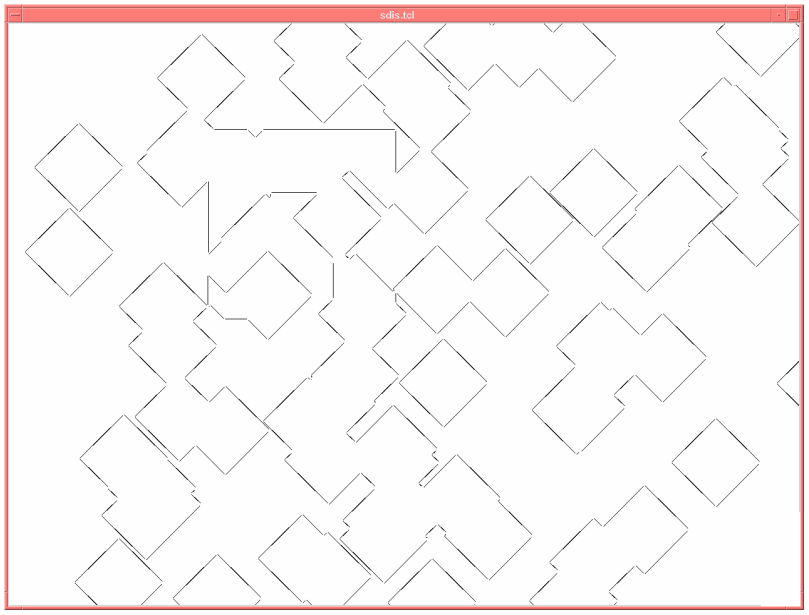


region absent/small diamonds

region present/large diamonds



region absent/large diamonds



Procedure

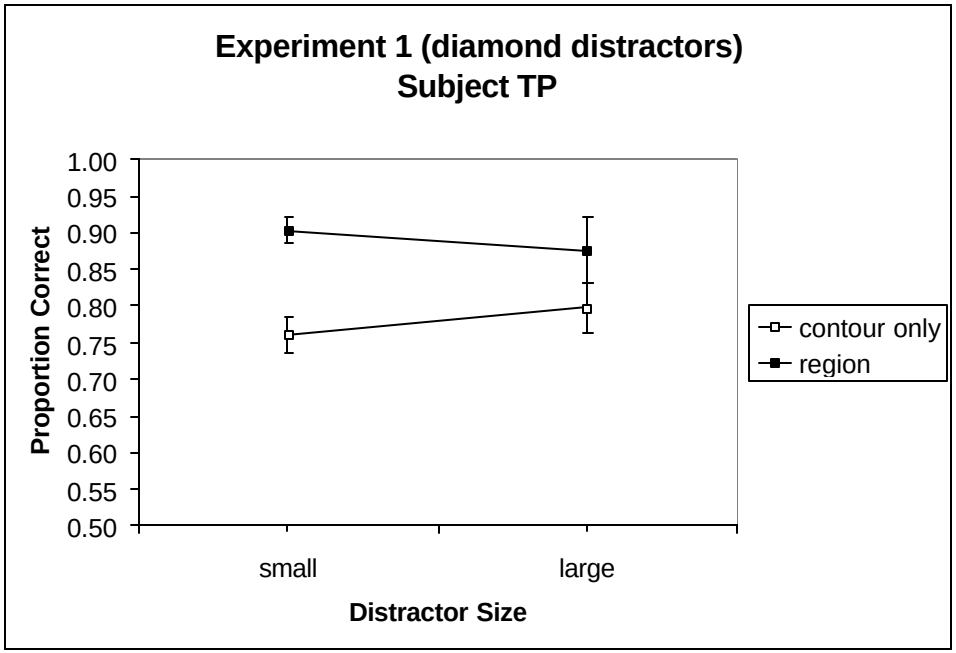
- Each experimental condition contained 500 trials. Across experimental conditions, the only things that varied were whether or not region information was present and the size (small or large) of the diamond distractors used. Order of experimental conditions was random and different for different subjects.

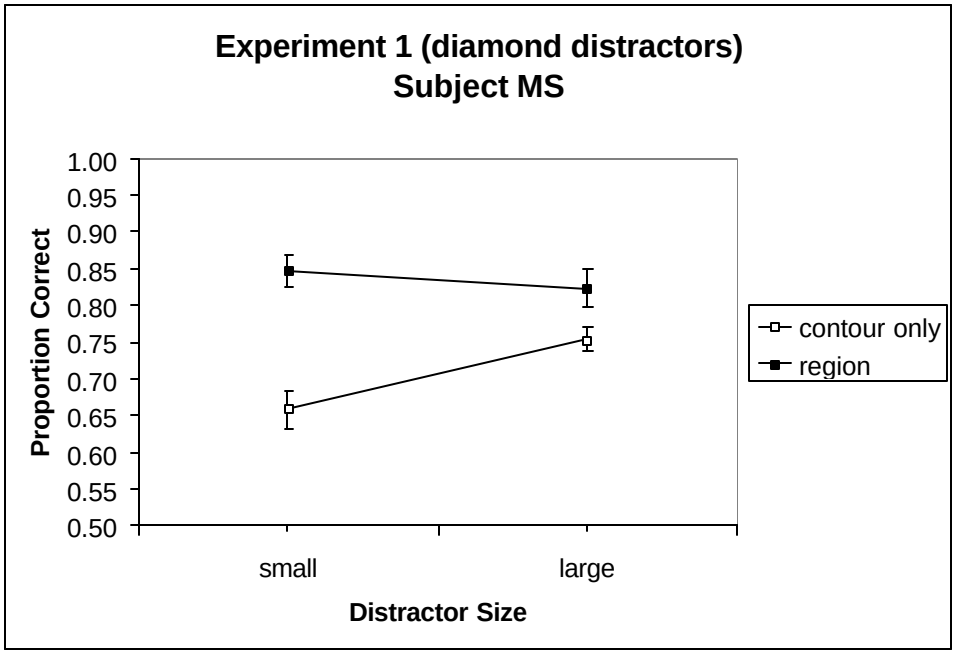
- On each trial, a subject was shown a stimulus (like one of the stimuli above). A stimulus was flashed on the monitor for 100 ms.

- On each trial, a subject's task was to respond whether the target figure appeared in its normal orientation or in the 180^{o}-rotated orientation.

- **Location of the target figure in a stimulus varied randomly from trial to trial.**

Results





Discussion

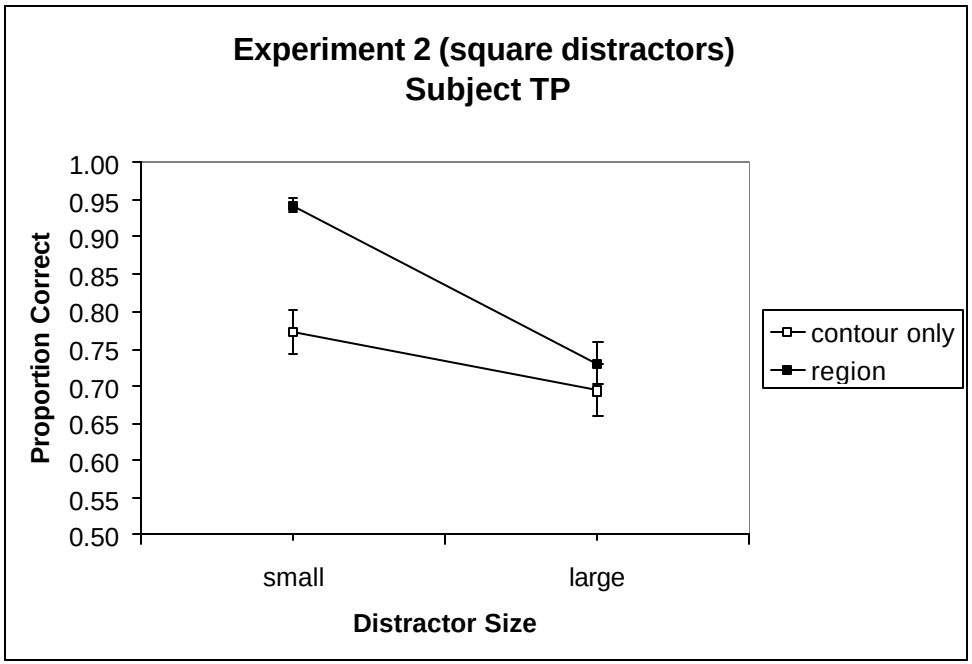
- Performance in the region conditions was clearly better than that in the contour-only conditions.
- It might be argued, however, that using white diamond distractors with white background and a black target figure creates illusory white diamonds that would have appeared ‘in front of’ the black target figure. If this was the case, we would not be able to claim an effect of region information.
- Therefore, we ran Experiment 2, using square distractors rather than diamond distractors. Since target figures have only horizontal and vertical contours, we expected that white square distractors would be less likely perceived as illusory white squares.

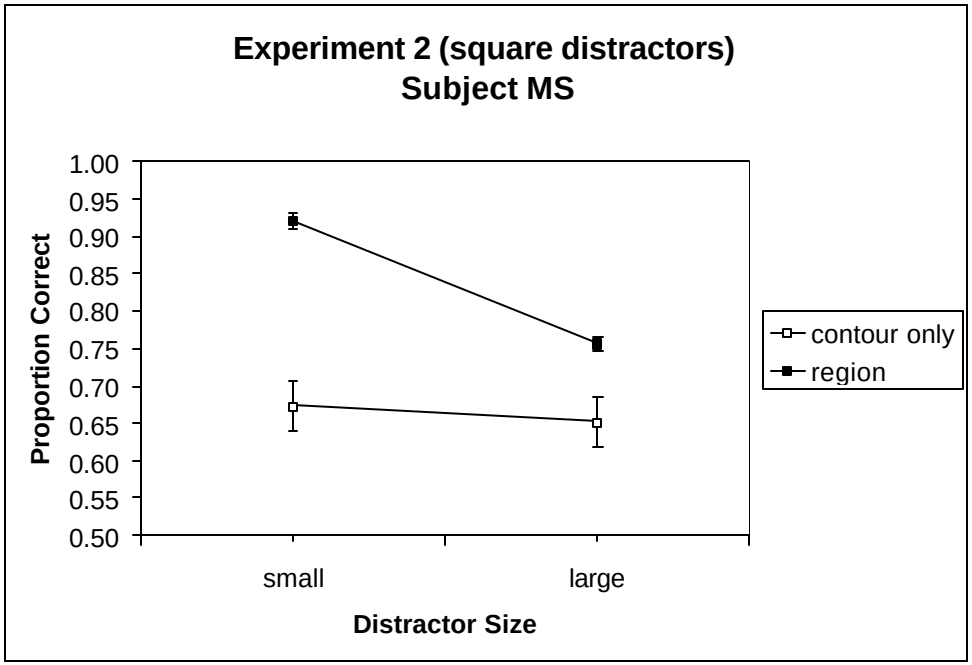
EXPERIMENT 2

region present vs. region absent (contour-only) square distractors

Experiment 2 was identical to Experiment 1, except that in all four conditions of Experiment 2 **square** distractors were used rather than **diamond** distractors.

Results





Discussion

- Performance was clearly better when region information was present than when it was absent (e.g., contour-only conditions).
- Because square distractors were used, results were likely due to the region information itself and not due to depth information derived from illusory shapes that may have appeared ‘in front of’ the target figure in a stimulus.

What is it about region information that facilitates perception of partially visible figures?

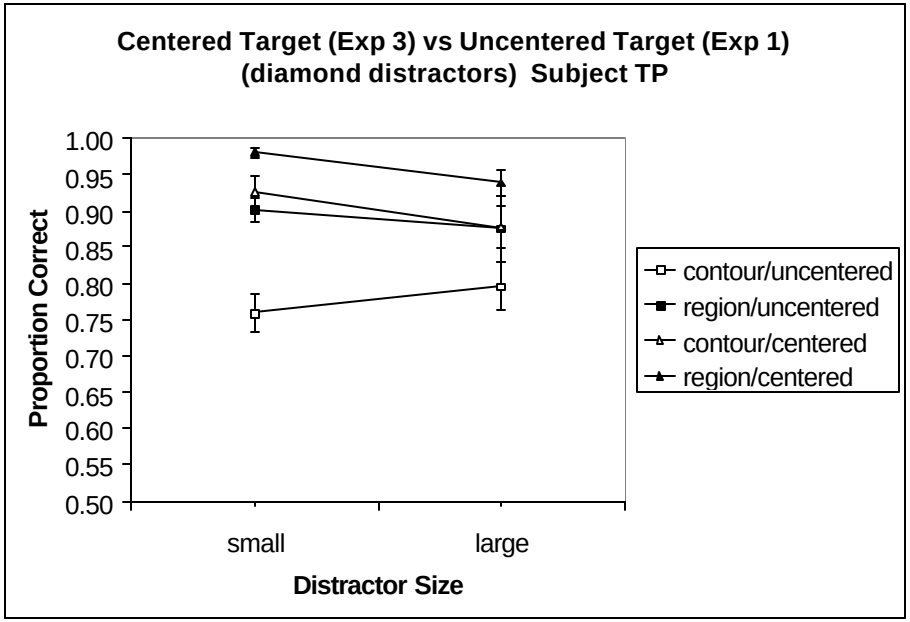
- First, note that in Experiments 1-2, a target figure was randomly placed in the stimulus image from trial to trial.
- In the ‘region present’ conditions, it is likely that, on average, the concentration of black was higher in that part of the stimulus image where the target figure was located.
- Though subject eye movements were precluded, due to 100ms stimulus display duration, it is plausible that a subject’s **attention** was drawn to the target figure by the higher concentration of black at the location of the target figure. This ‘drawing of attention’, if real, would not have occurred in the contour-only conditions, where black region information was absent.
- To test this possibility, we performed **Experiment 3**.

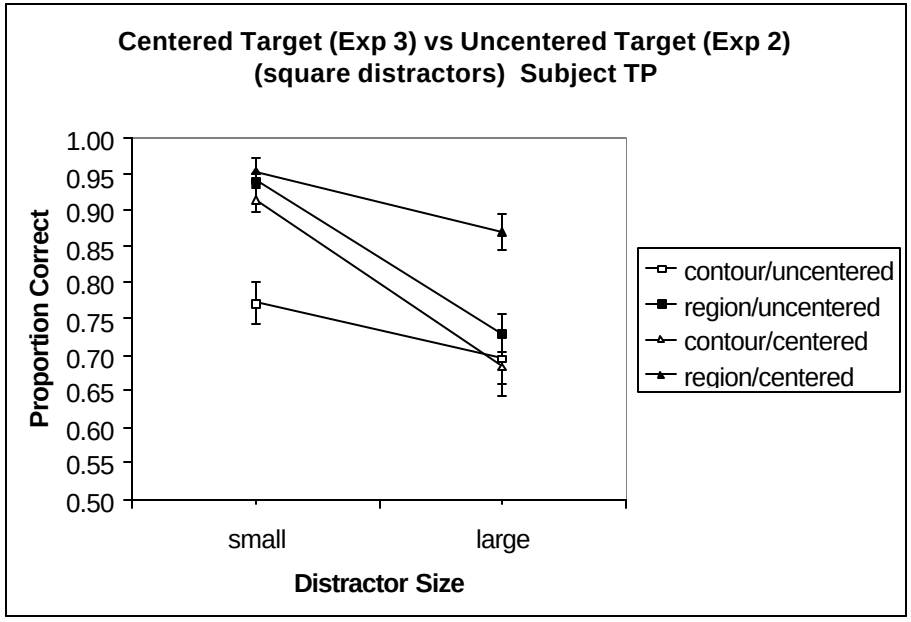
EXPERIMENT 3

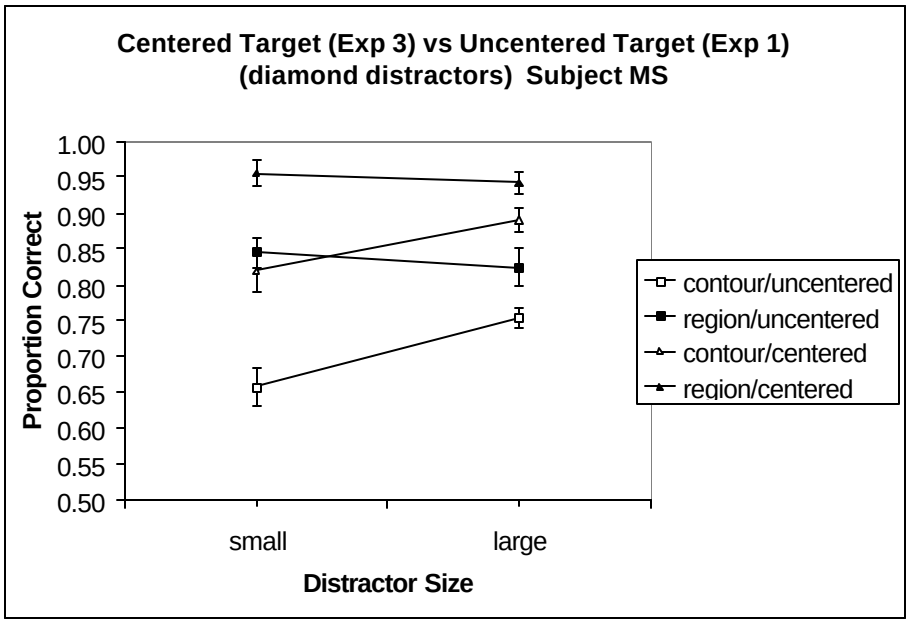
Centering the target figure in the image.

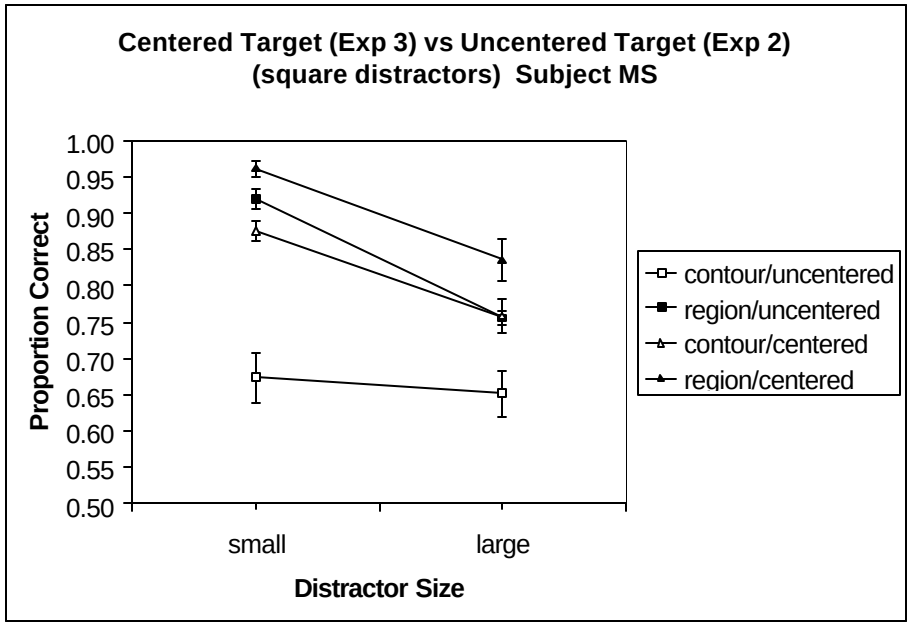
- The four conditions of Experiment 1 and the four conditions of Experiment 2 were replicated here, but in all eight conditions of Experiment 3, the target figure always appeared at the center of a stimulus image. All other details of Experiment 3 were the same as for Experiments 1-2.
- By centering the target figure, we expected performance to improve in all eight conditions.
- If the 'region present' conditions had some sort of 'attentional advantage' in Experiments 1-2, this advantage should be eliminated by centering all targets in Experiment 3. This would mean that improvements in performance in Experiment 3, should be greater in the 'region absent' (contour-only) conditions than in the 'region present' conditions.
- If the 'region present' conditions did not have an 'attentional advantage' in Experiments 1-2, we expected equal improvement in performance in Experiment 3 for corresponding 'region absent' and 'region present' conditions.

Results


Centered Target (Exp 3) vs Uncentered Target (Exp 1)
(diamond distractors) Subject TP
Proportion Correct
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
small
large
Distractor Size
contour/uncentered
region/uncentered
contour/centered
region/centered


Centered Target (Exp 3) vs Uncentered Target (Exp 2)
(square distractors) Subject TP
Proportion Correct
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
small
large
Distractor Size
contour/uncentered
region/uncentered
contour/centered
region/centered


Centered Target (Exp 3) vs Uncentered Target (Exp 1)
(diamond distractors) Subject MS
Proportion Correct
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
small
large
Distractor Size
contour/uncentered
region/uncentered
contour/centered
region/centered


Centered Target (Exp 3) vs Uncentered Target (Exp 2)
(square distractors) Subject MS
Proportion Correct
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
small
large
Distractor Size
contour/uncentered
region/uncentered
contour/centered
region/centered

Discussion

- Performance tended to be more improved in the ‘region absent’ (contour-only) conditions than in the ‘region present’ conditions.
- This suggests that the effect of region information found in Experiments 1 and 2 may, in part, be due to an attentional advantage provided by the region information of a target figure.
- That is, the region information in a figure may draw an observer’s attention to that figure, when the figure’s location is not known in advance.

Conclusions

- **While contour information may play a primary role in the perception of partially visible figures, region information also facilitates such perception.**
- **One role of region information may be to draw an observer's attention to a figure of possible interest.**

Future work: Run computer simulations to determine whether region information is always used by an observer or is used only when an image is ambiguous.