The effects of relative size of inducers and of viewing distance on perception of anomalous surface

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In the present study, the effects of relative size of inducers and of the visual angle on the perception of anomalous surfaces were investigated under the conditions in which the size of inducers, the separation between inducers, and the viewing distance were varied. It was found that the viewing distance (and thus the retinal size of the patterns) did not affect significantly the clarity of the anomalous surfaces. Interestingly, the clarity of anomalous squares was increased by increasing the proportion of the size of inducers to their separation. This suggests that the Gestalt factor of closure plays an important role in the occurrence of anomalous surfaces.

Key words: anomalous surfaces, visual angle, factor of closure.

Under a certain configurational condition, we see a form even when there is no physical discontinuity: This form is called anomalous surface. This phenomenon was first mentioned by Schumann (1900), but it was not studied systematically for a long time. Kanizsa's (1955) article is the first to state its importance in the field of perceptual organization with compelling illustrations and has stimulated succeeding investigations on the form of anomalous surface which bears his name. Kanizsa describes distinct characteristics of anomalous surface; change in brightness and/or mode-of-appearance, change in depth, possession of margin and acquirement of modal character. Most importantly, he points out a condition of the occurrence of anomalous surface: When we see it, we also find amodal completion of some pattern elements. However, the phenomenon has not been examined quantitatively by Kanizsa himself.

It has been demonstrated that anomalous surface is clearer and gets more stratified in depth as the size of the stimulus pattern is decreased (Dumais & Bradley, 1976; Bradley & Dumais, 1984). In these studies, combinations of the pattern size and the viewing distance were changed so that some patterns could have the same visual angle.

In the preliminary experiment, we found that when the size of pacman-like inducers was constant, anomalous surface was less clear if the interval between inducers was increased. This finding seems to be consistent with that of the previous studies mentioned above. These investigators considered the visual angle of the stimulus pattern as an important factor of the perception of anomalous surface. However, some spatial factor may have influenced the results. If the size of inducers is constant, the proportion of inducer's radius to their separation naturally changes when the separation changes. This suggests that the proportion of inducers would affect the perception of anomalous surface. It is necessary to confirm the influence of the visual angle on anomalous surface when the relative size of inducers changes. The present study, therefore, was designed to examine the effect of the visual angle of patterns under the condition where the pattern size and the viewing distance, and the relative size of inducers were systematically varied.

1 The author is grateful to the late Professor Kanizsa for reading an earlier draft of this paper. I would like to express my deepest grief for his sudden death.
Method

Materials

A black-on-white Kanizsa's square composed of four pacman-shaped inducers was used as anomalous surface stimulus (Figure 1). Spatial interval between inducers, that is, inducer separation ("a" in Figure 1), was changed in two steps, 3 cm and 6 cm. In each case, the inducer radius ("b" in Figure 1) was changed in three steps to make three different proportions of inducer size to inducer separation: 25%, 50%, and 70% (Table 1). The viewing distance was also varied in three steps: 57 cm, 115 cm, and 230 cm. Combinations of two inducer separations and three viewing distances gave four different visual angles: 0.75, 1.5, 3.0, and 6.0 degrees (Table 2).

Procedure

Observers looked a pattern displayed on a CRT (PC-KD854) with the right eye. They were asked to rate the clarity of anomalous square with a 7-point scale ranging from 6, "the square appeared clearer and distinct" to 0, "no square". Each pattern was presented randomly four times at each viewing distance. Before the rating, observers looked all the patterns to make a reference point of rating.

Observers

Nine undergraduates and three staff members of department of psychology participated in this experiment. All of them had normal or corrected-to-normal vision and had experienced anomalous surface phenomenon.

Results and Discussion

As clearly shown in Figure 2, the visual angle of stimulus patterns had no influence on the clarity or perceived strength of anomalous square. The appearance of anomalous surface remained unchanged despite the change in the viewing distance. This is an interesting character of this phenomenon: Like real objects, anomalous surface has a tendency towards perceptual constancy. This result is contradictory to Dumais and Bradley (1976)'s. It is probable that in their visual condition there were few cues that help the constancy.

On the other hand, the clarity of anomalous square was greatly influenced by the

![Figure 1](image.png)

Figure 1. An example of the patterns used in the present study. "a" is the separation between inducers and "b" is the radius, so that the proportion of inducers is represented as "b/a".

<table>
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<tr>
<th>Table 1</th>
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<tr>
<td>Proportions of inducer size to their separation (%)</td>
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<tr>
<td>Inducer size (radius) (cm)</td>
</tr>
<tr>
<td>0.8</td>
</tr>
<tr>
<td>Inducer separation (cm)</td>
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<tr>
<td>3</td>
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<th>Table 2</th>
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<tr>
<td>Visual angle of inducer separation (degree)</td>
</tr>
<tr>
<td>Viewing distance (cm)</td>
</tr>
<tr>
<td>57</td>
</tr>
<tr>
<td>Inducer separation (cm)</td>
</tr>
<tr>
<td>3</td>
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proportion of inducer radius to separation between inducers. This relative size effect was seen in the previous studies (Banton & Levi, 1992; Watanabe & Oyama, 1988). The clarity of anomalous square increased with increasing proportion of inducer size to their separation. This result suggests the importance of the factor of "closure" in organizing anomalous surface. If some area is surrounded by other areas, it is easy to be perceived as figure. This is called the Gestalt factor of closure. It seems that anomalous square corresponds with "figure" and is segregated from "ground". If the proportion of inducer size to their separation increases, the degree of closure of the central area surrounded by inducers increases and hence the area would be perceived easily as anomalous square.

How the factor of closure works can be demonstrated in patterns like Figure 3: the left is Kennedy (1979)'s pattern and the right is Parks and Marks (1983)'s. On the other hand, these patterns were often used to oppose the theory of amodal completion for explaining anomalous surface. Amodal completion is, however, not a concept, but a phenomenon that appears in the same pattern as anomalous surface (Kiritani, 1992). In these patterns like Figure 3, if the factor of closure works, then the central area might be cut off and is perceived as a "figure" easily. Although we could see Kanizsa's pattern in the same way, the factor of closure, by itself, might not organize anomalous surface: In order to see anomalous surface, in this pattern, the edges of inducers must be perceptually belonging to anomalous contours, not of inducers themselves ("one-sidedness" of contours). In Figure 4 which consists of fine four edges, we cannot "see" a square, but we can "imagine" it. If amodal completion occurs, we see that inducers lose their inner boundary and continue behind the central area which in turn could get its own boundary shaping anomalous surface.

Most investigators tended to consider that amodal completion necessarily precedes

![Figure 2](image1.png)

**Figure 2.** Clarity judgements as a function of visual angle for six patterns. The parameters represent the patterns: the former figure (3 cm, for example) is the size of inducers and the percentage is the proportion (50%, for example) is the proportion of inducer's radius to their separation.

![Figure 3](image2.png)

**Figure 3.** Patterns used in Kennedy (1979) (a) and Parks and Marks (1983) (b).

![Figure 4](image3.png)

**Figure 4.** In this pattern, we can imagine a square. Anomalous square, however, does not appear.
anomalous surface. This cause-effect notion is not proper. Michotte, Thiès and Crabbé (1964) defined amodal completion as follows: "When part of a visually perceived object is hidden by another object, the perceptual structure of the former can, in certain conditions, still be complete ...(p. 49)". Then, in Kanizsa’s pattern, if amodal completion of inducers occurs, they should be seen as partially occluded by something: They need a “cover”. In this case, it is anomalous surface that plays the role of the cover. Thus anomalous surface must precede amodal completion. This is a contradiction. We should not consider that two phenomena are in time-order. Rather, they are independent from cause-effect problem. The conditions that organize each phenomenon may work cooperatively. It seems that the factor of closure is one of the most relevant conditions for the occurrence of anomalous surface.

Conclusion

In the present study, the visual angle of stimulus pattern had no effect, but a new character of the phenomenon was revealed: Anomalous surface keeps its appearance constantly despite the change in viewing distance. On the other hand, the relative size of inducers on anomalous surface was most effective. Anomalous surface was clearer with increasing proportion of inducer’s radius to separation between inducers. Thus the factor of closure takes one of the most important roles in generating anomalous surface.

References


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