Illusory Figures are Induced by Perceptually Complete Figures

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We found that the illusory figure is perceived with the perceptually complete inducing figure but that it is rather weaker than the one with the perceptually incomplete inducing figure. The decrease of perceptual strength with the complete inducing figures was the largest for the depth stratification and was the second largest for the brightness enhancement, and was the smallest for the illusory contour compared with the one with the incomplete inducing figures. This suggests that the illusory figure with the complete figure makes quite different visual impression from that with the incomplete figure to keep the observers familiar with the illusory figure with the incomplete figure from perceiving the illusory figure with the complete figure because of their robust set.

Key words: brightness enhancement, depth stratification, illusory contour, illusory figures, incompleteness.

Introduction

Since the demonstration presented by Kanizsa (1979), it seems to have been widely accepted that the perceptual incompleteness of the elements of the inducing figure is necessary for perception of the illusory figure. It should be noticed, however, that Kanizsa (1979) himself did not present the quantitative data on the perception of illusory figure with a complete figure.

Day and Kasperczyk (1983) showed that the illusory contour is perceived in the area cornered with four complete crosses with 24 naïve observers. Perceptual strength of the illusory contour with the inducing figure consisting of complete elements was above the half of the one with the inducing figure consisting of incomplete elements (notched disks).

With four observers familiar with illusory figure and trained in tachistoscopic observation, Takahashi (1993) reported that brief presentation of the four complete crosses induced the illusory contour in the area cornered with them. Longer presentation reduced the perceptual strength of the illusory contour to zero. The perception of the illusory contour was best at about 30-40 ms in duration and was about 20-30 % in perceptual strength of the one with the inducing figure consisting of four notched disks steadily presented. These facts cast doubt on the claim that the perceptual completion of the incomplete inducing figure is essential for the perception of illusory figure.

Day and Kasperczyk's (1983) observers were naïve to the experiment of illusory figure

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perception and were clearly, though rather weakly, perceived the illusory contour in the area cornered with four complete elements. However, it is not clear from the data of Day and Kasperczyk (1983) whether the illusory figure with the complete inducing figure was qualitatively the same as the one with the incomplete inducing figure.

Failure of perception of the illusory figure with the complete figure by experienced observers might be due to the difference in nature of the induced illusory figure between the complete figure and the incomplete one. If the complete figure induces the illusory figure largely different in quality from the illusory figure induced by the incomplete figure, observers familiar with the illusory figure with the incomplete figure as the Kanizsa illusion might be difficult to perceive the illusory figure with the complete figure because of their robust set to the perception of the illusory figure with the incomplete figure.

In the present study, we investigated the difference in the perception of the illusory figure between the incomplete inducing figure and the complete one for naïve observers. The perceptual strength of the attributes of the illusory figure with the incomplete and complete inducing figures was measured. The illusory figure is known to have three perceptual attributes, that is, illusory contour, brightness enhancement, and depth stratification (Kanizsa, 1979; Lesher, 1995). If the ratio of the strength among the attributes of the illusory figure is largely different between the two types of inducing figures, the illusory figure will give the visual impression quite different in quality between the two types of inducing figures.

Method

Observers

Three hundred and fourteen undergraduates participated in the experiment. None of them had participated in the experiments on the perception of illusory figure and were aware of the purpose of the experiment. All had normal or corrected-to-normal visual acuity.

Apparatus and stimuli

The stimulus figures were shown in Figure 1. Figures 1a and 1c were the same as Kanizsa's (1979) Figures 12.5 and 12.1a, respectively. Both of them consisted of incomplete inducing elements.

In Figure 1a the horizontal, the vertical, and the oblique sides of notched octagon were 1.0cm, 1.1cm, and 1.3cm, respectively. The length of the additional line between the notched octagons was 0.7cm. In Figure 1c the diameter of the notched disk and the length of a line in the additional V-shaped figure were 1.0 cm and 2.0 cm, respectively.

Figures 1b and 1d were the same as Kanizsa's (1979) Figures 12.6 and 12.7, respectively. Both of them consisted of complete inducing elements. In Figure 1b, the length and width of the bar of the cross were 2.8 cm and 1.0 cm, respectively. The length of the mid-line of the additional diamond was 1.0 cm. In Figure 1d, the side of the triangle was 1.1 cm.

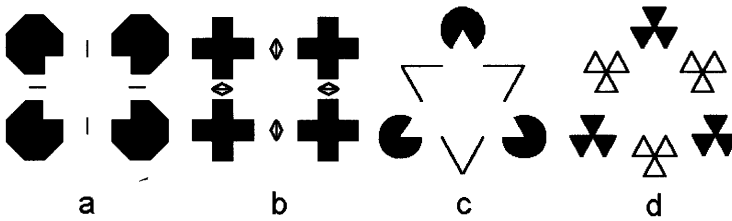In Figures 1a and 1b, the square area cornered with the inducing elements was 4.0 cm × 2.9 cm.

Figure 1. Stimuli presented in the experiment. Figures 1a, 1b, 1c, and 1d were the same as Kanizsa's (1979) Figures 12.5, 12.6, 12.1a, and 12.7, respectively.

In Figures 1c and 1d, the side of the triangular area cornered with the inducing elements was 5.8 cm.

The stimulus figures were drawn with black ink on the white paper. The luminance of the stimulus figure and its surround was 8.3 cd/m^2 and 86.5cd/m^2, respectively.

Procedure

The observers sat at a table and viewed stimulus binocularly at a distance of about 50 cm. Their head and eye movements were not restricted.

The task of the observer was to rate the perceptual strength of the attributes and the total strength (Takahashi, 1990) of the illusory figures with the complete inducing figures (Figures 1b and 1d) with respect to the illusory figures with the incomplete inducing figures (Figures 1a and 1c). The contour clarity, the apparent brightness, and the apparent depth were the measurements of the illusory contour, the brightness enhancement, and the depth stratification, respectively.

Rating with Figure 1b was made with Figure 1a as reference. Rating with Figure 1d was made with Figure 1c as reference. Ratings with Figures 1b and 1d were made in random order among the observers. Perceptual strength of each attribute and the total strength of the illusory figure for the reference were called 100. The observers were asked to report the magnitude of perception of each attribute and the total strength of the illusion by assigning a number to the stimulus relative to that for the reference.

The observer rated the perceptual strength of each attribute and the total strength of illusory figure only once for each inducing figure. Ratings for three attributes were successively made with each inducing figure but made in random order among the observers. Ratings of the total strength of the illusory figure were made after the tests of separate attributes.

Additional experiment

In order to test the reliability, or stability, of rating an additional experiment was done about 90 days after the main experiment mentioned above. Fifty-one observers participated in the main experiment were asked to do the same task as the main experiment again except the rating of the total strength of the illusory figure.

Results

Table 1 shows mean ratings of magnitude of the three attributes and of the total strength of the illusory figure with two types of complete inducing figures. Perceptual strength of the illusion with the complete inducing figures was less than half of the one with the incomplete inducing figures, which was called 100, for all the attributes. One-way ANOVAs revealed that there were significant effects of attribute, $F(2,626) = 123.59$, $p < .01$ for Figure 1b, and $F(2,626) = 93.96$, $p < .01$ for Figure 1d, respectively. Multiple comparisons using Fisher's LSD test revealed that there were significant differences between all the attributes. This means that the decrease of illusion with the complete inducing figures compared with the one with the incomplete inducing figures was the largest for depth stratification, and was the smallest for illusory contour.

The total strength of the illusory figure with the complete inducing figures was about one-third of the one with the incomplete inducing figures.

Table 2 shows the result of the additional experiment. Two-way ANOVAs revealed that there were significant main effects of attribute, $F(2,100) = 50.17$, $p < .01$ for Figure 1b, and $F(2,100) = 43.94$, $p < .01$ for Figure 1d, respectively. Main effects of order of measurement and interactions between order of measurement and attribute were not significant. This result shows the high reliability of the rating by our observers.

Table 1   Mean ratings of magnitude of three attributes and of total strength of the illusory figure with two types of complete inducing figures. Rating was made with the reference, the strength of the illusory figure with the incomplete inducing figures, called 100

	Contour Clarity	Apparent Brightness	Apparent Depth	Total Strength
Figure 1b	45.07	29.06	19.45	33.86
Figure 1d	41.80	29.54	18.92	34.14

Table 2   Mean ratings of magnitude of three attributes made twice with an interval of about 90 days

		First Measurement	Second Measurement
Figure 1b	Contour Clarity	40.69	41.39
	Apparent Brightness	24.90	26.76
	Apparent Depth	8.04	14.02
Figure 1d	Contour Clarity	39.02	33.59
	Apparent Brightness	21.18	25.10
	Apparent Depth	13.24	13.53

Discussion

In the present experiment, the illusory figure was perceived with the complete inducing figures though it was far weaker than the one with the incomplete inducing figures. This supports Day and Kasperczyk's (1983) result.

Albert (1993) pointed out that there is nearby edges parallel to the supporting edge in some complete inducing elements, which prevents observers from perceiving illusory contour. With removing the parallelism of the edge from the inducing elements, Albert demonstrated that the illusory contour is easily perceived with the complete figure. Albert's demonstration and our findings strongly suggest that the collinearity of the physically present edges between inducing elements (Rock & Anson, 1979) is more critical for perception of the illusory figure of Kanizsa type than the incompleteness of the inducing element.

The depth stratification was the largest and the brightness enhancement was the second largest, and the illusory contour was the smallest in decrease of perceptual strength in illusion with the complete inducing figures. This suggests that the illusory figure with the complete inducing figure may be different in quality to give the observer quite different visual impression from the one with the incomplete inducing figure. Perception of the illusory figure as a whole as well as perception of each of its separate attributes induced by the incomplete figure might be strongly influenced by the ratio of the perceptual strength among the attributes of the illusory figure. If so, the observers familiar with the illusory figure as the Kanizsa illusion induced by the incomplete figure may be difficult to perceive the illusory figure with complete inducing figures due to the robust set to the perception of such the illusion established by the repetitive observation of the incomplete inducing figures in the past.

In order for the difference of illusory figure between the incomplete inducing figure and the complete inducing figure to be made clearer, not only the quantitative research but also the qualitative research is necessary. In the qualitative research, the observers will be required to make careful observation of the stimulus to express in words or to sketch pictorially how it looks in detail. Our report on such the qualitative research on the illusory figure will appear soon.

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