BRIEF REPORTS

A note on the influence of grouping on illusory contours

STEFANO VEZZANI

Università di Padova, Padua, Italy

It is well known that dots superimposed on the Koffka cross change the shape of the illusory surface. It has been claimed, but never proved, that this effect is due to the shape of the virtual figure in which the dots organize. In this note it is proved that the shape of the virtual figure is indeed the crucial factor. In fact, the shape of the illusory surface changes if the way in which the dots organize is altered by adding other dots; if, then, the former organization is restored by adding further dots, the illusory shape is restored too, at least to a large extent.

In the so-called *Koffka cross*, an illusory central figure is seen whose shape depends on the width of the inducing rectangles (Sambin, 1974). An instance of the Koffka cross is depicted in Figure 1a: in this case, a disk is usually perceived.

In Figure 1b, four dots are added to the configuration (Day & Jory, 1980; Sambin, 1974): An illusory *square* is now clearly seen, although, by themselves, the dots generate only a *virtual square* (Figure 1c). Other illusory shapes can be obtained by arranging dots in different ways.

It has been claimed that dots have such an effect because of the shape of the virtual figure in which they group (Day & Jory, 1980; Gerbino & Kanizsa, 1987; Gilam, 1987). However, it has never been excluded that the phenomenon is due, instead, to local actions of each one of the dots. In this work, I try to disprove this possibility; this is a crucial question, since in the former case the effect of dots would be a global one, whereas in the latter it would be a local one. Of course, a compromise solution is possible in which both global and local factors play a role.

In Figure 1d other dots are added to those of Figure 1b. The four central dots do not group together any longer, as shown in Figure 1e: each one of them belongs now to a small virtual square of dots. Presumably as a consequence, their influence on the illusory surface is weakened, and the percept is more ambiguous: It is still possible to see a square, but it is possible to see a *rounded square* too, or even a disk.

Figure 1f shows that if the virtual square of Figure 1c is restored (as it can be seen in Figure 1g) *by adding more dots* to the configuration, the shape of the illusory sur-

face is restored too, at least to a large extent. Therefore, although residual local influences of the dots cannot be excluded, the virtual figures must play an important role in the shaping of the illusory surfaces.

METHOD

I ran an experiment in order to provide evidence for the previous informal observations.

Subjects

Thirty-six naive observers served as subjects. All had normal or corrected-to-normal vision.

Stimuli and Procedure

The stimuli were the six possible pairings of the four illusory surfaces of Figures 1a, 1b, 1d, and 1f; the position (left/right) of the stimuli was balanced across subjects, and the order of presentation was different for every subject. Each pair of figures was drawn at the center of a 21 cm (8.022°) × 29.7 cm (11.345°) horizontal sheet of white paper, and shown frontally to the subject from a distance of 150 cm. The two figures of each pair were spaced 90 mm (3.438°) apart (center to center). All figures were drawn using 0.5-mm (0.0191°) wide black lines; dots were 1 mm (0.0382°) in diameter. Each of the four branches of the cross was 17.5 mm (0.6685°) long and 3 mm (0.1146°) wide (including the lines); the two collinear pairs of branches (and dots in Figure 1b) were 21 mm (0.8°) apart.

The sides of the four virtual squares in Figure 1d and of the eight small virtual squares in Figure 1f were 4.5 mm (0.1719°) long.

At the beginning of the experiment, Figures 1b and 1c were shown to the subjects, in order to be sure that the difference between virtual and illusory figures was clear to them. Each subject was then asked to choose, for every pair, the figure in which the illusory surface was more similar to a square; judgments of equality were not allowed.

RESULTS AND DISCUSSION

The procedure outlined in Guilford (1954) for the method of pair comparisons was applied to the data. From

Correspondence should be sent to S. Vezzani, Dipartimento di Psicologia Generale, Università di Padova, via Venezia 8, 35131 Padova, Italy (e-mail: svezvani@ux1.unipd.it).

Figure 1. (a) The Koffka cross. (b) Four dots superimposed on the Koffka cross change the shape of the illusory figure. (c) By themselves, dots generate only a *virtual* square. (d) Dots have been added to Figure 1b, and the illusory shape appears now different. (e) The dots of Figure 1c are still there, but they do not group together anymore. (f) The illusory shape of Figure 1b is substantially restored by adding further dots to Figure 1d. (g) The virtual shape of Figure 1c is substantially restored by adding further dots to Figure 1e.

the z scores derived from the proportion scores, the lowest z score was subtracted, yielding the values shown in Figure 2. However, the χ^2 test carried out on the expected and obtained proportions was significant [$\chi^2(3) = 22.19, p < .0001$], so data are reliable only at the level of ordinal scale; I carried out the two-tailed bi-

nomial test on each pair of figures, and all the comparisons were highly significant (at least at the .0005 level).

The "squareness" of the illusory figures, then, reaches its maximum in Figure 1b, and Figures 1f, 1d, and 1a follow in descending order, as expected. Not surprisingly, many subjects spontaneously reported that in Figures 1a

Figure 2. Experimental results. The "squareness" of the illusory figures reaches its maximum in Figure 1b, and Figures 1f, 1d, and 1a follow in descending order, as expected.

and 1d (especially in the former) they perceived a disk, rather than a square.

These data indicate that dots are important in shaping the illusory surfaces *because of the virtual figures in which they group*. On the other hand, since the illusory surfaces of Figures 1d and 1f are similar but not identical to those of Figures 1a and 1b, a residual local influence of each dot cannot be excluded. However, the differences between Figures 1a and 1d, and between Figures 1b and 1f, could have an alternative *global* explanation. In Figure 1d, the four central dots may preserve some tendency to group together as in Figure 1b, consequently "warping" the central illusory surface. The same argument applies to Figures 1b and 1f: Probably the virtual square of Figure 1b is not perfectly restored in Figure 1f (compare Figures 1c and 1g), so it could be argued that the illusory square is less salient in Figure 1f, compared with Figure 1b, *because the virtual square is less salient as well*. For these reasons, the present work does not permit one to tell whether the *differences* between Figures 1a and 1d, and between Figures 1b and 1f, are due to local or global factors; on the other hand, it does permit one to tell that the

observed *similarities* between the aforesaid figures are due to global factors.

Finally, it must be noted that probably the smaller the figure is, the stronger the effect of the virtual shape is: In the small figures on the abscissa axis of Figure 2, the effects of the virtual shapes appear more marked than in Figure 1.

REFERENCES

- DAY, R. H., & JORY, M. K. (1980). A note on a second stage in the formation of illusory contours. *Perception & Psychophysics*, *27*, 89-91.
- GERBINO, W., & KANIZSA, G. (1987). Can we see constructs? In S. Petry & G. E. Meyer (Eds.), *The perception of illusory contours* (pp. 246-252). New York: Springer-Verlag.
- GILLAM, B. (1987). Perceptual grouping and subjective contours. In S. Petry & G. E. Meyer (Eds.), *The perception of illusory contours* (pp. 268-273). New York: Springer-Verlag.
- GUILFORD, J. P. (1954). *Psychometric methods*. New York: McGraw-Hill.
- SAMBIN, M. (1974). Angular margins without gradient. *Italian Journal of Psychology*, *1*, 355-361.

(Manuscript received August 29, 1997;
revision accepted for publication April 28, 1998.)