Illusions of bent line¹

FRANK RESTLE²
INDIANA UNIVERSITY

A recent paper offered an explanation of the Poggendorf illusion, assuming that it results from a failure of the visual system to make a perfect resolution of acute angles. Variations of the illusion were drawn eliminating all acute angles, and the illusion was shown to remain in full strength. A variation of the figure preserving the acute angle was drawn, and the illusion was found to reverse in direction. Several theoretical interpretations are considered but none accepted, and it is concluded that the illusion remains unexplained.

A recent article in this journal (Chiang, 1968) offers a theory of certain geometrical illusions drawn with crossing lines. The burden of Chiang's paper may be divided into two statements, one of which is refuted in the present paper.

The main point of Chiang's paper is that a variety of illusions, including the Zollner, Hering, Wundt, and various versions of moiré patterns, are elaborations of the Poggendorf illusion (Fig. 1) in which the two transverse line segments are colinear, but appear misaligned. The direction of the displacement is as if both lines were bent and the point of intersection displaced as shown, in exaggerated form, in Fig. 2. In the main body of his argument, Chiang shows how several other illusions can be produced by such an effect.

The second point of Chiang's theoretical paper is an explanation of the Poggendorf illusion, based on two notions: that a stimulus line gives rise to a distribution of stimulation, and that the impression of the location of that line lies at the maximum of the distribution. At an acute angle, if the distributions overlap closely, the maximum may lie between the two lines. A schematic drawing in Fig. 3 shows how this effect may lead to the Poggendorf illusion. It is this explanation of the Poggendorf illusion that can be refuted.

Chiang's explanation is that the illusion results from a failure to obtain complete and veridical resolution of the acute angle. Figure 4 shows the full Poggendorf illusion (4A) along with a modified version (4B) in which there is no acute angle, but the illusion still appears in its full strength. Figure 4C shows what happens when the illusion is redrawn preserving

Fig. 1. The Poggendorf illusion. The transverse lines are actually colinear but appear out of line.

Fig. 2. An exaggeration of the distortion seen in the Poggendorf illusions.

the acute angle and removing the line forming the obtuse angle; the illusion is reversed.

The appearance of Fig. 4 refutes Chiang's explanation of the illusion, for it is shown (a) that the illusion appears without the acute angle, hence with no opportunity for Chiang's explanatory principle to operate, and (b) that when just the acute angle is presented without the (theoretically) extraneous extension, the illusion is reversed in direction. More detailed measurements support the conclusions from inspection of the figure.

METHOD

Subjects

A total of 15 students from introductory psychology courses, serving as part of a course requirement or for pay, were tested. All Ss judged the same stimuli.

Materials

Stimuli were 36 slides, white lines on dark background. Each slide had two 150-mm segments of a line oriented at 60 deg and separated by approximately 100 mm. These line segments were parallel but misaligned by various amounts up to about 20 mm (measured as the perpendicular distance between one segment and the extension of the other). Actual misalignments were measured at the screen.

Nine control slides were prepared, containing just the 60-deg lines misaligned from -20 mm (the upper left-hand segment being too far to the left), to +20 mm (the upper segment being too far to the right). Nine more slides had similar lines, along with vertical lines to make a Poggendorf illusion as in Fig. 4A. Nine more slides had similar lines and the modified Poggendorf illusion, with obtuse angles only, as in Fig. 4B. Finally, nine slides had the acute angles only as in Fig. 4C. The actual lengths of the line segments and extended vertical lines were lengths suitable to keep the general appearance of the figures similar and minimize obvious cues by which particular figures could be remembered.

Procedure and Apparatus

Slides were shown in random permutation seven times to each S, in an automatic laboratory controlled by an IBM 1800 process-control computer. Each slide was shown until S

Fig. 3. Chiang's explanation of the distortion of intersecting lines. The lines appear to be at the locus of maximum intensity, indicated located at the solid line, when the figure actually is displayed as shown by the dotted lines.

responded, and there was a 5-sec interval between slides. On each presentation S pressed one of six buttons on a small box before him, the left-most button being identified with large misalignments in the negative direction (as defined above), the right-most button with large misalignments in the positive direction, and with instructions to use intermediate buttons for smaller misalignments. Thus, responses were by the method of single stimuli.

RESULTS

The main results are presented in Fig. 5 which shows that judgments of the control line were symmetrical and centered at Judgment 3.5 (just between the two middle buttons, 3 and 4) when the lines were perfectly aligned. The Poggendorf illusion and the version having only obtuse angles produce substantially the same illusion of approximately 12 mm. The version of the Poggendorf having only acute angles displays the opposite illusion, with a magnitude of approximately 12 mm. These illusions are estimated by measuring the displacement of judgments produced by the vertical lines, approximately 0.8 judgment unit in the case of the Poggendorf illusion. The control lines reveal that one judgment unit results from a change in alignment of approximately 15 mm.

The effects are highly reliable; inspection of the trial-by-trial data showed that with a single exception (a small inversion), the Poggendorf and obtuse-angle figures produced a net positive illusion and the acute-angle figure produced a negative illusion on every trial for every S.

Fig. 4. A. The Poggendorf illusion. B. A similar illusion without any acute angle; this illusion is not explained by Chiang's theory. C. The Poggendorf figure with the obtuse angles eliminated, and only the acute angles present. Notice that the illusion is reversed in direction.

DISCUSSION

The results of this experiment are decisive with respect to the original question, for it is clear that the illusion does not depend upon acute angles. The result does not, on the other hand, have any obvious explanation. One hypothesis might be that Figs. 4B and 4C are seen as pictures of "arrow heads," or two solid objects pointing somewhat toward one another. The S would then try to judge the alignment of one edge of each object but might instead judge the direction of the point. If this were correct, however, then the illusion in 4A would be quite different from 4B, yet the magnitude of the illusion is almost exactly the same, as shown in Fig. 5. If the result were attributed to some systematic distortion of angles, then again Fig. 4A, having both angles, should show a different illusion from Fig. 4B, but they are empirically the same.

The same results make it difficult to explain the result as a function of the directions of lines, either by assimilation or contrast, since Figs. 4B and 4C have the same directions represented, but produce opposite illusions.

The present study merely reveals that the Poggendorf illusion is one of a class of illusions of misalignment, that it can be measured exactly, and that the present level of perception theory is not adequate to account for the detailed experimental results.

Fig. 5. Experimental results: mean judgment of alignment as a function of physical misalignment for control lines and three experimental (illusion) displays.

REFERENCE

CHIANG, C. A new theory to explain geometrical illusions produced by crossing lines. *Perception & Psychophysics*, 1968, 3, 174-176.

NOTES

1. The research on which this paper is based was supported in part by NSF Grant GB 5714 and PHS Grant MH 12541 to the author. The assistance of David Lloyd in performing the experiment is gratefully acknowledged.

2. Address: Department of Psychology, Indiana University, Bloomington, Indiana 47401.

(Accepted for publication November 5, 1968.)