The perception of rotation with an oscillating trapezoid

ROBERT ZENHAUSERN, *St. John's University, Jamaica, N. Y. 11432*

The existence of a new perceptual illusion, the perception of rotation under conditions of veridical oscillation, has been demonstrated. This illusion was compared to the Ames phenomenon (the perception of oscillation under conditions of veridical rotation) in terms of the parameters of distance and replication.

The illusion in which a veridically rotating trapezoid is perceived as oscillating was developed by Ames (1951) as a demonstration supporting the transactional theory of perception. His explanation of the phenomenon is based on the assumption that the target is perceived, not as a trapezoid, but as a rectangle in perspective.

Zegers & Murray (1962), in a series of studies designed to determine the parameters of the illusion, found, among other things, that visual angle was the important cue in viewing various size targets at several distances. A small figure, viewed from a short distance, resulted in a similar number of illusory experiences as a larger figure viewed from a farther distance.

Their explanation of the illusion depended on the equivocality of the visual cues inherent in the target design and motion. They concluded that the perception of the illusion is not dependent on a single cue and Ss are differentially dependent on the various visual cues.

Cappone (1967), in an attempt to determine the effects of practice on the perception of the illusion, exposed her Ss to the targets for 10 sessions. She found increases in the reports of illusory experience for at least the first nine sessions.

Graham (1963) attempted to explain the perception of motion in terms of angular velocity cues. With respect to the trapezoid illusion, he concluded that for every segment of motion there were two opposing interpretations of these cues. Because of this ambiguity, the angular velocity cues were nullified and the observer was forced to rely on other cues.

Guastella (1966) felt that an observer would attend to that part of the rotating trapezoid that was undergoing the greatest rate of physical change. She was able to demonstrate geometrically that the larger end of the target always changed at a faster rate than any other part of the target. She concluded that, since the S always attends to the larger end, this is always perceived in the frontal plane, giving rise to the illusion of oscillation.

All previous investigations have been concerned with a rotating target. If a trapezoid were oscillated with the small end in the frontal plane, the same ambiguity of angular velocity cues, posited by Graham, would occur. It might be then expected that veridical oscillation would lead to the perception of rotation. The purpose of the present study was to determine if such a reverse illusion does exist. The effects of distance and practice on this illusion were also investigated.

METHOD

Subjects

The Ss in this study were 17 female and 11 male undergraduate volunteers. None had previous experience with any type of trapezoid illusion.

Apparatus

The trapezoidal target (Fig. 1) was constructed of 1/8 in. aluminum, with no cues for depth other than the pattern of the target itself, painted with Nite-Brite luminous paint. A constant speed motor, geared to operate at 31 rpm, was used to drive the target. By means of an enclosed transmission, the trapezoid could be oscillated through an angle of 120 deg at

62 oscillation per minute. A Gra-lab timer was used to control the length of the test period. An electric counter, operated by a microswitch, was used to record the responses.

Procedure

All testing was done in a totally light-proof room, painted matte black to eliminate reflection. The movements of the Ss were not restrained in any way. Before each condition the target was exposed to incandescent lighting and was observed in total darkness, illuminated only by the luminous paint on its surface.

After a 10 min dark adaptation period, the Ss were exposed to the target for 2 min at distances of 6, 8, 10, 12, 14, and 16 ft presented in random order. While the target was recharged for each trial, the S donned dark goggles and averted his closed eyes to preserve dark adaptation. The Ss were instructed to press the microswitch every time the target changed direction. The entire procedure was repeated on different days for a total of five sessions.

RESULTS

During a 2 min trial, the target oscillated 124 times. An illusory experience consisted in not seeing an oscillation. Therefore, the number of illusory experiences was determined by subtracting the total number of reported reversals from 124.

All 28 Ss reported some illusory experiences, with a range of 72 (2%) to 3,261 (88%). The total number of reported illusory experiences for all Ss, at all distances, and for all sessions was 44,702 (43%). Subjective reports indicated that the target does indeed appear to rotate. Table 1 gives the total number of illusory experiences for all Ss as a function of distance and session.

An A by B by S analysis of variance (Lindquist, 1953) was applied to the data and both the distance and sessions main effects were significant beyond the .01 level. The distance effect was subjected to the Neuman-Keuls procedure (Winer, 1962) to determine specific distance effect. Distances of 6, 8, and 10 ft resulted in significantly fewer illusory experiences ($p < .01$) than the other three distances, but there were no significant increases in the number of illusory experiences beyond 12 ft.

The Neuman-Keuls procedure was also applied to the session main effect. Although Session I resulted in significantly fewer illusory experiences ($p < .01$) than the other four sessions, there was no further consistent change in illusory experiences as a function of exposure.

Fig. 1. Dimensions of trapezoidal target.

Table 1
Total Number of Illusory Experiences for 28 Ss as a Function of
Distance and Repetition

Session	Distance					
	6	8	10	12	14	16
1	489	760	1089	1591	1623	1747
2	719	1260	1547	1629	1921	1834
3	872	1116	1533	1898	2050	2117
4	979	1316	1798	1823	1898	1860
5	978	1127	1476	1879	1856	1872

DISCUSSION

The most important finding of this investigation was the discovery of a new visual illusion: the perception of rotation under conditions of veridical oscillation. In order to perceive this illusion the S must constantly alternate between illusory and veridical perception. When the small end of the target is veridically in Quadrant 3 (Q3) of the unit circle and moves to Q4, this is perceived veridically. However, as it then moves back to Q3 and back again to Q4, it must be perceived in Q1 and Q2 for the target to be perceived as rotating. Thus one-half of every cycle must be perceived veridically, while the other half must be perceived illusorily.

A theory which attempts to explain the phenomenon on the basis of the physical stimulus alone will have difficulty. For example, Guastella attempted to explain the Ames phenomenon on the basis of attention to the large end. Her theory would lead to the prediction, that, under conditions of oscillation with the small end in the frontal plane, the target would be perceived as oscillating with the large end in the frontal plane. This theory is clearly inadequate to explain the perception of rotation under conditions of veridical oscillation. Furthermore, it seems unlikely that the Ames illusion and the present phenomenon would be explained by two entirely different mechanisms. Because of their similarity,

it seems that a common explanation should suffice. The specific nature of this common mechanism is yet to be determined, but it seems to be related to a perceptual confusion arising from ambiguous visual cues.

The fact that beyond 12 ft there were no significant increases in the illusion as a function of distance is consistent with past research. Zegers & Malone (1964) found that there were no significant increases in the number of illusory experiences of the Ames illusion beyond 18 ft. In terms of visual angle the target used in the present study, when viewed at 12 ft, was equivalent to the targets used by those investigators at 19 ft.

There was no consistent replication effect. Unlike the Ames phenomenon (cf. Cappone, 1967) exposure to the illusion did not have a significant effect. It would seem that the factors responsible for the perception of rotation under conditions of veridical oscillation are not affected by mere repetition.

REFERENCES

- AMES, A. A. Visual perception and the rotating trapezoidal window. *Psychological Monographs: General and Applied*, 1951, 65, No. 7 (Whole No. 324).
- CAPPONE, M. K. The relationship between linear perspective and perception of reversal in the Ames trapezoid illusion. Unpublished doctoral dissertation, Fordham University, 1967.
- GRAHAM, C. H. On some aspects of real and apparent visual movement. *Journal of the Optical Society of America*, 1963, 53, 1019-1025.
- GUASTELLA, M. J. New theory on apparent movement. *Journal of the Optical Society of America*, 1966, 56, 960-966.
- LINDQUIST, E. F. *Design and analysis of experiments in psychology and education*. Boston: Houghton Mifflin, 1953.
- WINER, B. J. *Statistical principles in experimental design*. New York: McGraw-Hill, 1962.
- ZEGERS, R. T., & MALONE, T. B. Perception of distortion: An experimental study of distance and perspective in the Ames trapezoid illusion. Technical Report: U. S. Naval Training Device Center 1215-1, 1964.
- ZEGERS, R. T., & MURRAY, P. Perception of distortion: An experimental and clinical study. Technical Report: U. S. Naval Training Device Center 506-1, 1962.