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A depth aftereffect caused by viewing a rotating Ames window

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Abstract. After a rotating Ames window has been viewed, a normal test window held diagonal to the subject's line of sight appears to be distorted, having a larger back than front. The effect does not occur if a normal window is rotated or if the test window is held perpendicular to the subject's line of sight.

1 Introduction

Ames (1951) devised a trapezoidal window constructed with exaggerated depth cues, so that when it is viewed perpendicular to a person's line of sight it appears to be at an angle. When this window is rotated it seems to oscillate every 180°, so that the long edge of the trapezoid tends to appear nearer to the viewer (for reviews see Murch 1973; Mingolla and Todd 1981). It was noticed in a classroom demonstration that students who had viewed the rotating Ames window reported that a stationary rectangular window held diagonal to their line of sight appeared distorted. In particular, the rectangular window seemed to be a trapezoid with equal top and bottom edges, but with the back edge larger than the front. Thus, it was as if the students' sense of depth had been altered to be more consistent with the exaggerated cues of the Ames window.

This illusion has since been found several times in informal classroom demonstrations by the author and his colleagues. Here, more controlled conditions have been employed. Experiment 1 demonstrates the finding and shows that an aftereffect does not occur if the rectangular test window is held perpendicular to the line of sight. Experiment 2 demonstrates that the aftereffect is due to viewing the Ames window, and cannot be dismissed as a response bias.

2 Experiment 1

2.1 *Method*

2.1.1 *Subjects.* Thirty undergraduates volunteered for the experiment.

2.1.2 *Materials.* A six-pane window (Ittlelson 1952), which had vertical edges of 60 cm and 32 cm and horizontal edges of 50 cm was rotated at 5 rev min^{-1}. The window was lit by two 40 W bulbs placed 18 cm in front of the axis of rotation. A rectangular white-cardboard six-pane window frame, 50 cm wide x 50 cm high, was used as a test figure.

2.1.3 *Procedure.* The subjects were divided randomly into three groups of ten. Each group was run separately. All groups viewed the rotating Ames window for 3 min from a distance of between 8 and 10 m.

Immediately after the 3 min inspection period the Ames window was replaced with the rectangular test window. One group had the test window held at 45° to their line of sight with the left edge forward, the second group had the right edge forward, and the third group had the test window held perpendicular to their line of sight.

All subjects were told to assume that the bottom edge of the rectangular test window was 300 units long and asked to assign a number to the length of the top,

left, and right edge of the test window. That is, a fixed-modulus magnitude-estimation procedure was used (Stevens 1975). The subjects were then asked if they had perceived the Ames window as rotating or oscillating. Only subjects who reported seeing the Ames window as oscillating and who judged the top and bottom edges to be the same length were retained. The latter criterion was included to check that subjects understood the magnitude-estimation procedure. All subjects met both criteria.

2.2 *Results*
The subjects in the perpendicular viewing condition all judged the left and right edges to be equal. The mean ratios of the back length to the front length judgments in the left-edge-forward and right-edge-forward groups were 1·12 and 1·14, respectively. Three subjects in the left-edge-forward group and four in the right-edge-forward group saw the two vertical edges as equal. No one saw the back edge as smaller. The means for the left-edge-forward and right-edge-forward groups are significantly different from no effect (a ratio of 1·00) ($t_9 = 3{\cdot}62$, $p < 0{\cdot}01$ and $t_9 = 3{\cdot}51$, $p < 0{\cdot}01$), but the difference between these two groups is not significant ($t_{18} = 0{\cdot}35$). A statistical analysis involving all three groups was not performed because there was no variance in the perpendicular viewing group.

3 Experiment 2

3.1 *Method*

3.1.1 *Subjects.* Sixty-eight undergraduates enrolled in an introductory psychology course took part in the experiment.

3.1.2 *Materials.* In addition to the Ames and cardboard rectangular windows used in experiment 1, a 1·3 cm thick wood rectangular window with dimensions equal to the cardboard test window was used.

3.1.3 *Procedure.* The subjects in the experimental group followed the same procedure as that used by the left-edge-forward group of experiment 1. The subjects in the control group followed the same procedure as the experimental group, except that they watched the rotating rectangular wood window instead of the rotating Ames window.

3.2 *Results*
The results of five subjects were not included either because they did not report seeing the Ames window as oscillating, or perceiving the top and bottom edges of the test window as equal.

The mean ratios of the back length to the front length judgments for the thirty-seven subjects in the experimental and the twenty-six subjects in the control groups were 1·14 and 1·01, respectively ($t_{61} = 2{\cdot}47$, $p < 0{\cdot}05$). Nineteen and two subjects from the respective groups saw the back edge as longer and no one saw the back edge as shorter.

4 Discussion

A new perceptual aftereffect has been demonstrated. While many two-dimensional optical illusions and figural aftereffects can be interpreted in terms of visual perspective (Gregory 1966), the aftereffect demonstrated here actually is three-dimensional in nature. The aftereffect can thus be seen as related to other three-dimensional aftereffects (eg Epstein and Morgan-Paap 1974; Köhler and Emery 1947; Wenderoth 1970) or to the plasticity of the visual system with respect to space perception (eg Held 1962). In the latter case it would be claimed that as the subjects adjust to the exaggerated cues of the Ames window they would find that the back edge of a rectangular window appears larger than expected.

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