Tilt discrimination and aftereffect with stroboscopic display of contours*

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Previous studies have shown that motion perception is degraded when the visual stimulus is stroboscopically illuminated. The present experiment indicated that the accuracy in discrimination of the orientation of an intermittently presented stationary grating is unaffected by flicker rate. In addition, the orientation aftereffect induced by successive display of a tilted and vertical grating is independent of the flicker rate of each stimulus. These results indicate that mechanisms engaged in neural representation of contour information are not conjointly sensitive to the rate of temporal intermittency within the visual display.

Perceptual judgment can be distorted by an abrupt change in spatial properties within the visual display, and shifts that occur in stimulation are generally accentuated in judgment. Aftereffects can be induced in the perception of orientation, motion, size, length, proximity, direction, curvature, spatial periodicity, and binocular depth. In the case of the motion aftereffect, a stationary pattern is seen as moving in the direction opposite to preceding real movement. This aftereffect is reduced if the stationary test figure is viewed in stroboscopic illumination (Anstis, Gregory, Rudolf, & MacKay, 1963). Discrimination of real motion is also impaired under the same conditions (MacKay, 1958), and it is therefore probable that intermittent illumination removes motion information from input to spatial analyzing mechanisms in the visual system.

The present experiments examined tilt discrimination and aftereffect with stroboscopic illumination of contours. In Experiment 1, Os were required to adjust an intermittently displayed grating to vertical, and it was asked whether flicker rate affected orientation discrimination. Experiment 2 examined the tilt aftereffect. When contours are continuously illuminated, it is found that a vertical line appears slightly tilted following exposure to tilted lines. This aftereffect has previously been attributed to selective adaptation of specialized feature detectors in human vision (see Coltheart, 1971; Over, 1971). The aftereffect paradigm is considered to yield perceptual error to the extent that the properties of the test stimulus would normally be signaled by detectors that are in an adapted state following exposure to the inspection stimulus. In terms of this logic, aftereffect functions provide information on the classificatory capacities of neural units in that inspection of one stimulus can affect the subsequent perception of another stimulus only to the extent that the two stimuli are normally represented in visual processing by common detecting mechanisms.

The issue examined in Experiment 2 was whether the tilt aftereffect is diminished when the inspection and test stimuli are displayed at different flicker rates. Temporal intermittency was selected for study in this manner following the demonstration by Pantle (1971) that detection of a square-wave flicker stimulus is impaired following exposure to a flickering light but not to a steady light of the same time-average retinal illuminance. Frequency specificity occurred in flicker masking in that detection of a high-frequency target was most impaired by inspection of a high-frequency adaptation stimulus. Pantle (1971) interpreted this specificity as evidence that neural channels engaged in signaling temporal intermittency within the visual system are tuned over only part of the flicker range. Pantle used unpatterned displays and therefore was not able to establish whether detectors selective to flicker rate are also tuned to the spatial attributes of the stimulus. The studies on motion perception cited above suggest that the flicker filter system does not process motion information efficiently. The purpose of the present experiments was to examine whether tilt discrimination and aftereffect are impaired by temporal intermittency in the display of contour information.

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EXPERIMENT 1

Nine undergraduate students acted as Ss. Their task was to adjust a square-wave grating (4 c/deg) to the apparent vertical. The grating subtended 3 deg 20 min in diam and was displayed in one field of a Gerbrands tachistoscope (Model T-3B-1). The illumination of this field could be modulated temporally by square waves of 1, 2, 4, 8, 16, and 32 c/sec. At 32 c/sec, the grating appeared to be continuously displayed. The space-average luminance of the grating at 32 c/sec was 10.8 cd/m^2, and the Michelson contrast was 1.0. The S was able to vary the tilt of the grating by operating rotary controls that rotated a Dove prism mounted in the eyepiece of the tachistoscope.

Each S was required to set the grating to the apparent vertical on 12 occasions at each of the six rates of temporal intermittency. Settings were made from randomly allocated starting positions 10 deg clockwise and counterclockwise from vertical. On each trial, the grating was shown for 5 sec and the S was required to complete his judgment in that time. The sequence in which blocks of measures were obtained across flicker rates was varied between Ss.

The response measure of interest was the intraobserver variability in settings to vertical at the different flicker rates. An analysis of variance indicated that the mean standard deviation of settings did not vary significantly across the six intermittency levels employed in the present experiment [$F(5,40) = .59$, $p > .05$]. These data indicate that although information about the motion properties of the visual stimulus is degraded by stroboscopic illumination (MacKay, 1958), there is no comparable distortion in the perception of contour orientation.

EXPERIMENT 2

In this case, S's task was to set a grating to the apparent vertical following inspection of a grating tilted 15 deg clockwise from vertical. A number of studies (reviewed by Over, 1971) have shown that this arrangement yields a tilt aftereffect of 1-2 deg when the inspection and test contours are continuously displayed. In Experiment 2, the tilt aftereffect was measured under the nine factorial combinations produced with the inspection and test gratings pulsed at 2, 8, or 32 c/sec. Four preinspection and two postinspection measures were obtained under each condition. When postinspection measures were being obtained, the tilted grating was presented for 90 sec, and after a dark interval of 2 sec, the test grating was presented for 5 sec. The S was required to set the grating to vertical

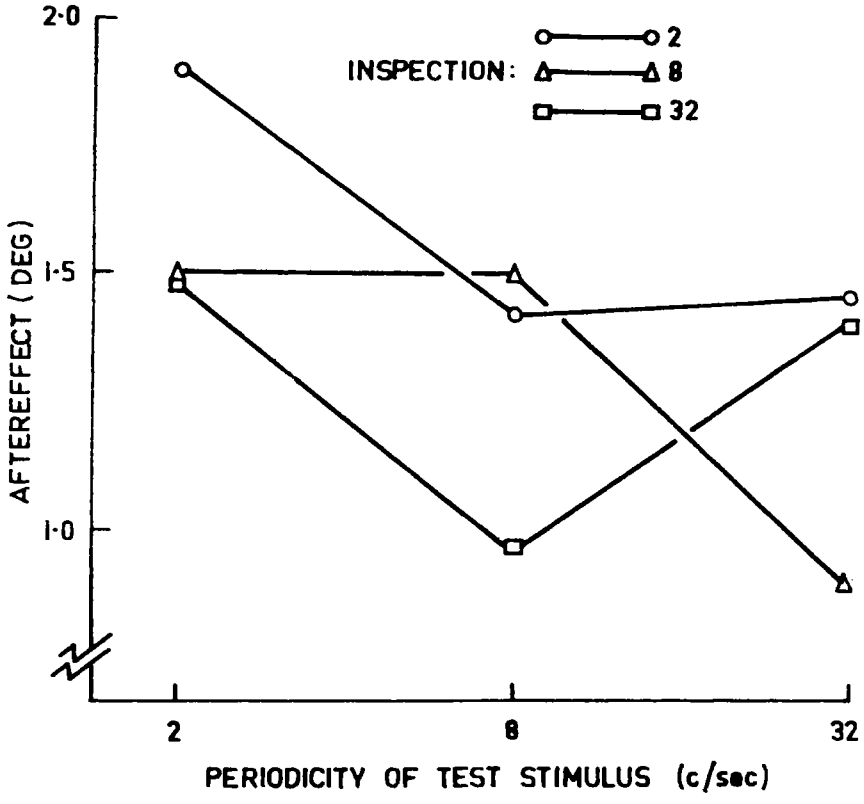

Fig. 1. Mean aftereffect obtained for the different combinations of flicker rate of the inspection and test stimuli.

in this period by operating manual controls that rotated a Dove prism. Settings were made from starting positions 10 deg clockwise and counterclockwise from vertical. Six undergraduate students acted as Ss. The order in which conditions were varied across Ss was determined by using one Latine square for inspection flicker rates and another Latin square for test flicker rates. The test flicker rates for any one S were constant across inspection conditions.

Aftereffects were measured in terms of differences between preinspection and postinspection settings made from a common strating position. Figure 1 shows the mean aftereffect obtained for the nine flicker rate combinations of the inspection and test stimuli. In each case, postinspection settings were shifted from preinspection settings in the direction of tilt of the inspection figure, the form in which the aftereffect traditionally occurs. An analysis of variance indicated that the mean aftereffect did not differ significantly as a function of the flicker rate of either the inspection stimulus [$F(2,10) = .21$, $p > .05$] or the test stimulus [$F(2,10) = 1.03$, $p > .05$]. The interaction was also insignificant [$F(4,20) = .58$, $p > .05$], and none of the differences between means was significant by Duncan's new multiple-range test.

DISCUSSION

Information about the motion properties of the visual stimulus is degraded by stroboscopic illumination (Anstis, Gregory, Rudolf, & MacKay, 1963; MacKay, 1958). The present experiments indicate that there is no comparable distortion in orientation perception. Tilt discrimination was unaffected by the rate of temporal intermittency in the display of contour information, and, in addition, the aftereffect induced by successive presentation of a tilted and vertical grating was independent of the flicker rate of the two stimuli.

It was earlier suggested that aftereffect functions provide information on the classificatory capacities of neural mechanisms in that exposure to one stimulus can affect the subsequent perception of another stimulus only to the extent that the two stimuli are normally represented in the visual system by common feature detectors. The issue of interest was whether there exist double-duty detectors (see Mayhew & Anstis, 1972) that conjointly process contour orientation and rate of temporal intermittency. The present experiments suggest that orientation detectors are not selective to visual flicker. However, in view of motion-flicker relationships that have been found, attention should be given to the question of whether tilt discrimination is impaired when a moving rather than a stationary grating is viewed under stroboscopic illumination.

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