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Monocularity of color-contingent tilt aftereffects

ANASTASIOS KAVADELLAS and RICHARD HELD
Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

The interaction between monocular channels involved in the color-contingent tilt aftereffect (AE) was investigated by inducing opposite AEs in subjects' eyes and comparing their magnitudes with those recorded after inducing identical AEs in the two eyes. Measurements obtained under the above two conditions did not differ significantly. No evidence was found for interaction between monocular channels.

A color-specific tilt aftereffect (AE) was first described by Held and Shattuck (1971). This AE is operationally the converse of the edge-orientation specific color AE discovered by McCollough (1965) and, as such, may entail the same mechanism. The discoverers of both aftereffects, as well as later investigators, established that the AEs induced monocularly will not manifest themselves if the unexposed eye is tested (McCollough, 1965; Shattuck & Held, 1975; reviewed by Stromeyer, in press).

More recently, several investigators have reported the induction of McCollough-type AEs by interocular combinations of color and pattern (MacKay & MacKay, 1975; Mikaelian, 1975; reviewed by Stromeyer, in press), although others failed to find this result (Over, Long, & Lovegrove, 1973). MacKay and MacKay have shown that when one eye views in alternation each of two orthogonally oriented achromatic gratings selectively paired with one of two complementary colors presented to the other eye, the AEs appear on test patterns shown to both eyes. Of most importance to the present argument is their suggestion that pattern information is transferred between monocular channels at some level prior to that responsible for the generation of the AE. Broerse, Over, and Lovegrove (1975) failed to find a color-contingent tilt aftereffect after presenting color to one eye and tilted exposure gratings to the other. Nevertheless, if the argument of MacKay and MacKay were correct, we should be able to detect such transfer by using a sensitive variant of the Held-Shattuck paradigm.

We used an experimental design in which two eyes were exposed to opposite adapting stimuli, thus inducing opposite color-contingent tilt AEs in subjects' eyes (Shattuck & Held, 1975). The magnitudes of these AEs were compared to those measured in a control experiment in which both eyes were adapted to identical stimuli. If the same mechanism is responsible for both McCollough and Held-Shattuck AEs and MacKay and MacKay are correct about transfer of pattern information, then the magnitude of the AE should be less after adaptation to stimuli of opposed orientation than that produced by stimuli of the same orientation. Interocular transfer of the adapting effects of opposed orientations should have reduced the effectiveness of the direct stimulation of each eye. A significant difference in the AE between the two conditions would lead us to concur with the inferences of MacKay and MacKay.

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METHOD

Subjects

Three experienced (J.B., A.K., and R.H., including the authors) and three naive subjects served in the experiment. All were found to have normal color vision on testing with Ishihara plates. On a Bausch and Lomb vision tester, all subjects, except P.W., could discriminate a depth difference produced by an angle of parallax at least as small as 15 sec. P.W. could discriminate to only 30 sec.

Apparatus and Procedure

Adaptation was achieved in two distinct ways. During half of each subject's sessions, both eyes observed the same exposure patterns (control session). During the other half, a dove prism (reversing images left to right) was placed in front of the right eye (experimental session). The latter condition induces opposite AEs in subject's two eyes. Under this condition, subjects observed continued rivalry between the eyes, an occurrence reported to have no influence on the magnitude of the McCollough aftereffect (White & Riggs, 1975). A projector alternated the red and green adapting gratings (Figure 1), tilted by 15° off vertical in opposite directions, every 5 sec.

Testing was based on an alternating double-staircase method (Cornsweet, 1962). The two staircases consisted of test gratings of the type shown in Figure 1. The testing instrumentation included a circuit with memory and two Kodak Carousel projectors, each carrying one set of testing patterns (the two staircases) spanning angles a from 178° to 182° in steps of 20′. The colors of the two half-fields were always the same within one staircase and inverted for the other, so as to equalize any color adaptation occurring during testing. The subject's task was to render angle a straight and to maintain it so (subjective a = 180°). A switch, pressed by the subject on presentation of each pattern, allowed him to indicate the direction in which angle a had to be altered for it to appear as 180°. Decisions had to be made for a series of 50 judgments.

An experimental session consisted of monocular preexposure

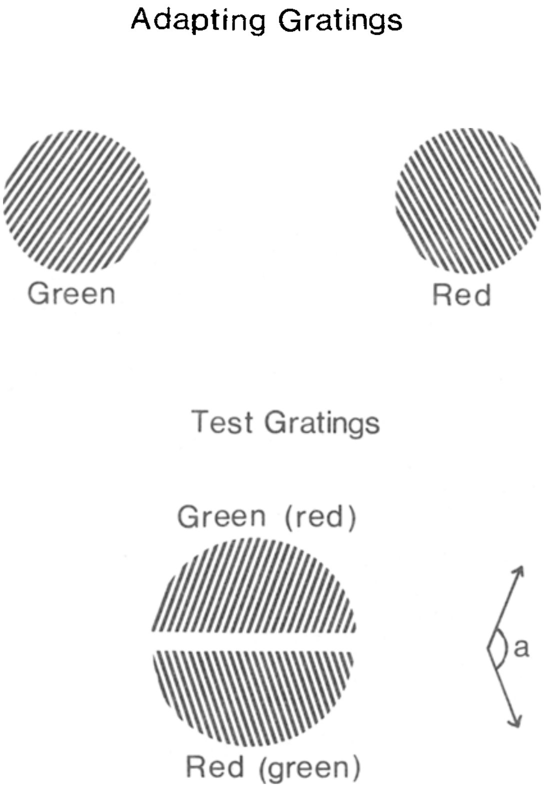

Figure 1. Adapting and test patterns.

testing of each eye, an adaptation period of 20 min, and a post-exposure repetition of the testing procedure.

Wratten filters No. 26 and No. 55 were used to produce red and green square-wave gratings with dark bars at a luminance of 2.5 fL, light bars at 63 fL. Both inspection and test patterns were circular and consisted of 8 cycles/deg gratings subtending 3.5° and 3.0°, respectively. They were rear-projected on a translucent screen viewed by the subject from a distance of 3.5 m.

Each of four subjects was tested once on both experimental and control conditions. Each of two subjects was tested repeatedly on both (see Table 1). Finally, in separate sessions, A.K. was exposed, using the control condition, for a total period of 80 min with test measurements taken binocularly after 10, 20, 40, and 80 min; R.H. was exposed similarly for 40 min with test measurements taken at 10, 20, and 40 min.

RESULTS

A staircase was considered as having reached the plateau level after the third reversal in the subject's direction of judgment. All a settings after this were averaged, and the resulting angle was deemed an estimate of subjective straightness. The differences (AEs), for each eye, between preexposure and post-exposure means are shown on Table 1. Positive values indicate AEs in the expected direction. The tabulated fraction is the AE recorded for the left eye over that for the right eye in minutes of visual angle. The comparable AE magnitudes of the identical vs opposite AE induction experiment were 61′ and 59′. The difference between these means was clearly nonsignificant. A t test of the difference between the means of the six subjects yielded t = 0.24.

The more prolonged exposure given to A.K. and R.H. yielded the following results. After 10, 20, 40, and 80 min, A.K. showed AEs of 23, 32, 41, and 57 min. After 10, 20, and 40 min, R.H. showed AEs of 54, 72, and 91 min. For these two subjects, the average magnitude of the AE achieved in 20 min of exposure is not at a saturation magnitude. That is, the size of the control AE was not limited by a ceiling on its achievable magnitude.

DISCUSSION

Failure to demonstrate a difference between control and experimental conditions suggests that there is no interaction, at the level responsible for

Table 1
Aftereffects for Control and Experimental Groups

Subjects	F.V.D.	A.K.	J.B.	R.H.	A.N.	P.W.	Average
Control	75/33	50/46	33/34	64/82	74/57	110/104	
	69/9	39/31					
	53/46	44/69					
	52/44	39/33					
	30/43	23/23					
		42/39					
	56/35	40/40					
Mean Aftereffect	46	40	34	73	66	107	61
Experimental	78/28	54/60	34/36	39/99	80/76	77/95	
	64/32	70/56					
	35/5	58/28					
	48/40	26/31					
	31/28	57/9					
		55/37					
	51/27	53/37					
Mean Aftereffect	39	45	35	69	78	86	59

Note—The tabulated fraction is the aftereffect recorded for the left eye over that for the right eye in minutes of visual angle.

the AE, between the color-edge information given to the two eyes in this experiment. Moreover, the binocular rivalry produced during exposure in the experimental condition has apparently not influenced the magnitude of the AE. For two subjects, the equivalence of the two conditions cannot result from a saturation limit, and we believe this conclusion is equally true for the other subjects. To the best of our knowledge, no experiment on color-contingent tilt AEs has produced evidence for interaction between monocular channels. On the other hand, there have been many claims for such interaction in the case of the McCollough AE (see Stromeyer's review, in press). This difference may distinguish the two AEs, which share so many similarities in their properties and in the conditions that generate them.

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ERRATUM

Hagino, G., & Yoshioka, I. A new method for determining the personal constants in the Luneburg theory of binocular visual space. *Perception & Psychophysics*, 1976, 19, 499-509—Following Equation 7′, T should correctly be defined as follows:

$$T = \frac{(\xi_1 - \xi_0)^2}{1 + \frac{K}{4}\varrho_0^2} = \frac{(\varrho_1 - \varrho_0)^2}{1 + \frac{K}{4}\varrho_0^2}.$$