Central integration effects with stabilized afterimages

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Prolonged patterned afterimages were used to study integration effects in stabilized images. Seven Ss were presented with various configurations of a pattern through a prism stereoscope, both monocularly and binocularly. Some of the fragmentations and regenerations reported in the binocular condition could only have resulted as a function of organization of the inputs to the two eyes, suggesting that postretinal processes are operative in stabilized image phenomena.

An image that is stabilized on the retina undergoes a wide range of qualitative changes. It is now well established that stabilization alters pattern perception, since fragmentation, disappearance, and regeneration phenomena have been observed. Several experiments cast doubt on a purely retinal explanation of stabilized image phenomena, strongly suggesting the involvement of central processes. Cohen (1961) found that the frequency of disappearance of a stabilized image could be reduced by concurrently stimulating the other eye, while Krauskopf and Riggs (1959) demonstrated the occurrence of interocular effects, both studies suggesting involvement of a central mechanism. Barlow (1963) used a light flash to measure slippage occurring with contact-lens systems, such as were used in the above experiments. It was then recognized that mechanical systems could be bypassed, and that stabilization could be studied with prolonged patterned afterimages. Bennet-Clark and Evans (1963), employing the flash technique, found image disappearance and regeneration comparable to that reported for mechanical stabilization. Evans (1966), also using the flash method, varied the size of a retinal projection from 30 min to 20 deg of arc on the retina while keeping shape constant. He found that fragmentation followed the same rules independent of size, lending additional support to the notion that cortical processes are involved.

The question of interest regards whether or not organization can occur at postretinal levels to influence fragmentation and regeneration of the stabilized image. Advantage can be taken of the binocular nature of the visual system by presenting different stimulus configurations to the two eyes in order to study the ability of the system to integrate the separate inputs. Due to the anatomy of the visual pathways, some pattern configurations experienced could only be a function of integration of information presented to the separate eyes, requiring the operation of postretinal processes.

METHOD

Subjects

Seven adult Ss were tested, five males and two females, including both authors.

Stimuli

The grid pattern shown in Fig. 1 was presented binocularly (a), monocularly (b and c), and in all possible combinations of pairs of whole lines (d, e, f, g, h, and i). The pattern measured 1¾ x 1¾ in., with a line width of 1/8 in., the figure subtending a visual angle of about 14.5 deg. Photographic negatives, i.e., clear figures on a black ground, were mounted in lantern slides for presentation.

Apparatus and Procedure

When the entire grid was presented to both eyes, neutral-density filters were used to equate intensity to the monocular level. After being dark-adapted for 5 min, the S viewed one of the stimulus conditions through an enclosed prism stereoscope. The slide holders were adjustable both for separation and for distance from each S's eyes. A piece of white opal glass was mounted behind the slides to diffuse the light from a Graflex Stroboflash that provided a flash of 50 W/sec for 1/1,200 sec, according to the manufacturer's specifications. The S was instructed to fixate on a dimly illuminated opaque yellow dot in the center of the figure, and when he indicated that he was ready, E flashed the strobe. Because blinking affects the afterimage, the S was told to keep his eyes closed after the flash and to continuously report any changes occurring in the pattern. Since changes occur very rapidly just after stimulation, the report repertoire was kept as simple as possible while still allowing the S to communicate his experience, e.g., "top," "verticals," "grid." Reports were recorded by marking on mimeographed sheets those parts of the figure that S reported were visible. To impose standardization on the period of reporting and because the dynamic effects of stabilization were usually completed during this time, reports were recorded only during the first minute. The interval between trials was at least 5 min or until the previous afterimage had disappeared. Each S received all stimulus conditions in each of five sessions to assess practice effects. Order of presentation was randomized for every session.

RESULTS

In spite of the simplicity of the pattern and of the report system, a sizable increase in total number of reports was observed across sessions. Mean frequency of report per S shows a fairly linear increase from 103 for the first session to 152 for the fifth session, with no sign of asymptoting after 35 min of total reporting time over a period of 5 to 7½ h. Complaints during the early sessions that changes occurred too rapidly to report, as well as postexperimental questioning of Ss, suggested increased facility in reporting rather than an increased rate of change in the afterimage.

Frequency of each classification of report is shown in Table 1 for each stimulus condition. Both the consistency within stimulus types and the differences between stimulus types is noteworthy. Binocular rivalry accounts for a large

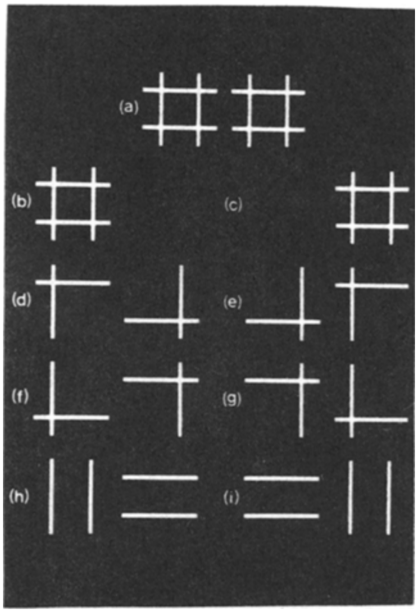

Fig. 1. Stimulus conditions.

Table 1
Frequency of Report Classification by Stimulus Condition

Report Classification	Stimulus Condition a	b	c	d	e	f	g	h	i
One line	50	65	61	59	74	53	44	103	108
Two lines									
Parallel[1]	72	52	45	129	109	157	130	–	–
Intersecting[1]	28	65	72	5	11	6	8	60	46
Rivalry[2]	–	–	–	241	223	233	266	385	387
Three lines	69	53	48	34	23	37	48	59	47
Four lines (grid)	73	87	86	18	23	23	23	7	4
Parts of lines	39	60	46	17	12	17	16	1	8
Total reports	331	382	358	503	475	526	535	615	600

[1] *One line from each eye for Conditions d through i*
[2] *Two lines from the same eye*

proportion of the reports in the cases where a different pattern was registered on each eye. While there are consistent differences between the binocular grid condition (a) and the monocular grid conditions (b and c), their classification profiles tend to be more similar to each other than to other conditions. The difference between frequency of four-line reports in the binocular and monocular grid conditions may be due to rivalry between the pattern stimulating one eye and nothing on the other eye in the monocular case, since rivalry results in a higher frequency of change in Conditions d through i. Equal proportions of total reports for the four-line classification in all three grid conditions support the interpretation.

In general, parallel lines form intersections more often than intersecting lines separate and form other intersections, although intersecting lines are likely to separate with two of the lines reappearing as parallels. In spite of an overriding tendency for parallel lines to appear and disappear together in Conditions d through i, there was no such effect for the whole-grid conditions, e.g., three lines appear together as often as parallel lines and intersecting lines appear more often than parallel lines for Conditions b and c, perhaps because there are only half as many ways parallels can occur. For the whole-grid conditions, all four lines appear approximately 25% of the time, more frequently than any fragment type.

Proportions of reports are categorized by stimulus type in two different ways in Table 2. The top section of the table classifies reports as rivalry, whole line(s), or parts of lines. The whole-line classification includes all reports of structured images, from a single line to all four lines of the grid. Proportions of whole and parts of lines were almost identical for the binocular (a) and monocular (b and c) grids. Parallel-line presentations (h and i) resulted in a greater proportion of rivalry reports and a smaller proportion of whole-line reports than did intersecting-line presentations (d, e, f, and g). A very small proportion of reports were of parts of lines when pairs of lines were presented to the two eyes.

The bottom section of Table 2 divides the reports into monocular and binocular classifications. The monocular class denotes report of a stimulus configuration presented to one eye, including rivalry, and single and part lines. The binocular class denotes report of an image that could have resulted only from integration of inputs to the separate eyes. Binocular classifications include reports of intersecting lines when parallel lines were presented and parallel lines when intersecting lines were presented, as well as reports of three lines and four lines. A larger proportion of binocular integrations resulted in the intersecting-line conditions (d, e, f, and g) than in the parallel-line conditions (h and i).

DISCUSSION

It is evident that some degree of image integration can occur at postretinal levels, since some of the regenerations reported could only have resulted as a function of organization at that level. These results corroborate physiological evidence from Hubel and Wiesel (1962), who found single cortical cells that responded optimally when driven by stimulation from both eyes simultaneously. Other cells found less frequently were fired only by stimulation to one eye or the other. The cells responsive to binocular stimulation have been found only at cortical levels and have not been found at the level of the lateral geniculate nucleus, where pathways from the two eyes converge.

Table 2
Proportion of Reports by Stimulus Type

Report Classification	Stimulus Type a	b & c	d, e, f, & g	h & i
Rivalry	–	–	.47	.64
Whole line(s)	.88	.86	.50	.35
Parts of lines	.12	.14	.03	.01
Monocular[1]	–	–	.61	.81
Binocular[2]	–	–	.38	.18

[1] *Includes rivalry, single and part lines*
[2] *Integration of inputs from different eyes*

In the present experiment, reports of integration of the inputs to the two eyes occurred with some frequency in each case where such organization was possible. More integration occurred when intersecting lines were presented than when parallel lines were presented. Parallel lines appeared dominant and did not separate often to integrate with other, nonparallel lines. Intersecting lines, on the other hand, more readily separated and reappeared as parallel lines. Others have noted the dominant effect of parallel lines. Bennet-Clark and Evans (1963) observed that disappearances and reappearances of patterns were often structured, in that single and parallel lines tended to function as units. Roessel (1966) found that when two lines disappear together, they are more likely to be parallel lines than nonparallel lines. He also found that as the distance between parallel lines increases, propensity of the lines to disappear also increases.

The results indicate that when integration of binocular inputs is of primary interest, it may be better to avoid patterns that are likely to lead to rivalry, e.g., parallel lines and lines that overlap so that some areas in the common visual field receive stimulation from both eyes. The problem of parallel lines tending to function as a unit might best be studied independently of other stabilization phenomena by varying the pattern context in which the parallels occur. The two issues suggest possible relationships among the following: (1) Brunswik and Kamiya (1953) found that parallel lines in scenes from motion-picture frames tended to belong to the same object—notwithstanding Hochberg's (1966) criticism of editing biases in selection of scenes and frames; (2) reaction times to identical patterns are shorter than they are to different patterns (e.g., Hawkins, 1969; Nickerson, 1967; Posner & Mitchell, 1967); (3) the response of single cortical cells remains constant regardless of retinal position so long as the stimulating lines have the same orientation, i.e., the retinal distributions are parallel; and (4) images of parallel lines tend to fade and to regenerate together when stabilized on the retina. Parallel lines are, by definition, redundant in variation and are likely to have significance concerning organization of the environment. It is reasonable, then, to consider that parallelness serves as a higher-order variable in reflecting organization in stimulation by means of a common path in perceptual processing by the central nervous system.

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NOTE

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(Accepted for publication August 1, 1969.)