A study of afterimages generated by monocular and dichoptic viewing*†

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Fragmentation of a prolonged afterimage of a vertical bar viewed monocularly against a background of either horizontal or vertical stripes was investigated. The background of vertical stripes produced greater partial fragmentation of the bar than did the horizontal background. This effect was not found for binocular viewing, in which the afterimage was viewed against a background seen by the other eye. Implications for present theories of fragmentation are discussed.

The fragmentation of afterimages of geometric shapes has been the subject of intensive investigation in recent years. The major findings have been that the whole or parts of a figure may disappear and reappear (Pritchard, Heron, & Hebb, 1960), that straight lines tend to disappear as wholes (Evans & Piggins, 1963), that this type of fragmentation appears to be cyclical (Piggins, 1968), and that similar patterns of fragmentation are found with three different methods of image stabilization, viz, that produced by a contact lens, by an afterimage, and by prolonged fixation (MacKinnon, Forde, & Piggins, 1969).

With respect to interaction of afterimages, Evans and Clegg (1967) have produced evidence that binocular afterimages do interact, and Smith (1968) has shown that the properties of fragmentation in binocular and monocular conditions are dissimilar. Evans and Wells (1967), however, have produced evidence both for and against the existence of binocular interactions in fragmentation.

In a neurophysiological study, Lehmann, Beeler, and Fender (1965) found blockage of the alpha rhythm after fading of a stabilized retinal image, and Evans and Robertson (1965) demonstrated cyclical activity in the visual cortex of the cat following brief high-intensity stimulation of the retina.

Explanations of fragmentation have involved rather vague references to interactions between cell assemblies, as proposed by Hebb. Recently, however, the well-established findings of Hubel and Wiesel (1962) and others have been seized upon to account for the phenomena of afterimage fragmentation. It is generally

argued that, since it has been demonstrated that cortical cells have receptive fields sensitive to line stimuli, the fragmentation of line afterimages as wholes suggests some sort of fatiguing activity of these cortical cells. Weinstein (1969) has pointed out the weaknesses of such arguments and has suggested that tests of psychophysiological hypotheses which are based upon fragmentation phenomena should be postponed until the basic parameters relevant to the fragmentation of afterimages have been more extensively explored.

Another criticism of some previous studies is that they have sought to demonstrate that phenomenal similarities are generated by different methods of stabilization and have led, consequently, to a predilection to invoke only one type of explanation of the afterimage phenomena, namely, a central-processing activity. Although the importance of peripheral activity is not completely disavowed (Piggins, 1968), it has been delegated a role in only the whole disappearance of the image.

The aim of the experiment reported here was to investigate fragmentation behavior in a situation that would provide a direct test of the central-processing hypothesis. The situation chosen was the viewing of an afterimage of a horizontal bar on a background of horizontal black and white stripes and on one of vertical black and white stripes. It was argued that the stripes would interact with the afterimage as if it were a real light, and, as a result of adaptation at a peripheral level, the background of vertical bars crossing the afterimage would tend to make the line fragment into parts, whereas the horizontal bars would tend to result in fragmentations of the afterimage as a whole, that is, complete disappearance. If the retinal adaptation hypothesis is correct, such effects should not transfer to the other eye. If the argument for a central explanation is correct, then similar fragmentation patterns should result when

the afterimage and background are viewed by separate eyes or by the same eye.

METHOD

A seated S with a chinrest fixated the center of a horizontal aperture, 3 in. long by 0.475 in. wide, mounted on a diffusing screen placed over the reflector of a Multiblitz flashgun. The flashgun was positioned 3 ft from the S and was offset 45 deg to the right of his visual axis. After a warning signal, the S triggered the flashgun; the brief illumination of the aperture produced a strong horizontal afterimage of a bar with an angular subtense of 4 deg 45 min by 45 min. The S was immediately swivelled 90 deg to his left, again rested his chin, and fixated the center of a large screen. The screen was illuminated by a back projection of a Ronchi ruling, which produced a pattern of equally spaced light and dark stripes. The stripes had a periodicity of 1 deg at the viewing distance of 3 ft.

A recording pushbutton was located under each of the S's hands. Ss held down the left button at the onset and for the duration of any partial fragmentation of the bar, and released it when the whole line reappeared or completely disappeared. Complete disappearances were recorded in a similar manner by the right-hand button. Each of the buttons was connected to a separate counter and cumulative timer, so that both total number of fragmentations and total time spent in fragmentation were recorded. A trial consisted of 3 min of steady fixation of the screen.

Both monocular and dichoptic viewing conditions were employed. In the monocular condition, in which the nonpreferred eye was covered, the S perceived both the afterimage and the background pattern with the same eye. In the dichoptic condition the eyepatch was removed, and a septum placed along the visual axis ensured that stimuli on one side of the screen were seen only by the eye on that side of the screen. In this condition the afterimage was again given to the preferred eye (the right eye for each of the three Ss¹ used in this study), and the screen was viewed by the left eye. Ss were instructed to converge so that the afterimage was centrally superimposed on the striped background.

Measures of partial and complete fragmentation were obtained for the monocular and dichoptic viewing conditions from each of the three Ss. Each S was given five trials in each of the four conditions.

RESULTS

The results from this experiment are given in Table 1, in which the mean

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Table 1
Mean Time in Minutes Spent in Partial and Complete Fragmentation as a Proportion of Total Viewing Time for Two Background Conditions and Two Viewing Conditions (N = 3)

Back-ground	Type of Fragmentation	MLM		LH		AH	
		Monocular	Dichoptic	Monocular	Dichoptic	Monocular	Dichoptic
Horizontal Stripes	Partial	0.05	0.03	0.09	0.08	0.02	0.04
	Complete	0.42	0.51	0.46	0.50	0.40	0.44
Vertical Stripes	Partial	0.38	0.08	0.33	0.10	0.42	0.06
	Complete	0.18	0.49	0.20	0.48	0.12	0.48

proportions of time spent in partial and complete fragmentation are recorded for each viewing condition.

Two features of the data are apparent. First, the background stripes in monocular view produced greater complete fragmentation when they were parallel to the afterimage and greater partial fragmentation when they were vertical to the afterimage. Second, the orientation of the background stripes in dichoptic view had no effect upon fragmentation behavior.

The slight differences between mean fragmentation times for the two conditions involving horizontal stripes were not found to be significantly different for any of the Ss. The marked differences between mean times for the two conditions involving vertical stripes was not subjected to any test.

It should be noted that total mean time spent in fragmentation (partial plus complete) is very similar for horizontal and vertical background conditions. In no case is the difference significant.

DISCUSSION

The hypothesis that the fragmentation of afterimages is due to a central process implies that the differential fragmentation effect, as a consequence of different background conditions obtained with monocular viewing, should also be obtained with dichoptic viewing. This was found not to be the case. On the contrary, the data indicate that the background stimulus had no apparent effect in three of the viewing conditions in which fragmentation rates were essentially the same; the temporal fragmentation pattern is changed only when vertical stripes serve as a background to the afterimage generated in the same eye. The finding that partial fragmentation is dominant in this

condition is not surprising if one considers the afterimage to be behaving in a manner similar to a real light seen against a background of vertical bars. The brighter bars of the pattern serve to reduce the contrast of those portions of the afterimage which are located on these bars and, hence, to reduce visibility. The most likely explanation of this effect would then be in terms of peripheral neural or photochemical adaptation.

Since there is no indication of interaction between the afterimage and the background, it appears that a background of horizontal stripes has little effect on the type of fragmentation obtained, and the finding that the afterimage fragments more as a whole than in parts is consistent with previous findings.

The similarities in total fragmentation time are of some significance, since this may be considered as evidence that some central factor may influence the overall rate of fragmentation. The nature of such a process is at present unclear.

In summary, the phenomenon of afterimage fragmentation is not susceptible to any single explanation; peripheral adaptation fails to account for similarities in overall fragmentation rate, whereas a central-processing hypothesis is rejected because of failure to find interactions. It is probable that fragmentation may be the consequence of a multistage process in which both peripheral and central factors play a role. The inadequacy of any explanation to date stems from a lack of parametric data on fragmentation and from a failure to explore the many stimulus situations in which fragmentation occurs. At present, explanations of fragmentation are unrelated to other research on afterimages, which has been fairly successful in treating the general case of the afterimage, e.g., Barlow and Sparrock

(1964). It is perhaps through studies of the interaction of displayed backgrounds with afterimages that more satisfying theories of fragmentation will evolve.

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NOTE

1. S. A. H. performed the experiments at the University of Guelph using similar but not identical apparatus.

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