Figural effects in afterimage fragmentation*

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Afterimages consisting of between two and five lines were observed in five experiments. Measures were taken of both the duration and frequency of visibility of the lines comprising the configurations, and also of all line combinations. In Experiments I-III, lines forming angles, triangles, and a square were varied in orientation. Neither the absolute nor the relative orientation of the lines had any systematic effects on the measures. These results are compared with those that have been derived from steady fixation and optical stabilization, in which vertical-horizontal line pairs yield greater stability than other orientations. In Experiment IV, afterimages of the letters N and Z were found to be more stable than those of their mirror-image reversals, both in terms of the duration of visibility of the entire configurations and the obliques. This pattern was not produced using a complex configuration that could fragment into either a letter or a reversed letter (Experiment V). Similar effects have been found during steady fixation.

Paired lines observed under steady fixation or optical stabilization exhibit a high degree of stability when they are inclined at 90 deg to one another (McFarland, 1968; Schmidt, Fulgham, & Brown, 1971). This stability, as indexed by the low frequency of disappearance of the whole line pair, is greater than that for either acute or obtuse angled pairs. Furthermore, it has been shown that the stability of right angles in which the component sides are vertical and horizontal is greater than for perpendicular lines inclined at 45 deg to these axes (Schmidt et al, 1971). This latter result was interpreted in terms of the increased stability of the horizontal line components over other orientations.

Single lines stabilized as prolonged afterimages do not evidence reliable duration or frequency differences with orientation (Wade, 1972). Consequently, it is of interest to determine whether orientation is a salient differentiating dimension for afterimages of greater figural complexity. Three experiments are reported which examined the pattern of fragmentations of afterimages comprising two, three, or four lines. In each experiment, stimulus configurations were employed which varied the absolute orientation of the line components, and for two of the experiments their relative orientations were also varied.

Furthermore, the stability of steadily fixated objects has been shown to be influenced by perceptual learning (Donderi & Kane, 1965; Tees & More, 1967) and by the verbal labeling of stimuli (McKinney, 1966). A similar effect was examined using afterimages of letters and their mirror-image reversals. A final experiment was conducted using a more complex stimulus configuration, the components of which could be either a letter or a reversed letter.

METHOD

Apparatus

Afterimages were generated by the discharge of a Multiblitz

*This research was supported by a grant from the Science Research Council. I thank Kirsteen Greig for her assistance in the collection and analysis of the data.

Report flash gun, with an output of 120 J in 2 msec. Black masking card, with apertures corresponding to the patterns, could be mounted directly in front of the flash gun. The stimulus configurations used in each experiment are shown in Figs. 1 and 2. For the paired lines, the orientations were: 0 (vertical) and 90 deg, 45 and 135 deg, 0 and 120 deg, and 30 and 150 deg for Configurations 1-4, respectively. The triangles comprised the same pairings as above, with the additional line being 45, 0, 30, or 0 deg, respectively. The square was presented with its sides either 0 and 90 deg or 45 and 135 deg. In all these instances, the line units subtended $1 \times \frac{1}{4}$ deg at the eye. In Experiments IV and V (Fig. 2), the parallel lines were each $2 \times \frac{1}{4}$ deg, and the oblique was at 45 or 135 deg.

The S's head position was controlled by means of chin and forehead supports. On the table in front of S was a panel with the same number of switches as lines in the stimulus pattern (except in Experiment V). These switches were connected to timers and counters, which recorded the duration and frequency of all possible combinations of switch depressions. They also activated separate channels of a Rustak event recorder. The apparatus was situated in a dark room.

Subjects

Sixteen (different) Ss participated in each experiment. All had normal or corrected vision, and they observed the afterimages with the preferred eye.

Procedure

The S was instructed to depress the appropriate switch or switches for the duration of unitary visibility of the lines comprising the stimulus configurations. A practice trial was given to ensure that the instructions had been understood, and this was followed by 10 min of dark adaptation. Four afterimage trials were given, one for each configuration in Experiments I, II, and IV, and two for each of the configurations in Experiments III and V. The observation period was 2 min (except for Experiment IV), and the intertrial interval was 5 min, during which S was dark adapted.

The orders of presentation of the figures were counterbalanced, with the restriction that pairs of the same relative orientation in Experiments I, II, and IV be successive. A luminous circle (4 deg in diam) surrounded the figures. Prior to the flash, S fixated the center of the circle, which corresponded to the "center of gravity" of the figure, and then observed the afterimage with eyes closed.

EXPERIMENT I

The four line pairs illustrated in Fig. 1 were used in

Fig. 1. The stimulus configurations employed in Experiments I-III. The letters denote the lines so labelled in the tables.

this experiment. If the pattern of stability for 0-90-deg pairs found under steady fixation and optical stabilization also holds for afterimages, it would be predicted that this pair would be visible for longer in unitary form than the other configurations. Configuration 3 should be the secondmost stable pattern due to the presence of a vertical line. Measures of the whole-line visibility were obtained in this experiment rather than whole-line disappearance. The former has been considered to represent the characteristics of afterimage fragmentation more precisely (Wade, 1972), although the latter would correspond to the indices of stability demonstrated with steadily fixated and optically stabilized figures. Since only measures of whole-line visibility were taken, the periods during which the switches were not depressed could have corresponded to whole or partial line fades. However, the dimensions of the lines were chosen to minimize fragmentations of the single lines into parts (see Atkinson, 1972a). Furthermore, with more complex line stimuli, the lines do disappear in a unitary manner most of the time (MacKinnon et al, 1969; Pritchard, Heron, & Hebb, 1960). The method did have the advantage of measuring each line separately, so that any effects due to the orientation of the line components could be assessed in a manner that is not possible for the data from steady fixation and optical stabilization (McFarland, 1968; Schmidt et al, 1971).

Results and Discussion

The mean durations and frequencies of visibility for each of the afterimage configurations are given in Table 1. The visibility measures are expressed in terms of the total pattern of switch depressions. That is, the duration for Line A in a given configuration corresponds to the total time that the appropriate switch was depressed, whereas that for AB represents that part of the latter duration in which B was synchronously visible. The duration for which each line was visible on its own

can be determined by subtraction.

Inspection of Table 1 indicates that the differences between the durations and frequencies of the line components and synchronous pairings over the four configurations are small. Separate statistical analyses were conducted on each of the component measures given in the rows of Table 1, and none of the differences between the configurations approached statistical significance ($p > .05$). The measure most similar to the frequency of whole-figure fades employed in the studies of McFarland and Schmidt et al was the frequency with which neither line was visible in its entirety. As noted above, this index may confound whole and partial fades, but Schmidt et al state that whole fades were highly correlated with the ratio of whole to partial fades. Therefore, the measure would be expected to differentiate between the configurations if similar processes were involved in all three methods. The mean frequencies for which neither line was completely visible were 4.3, 5.4, 5.1, and 5.9, for Configurations 1-4, respectively.¹ While the measures showed the ranking predicted, the differences failed to achieve statistical significance ($p > .05$). Therefore, the results with line afterimages fail to corroborate those obtained under steady fixation and optical stabilization.

In the study of single-line afterimages (Wade, 1972), measures of duration were more sensitive indices of afterimage characteristics than were frequencies of visibility. As such, it is of interest to examine the present duration data in more detail. First, it is clear that a 0-90-deg pair remains visible for no longer than a 45-135-deg pair, nor is a 0-120-deg pair visible in whole form for longer than a 30-150-deg pair. Second, the single-line durations do not suggest any orientation differences, either in terms of their total durations of visibility or the times for which they were visible on their own. This result is in agreement with those of the previous study (Wade, 1972). Most specifically, the horizontal line in Configuration 1 yielded no greater stability than any of the other lines, which result is contrary to that found under optical stabilization (Schmidt et al, 1971).

It is highly likely that the lines comprising the pair interacted with one another (see Atkinson, 1972b). However, the degree of such interaction is indeterminate from the present data, as no measures of single-line

Table 1
Mean Durations (Seconds) and Frequencies of Visibility of Single Lines and Pairs for Each Configuration

	Line(s) Visible	Stimulus Configuration			
		1	2	3	4
Duration	A	67.6	77.6	72.9	65.6
	B	67.3	75.8	68.4	66.3
	AB	59.8	66.7	62.2	57.8
Frequency	A	5.9	6.5	6.4	7.1
	B	5.3	6.9	6.9	7.1
	AB	6.4	8.0	7.1	7.8

visibility in the absence of the paired lines were made. The data do correspond to those of Atkinson's Experiment 3 in yielding no difference in this interaction as a function of relative orientation for perpendicular and acute-angled pairs. Atkinson found facilitatory interactions only between afterimages of lines in the same orientation.

The results of the present experiment plainly do not support those from studies using steady fixation or optical stabilization. Perpendicular lines when viewed as afterimages do not exhibit duration or fragmentation differences relative to acute-angled pairs, nor do pairs consisting of horizontal and/or vertical lines evidence any greater stability.

EXPERIMENT II

A third line was added to each of the paired configurations used in the previous experiment (see Fig. 1). The dimensions of the additional line were the same as those for the other two lines. Consequently, the separation of the ends of the third line from the other two differed for the right- and acute-angled triangles. Three switches were used by S to indicate the visibility characteristics of each line component.

Results and Discussion

The mean durations and frequencies of visibility of all lines and combinations are given in Table 2.² The durations of visibility of the whole triangular outline, pairs of lines, or the single-line components did not differ significantly over the four configurations. This result is consonant with those of Experiment I and shows that the addition of a third line to a pair does not enhance the stability of any parts of the figure in specific orientations. Indeed, it is noteworthy that the duration of visibility of the lines that were common to the pairs and triangles were very similar, although the frequencies of visibility were somewhat higher for the latter. The durations for which either paired or single lines were visible on their own did not differ systematically over configurations.

The frequencies of visibility of the whole triangles evidenced a marginally significant effect [$F(3,45) = 2.88$, $p < .05$], with those triangles having a vertical component (1 and 3) being visible less often. Since this pattern was not exhibited for the corresponding single-line components or for any pairings, it cannot be considered a systematic effect. It may be related to the slightly shorter durations of whole-triangle visibility of these two configurations.

Extracting the frequency with which no line was visible in its entirety from the event recording gave the following results for Configurations 1-4, respectively: 6.4, 6.4, 5.7, and 5.9. The frequencies did not differ significantly from one another ($p > .05$). Therefore, afterimages of outline triangles did not yield any

Table 2
Mean Durations (Seconds) and Frequencies of Visibility of Single Lines, Pairs, and Triangles for Each Configuration

	Line(s) Visible	Stimulus Configurations			
		1	2	3	4
Duration	A	65.6	67.1	66.6	67.5
	E	61.8	66.2	63.8	65.2
	C	67.1	65.8	64.9	71.4
	AB	51.0	54.9	53.7	55.4
	AC	51.4	53.5	52.7	60.1
	BC	48.6	51.8	51.2	59.0
	ABC	41.7	45.4	44.0	51.0
Frequency	A	8.3	8.2	7.9	8.6
	B	8.4	9.0	8.4	9.2
	C	9.6	9.0	8.1	8.2
	AB	7.9	8.6	8.5	9.8
	AC	9.6	9.2	7.4	8.9
	BC	8.2	9.1	8.0	9.4
	ABC	7.6	8.8	7.6	9.8

systematic differences in the pattern of fragmentations as a function of orientation.

EXPERIMENT III

Squares presented in the upright or oblique (45-deg) orientations were used in this experiment (see Fig. 1). In order to facilitate responding, the four switches were arranged in the form of a diamond for the upright square and in the form of a square for the 45-deg rotated square. This arrangement resulted in the switches corresponding to the midpoints of the component lines.

Results and Discussion

The results, in terms of durations and frequencies of visibility for all line combinations, are given in Table 3. The data for the two trials of the same orientation were averaged, there being no significant differences between them. The durations of visibility of the single lines were very similar to the values obtained from the previous experiments, although the whole figures were visible for shorter periods. There were no statistically significant differences in any of the conditions tested ($p > .05$).

The mean frequencies with which none of the lines were visible in whole form were 5.9 and 6.7, for the upright and rotated squares, respectively. This difference was not significant ($p > .05$).

The above results are in general agreement with those of MacKinnon (1971), although he analyzed fragmentation frequency alone. He reported that the pattern of fragmentation for a square rotated 45 deg was similar to that for an upright square when they were observed as afterimages. This result was obtained with squares having sides subtending 3 and 6 deg at the eye, in contrast to the 1-deg sides of the present study. The frequencies of whole-figure disappearance were greater than predicted on the basis of independent fragmentation of the sides. In like manner, the durations

Table 3
Mean Durations (Seconds) and Frequencies of Visibility of
Single Lines, Pairs, Triplets, and Squares for Each Configuration

	Line(s) Visible	Stimulus Configuration	
		1	2
Duration	A	72.2	66.2
	B	66.9	67.4
	C	71.6	68.5
	D	69.2	65.2
	AB	54.4	56.0
	AC	61.1	54.2
	AD	56.0	51.5
	BC	54.6	55.1
	BD	55.5	53.9
	CD	55.9	55.4
	ABC	48.4	48.6
	ABD	45.9	45.2
	ACD	50.0	47.2
	BCD	47.2	47.2
	ABCD	42.6	42.0
Frequency	A	9.3	9.6
	B	9.7	9.6
	C	9.0	9.2
	D	9.5	10.0
	AB	9.8	9.8
	AC	9.9	9.7
	AD	9.1	9.3
	BC	9.4	9.5
	BD	10.0	10.1
	CD	9.1	9.5
	ABC	9.7	9.6
	ABD	9.1	9.4
	ACD	9.0	9.1
	BCD	9.2	9.3
	ABCD	8.9	9.0

of whole-figure visibility in the present study were longer than would be predicted on the basis of random fragmentation of the constituent sides. However, this result cannot be considered as too surprising in view of the fact that the afterimages of all the lines were generated simultaneously.

EXPERIMENT IV

The previous experiments have shown that the orientation of the line elements in simple geometric afterimages do not exhibit the fragmentation characteristics evident for steadily fixated or optically stabilized figures. Another aspect of image fragmentation that has been demonstrated under steady fixation is dependent upon the significance of a given configuration. Figures that are presented simultaneously for many trials tend to disappear together during steady fixation (Donderi & Kane, 1965; Tees & More, 1967), as do stimuli that are judged to be similar (Donderi, 1963). Moreover, outlines of letters disappear less frequently and for shorter durations when they are described as letters rather than as designs (McKinney, 1966).

As with all effects generated under steady fixation, the image fragmentations are likely to be confounded by

eye movements. Indeed, the point of fixation on a figure has been shown to influence the pattern of disappearances that occur under such conditions (Hart, 1964), and the importance of figural significance has, in consequence, been questioned. If similar effects could be demonstrated under afterimage conditions, then the effects could not be ascribed simply to the pattern of retinal image displacements.

An experiment was designed to examine this problem using afterimages of letters and their mirror-image reversals. The letters selected were N and Z, as they consist of the same elements, but these are rotated through 90 deg. The four configurations used are shown in Fig. 2.

As in the previous experiments, S depressed a switch for the duration of visibility of each line in the figure, but the observation period was only 1 min. The instructions contained no reference to letters; all the configurations were described as consisting of three lines, two parallels and a diagonal.

Results and Discussion

The mean durations and frequencies of visibility for all the combinations of line elements are given in Table 4. The data for each line component, and their combinations were analyzed according to a 2 by 2 factorial design, with letter-reversed letter and N-Z form as the factors. The afterimages of the letters were visible in their entirety for significantly longer than their mirror-image reversals [$F(1,15) = 6.55$, $p < .05$]. Furthermore, the obliques—which are the differentiating features of the figures—evidenced a similar significant difference [$F(1,15) = 22.67$, $p < .001$]. The line components that were common to the figures (the vertical or horizontal lines) did not differ significantly ($p > .05$). Such was the case because the parallels were visible on their own for longer in the reversed letters.

There were no corresponding differences in the frequencies of visibility of the line components or in the frequencies of whole-figure disappearance.

These results lend support to those using steady fixation. Figures like letters that have developed some

Fig. 2. The stimulus configurations employed in Experiments IV and V.

significance to the O are more stable than their mirror-image reversals. This conclusion is valid only for the duration measures. McKinney (1966) reported frequency differences in one experiment and duration differences in a second. He remarked that the latter were more accurate than the former, but did not indicate whether frequency differences were also found in the second study. As in the previous afterimage experiments, frequencies of visibility were here found to be insensitive indices of afterimage characteristics. In view of this fact and also of the very large duration differences between the figures labeled letters and designs, it would seem likely that the instructions also had some effect upon the S's criteria for reporting disappearance in McKinney's experiments.

In the present experiment, the only structural difference between the letters and their reversals was the orientation of the oblique (either 45 or 135 deg). It is improbable that this factor alone could have accounted for the pattern of results, as it was balanced in the letters (N and Z). Moreover, single 45- and 135-deg line afterimages do not show any differences in their durations of visibility (Wade, 1972). It is of interest to note that the obliques of 45 and 135 deg are confused in certain animals (Sutherland, 1964) and also by preschool children (Rudel & Teuber, 1963). Children also make confusions between letters and their mirror-image reversals, but these are greatly reduced after training to read (Frith, 1971). This suggests that the significance attached to one of a pair of initially confused configurations following its increased frequency of presentation results in its greater stability in terms of visual processing. Such effects could be interpreted in terms of the development of some higher order processes of the general type discussed by Hebb (1949, 1963). While it is impossible to determine the relative frequencies of presentation of the letters and their reversals used in this experiment, Tees and More (1967) have shown that the frequency of presentation of pairs of digits influences the frequency with which they disappear synchronously under conditions of steady fixation.

With regard to afterimages, such a hypothesized higher order process confers added stability to a whole letter (as indexed by its unitary visibility), but differentiates between the single-line components only in terms of the discriminating feature—the oblique orientation. Due to the pattern of paired and single-line visibilities, the vertical and horizontal components of the figures were visible for about the same durations.

No differences were evident between the letters N and Z, even though the former has a far greater frequency of occurrence in written English (Baddeley, Conrad, & Thomson, 1960). This dictates caution in accepting the above interpretation, although the letters may be treated less differentially at the initial stages of learning to read.

EXPERIMENT V

If the visibility of a whole letter is more stable than a

Table 4
Mean Durations (Seconds) and Frequencies of Visibility of All Line Components for the Letters and Their Mirror-Image Reversals

	Line(s) Visible	Stimulus Configuration			
		1 N	2 M	3 Z	4 Σ
Duration	A	42.8	40.0	41.6	40.5
	B	40.8	35.5	43.1	36.8
	C	38.7	39.1	40.2	41.0
	AB	36.7	32.7	37.9	31.1
	AC	34.1	33.0	35.7	34.9
	BC	33.1	29.4	33.5	31.7
	ABC	30.8	26.9	32.3	27.7
Frequency	A	4.8	4.3	4.6	4.6
	B	4.9	4.9	4.4	5.1
	C	5.1	4.4	5.0	4.6
	AB	5.1	4.9	5.1	5.1
	AC	5.2	4.9	5.3	5.2
	BC	5.2	4.6	4.6	5.3
	ABC	5.1	4.7	4.8	5.0

reversed letter, will such a difference be evident in the fragmentation of a complex figure comprising both these components? An attempt was made to determine this using the patterns shown in Fig. 2. Each configuration contained both a letter (N or Z) and a reversed letter (Σ or M). Preliminary experiments had established that it was exceedingly difficult to follow the pattern of fragmentations with one switch for each of the five lines. Since it was desirable to test naive Ss, the task was simplified. Only three switches were employed: one was depressed for the duration of visibility of *both* verticals, one for the oblique, and one for *both* horizontals. When a single vertical or horizontal was visible, the appropriate switches were not depressed. This procedure enabled measurement of the duration of visibility of the letter and reversed letter components, but it clearly ignored a wide range of fragmentations involving single vertical or horizontal lines. Each configuration was presented twice in an alternating sequence.

Results and Discussion

There are no significant differences between the two presentations of the same configuration, and the data were combined. The mean durations and frequencies of visibility of the whole configurations and the selected fragments are given in Table 5. The parallel lines are labeled AA and CC to emphasize that depression of one switch corresponded to the visibility of two lines. The whole afterimage was visible for over 40 sec, and the fragments corresponding to the letters or reversals were visible on their own for only an additional 5-7 sec. It is clear from Table 5 that these values are not consistently different either within or between configurations. More specifically, the components corresponding to letters (ABA in Configuration 1 and CBC in Configuration 2) were not visible for significantly longer than those for the reversed letters ($p > .05$). This was the case for the

Table 5
Mean Durations (Seconds) and Frequencies of Visibility of
Line Components in Experiment V

	Line(s) Visible	Stimulus Configuration	
		1	2
Duration	AA	60.9	63.7
	B	62.4	71.1
	CC	64.9	67.2
	ABA	48.9	52.8
	CBC	49.6	54.2
	AACC	53.4	57.0
	AABCC	42.4	47.8
Frequency	AA	8.8	8.5
	B	9.9	8.8
	CC	9.5	8.7
	ABA	8.5	8.5
	CBC	8.8	8.3
	AACC	9.0	9.0
	AABCC	8.4	8.6

Note—The paired letters represent the visibility of two parallel lines.

reversed letters both in the same and in the alternative configuration.

Therefore, those parts of a complex pattern that would correspond to some higher order process in the Hebbian sense do not fragment differentially. However, this might have been due more to the stability of the complex pattern (as indexed by the duration of its unitary visibility) than to the variable stability of some of its parts. Further, the fact that both the normal and reversed letter shared the same oblique might have confounded any effect.

It is noteworthy that the durations of whole afterimage visibility correspond closely to those of the triangles and squares used in Experiments II and III, even though the lines employed in this experiment were twice as long. Likewise, the single line (B) was visible for a similar duration to those single lines in the other configurations. These observations provide some support for the view that partial line fragmentations are infrequent in complex figures, otherwise it is likely that the single-line durations in the present experiment would have been shorter than in the previous ones, and that the frequency of visibility would have been greater. MacKinnon's (1971) results, derived from a wider range of larger stimuli, speak to the same point.

GENERAL DISCUSSION

Afterimages of simple geometric outline figures exhibit no selective stability of component lines in relation to their orientation. Such was the case for measures of both the frequency and duration of visibility. These results correspond closely to those for the visibility of single lines in isolation (Wade, 1972), as these yielded no evidence of orientation selectivity. The durations of visibility of single lines in Experiments I-III were strikingly similar considering that different

configurations and Ss were used in them; the fragmentation frequency, on the other hand, increased with figural complexity.

Paired line afterimages evidenced no variations in stability with respect to absolute or relative orientation. More specifically, perpendicular pairs were visible for no longer than, and fragmented in a similar manner to, 60-deg line pairs; such was the case when the perpendiculars were vertical and horizontal or both oblique (Experiment I). This result is at variance with those reported for steady fixation and optical stabilization (McFarland, 1968; Schmidt et al, 1971). The discordance may represent some basic difference between the visual effects attendant upon the use of these various methods. Alternatively, additional processes might be operating with steady fixation and optical stabilization which are not present for afterimages. The most obvious possibility in this latter regard is that of retinal image displacement. This is certain to have been produced during steady fixation, but its magnitude under optical stabilization is considerably smaller (Barlow, 1963; Riggs & Schick, 1968). In a previous report (Wade, 1972), it was argued that greater image displacement in a vertical than in a horizontal direction could account for Schmidt et al's results with single lines. Their data with paired lines cannot be so readily interpreted without attaching some additional stability to a vertical line in a pair—an unlikely possibility in view of their data with single lines. However, departures from perfect stabilization in directions other than the vertical and horizontal may have been operative, and these would have influenced the pattern of fragmentations. It seems likely that image displacement was occurring due to the long observation periods employed. Until this possibility can be discounted, it is more parsimonious to assume that the differences in the patterns of fragmentation of stabilized lines are similar, but that those produced by optical stabilization (and steady fixation) are confounded by movements of the stimuli over the retina.

In this regard, it is instructive to examine the experiments in which these methods have been compared (MacKinnon, 1971; MacKinnon et al, 1969), particularly since outline square configurations were employed in both studies. The main differences in the patterns of fragmentation concerned the visibility of parallel lines alone; this rarely occurred with afterimages, but was more frequent under the other conditions. Furthermore, the departures of both the observed whole-figure visibility and disappearance frequencies from predictions based on the independence of line fragmentation were greatest for afterimages. Indeed, in the second study (MacKinnon, 1971), steadily fixated figures exhibited only small departures from the predicted frequencies in comparison to afterimage viewing. MacKinnon et al attributed the differences between the three viewing conditions to retinal image displacement during steady fixation and optical stabilization.

If a similar conclusion is accepted with respect to the differences between the observations of line pairs, then the data using afterimages must be taken as that reflecting the operation of processes in the visual system unconfounded by image displacements. As such, no differences in the pattern of fragmentations were found for line pairs, triangles, and squares in any of the orientations examined. That is, no increased stability of configurations involving perpendicular line pairs was found, nor were lines of a given orientation (vertical or horizontal) more stable than intermediate orientations. Consequently, the decreased fragmentation frequency of vertical-horizontal line pairs found during steady fixation and optical stabilization most probably reflected the pattern of retinal image displacements. This point is of some importance, as the pattern of fading for optically stabilized lines has been attributed to the adaptation of cells within the visual system which respond specifically to line stimuli (Cosgrove, Schmidt, Fulgham, & Brown, 1972; Schmidt et al, 1971). While it is reasonable to assume that image disappearance is related to the adaptation of such line analyzers, attributing differential sensitivity to certain orientations on the basis of the pattern of such disappearance is questionable. Differences in visibility with different orientations may represent the patterns of image displacement, if stabilization is not perfect. It has been argued above that such confounding factors may account for the differences between experiments on optical stabilization and with afterimages. Cosgrove et al (1972) considered that the *similarity* of the patterns of fragmentation with steady fixation, optical stabilization, and afterimages (as determined by MacKinnon et al, 1969) indicated that image displacements were not of great significance. This may be the case for the occurrence of disappearances in general, but it cannot be considered so for the orientation-selective effects that have been examined. Indeed, the more recent investigation by MacKinnon (1971) yielded quite marked differences between afterimages and steadily fixated figures. It could more reasonably be argued that the *differences* between the patterns of fragmentation using the three methods indicate the significance of image displacement in two of them.

With regard to the effect of figural significance on image fragmentation, the results using the steady fixation and afterimage methods are in closer correspondence. Configurations L, T, and V that are steadily fixated disappear for shorter durations when they were described as letters rather than designs (McKinney, 1966), and afterimages of the letters N and Z are visible for longer than their mirror-image reversals. It was suggested above that the way in which figures are described could influence the criterion used by S to report fragmentations. This point might also apply to the afterimage experiment, even though all the configurations were described similarly; the possibility that S modified his criterion upon recognizing certain

afterimages as letters cannot be excluded. However, one feature of the data renders this unlikely: those components that were common to both the letter and its reversal were visible for the same duration. That a similar effect was not produced in Experiment V was due, most probably, to the stability of the pattern and the common oblique shared by both normal and the reversed letter.

CONCLUSION

Afterimages of simple geometrical forms fragment in a similar manner irrespective of the orientation of their component parts, contrary to results found under steady fixation and optical stabilization. However, afterimages of familiar figures resembling letters exhibit greater stability in terms of their durations of visibility than do their mirror-image reversals. This result corresponds to similar effects that have been reported under steady fixation. Differences in the results using the three methods are attributed to image displacements in two of them.

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NOTES

1. The frequency with which neither line was visible in whole form was extracted from the event recording, because the other measures were for visibility rather than disappearance categories. For example, one line might be visible continuously for a given duration while the other line disappears and reappears, say, three times; this would be recorded as three whole-figure visibilities, but only one whole fade at the end of the period visibility of the two lines.

2. The duration measures denote the total time that 1, 2, or 3 switches were depressed. Thus, the duration for a given pair would be at least as long as the duration for all three lines and no longer than the duration of a single-line component. However, the frequencies of visibility of all three lines or paired combinations could be greater than those for their components, in the manner described in Note 1.

Received for publication June 1, 1973;
accepted September 5, 1973.)