However, the high number of pursuit movements significantly differentiated the eyes-closed-imagining conditions from all the rest, eyes-open-imagining, dreaming, and hallucinating conditions.

In another analysis the number of changes in direction of eye movement was compared (irrespective of pursuit or saccadic designation), and no significant differences were found between the following (OR's), the eyes-closed-imagining (CI's), or the eyes-open-imagining (OS's) conditions. When the frequency beat of the eye was compared to the frequency beat of the pendulum, as expected, a 1 : 1 relationship was found for the conditions of watching the real pendulum (WOR, TOR). In both the eyes-closed-imagining (WCI, TCI) and eyes-open-imagining (WOS, TOS) conditions a 1 : 1 relationship was also approached.

Visual imagery involving a beating pendulum may then be accompanied by pursuit or saccadic eye movements, or both. These findings suggest an objective technique for the identification and differentiation of certain types of visual imagery in the laboratory setting.

In this study, pursuit movements consistently developed in the eyes-closed-imagining conditions in the absence of a real moving visual stimulus. In the past, central control of eye movements has generally been discussed in terms of an "inflow" theory (*6*). Initially, this input was attributed to proprioceptive impulses from eye muscles, but the stretch reflex was soon shown to play little or no role in the eye of man (*6*). Such highly integrated mechanisms as must be involved in pursuit might be attributed to input after the development of a retinal image. These observations, however, suggest that a retinal image in itself is neither the necessary nor sufficient condition for the development of pursuit eye movements. Instead, I suggest that the necessary prerequisite for the elaboration of pursuit eye movements is the development of an appropriate cerebral image. This invokes and supports an "outflow" theory of eye movement control (*6*). This concept also accounts for those findings which relate eye movement to the content of dream imagery or to any imagery developing in the absence of a real visual stimulus.

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12. This investigation was carried out under the clinical investigator in psychiatry program of the research service of the Veterans Administration. I thank J. Shurley, V. Pishkin, and L. J. West for their suggestions and support, and D. Lagan and R. E. Brooks for technical assistance.

16 December 1963

Luminous Figures: Influence of Point of Fixation on Their Disappearance

Abstract. *When a simple luminous figure is viewed in a darkened room, parts of the figure seem to disappear. Usually, the part that fades from view is the part on which the viewer's gaze is centered (fixated). Figure parts which are not fixated seldom disappear independently; they are lost to view only if the entire figure disappears.*

McKinney (*1*) has recently reported a striking perceptual phenomenon—when luminous figures are observed in a darkened room, fragments of them disappear and then reappear, the cycle continuing indefinitely. In his initial investigation of these disappearance effects, McKinney demonstrated that subjects report many more disappearances when steadily fixating a point on a figure than when moving their eyes around the boundaries of the figure or when moving their eyes back and forth between a central figure and a peripheral figure.

Although McKinney did establish the significance of fixation as a determinant of the frequency of disappearance, he did not directly investigate the relationship between the particular parts of a figure that are fixated and the subsequent parts which disappear. He compared only the frequencies of disappearance under conditions of fixation and nonfixation.

It is important to study the relationship between loci of fixation and the loci which disappear, because it is the fixation point that may be the primary factor in determining which parts of the figure will be seen to disappear. McKinney has asserted that "disappearance occurred in perceptual units, not at random" and "meaningful perceptual units remained. . ." (*1*, p. 404). There is a critical question, however, as to whether the meaningfulness of the perceived disappearances was inherent in the perceptual process itself or in the scanning and fixating that preceded the perception of disappearances. Since McKinney did not manipulate loci of fixation, it is quite possible that the meaningfulness of the disappearances reported by his subjects was a secondary effect, produced indirectly by the meaningful manner in which his subjects fixated upon the parts of the test figures.

The data in this report indicate that the part of a figure upon which a subject is centering his gaze (fixating) is the part which is most likely to disappear.

These data were collected by tape recording the observations of subjects as they viewed luminous figures in a darkened room. The 2.5-cm lines of the figures (Fig. 1, *A–C*) were painted (*2*) on sheets of violet construction paper measuring 25 × 30 cm. The subjects, who were not previously adapted to the dark, viewed binocularly the individually presented figures while seated 2.7 m from a black display board. The figures used were smaller

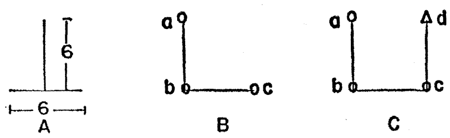

Fig. 1. Sample (*A*) and test figures (*B* and *C*) with points of fixation circled. The units are factors of the basic measurement, 2.5 cm or 1 inch.

vertically and horizontally than those used by McKinney; line width was the same in both studies. Testing prior to the experiments had indicated that with the smaller figures subjects could fixate a point and still easily, without shifting their gaze, see nonfixated points. Also, the smaller figures were less bright and appeared to yield more frequent disappearances.

It should be emphasized that all the figures used, when viewed from a distance of 2.7 m, fell entirely within the foveal area when any of their parts were fixated. The figures used by McKinney extended considerably beyond the fovea.

All 18 subjects were given the same instructions on the sample figure (Fig. 1*A*). They were told simply to report "any changes" they noticed in the figure. All subjects spontaneously reported disappearances.

The subjects then viewed each of the two test figures (Fig. 1, *B* and *C*) for three 2½-minute periods. Twelve of the subjects, those in fixation group 1, looked at a different point on the two figures during each of the six periods. The fixation points used are indicated in the diagrams by circles (the actual figures did not have the points circled). Viewing order was completely counterbalanced across these 12 subjects. They were instructed to fixate on a specific point and to attempt to continue holding their gaze at the approximate position of the point, even if it disappeared.

Table 1. The number of subjects reporting the disappearance of a point when fixated or not fixated on that point, and the number of disappearances reported. (For the 12 subjects in group 1, tested with Fig. 1*B*.)

Points	Subjects (No.)	Disappearances (No.)
Subjects fixated on that point		
a	12	66
b	12	88
c	12	79
Subjects fixated on another point		
a	1	1
b	2	5
c	2	5

In addition, it was emphasized that they were to report disappearances seen anywhere else on the figure and not just point-of-fixation disappearances. The six subjects in group 2 (nonfixation) were told to look at the figure in any way they cared to. The points *a*, *b*, and *c*, and *a*, *b*, *c*, and *d*, were described to them and they were told to refer to those points for descriptive purposes; but they were not instructed to fixate on them, nor were they told not to fixate on them. Group 1, therefore, constituted a directed-fixation group, while group 2 was a free-scanning group.

Between the 2½-minute viewing periods the subjects closed their eyes for 5 seconds. Since the latency of the first reported disappearance in any one period was almost always less than 30 seconds, it was possible when scoring the taped reports to get six complete 2-minute samples from nearly every subject. There were two exceptions, for which the samples were only 1 minute 45 seconds and 1 minute 30 seconds.

Table 1 shows that the subjects in group 1 invariably observed that a point disappeared when they fixated on that point, but almost never observed that a point disappeared when they fixated on another point. (By using the categorization of the subjects and applying a chi-square test for related samples, a value of $p < .01$ is obtained.)

Sixty-four percent of the part-disappearances (Fig. 1*B*) reported by the subjects in group 1 were of the fixation points. The other part-disappearances reported were usually of parts just below or just above the point of fixation, for example, the middle of the vertical when fixated on *a* or on *b*. Sometimes an entire line segment would rapidly disappear, usually beginning at the point of fixation, for example, the vertical line beginning at *a* when fixated on *a*, or from *b* upwards when fixated on *b*. Disappearances of the entire figure were also occasionally reported as well as perceptual tendencies to complete the figures either by perceptually extended lines or by a perceived filling-in of the spaces to produce a solid figure.

The disappearances in Fig. 1*B* for the 12 subjects in group 1, across all three sampled viewing periods, totaled 422; this total includes 57 disappearances of the entire figure. There were 235 fixation-point disappearances, 43 disappearances of nonfixation points, and 87 line disappearances—yielding 365 part-disappearances in all. The most significant aspect of these category frequencies is that line disappearances constitute only 24 percent of the part-disappearances and only 20 percent of the total disappearances; point disappearances, however, constitute 76 percent of the part-disappearances and 66 percent of the total. This preponderance of point disappearances over line disappearances is contrary to what would be expected if the disappearances were caused by the breakdown of neural perceptual units, since lines up to a point of intersection are taken as the basic units of figure perception in the revised Hebbian theory of perception (*3*) to which McKinney relates his results.

Although only the data for Fig. 1*B* are reported in Table 1, the results obtained with Fig. 1*C* were nearly identical. However, an additional interesting comparison between the subjects in groups 1 and 2 can be made from the results for Fig. 1*C*. The directed-fixation subjects in group 1 never fixated upon part *d* and never reported disappearances of that part. In contrast, all of the free-scanning subjects in group 2, during post-experimental interviews, did report fixations upon part *d*, and every subject saw at least three or more disappearances of part *d* during the viewing trials.

Because the results so definitely relate the loci of disappearance to predisappearance points of fixation, they seriously question any claim made about perceptual units or meanings that are revealed by disappearance effects. Most of the orderliness and meaningfulness in the disappearances of luminous figures is probably due to the meaningful ways that subjects scan and fixate upon the figures. If subjects fixated chaotically on random parts of a figure, then the observed disappearances would probably appear chaotic and random.

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4. Supported by a National Science Foundation predoctoral research fellowship. I thank Albert Hastorf of Stanford University for his helpful advice throughout the investigation, and J. P. McKinney for unpublished information about his research.

9 December 1963