M.A. ABSTRACT PSYCHOLOGY

THE EFFECTS OF FIXATION, ATTENTION, AND REPORT ON THE FREQUENCY AND DURATION OF VISUAL DISAPPEARANCES

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Subjects viewed steadily two luminous dots with various instructions as to where to fixate and attend, and what disappearances to report. An analysis of the results showed that the frequency and duration of disappearances was significantly influenced by fixation, attention, and report. A control indicated that the attention effect was not simply due to missing unattended events. It was suggested that these uncontrolled factors might have confounded some of the visual disappearance research results and that attention might be the primary determinant of the meaningful perceptual unit effect.

FIXATION, ATTENTION AND REPORT IN VISUAL DISAPPEARANCES

THE EFFECTS OF FIXATION, ATTENTION, AND REPORT ON THE FREQUENCY AND DURATION OF VISUAL DISAPPEARANCES

by

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INTRODUCTION

The visual disappearance research (Pritchard et al., 1960; Pritchard, 1961) has been primarily concerned with examining the tendency of steadily viewed visual stimuli to spontaneously disappear and reappear in meaningful perceptual units. The disappearances are thought to be due mainly to fatigue at various levels in the visual system, normally counteracted by eye movement but in these experiments deliberately induced by keeping the eye fixed in various ways on the stimuli (McKinney, 1963; Forde et al., 1966). The usual explanation for the perceptual unit effect has been a Hebbian one (Hebb, 1963). In particular, Donderi and Kane (1965) have shown that a common response tends to make different stimuli appear and disappear as units. Others have attempted to explain the phenomenon as simply due to meaningful fixation points (Hart, 1964) or have sought to attribute it primarily to attention (Schwartz, 1964), while still others have implicated report procedures (Dicara and Barmack, 1962).

The purpose of this study was to determine quantitatively the effects of fixation, attention, and report on the frequency and duration of disappearances (disappearance pattern) of steadily viewed luminous dots. The three studies each examining one of these factors in isolation (Dicara and Barmack, 1962; Hart, 1964; Schwartz, 1964) are inconclusive precisely because they fail to control the remaining factors. Exact instructions regarding fixation point do

not prevent the subject's attention from wandering to other points on the stimulus; and even if attention is fixed, the subject is free to report a multiplicity of events, depending on the complexity of the figure. Consequently, to determine the specific contribution of each of these factors to the disappearance pattern it is necessary to control all of them.

In the present study a simple stimulus consisting only of two dots was used, so that the only reportable events were the disappearances of one or the other of the dots. There were precise instructions as to which dot the subject was to fixate, which dot he was to attend, and of which dot or dots he was to report the disappearances.

PROCEDURE

Experiment I

Ten subjects (two McGill undergraduates and eight high school students supplied by a teen-age employment agency) took part in this experiment. They were seated in a dark room 60 inches away from the stimulus. Their preferred eye was open while an eye-patch was worn over the other eye for the duration of the experiment. The stimulus consisted of two small dots of luminous paint 10.5 inches apart on a black background. The angular separation of the dots was 10^{0}. The subjects held in each hand a button which, when depressed, displaced a corresponding pen on an eventrecorder.

The entire procedure was preceded by twenty minutes of dark adaptation. There were six experimental conditions lasting

five minutes each, separated from each other by a further five minutes of dark adaptation. During these five minute pauses the subjects were asked to cover both eyes firmly with their hands while the luminous paint was recharged by illuminating the room.

The instructions for the experiment were given as follows: Subjects were asked if they had ever fixed their gaze on a particular person or object and yet directed all their attention to an event that was occurring in the corner of their eyes. All subjects replied in the affirmative. Then they were told that this experiment concerned examining this ability of people to separate their attention from their fixation. They were told that they would be asked to stare without moving their eyes at two luminous dots and that these dots might disappear and reappear. These disappearances would be reported by depressing the corresponding button whenever the dot went and releasing it whenever it returned. They were further instructed that they would not always be monitoring both dots, but that they would sometimes be asked to pay attention to and report the disappearances of only one of them. Also, the dot which they were attending and reporting would not always be the one they were looking at, and at this point they were reminded that they had claimed to be able to do this. Finally they were told that it was extremely important that they follow the instructions: that their eyes not move from their fixation point, that their attention not wander from the attention point, and that they report only what they were instructed to report. They were further warned to avoid a state of divided attention between the two dots, and that auto-suggestion

might help to counteract this.

There was no direct means of measuring how well the instructions were followed in this experiment. Two indirect measures were used. One was recall of the instructions. This was checked immediately after they were given, after each condition, and after the entire experiment. If the subject recalled the instructions wrongly, his data were not used (only one subject was eliminated this way). A second check was asking the subject after each condition to give a percent figure indicating how confident he was that he had followed the instructions correctly. He was asked to particularly consider how well he had kept his attention where he was instructed to keep it. If his confidence fell below sixty per cent the condition was repeated. Of sixty possible repetitions (ten subjects and six conditions each), three conditions were repeated.

Six combinations of the following instructions were used:
Fixate: left dot, right dot, middle (equidistant from both)
Pay attention to: left dot, right dot
Report the disappearances of: left dot, right dot, or both
The combinations were chosen on the assumption that fixation and attention are entirely separable but that attention and report are only separable to the extent that one might reasonably ask a subject to report both an attended and an unattended event, but not an unattended one alone.

The six conditions, in order of presentation, are described below. Dot A is always on the side of the subject's preferred eye; this compensates for the tendency in the Schwartz experiment (1964)

for there to be more right side disappearances and prevents Dot B from falling on the blind spot of the eye, since the two dots are 10^0 apart on the retina.

Condition	Fixate	Attend	Report (+ middle)
I	A	A	A
II	A	B	B
III	A	B	AB
IV	A	A	AB
V	M^+	B	B
VI	M^+	B	AB

After conditions I, II and V, subjects were asked whether they had kept all their attention where they were instructed. All Ss said yes, Then they were asked if they had noticed whether or not the other (unattended, unreported) dot was disappearing. All replied that they had. They were then told that in conditions III, IV and VI, we would capitalize on this remarkable ability of theirs to notice things to which they were not paying attention by asking them to monitor both lights. They were once again warned not to divide their attention and to report unattended events only to the extent that they are noticed without disobeying the attention instructions.

Experiment II

The second experiment, involving another ten subjects (six McGill graduates, two undergraduates and two students from the teen-age agency), was identical to the first except that the presentation order of conditions was randomized for each subject, and it was preceded by the set of control conditions described below. The stimulus parameters were also slightly different: the subjects were

seated 40 inches from the dots which were 7.5 inches (11^0) apart.

The control conditions were introduced to check whether differences between the disappearance patterns of the various conditions might simply reflect differences in detectability of the disappearances due to the attention instructions rather than to actual changes in the frequency and duration of disappearances; i.e., the dots might always have the same disappearance pattern but in some conditions the disappearances are not detected because the subjects have been told not to attend to them. The control task also served to give subjects practice at following the instructions. The control stimuli consisted of two orange neon lights of the same size as the luminous dots and the same distance apart. They were controlled independently by impulses from two tracks of a tape-recorder which turned them on and off according to a program prepared in advance. Two other tracks fed the same program into the event recorder, displacing one of two pens whenever the corresponding light went off. Two other pens of the recorder were controlled as before by the subject monitoring the disappearances. In this way, the subject's responses could be compared to what was actually happening to determine how well he could detect disappearances in the different conditions. The program used could not exactly mimic the disappearance pattern of the luminous dots, since this varied widely across subjects. Instead it was recorded at a level of complexity slightly higher than that of the most complicated disappearance pattern reported in Experiment I.

In the control conditions the order of presentation of

Experiment I was preserved because of the heuristic value of the progression from condition to condition, which first separated attention from fixation and then report from attention. The conditions lasted two minutes each and were not preceded by dark-adaptation. The pause between conditions was just long enough to test recall of instructions and give the instructions for the next condition. The instruction procedures were the same as in Experiment I. Subjects were also told to regard the disappearances in the control condition in Experiment II as events occurring outside of them, which they could not control but were only passively monitoring while attempting to follow the instructions to the best of their ability.

RESULTS

The results of Experiment I and II were very similar. The data is tabled and explained in Tables I and 2. Ordinal magnitudesof the data from corresponding conditions were the same and the main effects in the analyses of variance were significant in both experiments. The differences in absolute magnitudes were due not only to the different samples, but to slight changes in stimulus parameters and randomization of order in Experiment II. The fact that Experiment II was preceded by the control conditions may also have contributed to these differences. Except in instances of direct comparison of the two Experiments, all further discussion will be restricted to the data of Experiment II which is free of the effect of order.

Of the six conditions, three involved reporting the

Table 1

Mean Frequency and Duration of Disappearances for Ten Subjects in Five Minutes of Testing per Condition for Experiment 1

Condition	Dot	Frequency	Total Duration (sec)
I	FA1	42	80
II	A1	15	24
III	A2	11	26
	F2	21	25
IV	2	10	18
	FA2	26	40
V	AM1	9	12
VI	AM2	10	11
	M2	6	7

Note: Each entry refers to data for a single dot, not to an experimental condition, since some of the conditions included the disappearance patterns of two dots.

F--dot fixated
A--dot attended
1--only this dot reported
2--other dot reported as well
M--fixation point between the two dots

Table 2

Mean Frequency and Duration of Disappearances for Ten Subjects in Five Minutes of Testing per Condition and the Mean Number of Errors in Control for Two Minutes of Testing, for Experiment II

Condition	Dot	Frequency	Total Duration (sec)	Control Errors
I	FAI	28	126	0.13
II	AI	17	52	0.25
III	A2	13	40	0.40
	F2	16	69	0.50
IV	2	10	31	1.00
	FA2	23	84	0.40
V	AMI	9	28	0.00
VI	AM2	8	11	0.25
	M2	3	6	0.75

disappearances of both dots, and three of only one dot. This yielded a total of nine dot disappearance records for each subject which were analyzed in order to yield two measures per record: frequency and total duration of disappearances of the dot in five minutes of testing. The nine records were then categorized (see Table 1) in terms of whether the dot being reported was fixated (F), whether it was attended (A), whether in that condition only one dot was being reported (1) or both (2), and whether in that condition the fixation point was a dot or in the middle (M).

The results (Table 2, Figures 1 and 2) indicate that either fixating a dot or attending it increases the frequency and duration of its disappearance. Reporting the disappearances of more than one dot decreases the disappearances of the dot under consideration, and when the midpoint between the dots rather than a dot itself is the fixation point, disappearances decrease. These effects are independent of one another.

Several two-way analyses of variance (AOVs) were performed with the ten subjects as the repeated measure(Tables 3 and 4). In both Experiments I and II there were significant main effects of Fixation, Attention and Report. The Middle Fixation effect was significant only in Experiment II. The only other difference between the statistical results of the two experiments is that in Experiment II the significance of the main effects increased and the significant interactions vanished. If the primary difference between the two experiments is the fixed order of Experiment I, then it seems that randomizing the order of conditions heightened the main effects and

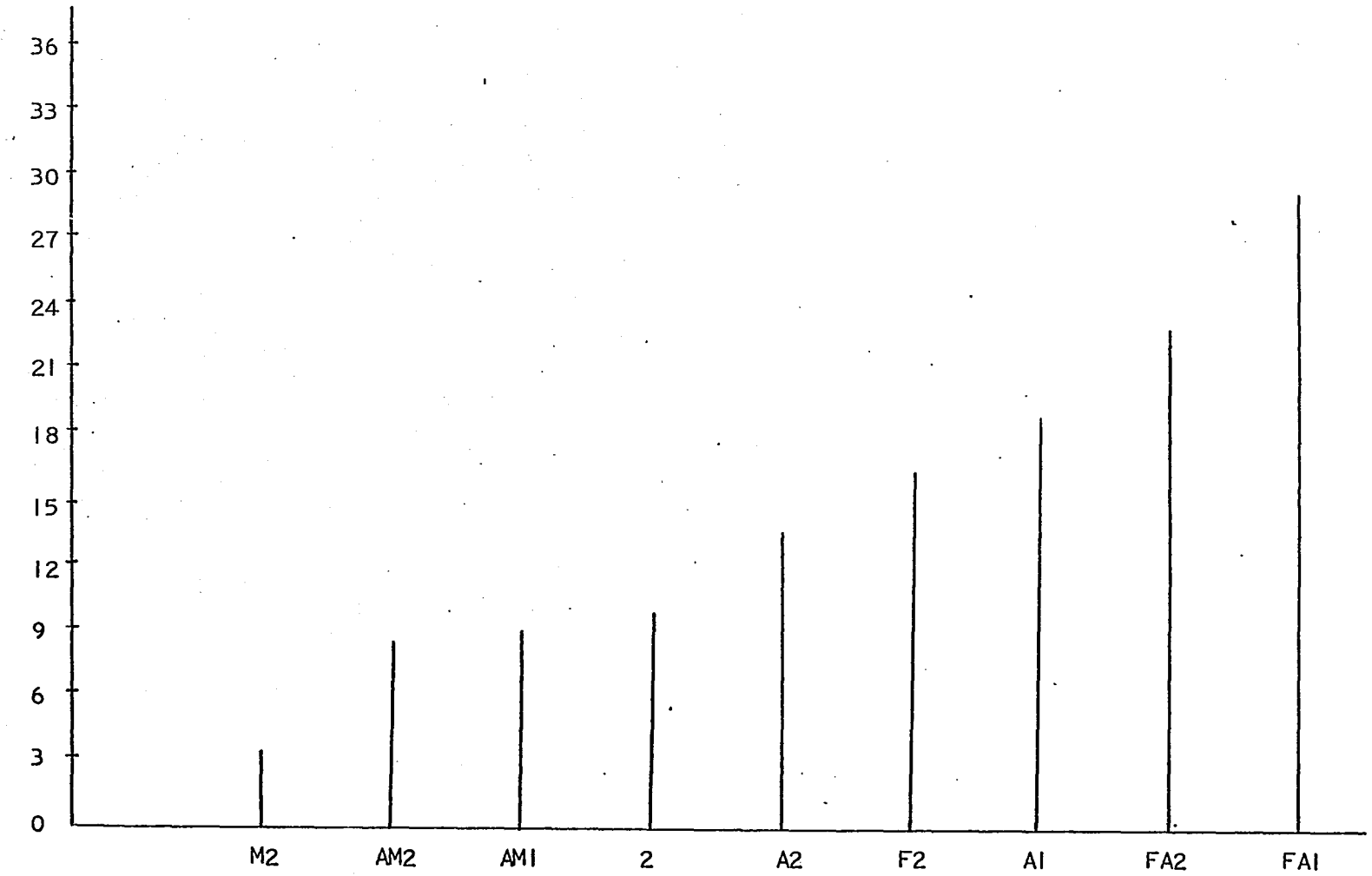

Figure 1. Frequency of disappearances under the different conditions.

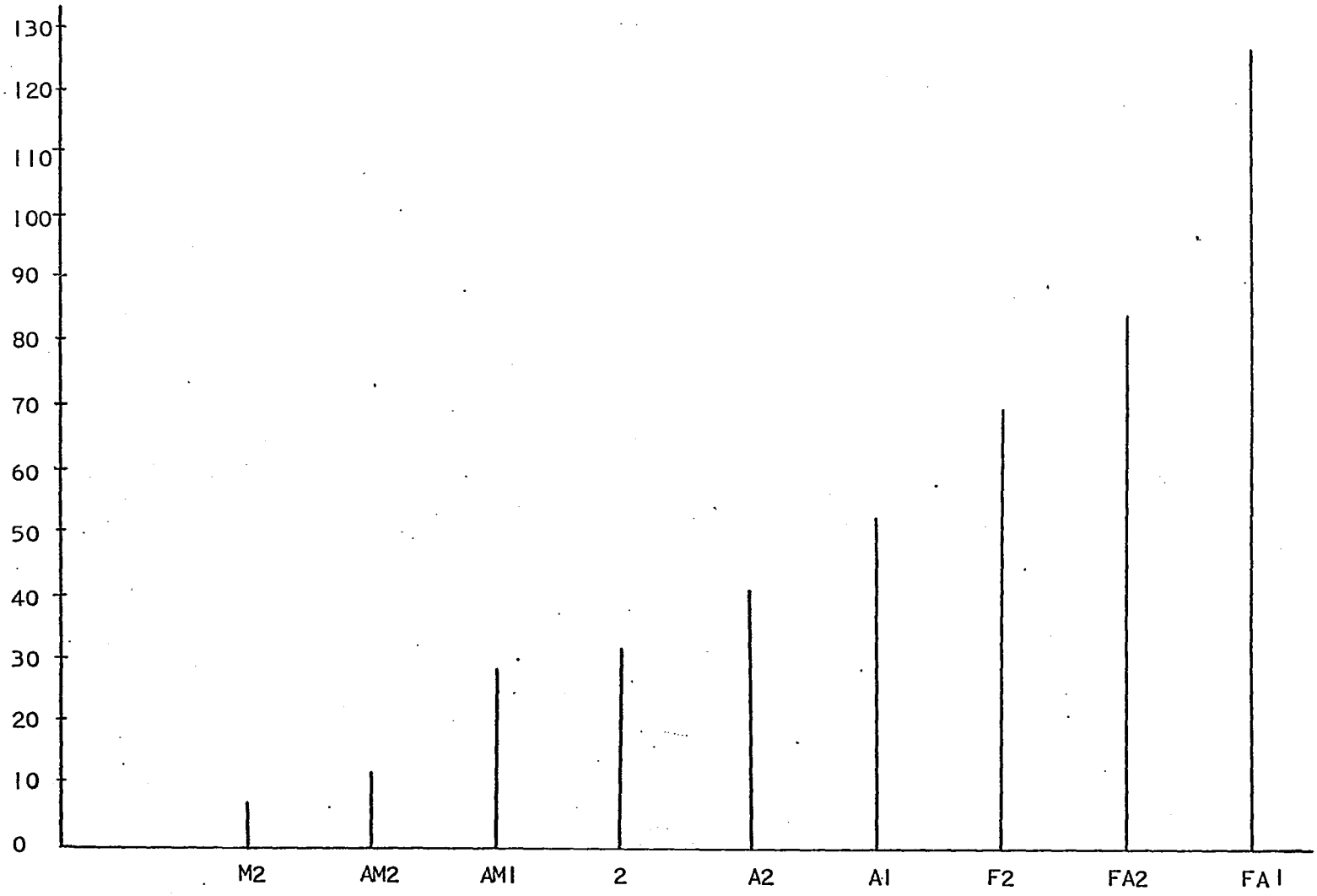

Figure 2. Duration of disappearances under the different conditions.

Table 3

Analyses of Variance for Experiment 1.

Source of Variation	MS	df	Error MS*	df	F-ratio	p<
f vs. a 3 X 3						
Frequency						
f	3870.2	2	202.7	18	19.1	.001
a	712.5	2	100.0	18	7.1	.01
fa interaction	282.2	4	48.6	36	5.8	.001
Duration						
f	11584.3	2	856.7	18	13.5	.001
a	3695.0	2	457.8	18	8.1	.01
fa interaction	2182.1	4	253.1	36	8.6	.001
f vs. a 2 X 2						
Frequency						
f	1690.0	1	222.0	9	7.6	.05
a	96.0	1	73.3	9	1.3	NS
Duration						
f	1600.2	1	708.2	9	2.3	NS
a	950.6	1	236.2	9	4.0	NS
f vs.r 3 X 2						
Frequency						
f	3523.4	2	52.7	18	23.1	.001
r	614.4	1	72.7	9	8.5	.05
fr interaction	337.4	2	65.9	18	5.1	.05
Duration						
f	12666.2	2	723.3	18	17.5	.001
r	3038.9	1	605.8	9	5.0	NS

* subject interaction

Table 4

Analyses of Variance for Experiment II.

Source of Variation	MS	df	Error MS*	df	F-ratio	p<
f vs. a 3 X 3						
Frequency						
f	485.9	2	66.4	18	7.3	.01
a	1932.8	2	158.8	18	12.2	.001
Duration						
f	2196.7	2	204.6	18	10.7	.001
a	11786.7	2	1373.1	18	8.6	.01
f vs. a 2 X 2						
Frequency						
f	221.0	1	38.2	9	5.8	.05
a	640.0	1	122.3	9	5.2	.05
Duration						
f	366.0	1	77.1	9	4.8	NS
a	182.0	1	412.9	9	0.4	NS
f vs. a 2 X 3						
Frequency						
f	340.8	1	65.2	9	5.2	.05
a	1041.1	2	103.2	18	10.1	.01
Duration						
f	370.0	1	87.8	9	4.2	NS
a	5875.2	2	1019.5	18	5.8	.05
f vs. r 3 X 2						
Frequency						
f	1516.5	2	130.0	18	11.7	.001
r	156.8	1	34.3	9	4.6	NS
Duration						
f	9492.6	2	974.1	18	9.8	.01
r	2053.3	1	299.2	9	6.9	.05
m vs. a 2 X 3						
Frequency						
m	707.3	1	132.6	9	5.8	.05
a	192.6	2	44.3	18	4.3	.05
Duration						
m	2535.0	1	168.6	9	15.0	.01
a	608.5	2	187.2	18	3.2	NS

* $\overline{\text{subject}}\overline{\text{interaction}}$

eliminated the interactions.

The structure of the analyses of variance is as follows.

The overall analysis:

3 X 3 Fixation (f) vs. Attention (a)

	a		
FAI	FA2	F2	
AI	A2	2	f
AMI	AM2	M2	

The subanalyses:

2 X 2 Fixation vs. Attention

a	
FA2	F2
A2	2

f

2 X 3 Fixation vs. Attention

a		
FAI	FA2	F2
AI	A2	2

f

3 X 2 Fixation vs. Report (r)

r	
FAI	FA2
AI	A2
AMI	AM2

f

2 X 3 Middle Fixation (m) vs. Attention

	a	
AI	A2	2
AMI	AM2	M2

m

The overall 3 X 3 AOV of Fixation vs. Attention was set up considering divided report (i.e., reporting more than one dot in a condition) to be a decreased level of attention, and Middle Fixation to be less reliable fixation. A subsidiary 2 X 3 AOV excluding data for middle fixation and a 2 X 2 holding divided report constant (excluding data for undivided report) were also performed. There were significant main fixation and attention effects in all of these analyses. Two further subsidiary 2 X 3 AOVs of Report vs. Fixation, and Middle Fixation vs. Attention also showed both main effects to be significant in each case.

No statistics were performed on the control data, since there was an average of less than one error per condition (Table 2).

DISCUSSION

Figures 1 and 2 illustrate the contributions to frequency and duration measures of the factors that appear to produce these disappearances. First, there is more disappearance at the fixation point than elsewhere in the stimulus. This may be due to the fact that the fixation point is in the foveal area of the retina where the cells might fatigue more rapidly than in the periphery. There are also more overall disappearances if the fixation point is a dot, rather than the blank point between the dots. Two possible explanations of this effect suggest themselves. It may be due to greater difficulty in keeping the eye fixed on an empty space rather than a dot, or it may be due to a single engram representation of both the fixation point and the attention point (since they are both dots) at some level of the visual system. If the fixation point were a blank, there would be less input to this engram, and less overall disappearance of either dot.

The next observable effect is that of report. If more than one dot is reported, the overall frequency and duration of disappearances decreases. The fact that this is not a performance artifact, in the sense that with divided report less disappearances are noticed, is discussed with the control results below. The report effect may be an independent one, indicating that response set can influence the disappearance pattern, or the effect may itself be due to decreased attention on the required dot whenever others must be reported as well. Attention itself is the final factor which appears to be operative. Wherever attention is directed, disappearances

increase (contrary to Hebb's prediction [1962] that attention has a supporting effect). This too is shown by the control results not to result simply from disappearances going unnoticed when unattended.

The relative magnitude of the fixation and attention factors requires some consideration. The 2 X 3 AOV for fixation vs. attention (Table 4) is presumed to be the most representative of the true effects of these factors for two reasons. First, the middle fixation condition should not be included as the lowest level of fixation because the m factor decreases overall disappearances of both attended and unattended dots. This means that m is not simply a fixation factor, restricted to the fixated dot, but some sort of general effect of unstable fixation. On the other hand, the very same reasoning suggests that the undivided report should be included as the highest level of attention. Since divided report decreases overall disappearances of both dots, it suggests that attention and report may not be totally separable, and that with divided report attention is to some extent shared between the two dots even though it is directed predominantly to the attended one.

On the basis of the above reasoning, A1 is the highest level of attention and the zero level of fixation, whereas F2 is the highest level of fixation and the lowest level of attention. Ideally, an F1 condition would represent a zero level of attention, but as mentioned in the Procedure, it was not considered feasible for a subject to report only an unattended event and still obey the attention instructions. If the frequency and duration data for these

two conditions are examined in Table 2 it will be found that they are approximately equal and, as expected from the absence of an interaction effect, combine additively in the joint highest level for both factors, FAI. This means that the contributions of fixation and attention to the frequency and duration of visual disappearances are approximately equal and additive.

One possible objection to these conclusions is that the attention effect is an artifact of the report instructions. That is, the reason unattended dots are reported as disappearing less is that the disappearances are simply not noticed as reliably by the subjects. The control conditions were included to answer this argument. It is obvious by inspection (Table 2) that although errors are slightly higher when a dot is unattended, this could not possibly account for the magnitude of the experimental attention effect. Even with the highly complicated control disappearance pattern, subjects averaged less than one error per condition and differences between conditions were of the order of one tenth of an error.

The implications of these results are two-fold: experimental and theoretical. Experimentally, they reflect on previous results and conclusions in visual disappearance research. Since the fixation factor and especially the attention and report factors are not usually explicitly controlled in these experiments, it is not known how they interact to produce a particular disappearance pattern.

Suppose that a subject is asked to look steadily at a complex luminous stimulus; and suppose for the sake of argument

that he is instructed to maintain a particular fixation point. Now the report instructions might involve a mental partitioning of the stimulus (with the accompanying undesirable suggestion effects) such as "report whenever events A, B, C ... occur;" or else report might be left open-ended, such as "report any changes that you might notice." But whether imposed or ad lib, the Ss report tactics will surely affect the disappearance pattern. Similarly, and to an even greater extent, his attention tactics will influence the disappearance pattern. All these confounding factors are present even if the subject assiduously maintains his fixation point.

As examples of this sort of pitfall in research in this area one can make the interpretation that in the experiments of Donderi and Kane (1965) the common response effect was actually due to implicit attention and report tactics on the part of the subjects; i.e., that they were attending to the three stimuli as if to two: the pair with the common response, and the third one. Consequently, the increased disappearances due to attention would not be distributed equally across the three stimuli but would be divided equally between the pair with the common response and the third stimulus. The report factor might also have been at work by making the subjects view the disappearances more as two events to be reported, rather than three. Similarly, in the Pritchard experiments (1961) the HB effect may be due to paying attention to meaningful units and reporting predominantly these. Harnad (1967) noted that if a figure is predominantly geometrical, it tends to disappear in geometric units, whereas if it is predominantly alphamerical, it tends to

disappear in alphameric units, even though there are units of the other type embedded in both figures. The overall impression of the figure affects how you attend to it and what response set you use.

The problems of experimentation involving these factors may not be solved by attempting to control all of them by instructions because it cannot be assumed that they are entirely controllable: in particular the attention factor. In the present experiment sixty per cent confidence in following the attention instructions was sufficient to produce the significant attention effect. But in a more precise experiment seeking to examine some effect independent of attention, the uncontrolled forty per cent might be sufficient to distort the results.

As for the fundamental visual disappearance phenomenon, spontaneous disappearance in meaningful perceptual units, it is quite possible that the meaningfulness is a function of fixation, attention and report tactics. But the partial uncontrollability of attention is of interest because it means that the phenomenon might still be a spontaneous one, not entirely under the control of the subject. The theoretical implication of these results then, is that it is through the medium of attention that the perceptual unit effect makes itself felt. Recall that in the Hebbian (1963) view, perceptual units are first established by motor responses, eg., fixating various points of a triangle. Then the engram is supposed to become partially independent of stimulation and response. Imagery becomes possible. It is aided by imagined eye movements, or mentally moving the fixation point along the image. Not only

does the image and its engram become independent of stimulation, but so does the scanning process itself. It is no longer a motor process, but an internal one. It is also not entirely voluntary, but dependent on past experience as the research on left-right scanning (Heron, 1957; Orbach, 1967) indicates. But this independent and semi-voluntary scanning mechanism is actually what we mean by attention.

In an experiment suggested by Hebb (Harnad, 1967), subjects were instructed to fixate the end of a luminous line and imagine eye-movement toward the other end. The line was found to roll up and disappear toward that end. It was hypothesized that the rolling effect might constitute the last phase of the reverberation of a cell-assembly which was originally established by motor responses and could now be activated by imagined motor responses. But what the subjects may actually have been doing was shifting their attention toward the other end of the line. The attention factor may have determined the disappearances. Thus it appears that the perceptual unit phenomenon still stands, although it appears to be governed largely by attention which in turn is governed by past experience.

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