"Parts" of perceived visual forms: New evidence¹

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Using the methods for producing partial and total disappearance and reappearance of visual stimuli, evidence has been obtained that both angle and straight line "parts" of rectilinear outline forms disappear, and that when "part" stimuli are presented singly, straight line and acute and obtuse angle "parts" disappear with higher frequency than a right angle "part". This evidence provides some support for the propositions that perceived outline forms are composed of both straight line and angle "parts" and that the high in toto disappearance of "spiky" forms may be related to the high disappearance of the "parts" composing such forms.

In order to study "part-whole" relations in visual form perception, a "part" response must be defined. Recently, there have been reports that subjects see partial and complete disappearances and reappearances of outline visual forms presented by appropriate methods. Three methods have been used. Forms have been presented: (a) in a manner to result in an after-image; (b) by means of a focusing system attached to a scleral contact lens; and (c) as a luminous target in a dark room. Methods (a) and (b) stop the stimulus on the retina despite eye movements; method (c) permits the stimulus to move on the retina as eye movements occur. All three methods have been used with different groups (Bennett-Clark & Evans, 1963; Evans, 1965; McKinney, 1963; Pritchard et al, 1960) and with the same group of subjects (Forde et al, 1966); subject protocols are essentially the same across methods of presenting the forms.

Employing these methods for presenting rectilinear forms, Hebb (1963) and Pritchard et al (1960) have defined the report of partial disappearance as a "part" response; the particular portions of forms which disappear is taken as an index of the "parts" composing the perceived "whole" form. The investigation of Pritchard et al in 1960 was initiated in order to develop support for Hebb's speculations (1948) concerning the "parts" of perceived "whole" forms. Their finding that line portions disappear and angle portions do not disappear was unexpected since, according to Hebb, "My own ideas about 'perceptual elements,' as in the Organization of Behavior, would have led me to expect that angles were more important than lines and I was surprised to get no support for this in the disappearances with outline figures, though there was some with filled-in ones, where corners tended to have more independent existence than sides (personal correspondence)."

At present, although as noted by Hebb himself (1963), others have reported that both line and angle portions of rectilinear outline forms disappear (Eagle & Klein, 1962), the Hebb position appears to be that the straight line is the primary perceptual "part." Experiments 1 and 2 provide evidence which is in conflict with the Hebb position but which is compatible with the position that rectilinear forms are composed of both straight line and angle "parts" (McFarland, 1965, 1967). Subjects in these experiments report the disappearance and reappearance of both straight line and angle portions of triangle and square outline forms. Experiment 3 provides evidence to support the position that the rate of a "whole" form's disappearance is some function of the disappearance rate of the straight line and angle "parts" composing the form. In these terms an explanation is possible for the fact that forms with "spiky" perimeters disappear in toto with high frequency as has been reported by Pritchard et al (1960) and confirmed by Evans (1965).

EXPERIMENT 1

The first study is an attempt to replicate the finding that angle portions of outline forms do not disappear and reappear.

Method and Procedure

The method (b) and form used are the same as those used by Pritchard et al; the subject views a transilluminated negative, the unexposed portion of which is an outline square, mounted in a focusing system which is attached to a scleral contact lens worn by the subject in front of the preferred eye.

A female subject, who has worn corneal contacts for a period of three years, serves as a subject. (A scleral contact lens was molded and fitted by an ophthalmologist and she had no difficulty wearing the tight-fit scleral contact for periods of 30 min.) She is paid for time required to fit the contact lens, time in the laboratory to practice inserting and wearing the lens, and time required for testing. The subject views the form, an outline square with 1° sides, for 10 min while in a supine position. Before the first viewing, the subject is instructed: "you may see the entire form disappear and reappear. If you see the entire form disappear, say 'all gone' when it disappears and 'all back' when it reappears. If you see a portion disappear and reappear, identify the line or angle portion by using right, left, top and bottom when you say 'gone' and 'back.' So, if the right side disappears and reappears, say: 'right line gone and back'; if the right bottom angle disappears, say: 'bot-

Table 1. Part Disappearances while Viewing Stabilized Forms

Form	Part	Mean Frequency 10 min Viewing
SQUARE	Line	37
	Angle	3
	Line and Angle	4
	Equivocal	9
TRIANGLE	Line	26
	Angle	9
	Line and Angle	9
	Equivocal	7
PLUS SIGN	Line	30
	Angle	0
	Line and Angle	0
	Equivocal	0

tom right angle gone and back.'" Reports of the subject are tape recorded and transcribed.

Results

Analysis of the transcription is in terms of four categories of partial disappearance: line (one or more entire lines), angle (one or more of the intersecting ends of adjacent lines), line and angle, equivocal (one or more nonintersecting ends of lines).

Line disappearances are most frequent, 70% of the total; but angle disappearances do occur (Table 1). Puzzled by the absence of correspondence between the reports of this one subject and the subjects of Pritchard et al (1960), a second, male subject was fitted with a scleral contact and both subjects viewed an equilateral triangle (1° sides) for 10 min each, and a plus sign (2° horizontal and vertical lines) for 10 min each on three separate occasions. Instructions to the subjects are the same as those described above.

For the triangle, both line and angle portions disappear, however for the plus sign, only line portions disappear (Table 1).

EXPERIMENT 2

In order to increase confidence in the finding of Experiment 1 that angle portions of some outline forms do in fact disappear, another method (c) of producing disappearances is used in this study. This study also serves as an attempt to replicate the finding of McKinney who, using this method, has also reported that angle parts of an outline triangle do not disappear (1963).

Method and Procedure

Nine subjects view, in the dark, a dim outline equilateral triangle (1° sides) for 5 min each and are instructed as the subjects in the first experiment. Subject reports are tape recorded and transcribed.

Results

Analysis of the transcriptions for these subjects shows that line and angle portions disappear; and there is no significant difference in frequency of disappearance (Table 2). Two subjects do not report angle or line dis-

appearances, three subjects report a higher frequency of line disappearance, two subjects report a higher frequency of angle disappearance, and two subjects report an equal number of line and angle disappearances.

The results of the first experiment and these results do not confirm the findings of others that angle portions of outline forms do not disappear. Results of these two experiments show that with methods (b) and (c) for producing disappearances, both angle and line portions of an equilateral outline triangle disappear. One possible explanation of the discrepancy between my results and those of others is a difference of instructions to the subjects. My subjects are instructed that angle and line portions of the form may disappear and reappear; however, from the procedures of other published reports it is impossible to tell what kind of instructions are given to the subjects.

EXPERIMENT 3

Given my results, the fact that outline forms with "spiky" perimeters disappear with a high frequency, as has been reported by Pritchard et al and confirmed by Evans (1965), may be due to the frequency with which portions of "spiky" forms disappear. In other words, the rate of a form's disappearance in toto may be some function of the disappearance rate of the "parts" composing the form. In order to test this explanation, the "part" composition of "spiky" and "non-spiky" forms must be decided; and the disappearance rate of these "parts" determined. If "parts" composing a "spiky" form disappear with a higher frequency than "parts" composing other forms, then support for this explanation of the high in toto disappearance of "spiky" forms is obtained.

From a consideration of the "spiky" forms used by Pritchard et al and Evans, the distinguishing mark is the absence of any right angle "part." Consider for example the starfish form used by Evans. This form can be considered composed of three types of "parts": straight lines (eight), acute angles (four), and obtuse angles (four). In this experiment, these three types of stimuli and a fourth type of stimulus which does not appear in "spiky" forms, the right angle, are presented singly using method (c). The stimuli can be considered to form a series of different sized angles: 30° , 60° , 90° , 120° , 150° , and 180° . The expectation is that acute angle (30° and 60°), obtuse angle (120° and 150°) and straight line (180°) stimuli will disappear with higher frequency than the right angle stimulus (90°).

Table 2. Part Disappearance while Viewing Unstabilized Forms

Form	Part	Mean Frequency 5 min Viewing
TRIANGLE	Line	9.5
	Angle	5.6
	Line and Angle	0.0
	Equivocal	1.1

Fig. 1. Mean disappearance frequency as a function of angle size—5 min viewing.

Method and Procedure

Twelve subjects in a dark room view each of the six stimuli (which are all 1° in perimeter) for 5 min with 5 min rest periods between viewings. Stimuli are counterbalanced in a 6 by 6 Latin Square design with one male and one female in each of the six sequences. Subjects are instructed: Press the key when the entire stimulus disappears; release the key when the entire stimulus or a portion of the stimulus reappears." Both frequency and duration of complete disappearance of the stimuli are recorded by means of Hunter Klockcounters.

Results

Frequency and duration are positively correlated across stimuli and the mean duration of a disappearance is about 1 sec, ranging from .86 to 1.11 sec. The variance of mean frequency is significant ($F = 3.27$, $df = 5/25$, $p < .05$); the variance of mean duration is not significant ($F = 1.55$, $df = 5/25$, $p > .05$). T tests show that mean frequency for the 90° angle is significantly different ($p < .05$) from mean frequency for all other stimuli which do not differ significantly from each other (Fig. 1). Of the 12 subjects, the number showing lower frequency for the 90° angle relative to the other stimuli is: 9 for 30, 60, 130, and 180° stimuli; and 11 for the 150° stimulus. The sign tests are significant at $p < .05$.

The results of this third experiment support the explanation that the high disappearance rate of "spiky" forms, composed of line, acute angle, and obtuse angle "parts" may be related to the lack of right angle "parts."

DISCUSSION

The findings of the three studies provide evidence that both line and angle "parts" of outline rectilinear forms

disappear and that when "part" stimuli are presented singly, line and acute and obtuse angle "parts" disappear with a higher frequency than a right angle "part." This later evidence provides support for the explanation of the high in toto disappearance rate of "spiky" forms, viz., such forms disappear with high frequency as they are composed of "parts"² which disappear with high frequency.

If the type of partial disappearance of outline forms can be used as an index of the "parts" composing perceived outline forms as Hebb and colleagues assume, then the results of these studies show that rectilinear outline forms are composed of line and angle "parts." Insofar as these results support the proposition that the rate of a form's disappearance in toto is some function of the disappearance rate of the "parts" composing the form, then these results provide some support for the proposition that the perceived "whole" form is equal to the sum of the perceived "parts" composing the form.

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Notes

1. The first experiment was supported by Denver Research Institute, second and third experiments were supported by PHS Grant MH 12449.
2. These results are compatible with the findings that there are different single units in the visual cortex of cats which respond optimally to straight line and angle stimuli, D. H. Hubel & T. N. Wiesel, *J. Neurophysiol.*, 1965, 28, 229-289, and that human subjects utilize the "variance of the distribution of straight lengths in the perimeter" and the "number of turns in the perimeter" of forms in judging similarity among forms, H. H. Stenson, unpublished manuscript.

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