fied by the presentation of a strong stimulus depends on many factors in addition to the nature of the stimulus. One important determinant of the effects of a stimulus is the manner in which it is scheduled; that is, the manner in which its presentation is related to responses. Electric shocks of the intensity that maintained responding in the present experiments could quite effectively suppress responding under other circumstances, for example, if a shock followed *each* response.

The development and maintenance of responding in a situation in which the only consequence of responding is the delivery of electric shocks also depends upon the history of the experimental subject and upon the ongoing behavior at the time the shock schedule is introduced. An untrained animal exposed immediately to the fixed-interval schedule of shock-presentation would have little tendency to press the response key. Similarly, an animal that had been trained only under a schedule in which each response produces food would quickly cease responding if the response requirement were abruptly increased to several hundred, but would develop a stable pattern of responding if the requirement were increased in gradual steps to the same value. Thus, a dependence of schedule-controlled performance upon prior behavior is not peculiar to experiments involving electric shock.

The present experiments, in which responding was maintained initially by shock-postponement and then by shock-presentation, emphasize that stimuli do not have immutable qualities; the way in which behavior is affected by even a strong stimulus is not invariant. The schedule of presentation, and the ongoing behavior at the time the schedule is imposed, are critically important determinants of the effects of electric shock on behavior.

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References and Notes

1. W. H. Morse, R. N. Mead, R. T. Kelleher, *Science* **157**, 215 (1967); Morse and Kelleher have carried out a variety of experiments on behavior maintained by schedules of electric shock-presentation; some of these will be reported in *Theories of Reinforcement Schedules*, W. N. Schoenfeld, Ed. (Appleton-Century-Crofts, New York, in press).
2. D. F. Hake and N. H. Azrin, *J. Exp. Anal. Behav.* **6**, 297 (1963).
3. M. Sidman, *Science* **118**, 157 (1953).
4. C. B. Ferster and B. F. Skinner, *Schedules of Reinforcement* (Appleton-Century-Crofts, New York, 1957).
5. B. F. Skinner, *The Behavior of Organisms* (Appleton-Century-Crofts, New York, 1938).
6. J. Dollard and N. E. Miller, *Personality and Psychotherapy* (McGraw-Hill, New York, 1950); O. H. Mowrer, *Learning Theory and Behavior* (Wiley, New York, 1960); G. A. Kimble, *Hilgard and Marquis' Conditioning and Learning* (Appleton-Century-Crofts, New York, 1961).
7. F. S. Keller and W. N. Schoenfeld, *Principles of Psychology* (Appleton-Century-Crofts, New York, 1950).
8. N. H. Azrin and W. C. Holz, in *Operant Behavior: Areas of Research and Application*, W. K. Honig, Ed. (Appleton-Century-Crofts, New York, 1966), pp. 380–447.
9. W. C. Holz and N. H. Azrin, *J. Exp. Anal. Behav.* **4**, 225 (1961).
10. R. J. Herrnstein and W. H. Morse, *Science* **125**, 929 (1957); L. R. Gollub, *J. Exp. Anal. Behav.* **7**, 337 (1964).

11. This work supported by grants MH 02094, MH 07658, and training grant 5 TI MH 07084, all from the USPHS. I thank Drs. W. H. Morse, R. T. Kelleher and P. B. Dews for helpful comments.

6 May 1968

Visual Perception and Xerography

Abstract. *An electrostatic copying machine was used to model the perception of simultaneous brightness contrast. Such a model may assist the study of sensory inhibition by permitting the study of complex situations as they are transformed by rules similar to those at work in neural integration.*

A century ago Mach showed that in human vision perceived brightness effects are related to the second derivative of the physical luminance distribution of the stimulus and described what are now known as Mach bands (*1*). Even though the stimulus distribution contains no discontinuities, the observer may still experience clearly demarcated stripes or bands. Ratliff has pointed out that a similar phenomenon occurs in such physical optical systems as the xerographic process (*2*). We think that this coincidence is a fortunate one, for it allows one system to be used as a model of the other.

A hallmark of xerographic copies is the "edge-only effect" whereby only the edge of wide areas is copied. Grundlach has described methods for obviating this Mach-bandlike effect (*3*). Broad areas are uniformly charged on the xerographic plate, but they can be transformed into an array of dots or lines which are then developed by edge-fields, through masking the original stimulus during projection, through selectively discharging the plate surface, or through initially charging the plate in a screen pattern.

We may compare these techniques to ones that have been discovered in the history of vision research for affecting the visibility of contrast effects: the dependence of the perceived brightness in one visual-field location on the brightness in another location. With a stimulus such as that shown in Fig. 1 a classical demonstration of simultaneous brightness contrast in hu-

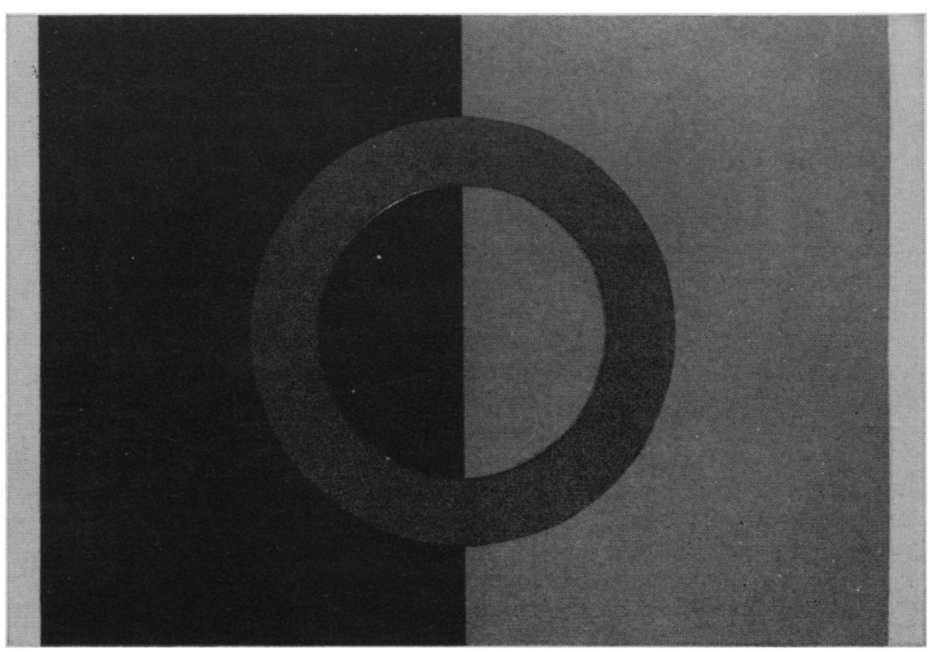


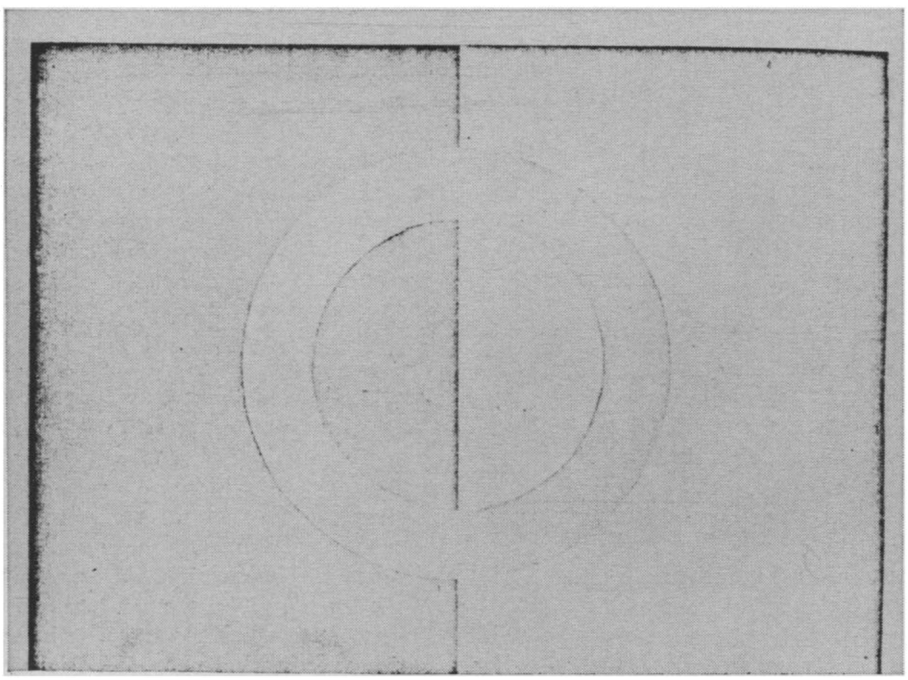
Fig. 1. A photograph of the original stimulus.

man vision is possible. The stimulus is a ring of medium gray (Munsell N5) on a background half somewhat lighter (Munsell N6) and half somewhat darker (Munsell N4). The photograph gives a fairly good picture of the original stimulus, in which the background measured 9 cm high and 12 cm wide with a ring 1 cm wide and 6 cm in diameter at its outside edge placed in the center of the background. Few observers see any lightening of the ring on the dark side or any darkening of the ring on the light side of the original stimulus. Similarly, there is no substantial difference in brightness between the two halves of the ring in a xerographic copy of the original stimulus (Fig. 2). Figure 2 illustrates, however, the edge-only effect of xerography. The electrostatic office dry copier used was a Xerox Model 2400.

Woodworth described the methods that can be used to make simultaneous brightness contrast quite obvious in such a stimulus as that photographed in Fig. 1 (*4*). His account combines clear method with dubious theory. He notes that ordinary viewing is likely to give slight contrast effects. However, covering the whole stimulus with white tissue paper or gauze makes the contrast striking, and even holding the stimulus close to the eye so that contours and texture are out of focus will favor the effect because the "field is deprived of object character."

When a woven fiberglass screen, 20 squares per inch, is placed over the original stimulus there is a vivid perceptual contrast effect. The half the ring on the dark side appears lighter than the half the ring on the light side. Now we are prepared to consider a xerographic copy of the original stimulus taken while it was covered by the fiberglass screen. This xerographic copy is photographed in Fig. 3. Now indeed the half the ring on the light side is copied darker than the half the ring on the dark side. The difference in the halves of the ring is an objective difference.

We began with a stimulus which was carefully chosen to show no great difference in the induced brightness on the halves of the ring for the eye as compared to the xerographic copier. We added to that stimulus a screen that made the halves of the ring different in brightness; in perception the difference is a consequence of subjective response to the workings of complex interactions in neural networks behind the retinal surface, whereas in the xerographic copy it is a consequence of the objective effects of electrostatic fields in the xerographic plate which are mapped in the xerographic copy.



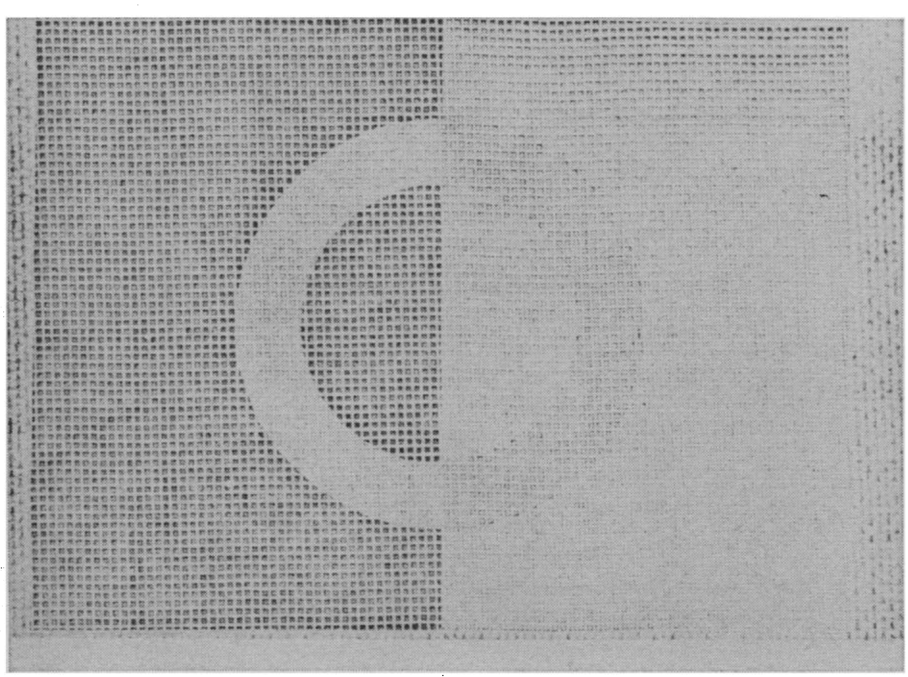


Fig. 2 (top). A xerographic copy of the original stimulus. Fig. 3 (bottom). A xerographic copy of the original stimulus with an interposed screen.

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References and Notes

1. E. Mach, *The Analysis of Sensations* (Dover, New York, 1959).
2. Floyd Ratliff, *Mach Bands* (Holden-Day, San Francisco, 1965), pp. 241–44.
3. R. W. Grundlach in *Xerography and Related Processes*, J. H. Dessauer and H. E. Clark, Eds. (Focal Press, New York, 1965), p. 276.
4. R. S. Woodworth, *Experimental Psychology* (Holt, New York, 1938), p. 568.
5. We thank Jack Botwinick, Alberta Gilinsky, Marcel Kinsbourne, and Robert Peckham for aid and encouragement in the formulations leading to this report.

13 May 1968