it had been in the experiment proper; this was followed by the four steps already described. Recognition was scored when a subject indicated he saw a duck, goose, swan, or, on the last trial, correctly indicated the location of the duck. A tally was made of the successful subjects at each step.

It should first be remarked that no subject spontaneously reported seeing the duck during the experiment proper. Of the 310 subjects, only one experimental and one control subject reported the duck on the first step—that is, after the same exposure as they had had in the experiment proper. Even at step 4, with a 30-second exposure and the information that "there is a duck somewhere in the picture," well over half the subjects failed to recognize the duck.

The presence of duck associates in the images was analyzed in relation to (i) the step at which the duck was recognized and (ii) recognition or failure to recognize the duck at any threshold step. In neither analysis did the chi-squares approach statistical significance. Thus it is evident that the ease or difficulty of recognizing the duck stimulus or, in fact, ability to recognize it at all had no bearing on the probability that duck associates would appear in the images.

It could be argued that subjects in fact consciously perceived partial cues (such as the duck's beak) from the hidden figure but did not report them, and that these cues would influence subsequent imagery. This argument cannot be entirely ruled out, but it is made less tenable by the fact that even after many exposures (six for the 1-second group and nine for the 1/100-second group) and the hint that "there is something in addition to the tree," only 9 of the 148 experimental subjects reported the presence of a duck, and no subject reported any partial cues related to duck. Nevertheless, the partial-cue argument is in a sense unanswerable, for it is always possible that unreported "fleeting" perceptions occurred. But perceptions too fleeting to be reported would seem to be operationally indistinguishable from stimulus registrations without awareness.

The fact that the 1-second exposure yielded a more clearcut effect than the shorter exposure suggests that greater opportunity to view the stimulus configuration is an important factor in obtaining the reported effects. Since the 1/100-second exposure allowed only a single fixation, it is likely that the subjects in that part of the experiment more often failed to view the background elements in the picture.

We propose the following hypothesis: The concealed duck registered, and it primed associations, that is, increased the probability of their occurrence (*5*). The nature of the task—that is, to form an image—allows the subject considerable latitude in the content of his responses. The emergence of particular contents associated with duck was encouraged by their congruence with the theme of a nature scene. Thus the instructions enabled the otherwise weak activations of the background stimulus to have some biasing effect. The experiments illustrate, then, a condition for the intrusion of a peripheral, concealed form: when both intended response and incidental activations are congruent in themes, and when the task is one that allows for a multiple response, there is created a setting favorable to intrusion of background, unattended elements of the stimulus into the stream of conscious thought.

Whether one conceptualizes the registration process of the concealed form as "fleeting" perception or discrimination without awareness, the results call into question the notion that a background form is a stimulus only insofar as it contributes to the perception of the phenomenally dominant figure, or becomes a dominant figure itself as a result of figure-ground reversal. Rather, the results suggest that the background can be independently registered, and that it is capable of influencing, under certain conditions, the subject's response to the total configuration.

Very likely the background form is only ground in regard to the perceptual experience of the dominant figure, as Gestalt psychology emphasized. We are suggesting, however, that connotative aspects of the ground, although apparently unperceived, may become manifest in nonperceptual response modes such as imagery. Thus, the figure–ground differentiation may be less relevant in accounting for the effects of registration than in accounting for the preferential selectivity of conscious perception.

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2 December 1965

Computer Stereography

Finkle's letter about computer production of Lissajous figures [*Science* **148**, 1541 (1965)] and Knowlton's article "Computer-produced movies" [*ibid.* **150**, 1116 (1965)] lead us to report on work in which we use the computer to produce stereographic representations of mathematical functions and geometric objects.

Originally this work was directed toward the analysis of functions, and digital-computer contouring procedures were developed to study complicated functions associated with problems of optimal orbital transfer. This technique allowed one to contour a 20-by-20 array of data points in a few seconds using an IBM 7094 and a SC4020 CRT.

A contour map composed of straight line segments resulted from this procedure (Fig. 1). While such

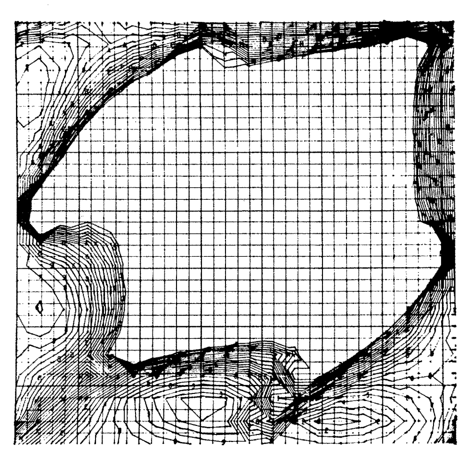

Fig. 1. Contour map of an optimum impulse function.

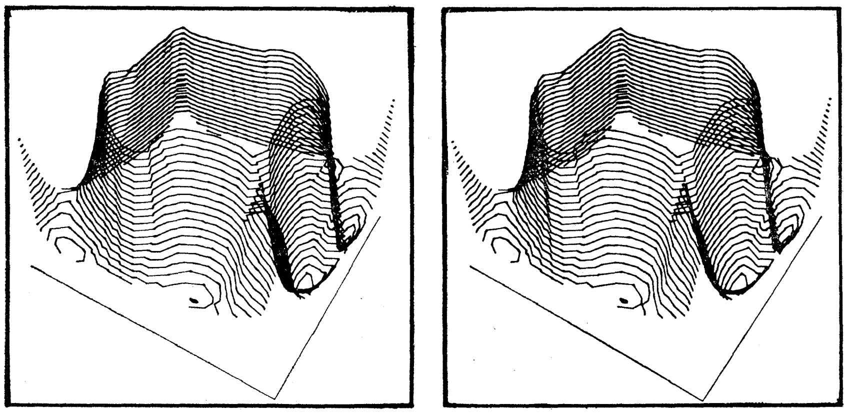

Fig. 2. Stereographic representation of an impulse function.

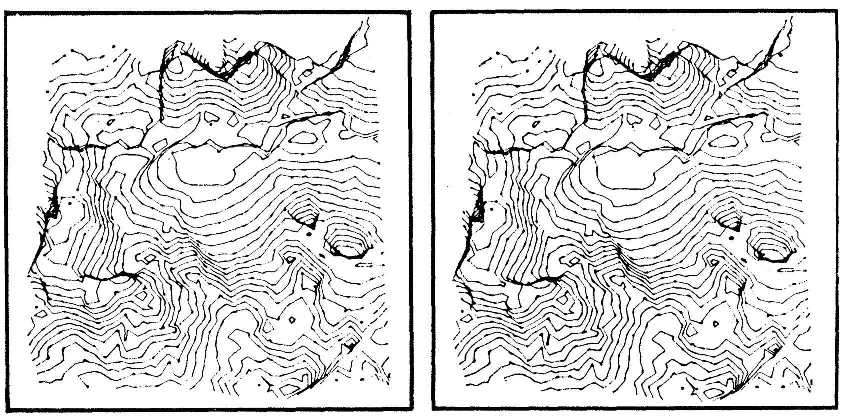

Fig. 3. Stereographic contour map of simulated lunar terrain.

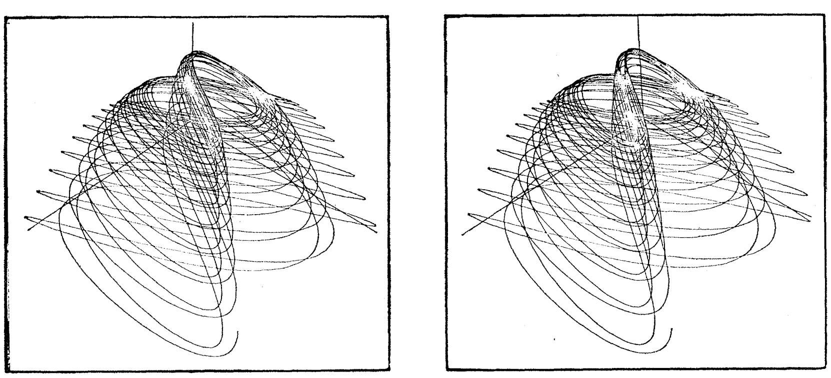

Fig. 4. Three-dimensional Lissajous figure. The input data (in Finkle's notation) were: $T_1 = .5$, $T_2 = .1$, $T_3 = 16{,}000$, $\alpha = 2\ \pi/12$, $\beta = 4\ \pi/12$, $a = 1$, $b = 1$, $c = 10$, $\delta\ T = .25$, and total time = 1000 sec.

maps proved very useful, many of the details concerning the nature and shape of the functions were not immediately apparent, even to the trained analyst. We then found that computer-generated perspective and stereographic projections (Fig. 2) were extremely helpful in understanding and interpreting the impulse functions. We are now employing the same basic technique for numerous other engineering and scientific applications. For instance, we have recently used it to generate stereographic contour maps of simulated lunar terrain (Fig. 3).

Since reading Finkle's letter, we have programmed the equations of motion of a damped three-dimensional oscillator, generated by adding a Z component to Finkle's equations for X and Y as follows:

$$Z = ce^{-\psi\tau} \sin \left\{ \left[\left(\frac{2\pi}{T_3} \right)^2 - \psi^2 \right]^{\frac{1}{2}} \tau \right\},$$

where ψ = damping coefficient, T_3 = fundamental period of Z component of motion, c = amplitude, and τ = time. A phase factor β was also added to the Y component. The result was a Lissajous figure in three dimensions (Fig. 4). At the present time we are extending this procedure to the production of "3D" movies.

The total IBM 7094 time required to produce the projections in Fig. 4 was 34 seconds. A similar amount of time is required for the generation of stereo contour maps.

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8 December 1965

Pain: One Mystery Solved

In the years before 1947 and for at least a decade after that time, scores of papers were written on experimentally contrived pain in man (*1*). Implicit in all these studies was the assumption that the more pain endings were stimulated, both in number and in intensity, the more pain would be experienced. Each investigator seemed bent on developing an ever more ingenious method of inflicting pain. Gradually, the Hardy-Wolff-Goodell method of placing measured amounts of heat on the skin took precedence over other methods such as shocks to teeth, pin pricks of the skin, tourniquet pain, pain produced by chemical agents in standardized techniques, and so on.

The Hardy-Wolff-Goodell method utilized the first perceptible pain produced, the so-called threshold pain, as did the other methods. From 1947 to 1949, Denton and I (*2*) struggled with this method. We had no doubt that the method was sound, for so many investigators had used it and said it was. The difficulty was that, when a properly designed experiment was set up, using the double-blind procedure, in which placebos were inserted as unknowns, and where mathematical validation of difference was required, a large dose of morphine (15 mg) could not be distinguished from a placebo (1 ml normal saline). Again and again we came up against this puzzling situation. Others got beautiful dose-effect curves; we could not distinguish even between the extremes. We turned to an experienced investigator who had