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Binocular Disappearance of Monocular Symmetry

Abstract. *In an earlier demonstration binocular shapes were produced from monocularly shapeless, random-dot stereo images. A reversal of this phenomenon is demonstrated. A stereo image is devised in which the monocularly apparent shapes of bilateral symmetry disappear when stereoscopically viewed. This phenomenon sharpens the implications of the earlier one.*

In 1960 a perceptual phenomenon was reported which demonstrated that binocular shapes can be perceived from monocularly shapeless and contourless, random-dot stereo images (*1*). The finding that correlated areas in the left and right images could give rise to stereoscopic depth perception, regardless of the fact that these areas were completely disguised when viewed by one eye, has several theoretical and practical implications. An obvious implication is that no monocular shape recognition is necessary for stereopsis. A possible reversal of this phenomenon might be also instructive. Would it be possible to generate monocular shapes which disappear when viewed binocularly?

In order to achieve such a goal the left and right images have to differ from each other, since identical or similar images yield a binocular percept which closely resembles the monocular constituents. On the other hand, different images can give rise to binocular rivalry and cannot be fused. The way out of this dilemma is the realization that it is not the physical images which have to be dissimilar but their monocular *percepts*. The nonlinearity of the perceptual processes can result in great differences in the perception of stimuli which differ only slightly.

In the reported experiment the technique of random-dot stereo images was employed. The only departure from randomness was introduced in the form of bilateral symmetry. The upper half of the left field of Fig. 1 was randomly dotted; the lower half field was its mirror image reflected across the central horizontal axis. This bilateral symmetry can be perceived spontaneously without scrutinizing the stimulus. The right image of Fig. 1 is identical to the left image except for horizontal translations. To achieve this, the image was subdivided into twenty horizontal stripes, each five picture-elements wide. The stripes were horizontally shifted alternatively to the left and to the right, by two picture-elements. These alternate shifts were arranged such that if the *n*th stripe above the symmetry axis was shifted to the right, then the *n*th stripe under the symmetry axis was shifted in the opposite direction. This procedure achieved two results. First, when viewed monocularly, the left image can be perceived as a "one-axis kaleidoscope" while the right image lacks the impression of bilateral symmetry. Second, when stereoscopically viewed, the right image can be perceived as an ordinary random-dot stereo image having alternate stripes at two depth levels.

When the stereo pair of Fig. 1 is presented in a stereoscope to subjects with normal stereoscopic vision, fusion occurs immediately and the horizontal stripes are perceived in vivid depth. Provided the subjects have no strong dominance of one eye, or provided the *symmetric* pattern is viewed with the *nondominant* eye, the bilateral symmetry cannot be perceived in the fused binocular image. Even when the images are first viewed monocularly and the bilateral symmetry becomes apparent in one of them, the binocular percept does not give the impression of a kaleidoscope (*2*). In the binocular percept, those horizontal stripes which are symmetrical belong to different depth planes and also seem to be shifted horizontally relative to each other. It is probably this alternate shift which obscures the symmetry. Indeed, when subjects with a strongly dominant eye fuse the stereo pair, such that the *dominant* eye views the symmetric image, the stripes are seen in depth but without the horizontal shifts. In this case, the bilateral symmetry can be detected in the binocular image, but is still not as spontaneously apparent as in the monocular image.

It might be argued that the disappearance of symmetry under stereopsis results from two factors: first, the symmetry is hard to detect even monocularly; and second, the nonsymmetric display for one eye is competing with the other. It is true that bilateral symmetry of random patterns across a horizontal axis is not as easily detectable as if the axis were vertical or the pattern contained several symmetries. Nevertheless, when the bilateral symmetry becomes apparent it gives a strong and stable impression. The second argument seems convincing, but actually the opposite is true. The nonsymmetric display is not uncorrelated "noise" which masks the symmetric pattern, but a totally correlated pattern which gives

Fig. 1. Stereo pair which, when monocularly viewed, contains an image of bilateral symmetry. When viewed stereoscopically, horizontal stripes are perceived in depth and the bilateral symmetry disappears.

rise to stereopsis. It is stereopsis which inevitably occurs and dominates over other processes to which the perception of symmetry belongs. It is an interesting paradox that when the symmetric and nonsymmetric displays are uncorrelated (by turning one through 90°), binocular rivalry results. One might expect for this case the largest masking of the symmetric pattern by the competing uncorrelated noise; the opposite is in fact the case, since during binocular rivalry the symmetric pattern is quite often visible as dominance alternates.

This binocular disappearance of monocularly seen symmetrical shapes sharpens the implications of the original demonstration (*1*). These demonstrated that binocular shapes can be perceived from random, shapeless images and indicated that binocular combination of monocular images *can* occur prior to the recognition of form. The phenomenon described here has a further implication. It suggests that whenever binocular combination occurs, this process *precedes* or *dominates* the recognition of bilateral symmetry. This result can be interpreted in the light of some neurophysiological findings in the cat (*3*). Even at the input layers of the striate cortex binocular neural units exist in abundance. There are also monocular units and binocular units of monocular dominance. The reported psychological phenomenon suggests that some monocular neural units might be inoperative when the two monocular images can be fused without binocular rivalry. In this demonstration bilateral symmetry was selected as an instructive example only, and the reported technique obviously can be applied to monocular shapes in general.

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References and Notes

1. B. Julesz, *Bell System Tech. J.* **39**, 1125 (1960); *Science* **145**, 356 (1964).
2. The unusual practice of omitting references to experimental statistics was intentional. The reported findings were obtained originally from 20 subjects with identical responses. Subsequently, the phenomeon was demonstrated on six different occasions to large groups of experimental psychologists, physicians, television engineers, architects, and artists, in excess of 500 total, who confirmed the findings. In cases of such universal phenomena, in my opinion references to number of subjects distort the generality of the results.
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4. I thank Ellen Gritz for developing the computer program which generated the displays and R. A. Payne for producing them in vectograph format.

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Memory Transfer

Learned behavior has been reported to be transferred as a result of injecting RNA-containing fractions from the brains of trained rats (donors) into untrained rats (recipients).

Such a result is of potential importance for the understanding of the mechanisms of learning and memory. We summarize here our separate attempts to reproduce the results reported (*1*). Each of the sets of experiments was independently undertaken in one of our laboratories; the unanimity of our results became apparent only in the course of subsequent informal discussions. We all found that the reported transfer of training due to transfer of RNA was not, in our laboratories at least, a demonstrable phenomenon.

Our general procedures may be summarized as follows. *Extraction*: In all experiments we used the phenol extraction procedure described (*1*). There were, however, some minor procedural variations on this method in different experiments. *Injection*: In some experiments recipients received the extract from the brain of a single donor. In others pooled brains were used for extraction and each recipient was given a portion of this extract. Injections were intraperitoneal except in a few instances in which the intracisternal route was used. *Training*: In different experiments donors were given one of the following kinds of initial training. (i) Acquisition of an approach response like that described (*1*); we also evaluated the effects of several variations of this technique that were designed to increase its sensitivity. (ii) Learning of a brightness discrimination in a T-maze (food reward). (iii) Learning of a complex maze problem (food reward). (iv) Conditioning of an emotional response (CER). In these experiments a stimulus was paired with a brief, inescapable electric shock; fear conditioning was measured in terms of the subsequent suppression of ongoing behavior (lever-pressing or consummatory behavior) in the presence of the stimulus alone. (v) Learning of a discrimination problem; this experiment was an attempt to replicate an earlier report of positive transfer (*2*).

In 18 experiments no clear evidence of a transfer of any of these kinds of training from trained donors to recipients was found. The detailed reports from all of our laboratories have been compiled and are available for examination (*3, 4*).

Our data extend and amplify those reported by Gross and Carey, by Luttges *et al.*, and by Gordon *et al.* (*5*). It is true that a negative result, indicative of "no difference," is easy to come by in any experiment. But it is also true that a positive result should have demonstrable replicability and generality. Unfortunately, the data bearing on both generality and replicability appear to be on the negative side.

Our consistently negative findings do not, of course, bear directly on the possibility that RNA may be involved in the mechanism of memory. They indicate only that results obtained with one method of evaluating this possibility are not uniformly positive. Furthermore, we feel that it would be unfortunate if these negative findings were to be taken as a signal for abandoning the pursuit of a result of enormous potential significance. This is especially so in the light of several other related but not identical experiments (*6*) that support the possibility of transfer of learning by injection of brain-extract from trained donors. Failure to reproduce results is not, after all, unusual in the early phase of research when all relevant variables are as yet unspecified (see *7*).

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