The Suppression of Monocularly Perceivable Symmetry During Binocular Fusion

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Symmetries that we can perceive with one eye can be made to disappear during binocular fusion—that is, a symmetrical pattern in one of a pair of stereoscopic images may not be seen when we view the pair stereoscopically. This phenomenon should not be confused with the classically-known binocular rivalry in which the left and right images cannot be fused and one of the images is alternately suppressed. The type of suppression phenomenon reported here is obtained for computer-generated random-dot patterns in which locally each picture element can be fused in a stable way. The binocularly suppressed symmetry can be one-, two-, and four-fold, and the experiments give some insight into the processes underlying the perception of symmetry. In addition to symmetries, it becomes possible to scramble text by exhibiting it stereoscopically.

I. BINOCULAR FUSION, RIVALRY, AND A THIRD POSSIBILITY

Recently, the author added a third possibility of perceptual response to the class of stereoscopic images traditionally consisting of binocular fusion and binocular rivalry.[1] In these computer-generated stereoscopic images the local and global properties are juxtaposed such that locally each picture element can be stereoscopically fused, causing the monocularly apparent global symmetry to disappear in the fused percept.

In the demonstration of Ref. 1, the left stereoscopic image consisted of randomly selected black and white dots with *bilateral* (one-fold) symmetry across the center *horizontal* axis. The right image was obtained from the left image by subdividing it into 20 horizontal stripes (of five picture element width) and shifting every even stripe to the left and every odd stripe to the right by two picture elements. Such a stereo image is shown in Fig. 1. When monocularly viewed, the hori-

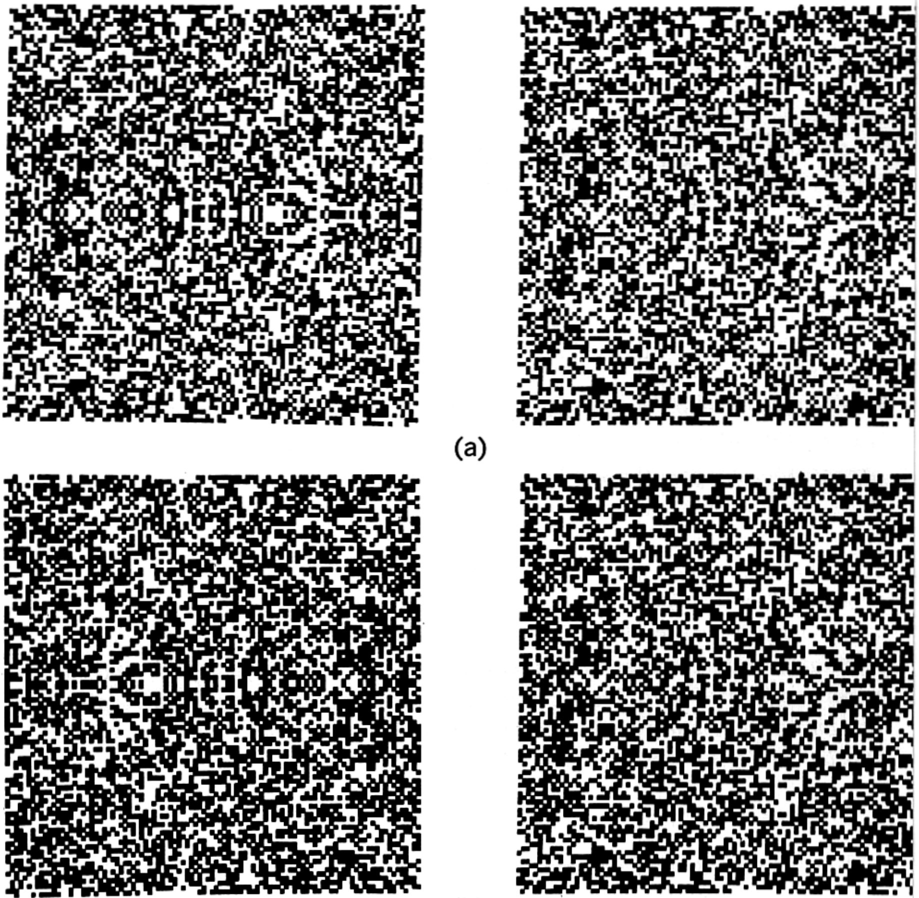

Fig. 1 — (a) Stereogram which, when monocularly viewed, contains an image of bilateral symmetry across the horizontal axis. When viewed stereoscopically, horizontal stripes are perceived in depth, and the symmetry is suppressed. (b) Stereogram identical to (a) except that the left image is mirror reflected to permit stereoscopic viewing with the supplied front-surface mirror as described in the appendix.

zontal bilateral symmetry is apparent in the left image, whereas the right image seems almost random. When binocularly viewed, the horizontal stripes are perceived alternately in depth, and if the symmetric pattern is viewed with the non-dominant eye the bilateral symmetry is suppressed in the fused percept.*

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* These stereograms can be viewed stereoscopically by using a prism in front of one eye or other similar stereoscopic device. For those readers who do not

In Ref. 1 it was emphasized that the demonstration was only an example and others could be devised along these lines. Because of the theoretical importance of this stimulus class, the present article demonstrates several new examples. They are more powerful than that of Fig. 1 and help to clarify some factors in symmetry perception.

II. POSSIBLE IMPROVEMENTS OF THE ORIGINAL EXPERIMENT

Although the original demonstration in Fig. 1, served its purpose, it suffered from some inadequacies. The primary limitation of the stimulus is our difficulty in perceiving bilateral symmetry along a horizontal axis. Is it possible to create stereoscopic images in which more powerful monocular percepts of symmetry are binocularly suppressed? For instance, can the monocularly apparent bilateral symmetry across a *vertical* axis be made to disappear, or what is more, can we binocularly suppress the strongly perceivable two-fold or four-fold monocular symmetries?

Another criticism can be raised when inspecting Fig. 1. One might argue that the right image is not symmetrical, but because of a few recognizable clusters which are similar in the upper and lower half fields, the appearance of the right image deviates from complete randomness. Although we could argue that the bilateral symmetry in the left field is effortlessly perceived, whereas in the right field we have to scrutinize the stimulus to detect departure from randomness, nevertheless, attempts should be made to deal with this criticism.

A third objection might concern the loose way of specifying the amount of symmetry suppression in the binocular percept. Of course, it might be a simple task to let subjects rank order the amount of symmetry in the left and right monocular percepts and in the fused binocular percept. On the other hand, the phenomena shown here are universal, i.e., observers with adequate stereoscopic vision do deviate little in their judgments. The skeptic can easily check the validity of these findings himself. Therefore, instead of quantification, all experimental efforts have gone into the creation and display of increasingly sophisticated stimuli. It should be mentioned that after rank

possess such viewing aids, a front-surface mirror is included inside the back cover of this issue. Since all the stereograms except Figs. 1, 2 and 10 contain an image with vertical bilateral symmetry, they can be fused both ordinarily or with the aid of the mirror as described in the appendix. Figs. 1(b), 2(b), and 10(b) cannot be fused with the aid of a prism but only with a mirror—Figs. 1(a), 2(a), and 10(a) can only be fused with a prism. In order to obtain the described binocular percepts with mirror viewing and not the reversed depth percepts, the *left* images of the stereograms should be viewed with the aid of the mirror by the left eye and the right images directly by the right eye.

ordering the left and right monocular percepts with respect to symmetry (or lack of symmetry), the symmetry in the binocular percept does *not* have to be the mean of the monocular percepts, but can be even weaker than that of the monocular percept with the scrambled symmetry.

In the experiments reported here a systematic attempt was made to break up the clusters and strengthen the perception of monocular symmetries. Binocular suppression of symmetry was still observed.

III. NON-TOPOLOGICAL OPERATIONS IN BINOCULAR VISION

The existence of locally correlated but globally uncorrelated stereoscopic images is based on a fundamental difference between monocular and binocular vision. When viewed with one eye, the retinal projections of objects usually change size and shape in a continuous manner. Exceptions are a few hidden parts which may suddenly enter or depart the visual field. Therefore, monocular perception mostly operates on continuous (topological) transformations of the stimuli, and prolonged departure from spatial-temporal continuity results in strange phenomena and distortions. (For example, imagine a television picture out of horizontal synchronism.) On the other hand, binocular vision can easily combine non-topologically related stereoscopic images to yield stereopsis and fusion. Parts of one stereoscopic image can be broken up and shifted horizontally in the other image and, if these shifts are kept within the critical limit of disparity, the two images will be combined in a single three-dimensional percept. These shearings and displacements when skillfully applied to binocular viewing can destroy many monocular percepts, particularly that of symmetry.

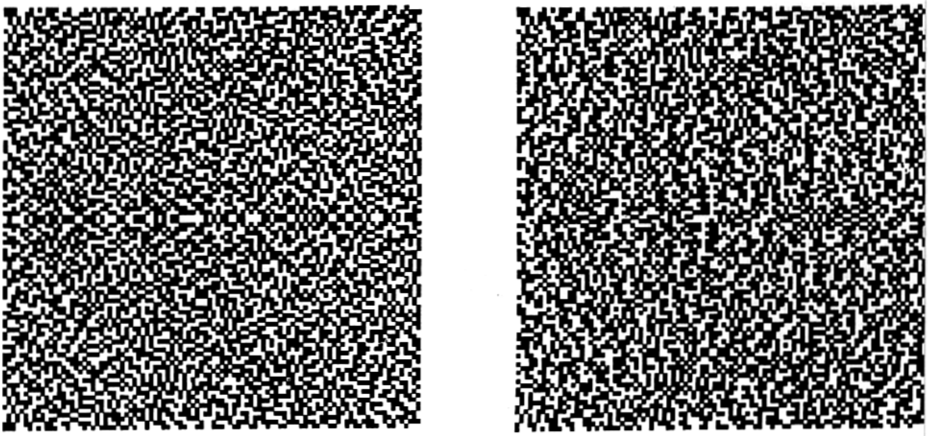
IV. THE ROLE OF CLUSTERS IN SYMMETRY PERCEPTION

The right image of Fig. 1, although not symmetrical, is seen to deviate from randomness when carefully viewed. One of the main cues for bilateral symmetry has been removed, namely the large symmetrically shaped clusters in the immediate neighborhood (within $\pm$ 5 picture elements) of the horizontal symmetry axis. On the other hand, within the five picture-element wide horizontal stripes, some characteristic micropatterns are formed by chance; these can be recognized and matched in the upper- and lower-half fields. In the binocular percepts, because each of these similar micropattern pairs is seen at opposite depth levels, their matching becomes more difficult. Therefore, the binocular percept seems even more random than the right monocular view.

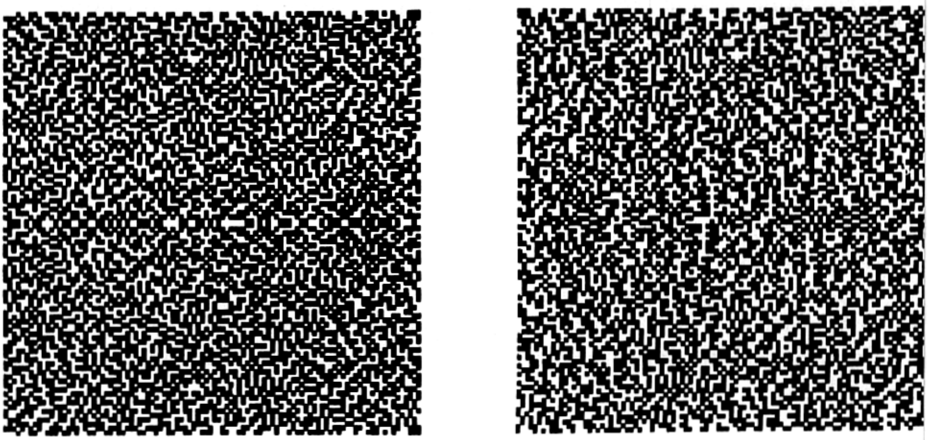
In addition to the microclusters formed by chance, the same random fluctuations can produce macroclusters which extend to large areas. The alternate horizontal shifts by a few picture elements, performed on the even and odd stripes are not adequate to break up these large dark or bright areas, and these are the last cues left in the binocular percept to reveal symmetry.

Is it possible to reduce the traces of symmetry by breaking up the micro- and macro-clusters in the random dot textures? Several attempts were made to break up the clusters. The first was a preprocessing of the left field of Fig. 1. Whenever a picture element was surrounded by more than six picture elements of the same brightness, its brightness value was complemented from black to white or vice versa; otherwise it was kept unchanged. This intervention prevented the formation of black and white clusters within a 3×3 array, but long horizontal and vertical lines were still present and were strongly perceivable both in the left and right images. A second cluster-breaking operation was therefore performed. If out of seven adjacent picture elements which lay on a horizontal or vertical line, six or more were white or six or more were black, the center one was complemented to opposite brightness value. The outcome of these two cascaded operations applied on a random dot pattern (similar to the left field of Fig. 1) yielded the left field of Fig. 2. This image looks very intricate, and the horizontal bilateral symmetry is mainly apparent because of the patterns close to the symmetry axis and because of some long diagonal line clusters that remained intact.

Another way of reducing recognizable micropatterns is to diminish the width of the horizontal stripes which are alternately shifted in the right image. In Fig. 2 the horizontal stripes in the right image are only two picture-elements wide (in contrast to the five picture-element stripe width in Fig. 1). Thus, no micropattern larger than two picture elements in the vertical extent stays unchanged. The right image of Fig. 2 gives a more random impression than the right image of Fig. 1. Unfortunately, with smaller stripe width, the amount of disparity has to be reduced in order to obtain stable stereopsis. Therefore, in Fig. 2 the even stripes are shifted to the left by two picture elements while the odd stripes are kept unchanged. The total disparity of Fig. 2 is only two picture elements, whereas in Fig. 1 it was twice this amount. Perhaps this precaution is unnecessary as seen in Figs. 7 and 8 which con-



(a)



(b)

Fig. 2 — (a) Stereogram which is similar to Fig. 1 except that the width and binocular disparity of the stripes is reduced and cluster formation of many proximate dots of equal brightness is prevented by preprocessing. When viewed stereoscopically, a transparent textured surface is perceived above the background (b) Stereogram identical to (a) except that the left image is mirror reflected to permit stereoscopic viewing with the supplied front-surface mirror as described in the appendix.

tain two picture-element wide stripes and a total disparity of four picture-elements, yet yield good stereopsis. When Fig. 2 is binocularly viewed, the thin stripes cannot individually be resolved but are perceived as a transparent textured plane in front of a solid textured background. In the fused image the symmetry is strongly suppressed, particularly when the non-dominant eye views the symmetric image. On the other hand, the reduced disparity makes it easier to find a few micropatterns in the two depth planes by scrutinizing the stimulus.

It should be possible to vary the stripe width in such a way that the upper half field contains combinations different from those of the lower half field, thus further reducing similar micropattern pairs. Nevertheless, instead of further attempts with horizontal bilateral symmetry, we turn our attention to vertical bilateral symmetry.

V. VERTICAL BILATERAL SYMMETRY

In these experiments the horizontal bilateral symmetry had two disadvantages over the vertical case. The first disadvantage has been already discussed; it was pointed out that horizontal symmetry is less perceivable than vertical symmetry. The second disadvantage will now be discussed. In Figs. 1 and 2 the left and right images contained the *same* picture elements except for a few picture elements that were uncorrelated in the small areas affected by the horizontal shifts. On the other hand, it is known from the random-dot stereoscopic image technique that areas presented to only one eye's view are perceived as continuations of the depth plane furthest behind.[2,3]

This perceptual response permits us to reduce further the similarity between the left and right image pairs. For instance, suppose we consider a left image with vertical bilateral symmetry. We now subdivide it into twenty *vertical* stripes of five picture-element width. The right image is identical to the left one, except each even vertical stripe is shifted to the left by two picture elements, as though it were a solid sheet. Because of the shift, bars two picture-elements wide along the left sides of the shifted stripes will be hidden by the dots which belong to the vertical stripes. The right sides of the shifted vertical strips will uncover new areas, which will be filled in with new random dots. Thus, every shifted even stripe will hide a bar (which belongs to the surround) of two picture-elements width (out of the five), and the odd stripes (which belong to the surround) of three picture-element width will be extended by a newly generated bar of two picture-elements width. Such a stereoscopic image is shown in Fig. 3, in which, in addi-

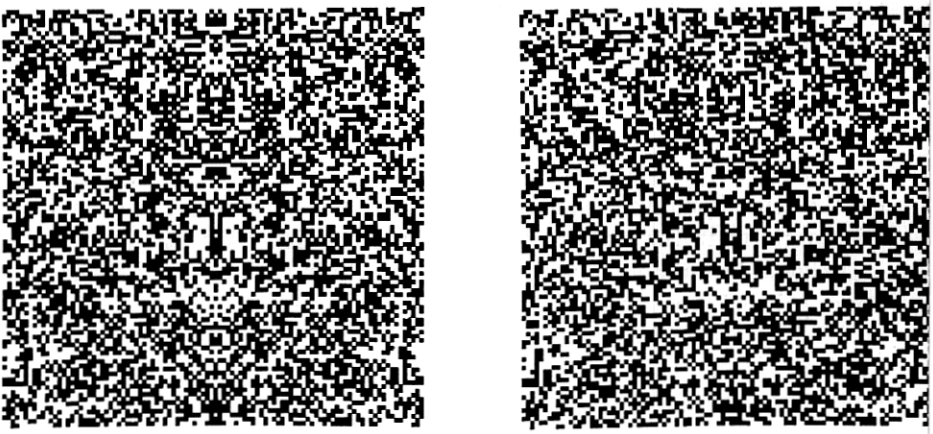


Fig. 3 — Stereogram which, when monocularly viewed, contains an image of bilateral symmetry across the vertical axis. When viewed stereoscopically, vertical stripes are perceived in depth, and the symmetry is suppressed.

tion to the shearing and shift, 2/5 = 40 percent of the dots are different in the right image as compared to the left. When the left image of Fig. 3 is monocularly viewed, the vertical bilateral symmetry is immediately apparent; when the images are binocularly viewed, vertical stripes are seen in front of a background, and symmetry is suppressed. The only cue for symmetry is the presence of some large black and white clusters which can be paired in the left and right half fields.

Fig. 4 is similar to Fig. 3, except that the same cluster breaking operation used in Fig. 2 was applied. Here the binocular percept is quite free from symmetry, except for a few diagonal checkerboard-like patterns which might be found under scrutiny. Anyway, there is no doubt that further preprocessing could greatly reduce these few remaining recognizable structures. It is also true that the bilateral symmetry is less apparent in the left image of Fig. 4 than before cluster breaking. It is a delicate operation to find the amount of cluster breaking which still gives a strong percept monocularly but which causes the binocular percept to disappear.

VI. TWO- AND FOUR-FOLD SYMMETRY

In a next experiment, a left image with two- and four-fold symmetry, respectively, was generated and a compatible right stereo image similar to Fig. 4 was devised. The only difference is that the vertical

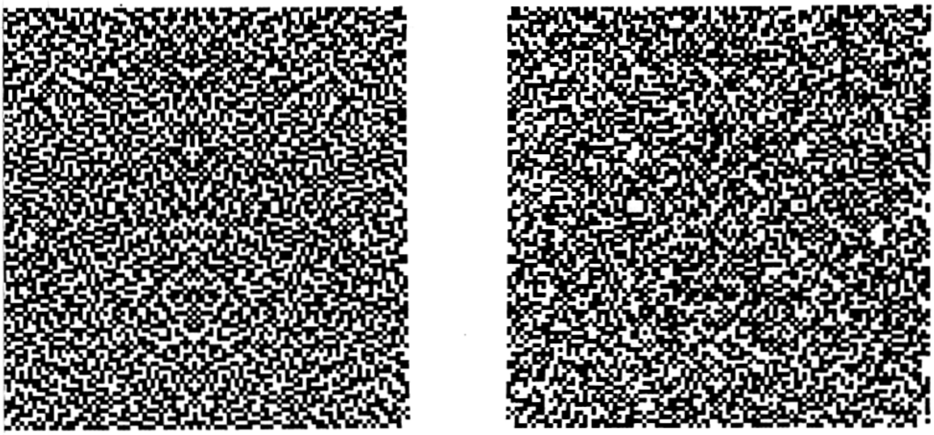


Fig. 4 — Stereogram which is similar to Fig. 3, except that clusters are broken up by preprocessing.

five picture-element wide alternate stripes are shifted in phase in the lower half field compared to the upper half field. Whereas, in the upper half field every even vertical stripe is perceived above the background, in the lower half field every odd vertical stripe is in front. Such stereo images are presented in Figs. 5 and 6 where the former contains a

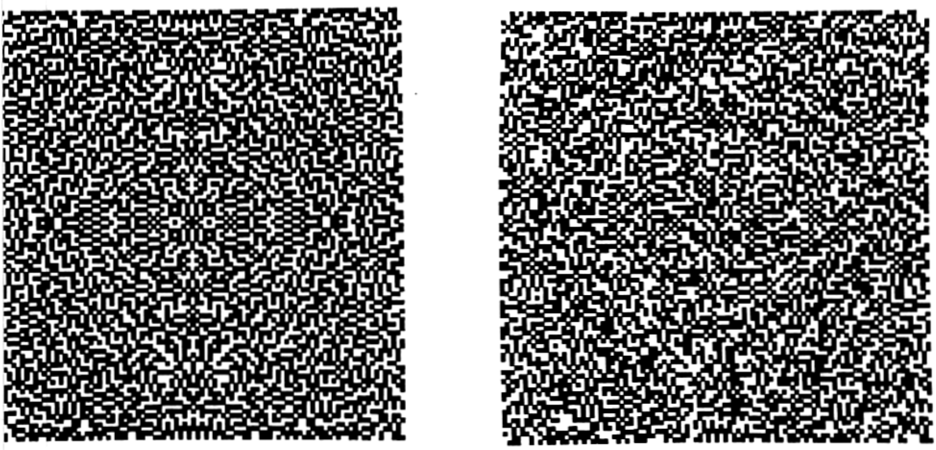


Fig. 5 — Stereogram which, when monocularly viewed, contains an image of two-fold symmetry. When viewed stereoscopically, vertical stripes are perceived in depth which are shifted in position in the lower half field with respect to the stripes in the upper half field. The symmetry is suppressed in the binocular view.

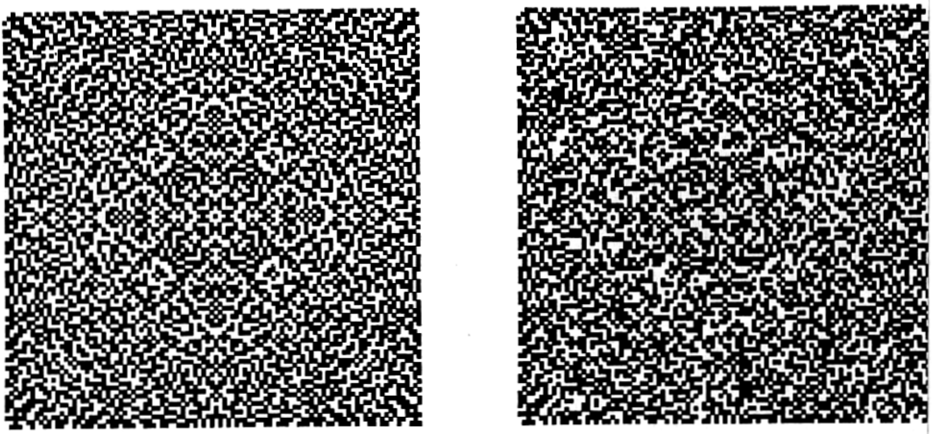


Fig. 6 — Stereogram which, when monocularly viewed, contains an image of octal symmetry. Otherwise similar to Fig. 5.

two-fold symmetry, whereas the latter a four-fold symmetry. The middle phase shift prevents the perception of the bilateral symmetry across the horizontal axis, while the alternate vertical stripes in depth suppress the symmetry across the vertical axis. The suppression of binocular symmetry is perhaps less striking for these cases than for the one-fold symmetry in Fig. 4; on the other hand, the two-fold and particularly the octal (four-fold) symmetry in the left field is so strong that the difference between the monocular and binocular perception of symmetry is very pronounced.

There are many other manipulations one could successfully apply in order to break up monocular global percepts. Instead of long stripes, rectangles can be selected at various depth levels and various widths. The horizontal and vertical stripes at various depth levels can be intermixed. The illustrations have served only to show the flexibility of the random-dot stereoscopic image technique.

VII. SOME CUES OF SYMMETRY PERCEPTION

It was already discussed how clusters affect symmetry perception and how much stronger bilateral symmetry is perceived across a vertical axis than across a horizontal one. Now, we are in a position to examine some of these problems in more detail. Since the images in these experiments are devoid of all familiarity cues, this preference to the vertical is characteristic of human perception and is much more prominent than one would expect from psycho-physiological findings on the detection of horizontal-vertical lines.[4,5] It is also interesting that in two- and four-fold symmetry perception—which are more strongly perceived than bilateral vertical symmetry—the strength of perceived symmetry across the horizontal axis is greatly increased.

In the preceding experiments we restricted ourselves to mirror symmetries. For the horizontal bilateral symmetry $F(x, y) = F(x, -y)$, and for the vertical bilateral symmetry $F(x, y) = F(-x, y)$ has to be satisfied. For the four-fold symmetry in addition to both of these equations, $F(x, y) = F(-x, -y)$ has to be satisfied as well. Besides mirror symmetries one can study the perception of centric symmetries, such as shown in the right image of Fig. 7. For this case $F(x, y) = F(-x, -y)$; $F(x, y) \neq F(-x, y)$ and $F(x, y) \neq F(x, -y)$. This image was derived from the octal-symmetrical left image by alternately shifting every even horizontal stripe (of two picture-element width) to the right and every odd one to the left. The monocularly apparent octal symmetry is very strong in the left image, while the centric symmetry is hard to perceive in the right one. Nevertheless, some large clusters in the corners can be detected in both images, which are also recognizable in the stereoscopic view. It is interesting to note that these macroclusters are easily detected and matched in spite of their differences in fine details.

Fig. 8 is identical to Fig. 7 except for the clusters, which are broken

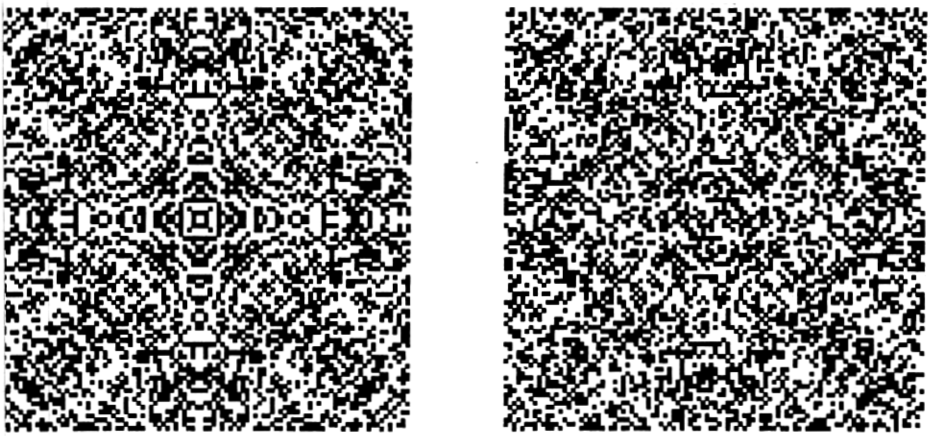


Fig. 7 — Stereogram which, in the left image contains octal (four-fold) symmetry and in the right image contains centric symmetry.

up by preprocessing. This experiment shows again that the larger the clusters are, the less similar they have to be in detail to be detected and matched at symmetrical locations. The centric symmetry in Fig. 8 is even harder to perceive than in Fig. 7. The symmetry in the binocular view is also greatly reduced, yet less so than in Fig. 6, since the left and right images of Fig. 8 are 100 percent correlated. In Figs. 2, 4, and 8, in which the macroclusters have been broken up in the left images, the microclusters have to be identical in their minutest details to be perceived as symmetrical. This is shown in Fig. 9, in which the left image was derived from a random-dot pattern with four-fold symmetry and then preprocessed by the cluster-cleaner. Obviously, the quadrants of the picture are not identical in their fine detail (since local changes by the cluster-cleaner affect the successive complementations) but are similar in their larger features. The right image of Fig. 9 was obtained by taking a quadrant of the left image and reflecting it across the horizontal and vertical axes sequentially. When the images are viewed at a short distance, they appear quite different; one looks symmetrical, the other not. When viewed from a distance, the two images appear identical and symmetrical, since only the similar macroclusters are perceivable.

This observation, that symmetry perception depends on cluster size, which in turn depends on texture density explains some of the difficulties with these demonstrations as they are presented in this article.

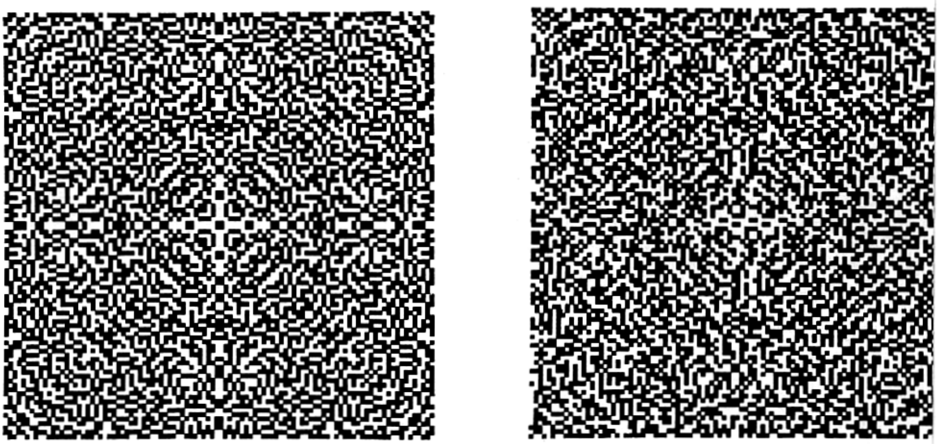


Fig. 8 — Stereogram which is similar to Fig. 7, except the macroclusters are removed by preprocessing.

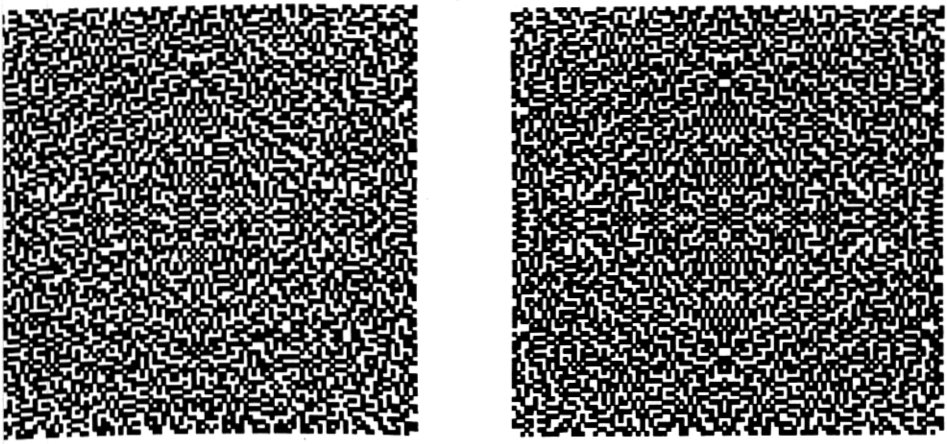


Fig. 9 — Two images which are similar in their macrostructure, but differ in their microstructure. When viewed at a short distance only the right image appears symmetrical, while from an increased viewing distance both appear symmetrical.

The figures as shown are already too small at the best viewing distance of 10 inches. If the images are made larger (in excess of 30 degree visual angle) the stereoscopically fusable local features will dominate stronger over the macroclusters.

Another observation, closely related to the previous ones, suggests a relationship between average cluster size and distance from the symmetry axis. Clusters on both sides of a symmetry axis can be detected as being symmetrical only within a certain distance from the axis, which is commensurate with the cluster size. Thus, small clusters must lie close to the symmetry axis, whereas larger ones may lie proportionally farther. This explains why the left image of Fig. 9 deviates from symmetry when viewed at a short distance. For large stimuli the large clusters cannot be perceived effortlessly, thus the nonsymmetrical microclusters dominate. When the stimulus size is reduced, the situation reverses; it is now the symmetrical macroclusters which can be effortlessly perceived, and differences in microclusters pass unnoticed.

Ernst Mach a century ago studied symmetry perception by using amorphic shapes.[6] His findings are similar to the results obtained by using random textures as long as large clusters of dark and light areas are contained in these textures. According to these findings vertical bilateral symmetry and centric symmetry can be spontaneously perceived. Horizontal bilateral symmetry is less well perceived. When the macroclusters are broken up centric symmetry does not yield spontaneous perception, whereas the perception of bilateral symmetry is not impaired.

VIII. SUPPRESSION OF MONOCULAR PERCEPTS IN GENERAL

Until now the monocular percepts to be suppressed binocularly were restricted to global symmetries. Needless to say, many other monocular global percepts can be destroyed binocularly. Since symmetry is easy to generate, it was emphasized over other perceivable forms. For instance, the left random field could contain a written text of black or white letters that could be perceived and read with one eye. The right image would be totally correlated with the left one, except rows or columns would be shifted horizontally in some random way. In the resulting binocular percept, the letters would be scrambled both because of the horizontal shifts and because of these shifts causing various letter-segments to be perceived at different depth. This could render the binocular percept unreadable. While in symmetry perception there is always a possibility that various amounts of symmetry can be traced, for this example a dichotomy can be obtained. Either the perceived image contains a readable text, or not.

One might argue, that it is not surprising that a text in one channel disappears when some "noise" is added to it through the other channel. This argument seems convincing, but actually the opposite is true. This random pattern is not uncorrelated "noise" which masks the text in the other display, but a totally correlated pattern which gives rise to stereopsis. It is an interesting paradox that when the two images are uncorrelated, binocular rivalry occurs. One might expect for this case the largest masking of the text by the competing uncorrelated noise; the opposite is in fact the case, since during binocular rivalry the text is quite often visible as dominance alternates. For the type of stimuli demonstrated here, the local fusion is perfect and stable, therefore, if the text is masked in the binocular view, it stays so indefinitely.

Fig. 10 shows such a stereoscopic image. The word "YES" is inserted in the random texture of the left image by a computer program. The right image is derived from the left image by alternately shifting every even and odd horizontal stripe of two picture-element width to the left or right direction respectively. When this stereoscopic pair is presented binocularly to subjects—who have not seen the images monocularly yet—the impression is a transparent textured surface above a textured

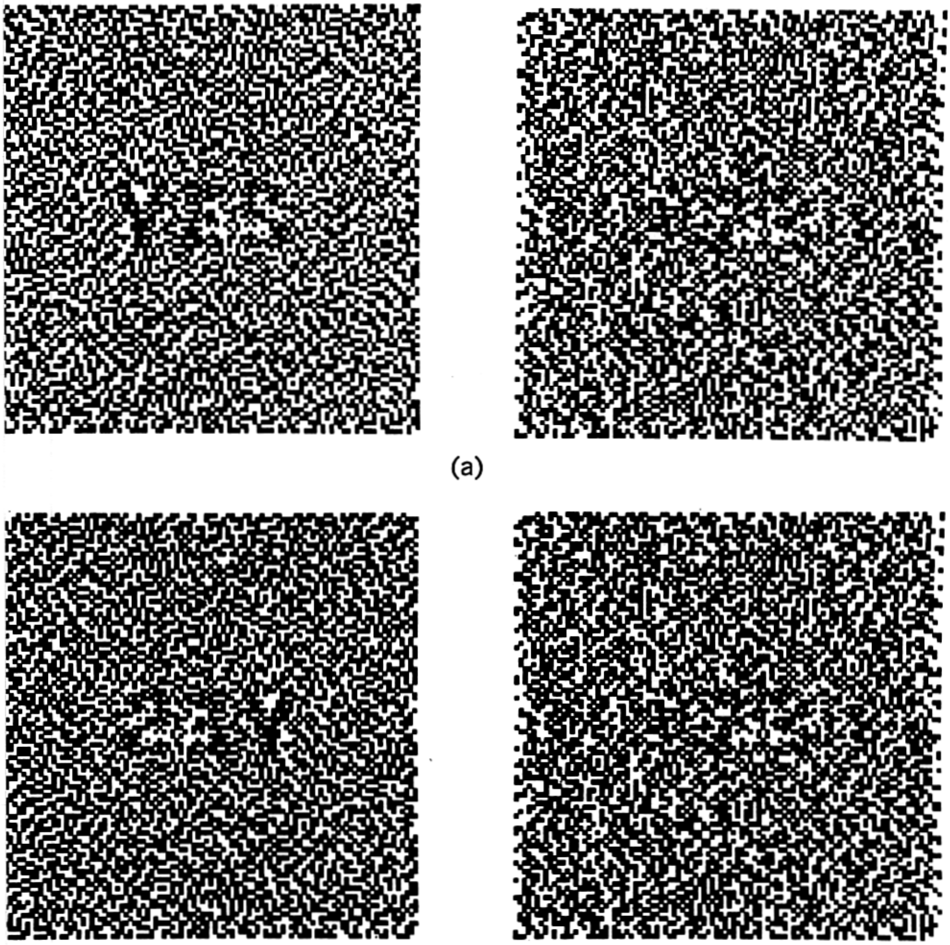


Fig. 10 — (a) Stereogram which, when monocularly viewed contains the word "YES." When viewed stereoscopically, the letters become fragmented, rendering the text unreadable. (b) Stereogram identical to (a) except that the left image is mirror reflected to permit stereoscopic viewing with the supplied front-surface mirror as described in the appendix.

background. All the eight subjects perceived both surfaces as randomly textured without being able to find and read the disguised word when instructed to search for it. After being instructed to close the right eye, each of the subjects recognized the word "YES" in the left image. The uniformly dark letters were intentionally sprinkled with random white dots in order to aid local fusion. If the macroclusters out of which the letters are composed are not broken up, it is possible to detect them in the random texture of finer grain. This enables the subjects to shift the entire letters in the left field in registration with the unshifted segments of the same letters in the right image. In Fig. 10 the letter "Y" is more robust than the rest, and after it has been detected monocularly, some of the subjects could shift the entire letter in registration when binocularly viewed. Of course, by covering this letter with more random texture, it can be made to disappear in the binocular view as the rest.

These observations suggest a cluster processor prior to stereopsis. If clusters of a certain granularity exist in a finer or coarser textured surround, they might be extracted and separately fused from the rest. When the clusters in the stereoscopic images have the same average clustering, this preprocessing becomes inoperative and stereopsis occurs on a point-by-point basis.

There are many other examples in which monocular percepts are suppressed in the binocular view. In Refs. 2 and 7 several random-dot stereoscopic images have been presented in which one of the images was perturbed, yet this monocularly apparent perturbation was suppressed binocularly. For instance, when one image of the random-dot stereoscopic pair is blurred, binocular depth can be still experienced and the binocular percept appears as the sharp image.[2] This suppression of the contour-impoverished image by the contour-rich image seems to be a general property of binocular combination and was recently studied by Levelt.[8] Although, these phenomena corroborate the basic theme of this article, they differ from the examples given here, since they are a special case of binocular rivalry. According to Levelt, the greater the difference between contour content in a stereoscopic pair the more the contour-rich channel is weighted. On the other hand, in our experiments the stereoscopic pairs are weighted equally, and binocular rivalry never occurs—only perfect point-by-point fusion.

IX. CONCLUSIONS

In 1960 a perceptual phenomenon was reported in this Journal which demonstrated that binocular shapes can be perceived from monocularly shapeless and contourless, random-dot stereoscopic images.[2] The finding that correlated areas in the left and right images could give rise to binocular 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 global percept (form recognition) is necessary for stereopsis. Recently, a reversal of this phenomenon was demonstrated by the author.[1] A stereoscopic image was devised in which the monocularly apparent shapes of bilateral symmetry across a horizontal axis disappeared when stereoscopically viewed. This phenomenon sharpens the implication of the earlier one. It suggests that whenever binocular combination occurs, this process precedes or dominates the recognition of horizontal bilateral symmetry.

The demonstration of Ref. 1 had a few inadequacies which were overcome in the experiments presented here. In order to improve on the weakly perceived bilateral symmetry across a horizontal axis, ways were found in which *vertical* bilateral symmetry could be presented monocularly without affecting symmetry suppression in the binocular view. Similar binocular suppression was obtained for monocularly apparent two- and four-fold symmetries. Micro- and macro-clusters, which are always present in random textures, were broken up in the stimulus and the results of this preprocessing on symmetry perception were studied.

An elaboration on these experiments substituted monocularly apparent symmetry with monocularly readable text to be incorporated in the stereoscopic images. In the binocular view the letters of the text were perceived as being scrambled and the letter fragments were perceived at various depths rendering the text unreadable.

X. ACKNOWLEDGMENTS

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APPENDIX

A Method of Viewing Stereograms

Figs. 1(b), 2(b), 3 through 9, and 10(b) may be viewed stereoscopically with the aid of the front-surface mirror supplied inside the back cover of this issue. Ordinary (back surface, glass) mirrors cannot be used. The mirror is made of polystyrene and is quite fragile—carefully remove the mirror, taking care not to scratch or mar the surface. For best results, the mirror should be flattened by fastening it to a piece of stiff, flat cardboard by means of transparent tape laid along the edges.

Fig. 11 — The author demonstrating a method of viewing stereograms.

Fig. 11 shows a method of viewing the stereograms. To obtain stereopsis, hold the mirror facing toward the left image so that the left eye views the image reflected in the mirror while the right eye gazes directly at the right image, as shown in Fig. 11. The mirror should be nearly perpendicular to the image plane. The reflected image will appear to float over the directly-viewed image. Adjust your position (or the mirror) until the reflected image and directly-viewed image are superimposed and the reflected image is the same size as the directly-viewed image. At this point the images fuse and give the stereoscopic effect.

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