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The role of monocularly conspicuous features in facilitating stereopsis from random-dot stereograms

Ann Saye, John P Frisby  
Department of Psychology, University of Sheffield, Sheffield S10 2TN, England  
Received 10 February 1975

Abstract. Two experiments are reported which investigated the effects on stereopsis perception times of including monocularly conspicuous features in random-dot stereograms. It was found that such features facilitated stereopsis in large-disparity but not in small-disparity stereograms, perception times for the latter being relatively short with or without monocular features. Facilitation in the large-disparity stimuli came about both from features which delineated the shape of the whole disparate area and from features which merely happened to lie in the same depth plane as the disparate area, but which did not give any shape cues. It is argued that these various results can be well accounted for by a 'vergence hypothesis', which supposes that the long perception times often found with random-dot stereograms are due in part to the absence of stimulus features which can guide the vergence movements necessary for fusing the display.

1 Introduction

It is well known that naive observers of a random-dot stereogram often take a considerable time to perceive the 'hidden object' on their first few viewings (see Frisby and Clatworthy 1975, this issue, for a review). One possible explanation (here referred to as the 'vergence hypothesis') of these initially long perception times suggests that the observer has to learn an appropriate sequence of vergence movements for fusing the display (Julesz 1971 pp 216–217). Such eye movements are necessary for obtaining stereopsis from random-dot stereograms with disparities larger than about 6°, as the work of Fender and Julesz (1967) has made clear. Using stabilised retinal image techniques they found that random-dot textures cannot be fused unless they are brought within this limiting amount of horizontal misalignment. The only way this can be achieved during normal viewing of the disparate-texture plane incorporated within a relatively large-disparity stereogram is by appropriate vergence movements. Note that such vergence movements would not usually disturb the binocular unity of parts of the stereogram which had already been fused, since Fender and Julesz have also shown that horizontal misalignment of about 2° can be tolerated by fused areas before they break apart.

But before the vergence hypothesis can be regarded as wholly adequate to account for the long initial perception times often found for random-dot stereograms it is necessary to explain why appropriate vergence movements should be difficult to make when these stimuli are being inspected. One obvious explanation is that a random-dot stereogram presents no adequate features to guide the required eye movements. When normal scenes are being viewed, there is an abundance of monocularly-discriminable information about the location of objects in the visual scene which could serve this function. Intrinsic to the design of random-dot stereograms, however, is the fact that no objects can be detected until after fusion has been obtained. Thus it could be that it is the absence of monocularly-prominent contours which is the important factor underlying the difficulty in executing the vergence movements required by any given random-dot stereogram.

The experiments reported here explored the effects of adding prominent monocular features to random-dot stereograms which contained a central square-shaped area of disparate elements. Two kinds of features were used: either an outline square
Figure 1. The small-disparity random-dot stereograms used in experiment 1: (a) the Square condition, (b) the Cross condition, and (c, on the right) the Control condition. These stimuli should be inspected from about 45 cm so that the disparity projected by each one is about 5'.

depicting the boundaries of the disparate area (the Square condition, figures 1a and 2a), or a cross which bisected the disparate area vertically and horizontally (the Cross condition, figures 1b and 2b). Naive subjects were shown these stereograms, each subject seeing just one kind of stimulus, and their perception times for seeing stereopsis were measured and compared with the times recorded from other subjects who saw the same basic stereogram without the added features (the Control condition, figures 1c and 2c). Stereograms of these three types were examined both for a small disparity (5', figure 1) and a large disparity (1°17', figure 2). If the argument developed above concerning the role of vergence movements and prominent monococular
features in fusing random-dot stereograms is valid, it would be expected that:
(a) the large-disparity Control stimulus should show relatively long perception times
(reflecting relatively great difficulty in initiating suitable vergence movements),
whereas the large disparity Square and Cross stimuli should not (their features guiding
appropriate vergence);
(b) the small-disparity Control stimulus should show relatively short perception times
(no vergence movements required) as should the Square and Cross stimuli (no
advantage over the Control stimulus);
(c) the Square and Cross stimuli should give similar perception times throughout
(because they should provide equal facilitation of vergence).

It should be noted that: (i) a random-dot stereogram with added monocular
features is, of course, no longer a random-dot stereogram in the true sense, but we
avoid introducing a new term to describe such stimuli and simply allow the context
in which we use the term 'random-dot' to determine what we mean; (ii) the Square
and Cross features would provide adequate stimuli for generating vergence movements
(Westheimer 1971); and (iii) the small and large disparities of 5' and 1°17' were
chosen because they fall, respectively, well within and well beyond Panum's fusional
area for central vision, so ensuring that vergence would be necessary for fusion of the
large-disparity stimuli.

2 Experiment 1: Stereopsis perception times for small-disparity stereograms
2.1 Stimulus presentation
The experimental stimuli were two planar random-dot stereograms consisting of black
circular elements on a white background (figure 1). The brightness of the elements
was < 3.4 cd m⁻² while that of the background was 34.3 cd m⁻². The stimuli
were back-projected on to a ground glass screen. Subjects viewed the stimuli through
opposed polaroid filters, mounted on a chinrest at a distance of 114 cm from the
screen. The filters were arranged so that the disparity contained in the stereograms
was crossed, i.e. the disparate area appeared to lie in front of the surrounding area
(which itself lay in the plane of the screen).

The stereograms were generated on an ICL 1907 computer and graph plotter.
Each half-stereogram subtended 8°48' x 8°48' and each was composed of 576
elements with diameters of 6'. The elements were evenly spread over the display in a
Monocularly conspicuous features in random-dot stereograms

(c)

Figure 2. The large-disparity random-dot stereograms used in experiment 2: (a, top on the left) the Square condition, (b, bottom on the left) the Cross condition, and (c) the Control condition. These stimuli should be inspected from about 45 cm so that the disparity in each case is about 1°17′. It was more convenient when constructing these stimuli to make them somewhat larger than those of experiment 1 (their overall dimensions were 11°6′ × 11°6′ and the size of their elements was 7·5′).

24 × 24 matrix except that the midpoint of each element was randomly varied in the range ±11′ horizontally and vertically from perfect regularity of spacing. The central disparate square area in each stimulus contained 36 elements, all possessing 5′ disparity. The monocular features were created by adding to the basic stereogram of figure 1c extra elements so that lines of higher element-density appeared (figures 1a and 1b).

A demonstration stimulus of a non-random-dot kind was used at the start of the experiment for showing the subject the kind of depth experience he should expect to see when the experimental stimuli appeared. This demonstration stimulus consisted of a large circle (diameter 5°24′) which lay in the plane of the screen and which enclosed a smaller circle (diameter 30′) possessing 5′ crossed disparity.

2.2 Subjects
Eighteen university undergraduates participated in experiment 1. They were required to have emmetropic or fully-corrected vision with no history of binocular disorder. All were totally naive as to the purpose of the experiment and none had previous experience of random-dot stereograms.

2.3 Experimental design
Subjects were randomly assigned to one of three experimental conditions, called the Square, Cross, or Control conditions according to the stimulus used in each. Each subject thus saw only one kind of stimulus.
2.4 Procedure
Before the experiment commenced, the subject was given a full verbal description of
the experimental stimulus he was about to see, which included references to monocular
features where relevant. Description of the depth percept he was to respond to was
aided by presentation of the demonstration stimulus. His task (see below) was also
described fully at this stage.

Each presentation trial commenced with a 3 s warning tone, at the onset of which
the subject was required to fixate a spot provided at the centre of the screen. When
the tone ended, the fixation spot was replaced by the experimental stimulus and a
timer started. The task of the subject was to press a button when a “clear, roughly
square-shaped area lying in front of the rest of the slide” could be seen. The button
press stopped the timer. A 3 s delay was interposed between the button press and
removal of the stimulus during which the subject was instructed to continue inspecting
the stimulus. This enabled the subjects to view the successfully fused stimulus for
more than a brief instant. If no response was made within 35 s the exposure was
automatically terminated.

The subject was shown fifteen presentation trials of the above kind. The time
between the onset of successive warning tones was 50 s, a value which ensured that
each subject had a minimum rest period of 12 s between the end of one stimulus
presentation and the start of the next.

It was decided that potential subjects who could not obtain stereopsis within the
first 35 s presentation trial would be excluded from the experiment. This precaution,
which had the objective of screening out subjects with particularly weak stereopsis in
order to reduce unnecessary statistical ‘noise’, could have proved unfortunate if one
of the conditions had been particularly difficult. This difficult condition would then
have tended to collect subjects with above-average stereopsis, thus introducing bias
into the results. In fact, however, only one subject (viewing the Control condition)
was eliminated on the basis of this criterion so the question of appreciable subject
selection bias did not arise. Group median latencies for the three conditions over the
fifteen presentations are shown in figure 3. This graph thus displays the learning
curves for each kind of stimulus.

![Figure 3. Results from experiment 1: group median latencies for the fifteen presentation trials of each condition. The reader can informally assess the validity of these results for himself by inspecting the stimuli of figure 1 and noting whether his stereopsis perception times for the three conditions are approximately equal, although it should be remembered that in the experiment each subject saw only one type of stimulus.](image)

2.5 Results
The Square and Control conditions produced very similar results. The Cross condition
showed a tendency to generate rather longer latencies, at least until the last few trials,
but in fact the three conditions are not significantly different either with respect to
the first presentation latencies or with respect to the median latencies over all fifteen
presentations (Kruskal–Wallis tests, $H = 0.64$ and $3.58$, respectively, d.f. = 2) or
over blocks of five trials ($F = 1.31$, d.f. = 2, 15), where for this analysis each
subject's mean latencies for successive blocks of five trials were used, so taking advantage of the central limit theorem to compensate to some extent for any deviation from normality in the data. A sample size of five is rather small in terms of this theorem, but the analysis of variance technique used is reasonably robust with respect to slight violations of normality assumptions. This last analysis also revealed that a significant reduction in latency occurred over trials \( F = 15.35, \text{d.f.} = 2, 30 \), but that no significant interaction was present between trials and conditions.

The individual subject latencies for the first two tests are shown in table 1 and it can be seen there that the groups overlap to a considerable degree despite the tendency shown in figure 3 for the Cross condition to generate longer latencies.

These findings will be discussed in conjunction with those of the next experiment.

**Table 1.** Individual subject (S) latencies (in seconds) from experiment 1 for three conditions: F first presentation latencies; M median latencies from all fifteen presentations.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Square</th>
<th>Cross</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>2.18</td>
<td>1.84</td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td>7.00</td>
<td>4.20</td>
<td></td>
</tr>
<tr>
<td>S3</td>
<td>17.32</td>
<td>2.80</td>
<td></td>
</tr>
<tr>
<td>S4</td>
<td>11.76</td>
<td>0.74</td>
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<tr>
<td>S5</td>
<td>0.90</td>
<td>1.14</td>
<td></td>
</tr>
<tr>
<td>S6</td>
<td>1.92</td>
<td>1.76</td>
<td></td>
</tr>
</tbody>
</table>

3 **Experiment 2: Stereopsis perception times for large-disparity stereograms**

3.1 **Method**

The method used was for the most part the same as that of experiment 1. Certain alterations were, however, made as follows:

(i) The stimuli (figure 2) now had a disparity of 1°17'.
(ii) The two-circles demonstration stimulus was replaced by three presentations of the small-disparity Control stimulus of experiment 1. This change had two advantages: it enabled the same criterion to be used for excluding potential subjects from experiment 2 as was used in experiment 1 (three subjects were eliminated from experiment 2 in this fashion but no question of subject selection bias arises this time because subjects were allocated to conditions after the presentation of the small-disparity Control stimulus); and it made sure that all subjects knew very well the kind of depth experience on which to base their response. This latter point was an important one because pilot runs had suggested that many subjects would find the large-disparity Control stimulus particularly difficult and giving them prior experience of three successful fusions seemed a suitable way of maintaining their motivation for the task. After these three initial presentations the subject was told that the stereogram would be changed and, as in experiment 1, he was given a full verbal description of what to expect.

(iii) Twenty-four subjects participated (eight in each group instead of six).
(iv) A preliminary investigation of possible transfer of learning from the Square and Cross stimuli to the Control one was incorporated into the experimental design. This was achieved by showing subjects in the Square and Cross conditions five presentations of the large-disparity Control stimulus immediately after the fifteen presentations of their experimental stimuli proper (Square or Cross). The performance of these subjects on the Control stimulus could then be compared with the performance of
the subjects in the Control group on their first five presentations of the large-disparity Control stimulus. Thus the transfer design was A–B versus blank–B, where A was a fifteen-trial learning experience with either Square or Cross stimuli and B was a set of five test trials on the Control stimulus. Obviously, other transfer designs (most notably of a pre-/post-test variety, such as B–A–B versus B–blank–B) could be applied with possible benefit in terms of sensitivity and control. Nonetheless, the present design seemed worthwhile as a preliminary investigation. A further two presentations of the Square or Cross stimuli (according to condition) followed the five transfer test presentations of the Control stimulus to examine whether latencies to these stimuli were affected by exposure to the Control stimulus.

3.2 Results

Group median latencies for the three conditions are shown in figure 4. Conclusions drawn from various analyses were as follows:

(a) The three groups did not produce significantly different median latencies to the three initial presentations of the small-disparity Control stimulus (Kruskal–Wallis $H = 2.49$, d.f. = 2). This suggests that the random assortment of subjects to conditions had produced three fairly well balanced groups.

(b) The Square, Cross, and Control stimuli yielded significantly different results both with respect to first trial latencies (Kruskal–Wallis $H = 7.91$, d.f. = 2, $p < 0.02$) and with respect to the median latencies over all fifteen presentations (Kruskal–Wallis $H = 8.50$, d.f. = 2, $p < 0.02$) and with respect to successive blocks of five trials ($F = 15.92$, d.f. = 2, 21, $p < 0.001$). There was no significant trials factor present in this last analysis ($F = 0.31$, d.f. = 2, 42) nor was there a significant interaction between trials and conditions ($F = 0.22$, d.f. = 4, 42). Subsequent comparisons showed that the Control condition produced significantly longer latencies than the Cross (Mann–Whitney $U = 7.50$, $N_1 = 8$, $N_2 = 8$, $p < 0.005$) and those of the Cross

![Figure 4. Results from experiment 2: group median latencies for the various presentation trials. Once again, the reader can consider the results from the three experimental conditions with respect to his own viewing of the relevant stereograms (figure 2).](image-url)
were themselves significantly longer than those of the Square \((U = 6.00, N_1 = 8, N_2 = 8, p < 0.002)\).

(c) The results from experiments 1 and 2 were compared by means of a set of three Mann–Whitney \(U\) tests. These provided a simple and straightforward way of comparing the two experiments, with the comparison itself being justifiable because the two experiments were conducted under similar conditions (i.e. same method, experimenter, and test location), and because subjects were taken from the same undergraduate class so that the two subject samples could be regarded as homogeneous.

Overall median latencies from the Square condition were not significantly different from the equivalent latencies from the small-disparity Square condition of experiment 1 (Mann–Whitney \(U = 22, N_1 = 6, N_2 = 8\)). Similarly, the Cross conditions from the two experiments did not produce significantly different latencies (Mann–Whitney \(U = 15, N_1 = 6, N_2 = 8\)). In contrast, but as expected from inspection of figures 3 and 4, the Control conditions of the two experiments did give significantly different latencies (Mann–Whitney \(U = 4, N_1 = 6, N_2 = 8, p = 0.004\)).

(d) There was no statistically significant evidence of transfer of learning from the Square or Cross conditions to the Control stimulus. Figure 4 shows that the latencies produced by the Square and Cross groups to their five presentations of the Control stimulus differed little from the latencies produced by the Control group who had no benefit of prior exposure to the Square and Cross stimuli. Such slight improvements as appeared were not significant. Thus first-trial latencies in the Control group did not differ significantly from first-transfer-trial latencies in the Square and Cross groups (Kruskal–Wallis \(H = 2.67, d.f. = 2\)). Nor were the median latencies derived from all five transfer trials significantly different from the equivalent latencies derived from the first five trials of the Control group (Kruskal–Wallis \(H = 1.24, d.f. = 2\)). It can be seen very clearly in figure 4 from the post-transfer trial presentations of the Square and Cross stimuli, that the five transfer trials did not disturb the asymptotic performance levels achieved by the Square and Cross groups in their pre-transfer presentations.

4 Discussion
The results of the two experiments give substantial support to the vergence hypothesis insofar as:

(a) relatively long perception times were produced by a large-disparity stereogram unless prominent monocular features were present which could have served to guide the required eye movements (experiment 2);
(b) relatively short perception times were recorded for a small-disparity stereogram whether or not prominent monocular features were included (experiment 1);
(c) facilitation in experiment 2 was produced by both Square and Cross features, and in experiment 1 both Square and Cross times were not significantly different from those of the Control.

Certain aspects of the results, however, were not completely in keeping with expectations derived from the vergence hypothesis. Thus the Cross stimulus of experiment 2, while producing significantly shorter latencies than the Control condition as expected, nonetheless did not facilitate stereopsis to quite the same degree as the Square. A similar tendency was evident in the data from experiment 1 (figure 3), although in that case the Cross latencies were not significantly slower than those of the Square. These results could be accounted for in terms of eye movement control by suggesting that the Cross did not, contrary to initial expectations, provide quite such a good guide to the necessary eye movements as did the Square. For example, the Square might have led not only to appropriate vergence movements but also to an appropriate set of conjugate movements over the whole disparate zone.
because the contours of the Square completely enclosed this area. In contrast, the Cross might have tended to direct conjugate movements simply to the central part of the disparate area. One advantage of this suggestion is that it can explain why the Cross latencies of experiment 1 tended to be slower than those of both the Square and the Control—the Cross tending to produce slower latencies even than the Control (in the small-disparity case) because it directed attention for too long on just the centre of the display. This slight hindrance would not occur in either the Square or the (small-disparity) Control conditions. Alternatively, the Square might have conveyed extra benefit for reasons quite unconnected with eye movements (e.g. shape cues per se). We are at present investigating these questions by exploring the effects of further kinds of monocular features.

It is of some interest to ask at this point what might be the effects of including dissimilar features in each half-stereogram. Westheimer and Mitchell (1969) found that tachistoscopic presentation of disparate dissimilar images led to the initiation of an appropriate vergence but not to its completion. For completion of the movement and for the eyes to remain locked into the appropriate vergence position, similar left/right images were necessary. In the present situation one might therefore expect, given the vergence hypothesis, either that the presence of dissimilar left/right features might facilitate speedier fusion in that they should at least set appropriate vergence movements underway, or that dissimilar features might actually hinder fusion by making the display rivalrous and thus making it more difficult to hold the correct vergence. Accordingly, the use of dissimilar features does not provide a critical test of the vergence hypothesis, but it is nonetheless an interesting question to ask what the effects of such features would be. The reader can ascertain how they affect his own fusional system by inspecting the anaglyph shown in figure 5a which is a large-disparity stereogram with Square and Cross monocular dissimilar features. We have shown this stereogram to eight fairly experienced viewers of random-dot stereograms, using the general experimental conditions obtaining in experiment 2. These subjects were also shown a large-disparity Control stereogram (figure 2c), with half the subjects seeing first the dissimilar-features stereogram and half the Control stereogram. This repeated-measures design seemed justifiable in view of the lack of transfer of learning found in experiment 2 (see below). Each stereogram was presented ten times and table 2 shows each subject’s median latencies for the two kinds of stereogram. It can be seen that two subjects (S1 and S7) treated both the Control and dissimilar-features stereograms similarly in that they were unable to fuse either on any presentation, that four subjects (S2, S4, S6, and S8) were hampered by the dissimilar-features, and that two subjects (S3 and S5) were helped by them. Quite obviously, no uniform picture emerged from this study. Most subjects reported the dissimilar-features stereogram as rivalrous and unstable, with the vertical line of the Cross sometimes fusing with the left vertical line of the Square and sometimes with the right. Indeed, one observer succinctly expressed the common reaction to the dissimilar-features stereogram when he likened his attempts to maintain correct fusion as being similar to “trying to stick a drawing pin into a ball-bearing”.

We have also explored informally the effects of dissimilar features which are less markedly different than Square and Cross. Figure 5b shows a stereogram with Square and Circle monocular features and the reader can check for himself our findings with this stimulus, namely that most observers find this stereogram easier to fuse than either the Square/Cross or the large-disparity Control ones. This finding is

Figure 5 (on the right). Large-disparity random-dot stereograms containing dissimilar monocular features (see text): (a) Square and Cross, and (b) Square and Circle. Instructions for inspection are as for figure 2.
Monocularly conspicuous features in random-dot stereograms

(a)

(b)
understandable because there is a reasonably good match between the monocular features in the two fields, and so this makes for less rivalry and a more stable fused percept.

Further experiments using dissimilar features obviously spring to mind. For example, the rivalry induced by such features might be eliminated without loss of their useful vergence-triggering ability by creating a stimulus situation in which they were removed from the stereo display soon after the stereogram had been presented. Alternatively, but with much greater difficulty, one might arrange to have the monocular features disappear once a suitable vergence movement had begun. But perhaps the best way to investigate the vergence hypothesis further is to record these movements as an observer is attempting to fuse a random-dot stereograms of the note how these vergence movements change with learning, with the presence of similar or dissimilar monocular features, etc.

Summarising this brief exploration of the effects of using dissimilar features, it seems fair to say that the exact consequences will depend partly on the observer and partly on the degree of dissimilarity employed. This conclusion is, of course, quite in keeping with the vergence hypothesis.

There was no evidence of transfer of training in experiment 2 from the Square and Cross conditions to the Control one. In terms of the vergence hypothesis, this result suggests that merely knowing where to direct eye movements is not sufficient to shorten stereopsis perception times: rather, for large disparity stereogram of the present kind, ‘on-line’ guidance of vergence movements by monocular features seems to be required. [It is perhaps worth pointing out in this connection that subjects in both experiments 1 and 2 were given foreknowledge of what to expect. This was done because we have found that subjects who are not given this information show more variable latencies, at least on the first trial, simply because they do not know what constitutes an adequate basis for a response. “Is this the required ‘object’ I am seeing or not?” they have to ask themselves. Problems of this kind were eliminated in the present research by giving foreknowledge and this design factor had the added advantage that differences between the two experiments cannot be explained in terms of differential response criteria operating in each case. Of course, it could be argued that foreknowledge might be of greater benefit in small-disparity than in large-disparity stereograms, but even if this were true it is difficult to see how this could help in interpreting the present data.]

Finally, it is worth noting that Frisby and Clatworthy (1975) found that stereopsis perception times for a large-disparity complex multi-planar random-dot stereogram were not shortened by the inclusion of monocular features in the display. This result

Table 2. Median subject latencies (in seconds) for large-disparity stereograms containing either dissimilar monocular features or no monocular features (Control).

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Dissimilar features</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>S2</td>
<td>35</td>
<td>27·16</td>
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<tr>
<td>S3</td>
<td>20·57</td>
<td>24·69</td>
</tr>
<tr>
<td>S4</td>
<td>13·77</td>
<td>4·80</td>
</tr>
<tr>
<td>S5</td>
<td>4·66</td>
<td>35</td>
</tr>
<tr>
<td>S6</td>
<td>35</td>
<td>20·04</td>
</tr>
<tr>
<td>S7</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>S8</td>
<td>35</td>
<td>29·93</td>
</tr>
</tbody>
</table>

Note: A latency of 35 s indicates that no fusion was obtained on any trial.
seems at first sight at odds with the present findings. Their stereogram, however, for all its apparent complexity (it was a spiral staircase protruding from a screen towards the observer) did not produce the long perception times found here with the two-planar stimulus. Thus it seems that a large-disparity complex spiral stereogram presents observers with a less demanding fusional task than does a simple square-plus-surround stimulus of similar disparity (note that the methodologies were very similar in the two experiments and the disparities in both were just over 1°). This is a counter-intuitive result and it is interesting to ask whether the vergence hypothesis can deal with it. Now careful inspection of the spiral staircase stereogram shows that, although considerable overall depth is present, nonetheless the staircase structure is such that the disparity shifts from step to step are small. Thus, even when no monocular features are present, it might still be a relatively easy large-disparity stimulus in vergence terms, because, although appropriate vergence movements are indeed required, each one could be of a quite small size (roughly comparable to the vergence shift involved in changing fixation from surround to square in the small-disparity stereograms used here). The two-planar stereogram of experiment 2, in contrast, requires the subject to make one large vergence shift to accommodate over 1° of disparity all at once. The vergence hypothesis can therefore explain a surprising result in a straightforward and convincing fashion and this lends added weight to its credibility.

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References