by cracking and the deep component to failure by anticracking. The exponential drop-off of the shallow component might be due to fluid-assisted cracking (Terzaghi effect)[41] down to depths of perhaps 250 km; the similar rapid rise of the deep component is consistent with faulting by anticracking in response to increased overstepping of the olivine→spinel phase boundary at greater depths. Faulting finally falls off rapidly at depths >650 km as the spinel→perovskite+magnesiowüstite transformation is completed and no other transformations are available[22]. □

Received 25 April; accepted 11 September 1989

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ACKNOWLEDGMENTS. H. W. G. thanks P. J. Vaughan for introducing him to the problem of phase-transformation under stress. We also thank D. Prior for help with the SEM, J. Abril and N. Winter for technical assistance and S. Raubach for preparing the manuscript. This work was supported by the NSF.

Perception of multiple transparent planes in stereo vision

Daphna Weinshall

Center for Biological Information Processing, Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, E25-201, Cambridge, Massachusetts 02139, USA

INFORMATION about the distances of objects that we see can be obtained from the disparity in position of their images in our two eyes. This process entails solving the problem of stereo-matching, which involves the determination of which points in the two images correspond to the same object. This is particularly problematic when features in the visual field are repeated, allowing more than one possible solution to the stereo-matching problem. Here I describe a situation in which a repetition of a random dot pattern leads to the perception of multiple transparent planes under some conditions, and of a single opaque plane under other conditions. This result shows that stereo-matching is not necessarily unique—a given point of the image in one eye may be matched simultaneously to more than one point in the other eye, each match defining a different depth plane. Current stereo-matching algorithms in computer vision do not account for these observations.

The stereoscopic matching of points in images involves a difficult computation, as shown in Fig. 1*b*. Here the two bars in the left image can be matched to the two bars in the right image

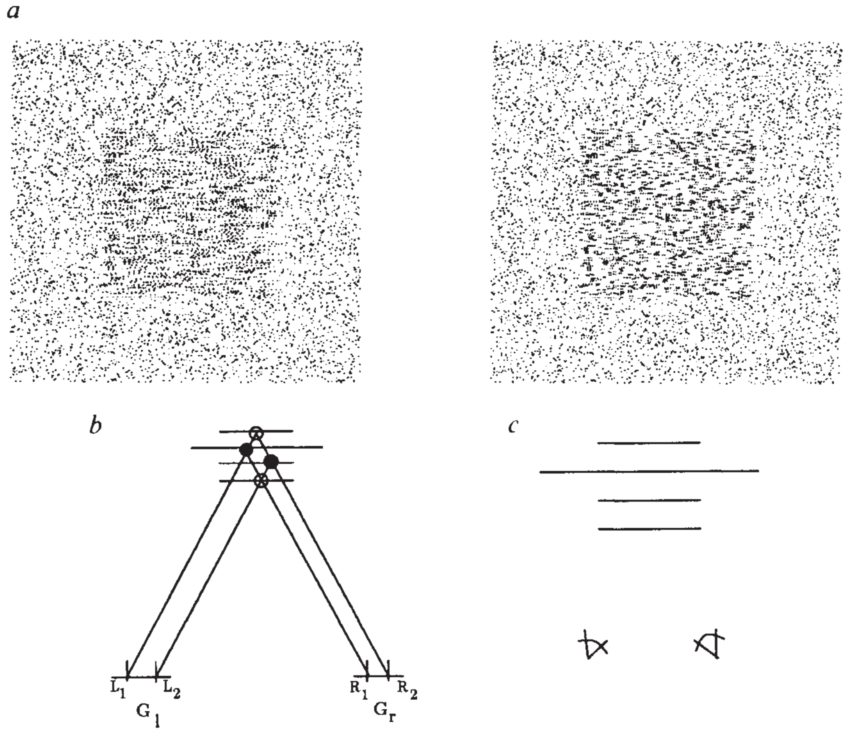

FIG. 1 *a*, An ambiguous stereogram with $G_r=10'$ and $G_l=20'$. After some time four planes emerge: two in front of the background, the background (all three transparent), and one behind the background. The deepest plane is often difficult to see; it helps to slightly diverge the eyes to capture it. Note the two bars ('nails') in the middle of the stereogram, which are usually seen on the two middle surfaces only, and which are hard to flip to the other surfaces. Because it takes some time for the impression to build, it is recommended to use a stereo viewer ~12.5–15.5 cm high. *b*, A graphic illustration of the projections of the two bars from the stereogram in *a*. The two pairs of matches that are mutually exclusive if matching is unique are separately marked by filled and hollow circles. This is also an illustration of the stimulus in the double nail illusion, where two nails are placed one behind the other with respect to the viewer. The resulting stereo pair looks like *b*, except that the ghost matches are in fact the correct ones. Humans, however, seem to prefer the order-preserving matches, and see an illusory percept of two nails side by side at the same depth[3]. *c*, The depth profile of the four possible matches of the stereogram in *a*. Braddick has used related stereograms (unpublished results; also see ref. 10) with effectively $G_r=0$ (or $G_l=0$).

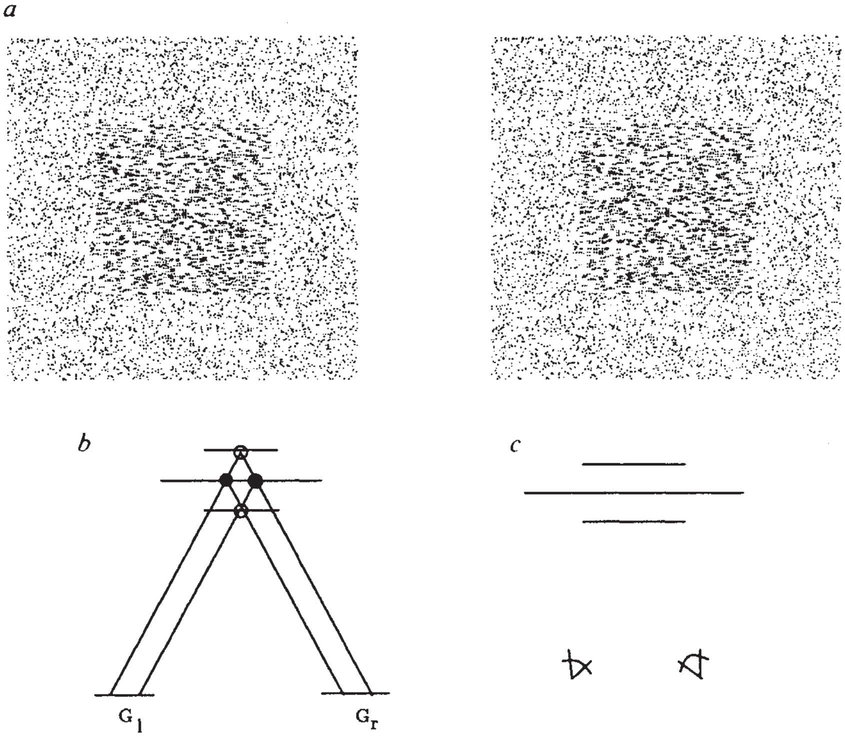

FIG. 2 *a*, An ambiguous stereogram with $G_r = G_l = 10'$. Here only one opaque surface is seen, the background, and no vergence can help detect the other two surfaces (one above the background and one below it). *b*, A graphic illustration of the projections of two points from the stereogram in *a*. *c*, The depth profile of the three possible matches of the stereogram in *a*.

in four different ways. Two of these correspond to the matching of the left bar in the left image to the left bar in the right image, and the matching of the right bar in the left image to the right bar in the right image. These order-preserving matches are generally presumed to be correct[1,2]. The other two matches are the 'ghost' or false matches. Humans seem to prefer the order-preserving matches even under experimental conditions where the ghost matches are in fact the correct ones (the double-nail illusion shown in Fig. 1*b*, see also ref. 3). The ambiguity of matching is higher with random dot stereograms, where each point has many false matches in the other image (see Fig. 1*a*). Matching algorithms are usually meant to resolve such ambiguities and to obtain a unique correspondence (for example, see refs 4 and 5).

To test whether matching in human vision is always unique, I used an ambiguous random dot stereogram, which is an extension of the double-nail illusion. This was generated by first computing a random dot pattern, which was then copied twice in each image, with a different horizontal spacing of G_r minutes of arc in the right image and G_l minutes of arc in the left image (Figs 1*a* and 2*a*). The random pattern background was identical in both images. Observers who could fully fuse these stereograms saw four transparent surfaces corresponding to all the four possible matches shown in Fig. 1*b* (with the help of vergence

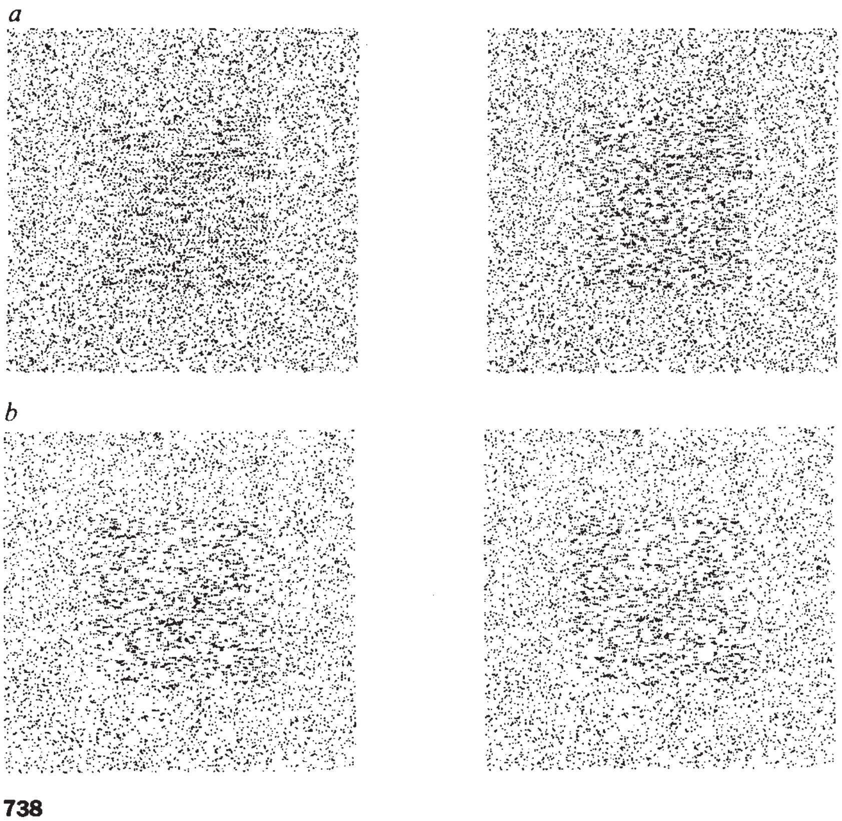

FIG. 3 *a*, As in Fig. 1*a*, where the number of points in the deepest plane have been doubled with new unambiguous points. *b*, As in Fig. 2*a*, with an additional new uncorrelated plane at disparity 20′, twice the disparity of the suppressed planes (10′ and −10′).

and memory; vergence is often needed in the perception of transparent stereograms[6]). These observers could judge the depth of the ghost surfaces correctly. This perception is unlike the perception of only two matches with single features (the double-nail illusion).

This result indicates that all sufficiently strong disparities give rise to the perception of distinct transparent surfaces. I define the strength of a given disparity at a given pixel to be the value of the correlation function between the two images (see Fig. 4 legend). A sufficient strength is a correlation value that is sufficiently above random. I call the corresponding disparity a 'solution'. To test the above hypothesis I used a special case of the stereogram that was used in the first experiment, in which $G_r = G_l$ (see Fig. 2). In this case there are three possible solutions (Fig. 4*b*). One might expect to see three transparent planes, by analogy with the first experiment. Surprisingly, only the strongest solution was seen, and this perception was quite robust.

Perhaps only solutions with approximately equal strength, that is, with comparable maxima in the correlation function, are detected, whereas weaker solutions are suppressed. To test this hypothesis I used the initial stereogram, in which $G_r \neq G_l$, but the amount of points in one plane was doubled by adding unambiguously matched points. All four solutions were still seen (Figs 3*a* and 4*c*). The other surfaces were visible even when the number of points in one surface was quadrupled.

The suppressed planes of Fig. 2*a* could be made to reappear for some observers. Either the number of points in each image was doubled by adding unmatched random dots, or correlated points were added to both images, forming a new plane (see Figs 3*b* and 4*d*).

The independent local selection of one of the possible ambiguous matches cannot by itself explain why the ambiguous planes were suppressed in Fig. 2 and visible in Fig. 1. I will now briefly outline a computation scheme that is consistent with these results. Initially, surfaces are constructed that take into account all possible matches of all the pixels. Let the support set of a surface be the set of points within a window of size W in one image, which contribute to its construction. Assume W is large enough so that random matches occur at all disparities. A surface is retained it is has a sufficiently large support set that is not included in the support set of a different surface. With simple transparencies (see refs 7 and 8) all possible solutions survive, as their support sets are disjoint. In the stereogram of the first experiment (Fig. 1) all four solutions survive because part of the support set of each solution is derived from random matches (as shown by the fact that the peaks in Fig. 4*a* are ~10% greater than the value of 0.5 expected from the strict matches shown in Fig. 1*b*). In the stereogram of experiment 2 (Fig. 2), the strong solution suppresses the others because its support set includes all the points in any region.

The main implication of the above discussion is that the resolution of matching ambiguities is not as simple as nearly all the computational theories of stereo vision assume. A unique solution is a stated objective of these theories. My results require their extension to describe surface interpolation, which allows and uses multiple matchings. Possibly, the processes involved in feature matching and the resolution of ambiguities are different from those involved in surface interpolation (see ref. 9). □

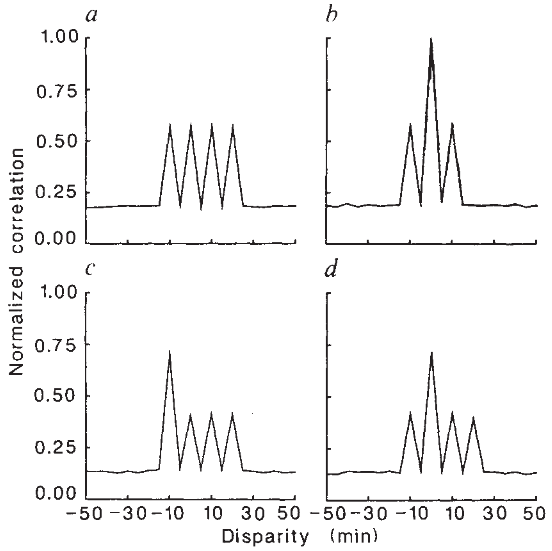

FIG. 4 The normalized correlation between the left and the right images at their centre: $\sum_i^W \sum_j^W I(x_i^R, y_j^R) I(x_i^L + D, y_j^L)$. The *x*-axis is the disparity *D*: *a*, Stereogram of Fig. 1; *b*, stereogram of Fig. 2; *c*, Stereogram of Fig. 3*a*; *d*, stereogram of Fig. 3*b*. The size of the window *W* is the width of the ambiguous square at the middle of each image. The correlation value is normalized by the number of features in the window so that it equals 1 if all the points are matched for some disparity value. These plots have been computed for stereogram with dot density of 10%. The noise level (10% in *a*) increases with dot density. Note that only in *b*, the only case where a single opaque plane is perceived, has one of the possible solutions a normalized disparity value of 1. This observation indicates a way to modify an area-based correlation stereo-matching algorithm to give the above results (for example, see ref. 11).

Received 14 June; accepted 4 September 1989.

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ACKNOWLEDGEMENTS. I thank Scott Kirkpatrick, Graeme Mitchison and Tommy Poggio for discussion, advice and criticism. Shimon Edelman provided useful comments. The research was supported by a Chaim Weizmann postdoctoral fellowship, the Sloan Foundation, the ONR, DARPA and the NSF.

Arachidonic acid induces a long-term activity-dependent enhancement of synaptic transmission in the hippocampus

J. H. Williams, M. L. Errington, M. A. Lynch & T. V. P. Bliss

Division of Neurophysiology and Neuropharmacology, National Institute for Medical Research, Mill Hill, London NW7 1AA, UK

LONG-term potentiation (LTP) is a widely studied model of the synaptic basis of information storage in the mammalian brain[1,2]. The induction of LTP is triggered by the postsynaptic entry of calcium through the channel associated with the *N*-methyl-D-aspartate (NMDA) receptor[3–7], whereas its maintenance is mediated, at least in part, by presynaptic mechanisms[8–12]. To explain how postsynaptic events can lead to an increase in transmitter release, we have postulated the existence of a retrograde messenger to carry information from the postsynaptic side of the synapse to recently active presynaptic terminals[10]. Candidates for a retrograde messenger include arachidonic acid or one of its lipoxygenase metabolites[12–18]. Here we report that weak activation of the perforant path, when given in the presence of arachidonic acid, leads to a slow-onset persistent increase in synaptic efficacy both *in vivo* and *in vitro*. The activity-dependent potentiation thus produced is accompanied by an increase in the release of glutamate, and is