nance edges to match". The vertical luminance edges on the left side of the left-eye view clearly have no corresponding luminance edges on the right side of the right-eye view and yet these luminance edges, and the surfaces bounded by them, appear at different depths. The authors attribute the depth perceived in this stereogram to the presence of unpaired (monocular) regions which give rise to the perception of an occluding surface. They found that the degree of depth perceived is predicted by the width of the monocular regions.

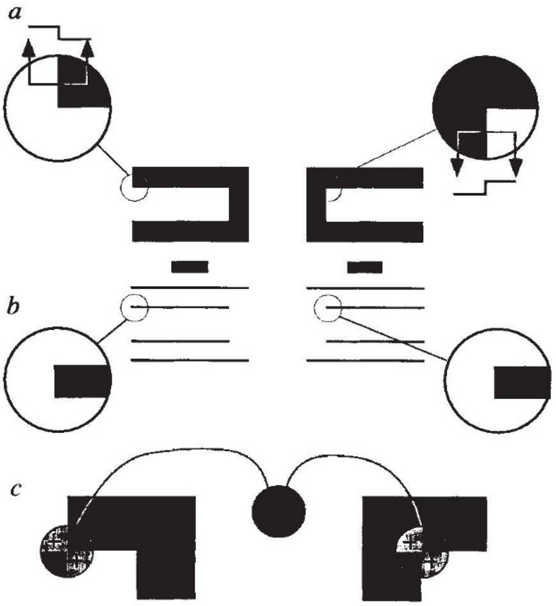

Fig. 2 Pairing of features (see text for details).

I suggest that the rejection of conventional stereopsis as the source of depth in these stereograms is premature. The absence of matching vertical luminance edges is not in dispute. The stereogram, however, contains matching horizontal luminance edges with disparities given by their end points. This is illustrated in Fig. 1*c* in which the horizontal luminance edges of the Liu *et al.* stereogram have been replaced by horizontal lines with the same lengths and positions. Despite an absence of unpaired components in Fig. 1*c* the same region is seen in depth in this stereogram as in Fig. 1*b*, apparently to the same degree. The inner pair of horizontal luminance edges in both cases is in crossed disparity relative to the outer pair and appears in front. The disparities of the horizontal luminance edges also account for the quantitative data of Liu *et al.* as these disparities increase as the widths of the monocular regions increase.

Thus it is not necessary to attribute the depth perceived in the Liu *et al.* stereogram to the presence of unmatched components and that it has yet to be established that quantitative stereopsis can be obtained without corresponding luminance edges.

Barbara Gillam
Department of Psychology,
Harvard University,
Cambridge,Massachusetts 02I38, USA

LIU *ET AL.* REPLY — The classical concept of binocular matching involves the pairing of features located near the corresponding retinal positions and which have similar, if not identical, shapes, orientations, spatial frequencies and contrast polarity. In this sense, our "phantom stereopsis" stimulus (Fig. 2*a*) does not possess matching elements. In *a*, a pair of corners is magnified to show that the features near the corresponding points are very different. We thus conclude that the quantitative depth perception produced by this stimulus represents an anomaly within the current theories of stereopsis. Replacing contrast edges with line segments alters the crucial contrast polarity information that makes the ends of the horizontal edges unmatchable in the conventional sense, thereby altering the nature of the stimulus. The magnified end points in Fig. 2*b* illustrate that the line segments have introduced matchable vertical contours that do not exist in the original stimulus.

We think Gillam's diagram is misleading because it gives the readers the impression that the depth perception in the phantom stereopsis stimulus is simply elicited by the horizontal lines. If Gillam's idea is to show that there are some "place-holders" in the display whose positions can be used to calculate binocular disparity, then we agree with her. However, these "place-holders" are not the traditional matching vertical contours but are a novel phenomenon . One possible mechanism that might respond to these dissimilar corners is illustrated by the quadratural receptive fields shown in Fig. 2*c*. These receptive fields would give equal responses to the different corners in Fig. 2*a*, and therefore would be disparity-tuned for this stimulus. Another possibility is that the disruption of binocular correspondence along a continuous vertical edge may indicate both the existence and the position of a occluder. Whatever the mechanism, conventional notions of matching features are inadequate to account for the distinct impression of depth this phenomenon produces.

L. Liu
S. B. Stevenson
C. M. Schor
School of Optometry,
University of California,
Berkeley,
California 94720, USA

Random laser?

SIR — Lawandy *et al.*[1] describe optical experiments on colloidal suspensions of TiO_2 microparticles in rhodamine dye solutions. These suspensions were pumped with 532-nm pulses and the spectral and temporal behaviour of light emitted from the pumped surface was recorded. Above a certain pump power threshold a dramatic narrowing of the emission linewidth and a shortening of the emitted pulses were observed. These are known characteristics of laser action. As the same effects were not observed for a clear dye solution, the laser-like behaviour was ascribed to the presence of the microparticles. The authors suggested a possible interpretation in terms of a feedback mechanism supplied by photon diffusion, which would make their system a fascinating 'random laser', but they also point out that part of their data remains puzzling. In view of the large reported values for the (photon diffusion) mean free path, we expected the proposed feedback mechanism to be very unlikely. We therefore decided to look into the reported phenomena.

On the basis of our experimental findings, we propose an alternative explanation in terms of amplified spontaneous emission, which is a common phenomenon for pumped laser dyes[2,3] and does not require optical feedback. Laser-dye molecules absorb light in a frequency range known as the pump band. Once excited they become non-absorbing for pump light (the dye is 'bleached'). The excited population decays spontaneously with some characteristic lifetime, under emission of broadbanded light at lower frequencies. This is called spontaneous emission. If the emitted light passes through a region containing excited dye molecules, it may de-excite these, being amplified in the process (stimulated emission). This accelerates the decay and therefore shortens the (pulsed) output. Because the gain is strongest at the wavelength where the cross-section for stimulated emission is highest, (exponential) amplification also leads to band narrowing. In a laser, cavity mirrors bring about a multiple passage of the light through the amplifying region. This feedback mechanism is used to obtain a high gain. In the absence of feedback, however, single-pass amplification may already produce significant band narrowing and pulse shortening, a phenomenon termed amplified spontaneous emission (ASE).

Within a pumped region, ASE will occur in the direction(s) of highest gain, that is, in general, in the direction(s) in which this region is most extended. If a spatially broad pump pulse is incident on a dye cell, its front edge will create a disk-shaped amplifying region, and ASE will develop in the plane of this disk, parallel