has observed the line in M 17 and the Orion nebula at $\nu_L = 5736$ Mhz, corresponding to the transition $n_{105} \rightarrow n_{104}$ (*8*). Their quantitative values for M 17 ($T_L/T_C = 3.8 \pm 0.5$ percent, $\Delta\nu_L = 1.3 \pm 0.3$ Mhz) do not agree too well with our results. The Lebedev group observed the excited hydrogen line at $\nu_L = 8872.5$ Mhz, corresponding to the transition $n_{91} \rightarrow n_{90}$ (*9*). They found the line only in M 17 but, surprisingly, not in Orion A, and report for M 17 the result $T_L/T_C = 4.2 \pm 1.9$ percent, and $\Delta\nu_L = 1.3 \pm 0.3$ Mhz.

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Visual Contours in Homogeneous Space

Abstract. *With the aid of the Julesz figures, we introduce the concept of the stereoscopic edge, an edge which exists visually in the absence of physical contours. This edge, as well as the full complex of normal stereoscopy, can be present in the complete absence of physical contours at the fovea to approximately ± 3.00 degrees from fixation.*

In 1960, Julesz reported a new approach to the study of stereoscopic vision (*1*) which has led to the solution of many old problems by surprisingly simple means (*2, 3*). I would like to concentrate here on two issues which the Julesz figures have encouraged me to examine: one is the role of foveal contours in stereopsis and the second, more important, is the nature of the stereoscopic edge.

One term that must be defined is the *stereoscopic edge*. In classical stereograms, figural edges are almost invariably delineated by completed contours. If there are broken contours, they are not systematic nor analyzed as such. Figure and ground are fundamentally different. In the binary Julesz figures, on the contrary, figure and ground are equivalent and contours are invariably incomplete, in the Gestalt sense: if the figures are truly random, a contour line is as likely to be given by the triple of dots, black-white-black, as it is by any other permutation of three binaries. Nevertheless, the stereoscopic edge is as definite through the *white dots as it is through the black*.

This description of the Julesz figures is my own. I would like to point to its significance by asking "how big can the white (or, for that matter, the black) dots be?" Thus, "How much unstructured stereoscopic ground can there be between the figures?" Thus, "Is stereoscopic edge perception possible in or through a ground where there is nothing but undifferentiated white?" "Undifferentiated black?" "An empty visual Ganzfeld?"

The logic of the experiment is developed in Fig. 1*A*. This is a binary field in that the units are densely packed and are either black or white. More important, the units are of equal size and shape. The vertical columns consist of three bits. As a Julesz figure, let this pattern be that in the right eye, and let the pattern obtained by "moving the column marked δ over to the position marked δ′ and sliding the remaining columns the distance δ to the left" be that in the left eye. Since the bits are the same size, the horizontal retinal disparity (a function of δ) is basically constant over the field (*1*).

In Fig. 1*B*, however, I arbitrarily altered the horizontal dimensions of the bits. Nothing has changed from the point of view of information theory, since the topology has not changed (true also of Fig. 1*C* and Fig. 1*D*), but the retinal disparity is no longer constant over the field. Figure 1*C* shows a dilatation in the vertical direction. In this case, δ remains constant. Figure 1*D* combines both horizontal and vertical dilatations.

This experiment derives from Fig 1*C*, as illustrated in Fig. 1*E*. Since vertical dilatation leaves the retinal disparity constant, the middle row can be dropped and be replaced entirely with a homogeneous inner-region, either all light or all dark, of variable width *s*. Since neither the binary character of the Julesz figures nor their dense packing is essential, and since it is possible to keep δ acceptably small and reasonably constant by careful typesetting, it is feasible to use meaningful targets such as letters, numbers, diacritical signs, complex figurines, or what have you (see also *3*). Thus a target such as that in Fig. 2*A* was devised. It demonstrates a principle—as well as the possible relevance of this work to clinical ophthalmology—but *any* other target will do as well. The three uppermost and the three lowermost rows are nondisparate rows and thus provide a strong ground or reference plane; the four inner rows are disparate (δ = ♅ and δ′ = ⊕) but are otherwise identical so as to aid in the development of the figure or displaced plane. (Trials with nonidentical inner rows resulted in discrete, unevenly displaced planes. The careful observer may see that certain rows are still uneven!) A minimum number of rows is essential: an outer nondisparate pair, and an inner disparate pair (or vice versa, though the effect is less marked). I have used ten rows only as an experimental convenience. Without the nondisparate outer rows, the stereoscopic displacement occurs only indistinctly and certain ancillary perceptual effects (noted below) are absent.

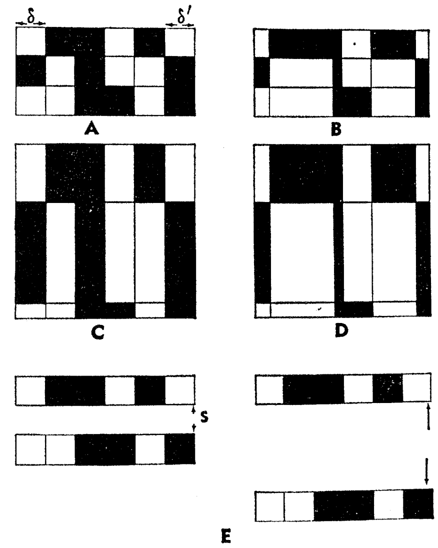

Fig. 1. The logic of the experiment.

The upper set of ten rows (two sets of five rows, side by side; one set for the left eye and one for the right) was photographically placed upon the upper surface of an otherwise clear sheet of film. The lower set of ten rows was similarly placed on the under surface of another clear sheet of film. Especially good film was used, with no visible scratches; the films were brushed with camel's hair to remove all traces of dust. No surface marks were visible during the experiment. The film sheets were then placed one on top of the other, emulsion surfaces together, so that the figures were all in the same physical plane and were equally contrasted to the eye. The bottom sheet was fixed to a diffuse transilluminator (a viewing box) and the top sheet was slid up and down on top of it to give the variation s as shown in Fig. 1 *E*. Thus, there are black figures on a visually empty self-luminous ground (Fig. 2*A*). A second method was also used. The targets were developed as reverse 2×2 slides (that is, white on black) and were placed in two adjacent projectors; s was controlled by adjusting the positions of the projected images. Thus, there are now self-luminous figures on a visually empty black ground (Fig. 2*B*) (*4*). Although these two situations are quite different retinally, they are identical from the point of view of information theory. The perceptual results, as we shall see, are also formally quite comparable.

The visual experience is clear in both instances and can readily be obtained without optical aids by any normal observer trained in free-viewing stereoscopy, or by others with aids. It is shown schematically in Fig. 2*C* for homonymous (crossed-eye) viewing and in Fig 2*D* for heteronymous (parallel-eye) viewing.

For small s, say equal to the normal interline spacing, one sees two surfaces: a near reference- or ground-frame formed by an apparently flat plane through the nondisparate rows, and a far displaced- or figure-plane, formed by the disparate rows (together with the spaces between them), removed some distance behind the reference plane. The displacement distance is a function of the disparity and an observer parameter (see, for example, *5*).

What concerns us particularly is the vertical edges of the displaced figure (the wiggly lines in Fig. 2*C*), because these can be controlled by s. Initially, these edges were formed by a perceptual (Gestalt) organization occurring in the two end-columns: at the left, four ⊙'s, at the right, four ⊕'s, uniting these symbols with the three equal interline spaces between them. Now, when

Table 1. Limits of stereoscopic edges and displacements in a homogeneous visual field.*

Observer	Near target, black on white (20 cm; $\eta = 0.64°$)		Distant target, white on black (325 cm; $\eta = 0.43°$)	
	Edge formation	Stereopsis	Edge formation	Stereopsis
T.S.	$3.90° \pm 0.32°$	$3.70° \pm 0.37°$	$3.38° \pm 0.19°$	$2.36° \pm 0.22°$
A.F.	$3.75° \pm 0.24°$	$3.96° \pm 0.76°$	$1.91° \pm 0.16°$	$2.70° \pm 0.20°$
S.S.	$3.53° \pm 0.58°$	$3.82° \pm 0.54°$	$2.24° \pm 0.17°$	$1.77° \pm 0.16°$

* All values are means of 50 measurements, alternating in and out motions of s, together with their respective standard deviations. They are the half-angle ($s/2$) at the fovea. The only statistically significant trend is that the values for the near target, with the greater disparity (η), are uniformly larger than the corresponding values for the far target. These data were taken with free-viewing stereoscopy (homonymous diplopia) and are thus probably minimum magnitudes, since this technique requires training and puts a strain on the accommodation-convergence relationship. To some extent, these data also provide the first quantitative individual index of this skill in the literature.

s is increased, the side walls grow accordingly. This is the result of interest. As the rows separate, the displaced figure (plane) grows between them, and a white (or black) displaced window appears in the white (or black) ground in very crisp outline. These are pure edges, stereoscopic edges without physical contour. The rows can be separated by more than 3 cm (with the observer at about 20 cm) and the window will stretch out to this size. If the eyes scan up and down the edges, the angles in columns 2 and 4 ("Edge formation") of Table 1 can be achieved. These values will vary, of course, depending upon the experimental conditions, but especially upon the disparity. Comparable data for the heteronymous view give slightly smaller angles. They all show, however, that depth within the empty field is somehow induced by disparity at the corners.

Interestingly, a very faint grey line appears at this visual edge, which is indicated by the wavy lines in Fig. 2, *C*

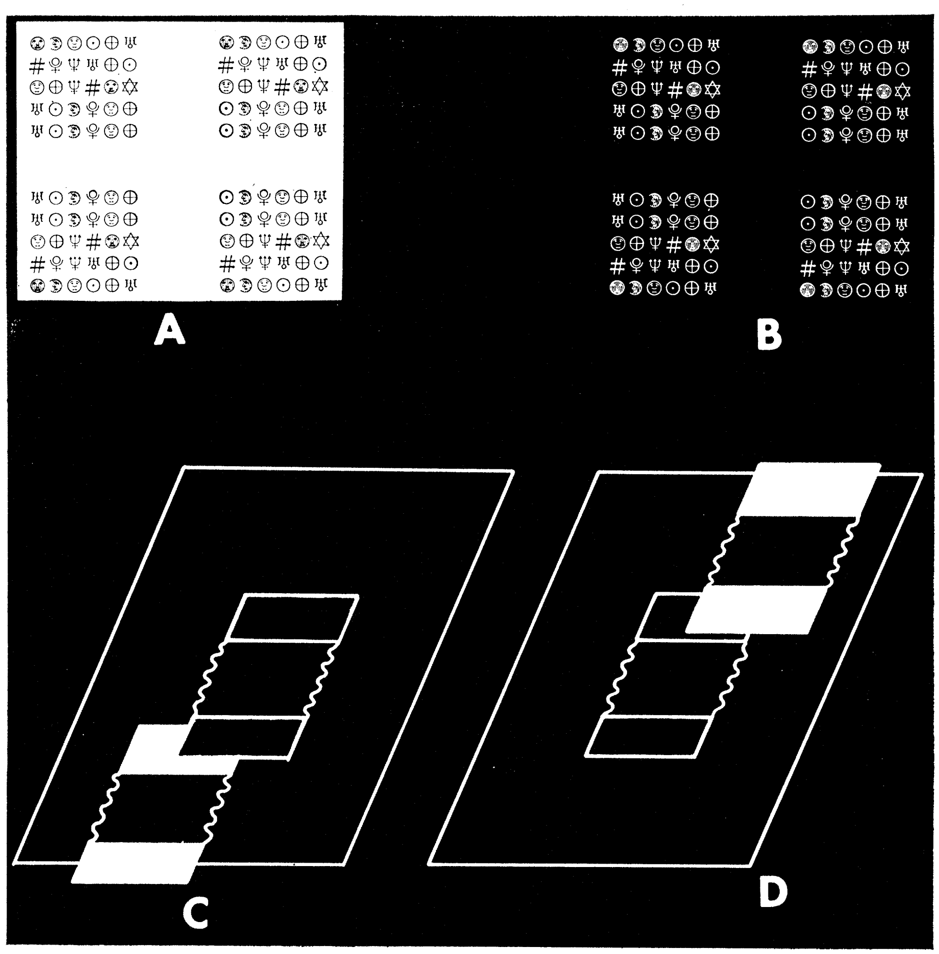

Fig. 2. Experiment as done. (The average reader trying this experiment with the targets shown may do better with optical aids than with free-viewing stereoscopy. For best results, the surroundings should be shielded.)

and *D*. Thus, in the absence of a physical contour, the stereoscopic sense imposes one.

Further, the self-luminous displaced plane appears slightly lighter (sometimes darker) than the identical self-luminous ground (*6*). In the heteronymous view, on the other hand, where the displaced plane comes forward, as in Fig. 2*D*, it now appears slightly darker (sometimes lighter) than the ground. These brightness effects may appear even before the stereoscopic edge. They are delicate, but they are reliably present to a trained eye.

Although there is no target in the center of *s*, it is nevertheless possible to fixate the center of the inner field reasonably well. Now a further increase of *s* will cause the stereoscopic edges to disappear and the floor of the window to break up into two separate parts composed of the no-longer-unified upper and lower disparate rows. The stereoscopic displacement of these rows is still perceived, however, out of the corner of the eye (best in the inferior field, in my experience), until the angles given in columns 3 and 5 ("stereopsis") of Table 1 are reached. Whatever else this may mean, it can at least be asserted that stereoscopic experience can occur in the total absence of physical contours at the central fovea.

By particularly steady fixation, one can induce a temporary local-adaptation in both eyes, a perceptual fading known as the Troxler effect. Or, using Kaufman's approach (*3*), one can induce a foveal suppression or rivalry by placing a letter (say an *e* or an *L*) at the center of *s* for the right eye and another rival letter (say an *a* or an *F*) at the distance δ to the left of the center of *s* for the left eye. In the present experiment, these two methods bring us as close as we can come to whatever is meant in clinical ophthalmology by "suppression" or "rivalry." Under the first condition, the stereopsis will fade, unless one is permitted at least some very slight sideways oscillation of fixation; but under the second condition the peripheral stereopsis remains, provided that neither is *s* too large nor δ too small. Thus there appears to be a difference between the effect of Troxler adaptation and the effect of "suppression." At the present time we can only conjecture what this means physiologically.

Current theories of stereoscopy hypostatize three neurophysiological events, reified under the names of "rivalry" and/or "inhibitory suppression" and/or "facilitative fusion," to account for three associated and variously distinct perceptual events. However, these neurotheoretical concepts are based upon experience with targets having completed physical contours. What can be said in the present instance where we have stereopsis in the absence of contours? There is rivalry at δ since it is monocular, and the ♅'s of Fig. 2 float about in a disconcerting fashion. But within the empty visual field itself, there is no consistent iridescence (but see *6*), fragmentation, or fading. On the other hand, it is hard to decide what, if anything, could have been "fusing," especially in the *black* empty visual field. The fact that the displaced self-illuminous plane appeared slightly brighter (facilitation?) than the ground in homonymous view is offset by the fact that it appeared slightly darker (inhibition?) than the ground in heteronymous view. Are these effects related to the Fechner paradox or to the Hermann illusion? Perhaps the stereoscopic edge is a true Gestalt organization (specifically not derived from monocular form recognition) in which formal or probability "fusion" and/or "rivalry" and/or "suppression" and/or "differencing" occur as contingencies. A theory of this nature seems to be the only kind that could be consistent with the present finding of visual contours in homogeneous space. And, unlike these others, it could also be consistent with the concept of correspondence in the single eye (*7*).

Finally, and perhaps most important, only a Gestalt theory could account for the beautiful sharpness of this stereoscopic edge, as noted by all experimenters, despite the use of physically blurred and out-of-focus targets. This sharpness is especially apparent to the user of free-viewing stereoscopy because some accommodative blur almost invariably appears for him as an unwelcome rider on his method of observation.

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6. The brightness of the dark displaced plane is particularly difficult to specify; sometimes it is iridescent, suggesting a rivalry. Similar iridescence occurs with Julesz's fig. 36 (*1*, p. 1156), which is inconsistent with his statement (*1*, p. 1159) that ". . . as long as depth is seen, no rivalry can be present." Iridescence is one form of rivalry. See especially Kaufman's fig. 5 (*3*, p. 399), which is conclusive on this point.
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Constitution, Viability, and Lactate Dehydrogenase in Stationary-Phase L-Cell Suspension Cultures

Abstract. *Starved suspension cultures of L cells exhibit a plateau phase of short duration followed by loss of key cellular constituents and rapidly decreasing viability. In contrast, regularly fed, undiluted cultures remain stationary at a high cell density for prolonged periods without structural alterations or loss of viability. The L cells contain a single lactate dehydrogenase isozyme with an electrophoretic mobility similar to that of lactate-dehydrogenase-5. High-density stationary cultures show a tenfold increase of the specific activity of this enzyme and a recurrent biphasic pattern of carbohydrate utilization with, first, production and, later, consumption of lactate.*

It has been suggested that the study of the transition of a bacterial or mammalian cell culture from logarithmic growth to the plateau phase might yield information relevant to the regulation of growth in complex organisms (*1*). Plateau-phase cells, however, have been known to undergo structural alterations and loss of viability (*2*), and therefore comparisons with nongrowing tissues *in situ* are open to criticism (*3*). We are now reporting that, when the plateau phase is induced by starvation in suspension cultures of L cells, there is a rapid loss of key cellular constituents and a progressive decrease of viability. These changes are absent when the plateau is the result of increased cell density in regularly fed undiluted cultures. In addition, such undiluted