The effect of texture on the magnitude of simultaneous brightness contrast

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The magnitude of simultaneous brightness contrast was measured while the coarseness of the textural overlay was varied. Results from 10 Ss indicate that as the size of elements in the texture increases, the amount of obtained contrast decreases. An interpretation of these results in terms of the spread of lateral inhibitory effects is offered.

If we place a visual stimulus on a bright background, we find that its apparent brightness is reduced. This is, of course, an example of brightness contrast. The majority of studies on brightness contrast have used one of two methods to produce the stimulus array. The first method creates self-luminous targets through the use of a Maxwellian-view optical system (i.e., Fry & Alpern, 1953) or by transillumination through opal glass or milk glass diffusers (Diamond, 1962; Heinemann, 1955). Many of the classical studies, and a goodly proportion of the current work on brightness contrast, use papers differing in reflectance as an alternate means of constructing stimulus configurations (Coren, 1969; Hering, 1964; Leibowitz, Myers, & Chinetti, 1955). Since both of these techniques produce the expected brightness induction effects, the data from these two paradigms tend to be used interchangeably. It is important to note, however, that there are important differences in the stimuli produced by these procedures. A stimulus created in an optical system or via transillumination tends to be textureless, while an array constructed from papers contains a certain amount of visible microstructure which provides the equivalent of a textural overlay. Very few investigators have considered the possible effects of such a texture on brightness contrast. James (1890) casually reports his phenomenal impression that the presence of texture increases brightness contrast, while Beck (1964) finds some decrease in contrast when large spots are superimposed on a contrast configuration. If we recognize the evidence which seems to indicate that contrast effects are predominantly caused by lateral inhibitory interactions on the retina (Diamond, 1960; Ratliff, 1965), there are cogent reasons for expecting that the amount of visible texture on the stimulus surface should affect the amount of measured brightness contrast. Let us consider each textural element individually. It represents a sharp transition in brightness, which then acts as a small contour. A number of investigators have suggested that the visual system interpolates between contours and

assumes uniformity of stimulation in regions where little change is taking place (Festinger, Coren, & Rivers, 1970; Fry, 1948; Krauskopf, 1963). In the presence of rapid local changes in stimulation, this filling-in process is impeded. This is supported by the observation that inhibitory influences do not seem to easily cross intervening contours (Berman & Leibowitz, 1965; Fry & Bartley, 1935). An extension of this principle also accounts for the reduction of brightness contrast with the introduction of a separation between the test and inducing fields (Leibowitz, Mote, & Thurlow, 1953). Consider now the effect of the presence of a textural overlay on a test field which is surrounded by a bright inducing field. Large textural elements will evoke retinal processes which are similar to those evoked by contours. These contour processes will impede the spread of inhibition across the test stimulus. This should result in a reduced amount of measured brightness contrast. Of course, the likelihood that such contour processes will be elicited by individual textural elements is increased as the size of the elements in the texture is increased. We should thus be able to predict that the amount of measured brightness contrast would be reduced by the presence of texture, and that this reduction would be proportional to the size of the elements in the textural overlay.

The following experiment tests these implications by systematically assessing the effects of texture on the magnitude of brightness contrast.

METHOD

Stimuli and Apparatus

All stimuli were created through the use of transilluminated flashed opal glass. The illumination was provided by a projected beam with a correlated color temperature of 6,500°K. Each display consisted of two simultaneously visible stimuli. One was a circular field, 2.5 deg in diam, with luminance continuously controllable by S through a variable neutral density wedge. This stimulus served as the match field. A second field, the same size

Fig. 1. Amount of luminance match reduction in millilamberts when the bright surround is present, plotted against element diameter in minutes of arc.

and separated from the match field by a center-to-center distance of 10 deg, provided the test stimulus. It had a fixed luminance of 50.1 m.L. Both stimuli were imaged against a black (0.001 m.L.) background; however, the test stimulus could be presented with a 7-deg-diam annulus whose luminance was 100 m.L. To control for possible interactions between the test and matching stimuli, the array was haploscopically viewed with the match stimulus presented to the right eye and the test stimulus to the left eye.

Normally, a stimulus produced through transillumination is textureless. To provide textures, clear acetate overlays were prepared with a regular array of black dots of uniform diameter and spacing. This produced a set of stimuli in which element diameters were 8 min 42 sec, 7 min 16 sec, 5 min 31 sec, 3 min 43 sec, or 2 min 45 sec of visual arc. The corresponding element densities were 310, 433, 740, 1,732, and 2,961 units per degree. The amount of luminous flux is constant for all textures, since regardless of element size the sum of the stimulus area occluded by the texture is held constant at a value of 40%.

Subjects

Ten Os with 20/20 vision served. All had had previous experience with brightness matching, although they were naive as to the purpose of this experiment.

Procedure

Os were dark-adapted for 20 min to prevent state changes during the test session. For each texture and for the uniform stimulus, Os made two matches of the brightness of the test stimulus imaged against the black background, and two matches of the test stimulus surrounded by the bright annulus. The order of presentation of the stimuli was random, and the match field was always presented with the same textural overlay as the test field.

RESULTS AND DISCUSSION

The difference in the matched luminance of the test field viewed in isolation as opposed to the matched luminance in the presence of the bright inducing surround serves as an index of the amount of brightness contrast obtained. If we now look at the effect of texture on the magnitude of brightness contrast, we obtain the results shown in Fig. 1.

It is clear that increasing the size of the elements in the textural overlay results in a reduction in brightness contrast. This reduction manifests itself in a linearly decreasing trend, which is statistically significant ($F = 6.66$, $df = 1/45$, $p < .01$). This is further substantiated by the fact that a correlation of texture element size against the magnitude of brightness contrast measured in millilamberts produces an r of -0.66 , which is significant with $p < .01$. These results are clearly in accord with those of Beck (1964).

It seems clear, then, that, as the individual test elements increase in size, the associated contour processes become more pronounced and thus provide an effective barrier to the spread of lateral inhibitory influences. In the absence of such a texture, the inhibitory effects would be free to spread and fill the region between the contours.

These results also shed some light on the often repeated observation that contrast effects are never as effective when printed in texts or reports as when they are prepared from the actual gray papers or by actually spinning a disk to obtain the brightness pattern. The cause of this might well be the superimposed texture necessitated by the halftone printing process. The visible texture is somewhat reduced through the use of standardized gray papers, and virtually eliminated by the use of a spinning disk. It may also help to clarify the operation of some techniques that have been traditionally recommended as procedures to increase the magnitude of contrast. Thus, Woodworth (1938) suggests that contrast patterns be placed "a few inches from the eye, too near for good focus." This would serve to eliminate the effect of texture by blurring it from view. A similar effect might be responsible for the so-called "tissue paper contrast effect" in which a piece of tracing paper or fine gauze is held in front of a contrast pattern and the apparent magnitude of contrast is increased. If the eye is accommodated for the stimulus pattern behind the overlay, the texture of the tracing paper will be somewhat out of focus and hence will not serve to impede the flow of lateral inhibition. If we trace the contours of the test field, or place a bit of gray paper over it, this tends to reduce the magnitude of contrast by shifting our accommodation back to the surface of the overlay, hence bringing its texture into focus (Helmholtz, 1962).

An important methodological point to come out of these data is that one cannot expect to find the same magnitude of brightness contrast in paradigms utilizing

papers or other textured materials as is found in experiments where the stimuli are optically produced or are transilluminated textureless surfaces. Any texture on an array will result in an underestimation of the amount of brightness contrast present.

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