VISUAL CONTRAST

February - 1941 Vol. 2 No. 5

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Almost everyone is familiar with contrast effects. They may be observed in brightnesses, hues, sizes, shapes, motions, etc. If an artist is painting a picture and the greenest green paint he has is not green enough he does not worry. He simply places a little bright red somewhere near, and in its presence his green now is green enough. Brightnesses may be made more or less bright; test objects may be rendered more or less visible, simply by arranging the proper relations for contrast.

Almost all theories of contrast go back originally to Hering. They hold essentially to the view that contrast effects are physical and physiological, and reduce to simultaneous light induction. A bright patch induces black in its whole surroundings, the magnitude of the effect decreasing in an unknown way with distance. Since black itself is said to be a contrast-effect and hence no local stimulation process produces it, a dark patch does not induce brightness in its surrounds, as the converse to the first case, except perhaps under certain very special conditions. Aside from the difficulty of explaining how this latter phase of the process works, the Hering principle is based on theory that contrast is summative and absolute. The effect varies with areas, intensities, separations, etc. Accordingly, also, it is presumed that the number of retinal elements firing, particularly rods in the case of brightness contrast, is the principal determinant of the magnitude of the contrast effect.

The conventional method of designating and measuring contrast, employed by engineers, physicists, physiologists, etc., may be illustrated as follows: A test object on its background is said to have "65% contrast." This means that if the brightness of the test object (b) is subtracted from the brightness of the ground (B), and this difference divided by the brightness of the ground (B), the quotient will be the degree of contrast (C), if proper steps are taken to convert it into percent.

$$C = \frac{(b-B)}{B}$$

This formula can be written:

$$C = \frac{(B-b)}{B}$$

where the ground has a greater brightness than the test patch. The difference in brightness which is the numerator of the fraction is always a positive number. Contrast thus depends simply upon the one thing—the ration of the brightnesses of figure and its ground, if the Hering theory or one of its derivatives is correct.

But the late Professor Troland used a little different way of denoting contrast. For him, $C = k\ (b-B)$ where $\underline{C}$ is again the contrast effect, $\underline{b}$ and $\underline{B}$ are the figure and ground brightnesses and $\underline{K}$ is a constant, which under certain most favorable conditions may equal 1. k is a parameter of all such conditions as area, shape, distance of the contrasting surfaces, etc., which Troland knew could and did affect the amount of the contrast. Thus it seems that the first step was taken away from the over-simplicity of the Hering concept. More recently we have had to move still farther away from this position, because we must expand our view of contrast to cover demonstrable instances not cared for in previous theories, and we must recognize that the full theoretical significance of contrast problems were not realized today by those whose training and point of view has been confined to narrow lines.

It is our object to supply you some contrast demonstrations which may interest you and set you to work upon the problem. Let us begin with a simple case of brightness contrast. Secure a supply of black, white and medium gray papers. Cut 8 squares of black, gray and white. In the center of each place a 1 inch square of the same gray. Place the three large squares in a horizontal row on a table in a good light. You will note that the small gray patch on the black looks distinctly brighter, and on the white distinctly darker. Now cover them all with a sheet of white tissue paper and note the change. If you own or have access to a suitable photometer, measure the reflectances of the papers and compute the per cent contrast using the formula given above.

Now, take a Maxwell disk rotator and place on it white and black disks. Adjust the proportions of black and white until you secure the closest possible match of the small gray squares, viewed both with and without the white tissue. Now match a sample of the gray, independent of any ground. From these data you can easily compute the increased or decreased brightness induced by contrast. How do the matching results agree with the Hering method of denoting the contrast? How do you account for the difference?

Now examine carefully the middle square—the gray on gray. Look at it with and without the tissue cover. Look at it at 16 inches, at 3 feet, 9 feet, 20 feet. Describe carefully what you see and try to render a theorectial "explanation" of the contrast effect—where, of course, (b-B) = 0 in the Hering formulation.

Contrast effects can be tremendous as everyone knows who has looked into the eye-piece of a Macbeth illuminometer. Here you see a doughnut shaped ring of light, which can be varied in brightness to match the inner spot or test patch to be measured. If this spot is a mid-gray it can be made to appear as white or as black, although remaining perfectly constant in brightness, merely by changing the brightness of the external ring of light.

Opposing any hue or brightness inductance is always the phenomenal fact of hue and brightness constancy. Often the unexpected contrast effect either fails to materialize or it occurs in the wrong direction, due to the operation of this factor of constancy, which is a tendency for things to maintain their "real" hues or brightnesses even under relatively extreme conditions favoring large contrast distortions.

Appurtenanee is a further factor in contrast. Its meaning can be demonstrated and made clear by repeating an experiment made some years ago by W. Benary.

From a piece of black paper or black cardboard prepare a cross like A in Figure 1, and mount this on a white cardboard background about 11 inches by 14 inches, or 16 inches by 20 inches. The width of the arms of the cross should be about 3 cm. and the length of the protruding arms of the cross about 4 cm. Prepare two small triangles cut from a neutral gray paper such that the base of the triangle is about 2 cm. These triangles can be practically equilateral so that they may be placed as indicated in A of Figure 1. That is, small gray triangles of equal brightness are placed at g_1 on the upper vertical bar of the cross and g_2 on the background at the angular junction of the right and lower arms of the cross. The optimal observation distance is from 4 to 8 meters. Note that the upper triangle g_1, is a part of the figure and lies on or within the cross; while g_2, the lower triangle lies on the white ground. Note also that g_2, actually has a little more black and a little less white in its surrounds than g_1. According to a summation theory of contrasts, g_2 should therefore appear brighter than g_1. But you will note that g_1 is clearly brighter than g_2. The amount of the difference in brightness can be measured by a matching method. This consists of placing black and white disks on the Maxwell disk rotator and adjusting the proportions of white and black until a matching gray is secured for g_1, and g_2. The difference in brightness can therefore be specified in terms of the difference in the coefficients of reflectance of the two test patches. In the above instance the contrast effect depends on whether the small gray triangle is seen as belonging to or as a part of the figure or of the ground. If it is seen as part of ground, and tends to take on the properties of the ground, and similarly for figure. This is the principle of appurtenance. Because of its influence brightness differences may be observed which are the exact reverse of the effect demanded by a summation theory of contrast. If we suspect that the effect is due to some peculiarity of the shape of the figure we have used this can be proven by repeating the observation on parts B and C, of Fig. 1. In this case rectangular patches of gray are inserted as whown in the figure, on the bar of the I and above the bar of the H, and the same result will be noted.

In figure 2 again, two small gray triangles are placed in such positions that one may see the figure normally as a gray-on-black as ground and therefore as brighter than the gray-on-white. This is under the condition where upon first looking at the whole pattern, the black portion to the left seems to be a figure set in a white ground. By studying the figure carefully it is possible to see the left and right portions as simultaneous equivalent figures. Where this is done it does not alter the brightness relation between the two grays, that is, the gray-in-black is still brighter than the gray-in white, and so we must conclude that the brightness difference depends not upon figure and ground but upon surface appurtenance. Experiments such as the foregoing demonstrate that brightness contrast is a function not only of brightness differences but of other more complex relations of figure and ground. One must conclude that all theories which base the contrast effect wholly upon a function of differential brightness are therefore incomplete and unacceptable.

Suppose now we consider the case of color contrast because virtually all contrast effects involve a combination of brightness, color, form, etc. Where color is involved the contrast effect is always in the direction of the greatest qualitative opposition. The contrast effect will be greater the more saturated the inducing color. Nearness of the contrasting surfaces will be found to increase the contrast effect just as the elimination of contours will produce the same result, and finally color contrast will be at its maximum when brightness contrast is eliminated. The converse would logically follow, that in order to reduce color contrast effects we should make brightness contrast a maximum.

A critical test of conventional theories of contrast is found in some simple instances of color contrast. One of the most famous of these is the experiment made by Max Wertheimer in 1916.

1 2 3

FIG. 4

MRS. HEIDER'S EXPERIMENT

The backgrounds marked 1, 2, and 3, in this figure are square patches of bright blue. In No. 1, the central figure is a gray annulus. In No. 2, the gray ring is made equal in total area to the annulus in No. 1. In No. 3, a series of small disks of the same gray are arranged as a circle. In all three cases the total area of gray is the same. The theory demands that the contrast effect should be greatest in No. 3, next in No. 2, and least in No. 1. Observers uniformly have reported that the opposite holds. The maximal contrast effect is found in No. 1, the figure having the simplest and most perfect organization, and the least contrast is seen in No. 3. Conventional theory again demands that No. 3 should be more colored, but observation reports it to be least colored. Apparently the more coherent the figure the greater is the inductance.

This conclusion seems to be a direct contradiction of the result observed in the experiment shown in Fig. 1 above. There, the most cohesive figure was least colored, while in the Heider experiment it is the most colored. Professor Koffka offers the following explanation for this fact: In the experiment of Fig. 1, "the uniformity which was enforced by the greater cohesiveness had to be a neutral uniformity, while in Mrs. Heifer's experiment no such connection between uniformity and neutrality exists." Any interpretation of the difference between the two effects should be based on the consideration of differences in structural organization, in figure-ground relations, in the manner in which the observer sees the total figure, etc. The complete statement of the laws of brightness and color contrast can the efore not be formulated until complete descriptions have been rendered of the mechanics of visual pattern discrimination.

A

B

C

FIG. I BENARY'S FIGURES

FIG. 2

FIGURE AND GROUND

AND SURFACE APPURTENANCE

FIG. 3
Wertheimer's Experiment

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