Separation thresholds for bar targets presented with color contrast only¹

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Separation threshold scores for rectangular bar targets with combination of red, yellow, green and blue targets and grounds were obtained. Threshold scores were low, with small differences between scores obtained with the different color combinations.

A number of studies have amply demonstrated that stimulus color contrast alone is a sufficient basis for good visual acuity, (e.g., Eastman Kodak Company, 1944; Crook, 1958; Cavanaugh & Schumacher, 1966; Bishop, 1966). The results of these as well as other studies are not in complete agreement and indicate that the various stimulus and subject variables interact in quite a complex manner.

In previous work (1966) the author used rectangular bar targets equated in luminance to the ground on which they were presented. With colored targets on a white ground the minimum separation scores, obtained with yellow targets, were slightly greater than those obtained with the same targets presented on a black ground. The largest separation scores were obtained with the blue and red targets. Data gathered with the color contrast direction reversed, white targets on different colored grounds, were of particular interest in that very high separation scores were obtained with the yellow ground; and the scores obtained with the red and blue grounds were comparable to the lowest obtained with the colored targets. It was tentatively concluded that this reversal of pattern might be related to the accommodatory state and optical characteristics of the eye and to so-called foveal tritanopia.

Cavanaugh and Schumacher used two-colored grid patterns with the colors equated in luminance. Aerial images of the patterns were viewed through an eye piece and an over-corrected lens which reduced the effects of the chromatic aberration of the S's eye. With sufficient difference in the wavelength of the color pair, the obtained acuity scores were comparable to those obtained with black and white patterns. With decreased wavelength difference, the acuity scores were depressed more or less rapidly depending upon the spectral region employed.

In the experiment reported below, preliminary threshold separation scores for a number of combinations of colored grounds and rectangular bar targets, directly viewed, are reported.

Subjects

One female and three males, ages 21 to 37, served in the experiment. The males wore corrective lenses and all Ss scored 1.0 or better in the far and near visual

acuity tests on the AO Ortho-rater. All Ss scored 100% on the Ishihara and AO tests for color deficiency.

Method

The test stimulus pattern was a pair of rectangular bars which subtended approximately $0.5^\circ \times 1.1^\circ$ of visual angle at 63 cm, presented against a 7° ground. A larger annular surround increased the illuminated field to 22° . The target, ground and surround were independently illuminated from small diffuse sources with the light directed to the eye in a modified Maxwellian manner. The targets, ground and surround were equated at 5 ft-L. The colors of the targets and the grounds were obtained with Corning and Wratten filters with the following calculated dominant wavelengths: C-(Corning) 2-59, 640 nm; Wratten No. 73, 571 nm; C-4-64, 528 nm; C-5-60, 458 nm.

Before an experimental session the S was dark adapted for 1/2 hr. He was then positioned at the apparatus and light adapted for 5 min. to white light at 5 ft-L. After light adaptation the S was given 10 practice adjustments with black bars presented on a white ground. He was then adapted to white for 2 min. after which the first test condition was presented. Observation was monocular through a 3-mm artificial pupil with head and eye position controlled by means of an adjustable bite board bearing the S's dental impression.

The task for the S was to make two sorts of adjustments of the target bar pair. Starting with the bars well apart he brought them together to the point at which the line of separation just was not seen, a together judgment. This setting was read from a calibrated dial on the target carriage mechanism and the targets were then moved more closely together. The S then moved the targets apart until he just perceived a line of separation, an apart judgment. Ss were allowed to bracket the judgment point but were restricted to making the last movement in the indicated direction. The mean of the pair of judgments was taken as the threshold score. The Ss made five pairs of judgments for each stimulus combination with a 1-min. adaptation to white light between each of the combinations. Threshold scores were obtained for all combinations of target and ground luminance for a given color during a single session, and four counterbalanced replications were obtained for each color with each S.

Results

The curves in Figs. 1 and 2 show the mean separation threshold scores for all Ss combined. Each point is based on 20 pairs of judgments for each of the four Ss. Mean scores of individual Ss are shown by the coded

Fig. 1. Mean detectable bar separation of $0.5^\circ \times 1.1^\circ$ different colored bars presented on each of four colored grounds. Dashed lines are included solely to facilitate comparison and do not imply probable trend.

points plotted about each of the group means. For economy of space the ordinates in the figures are broken and repetitive ordinate sections employed to facilitate comparison. It should be noted that the dashed line sections of the curves for the 571- and 528-nm target or ground conditions were included solely to facilitate comparison. They do not imply a probable trend of results which would be obtained with illuminant wavelengths between those with which data was obtained.

In Fig. 1 the curves show the scores obtained with the several target colors with each of the background colors in turn. Although differences are not large, the separation scores obtained with the blue and red targets tend to be greater than those obtained with the yellow and green targets, irrespective of ground color.

The data are replotted in Fig. 2 to show the changes in scores obtained with each target color as the color of the ground was changed. It may be seen here that the separation scores tend to increase as the difference between the target and ground color wavelength is decreased.

Discussion

The results as a whole are consistent with the conclusion that stimulus color contrast alone is a sufficient basis for good visual acuity. The trend of increase in the separation scores as the wavelength difference between the target and ground was decreased is in line with the results reported by Cavonius and Schumacher discussed above.

Fig. 2. Mean detectable bar separation for each of four different colored $0.5^\circ \times 1.1^\circ$ bars presented on different colored grounds. Dashed lines are included solely to facilitate comparison and do not imply probable trend. Scores are those of figure 1 replotted to show changes associated with change in ground color for each target color.

In comparison with the data gathered previously with the white ground the pattern of higher separation scores obtained with the blue and red target colors is the same, but the differences are less marked and there is some interaction with ground color. Again the results show that the scores obtained with a particular target-ground color combination to be specific to the assignment of color to target and to ground. For example, the scores obtained with red targets on a green ground are higher than those obtained with green targets on a red ground.

References

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Notes

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