Discrimination of Color. IV. Sensitivity as a Function of Spectral Wavelength, 410 through 500 mµ

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(Received 2 January 1964)

Color discrimination functions for three observers were plotted in the short-wavelength region of the spectrum. The method of constant stimulus differences was used. Comparisons between the present results and earlier results are reported. Sensitivity proved more variable in this region than elsewhere in the spectrum.

In earlier work on spectral color discrimination, we plotted the delta lambda function from 510-630 mµ.¹ This report is an extension of that study from 410-500 mµ. Much of the early research in color discrimination is summarized in Parsons.²

APPARATUS

A Farrand 1000-mm monochromator with independently adjustable double exit slits was used. The light source was a 900-W xenon arc. A 5-mµ bandwidth was set from 420-500 mµ; however, it was necessary to increase the bandwidth to 10 mµ at 410 mµ in order to achieve the desired stimulus luminance. It has been established that color discrimination at wavelengths above 500 mµ is not affected by such a change in bandwidth.³ To eliminate stray light, a Kodak Wratten filter number 38A was used. The exposure time was 0.2 sec.

PROCEDURE

The method of constant stimulus differences was employed. Stimulus ranges of five discrete steps were established on both sides of the standard wavelength following the method suggested by Boring.⁴ The observers were presented a circular field of light split along a horizontal diameter and subtending 2 deg at the point of observation. The upper half of the field was for the standard and the lower half for the variable stimulus.

The observer's task was to state whether or not the variable stimulus differed in a particular color quality from the standard stimulus; for instance, whether or not the lower half of the field was greener than the upper half. The observer's response was indicated by pressing one of two signal buttons.

Data were collected using standards from 410-500 mµ in 10-mµ steps. In all cases the luminance of the standard half of the stimulus field was 0.2 ft-L while the surrounding field was a white (approximately Illuminant A), also at 0.2 ft-L. Each observer adjusted the brightness of each of the five variable stimuli to be presented at one session to match the brightness of the standard stimulus.

OBSERVERS

Data were obtained from three members of the laboratory staff. Two of the observers were myopic and the third was hyperopic; however, all observers wore corrective lenses and had normal color vision. All observations were made foveally with the right eye.

RESULTS

Cumulative frequency distributions of positive responses were compiled for each observer for all series of five stimulus differences and plotted on normal-probability paper. Both limens and standard deviations were calculated from the plots. The limen was defined as half the distance along the abscissa between the two 50% points, while the standard deviation was defined as the distance along the abscissa between the points at 84% and at approximately 84%. In practice, the average of the two standard deviations at each wavelength was used as a response measure. A more complete description of these measures may be found in an earlier paper.⁵

Figure 1 presents the limens for each of the observers from 410-500 mµ. For one observer the liminal point at 410 mµ could not be calculated since measurement was made in only one direction for him at that wavelength and since both directions must be measured to calculate the limen as defined here.

Figure 2 presents the standard deviations. The limens and the standard deviations have been plotted on the same axes for each observer as shown in Figs. 3-5.

In Fig. 6 the mean limens and standard deviations are reported from 410-630 mµ. The data from 510-630 mµ are those of Siegel and Dimmick.⁶ In contrast with

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¹ See Ref. 1.
² See Ref. 1.
³ See Ref. 1.
⁴ See Ref. 1.
⁵ See Ref. 1.
⁶ See Ref. 1.
our earlier results, there is little agreement between the measures at the shorter wavelengths. Below 450 μm, the liminal scores are consistently higher than the standard deviations. As in the region from 510–630 μm split-half reliabilities of the two response measures show more consistency and stability among the standard deviations than among the limens. Because of this, the interpretations of the data are based largely on the standard deviations.

In the spectral region from 410–500 μm, there is one zone of peak sensitivity ranging from just above 450 μm to just below 460 μm. On both sides of this region, the delta lambda curve rises gradually. Several investigators\(^7\) have reported a secondary point of peak sensitivity below this region. Examination of the standard-deviation data of the present study indicates no such point.

**DISCUSSION**

The results of the present study along with the data obtained by Siegel and Dimmick\(^8\) and the earlier re-

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\(^8\) See Ref. 1.


lambda. The fact that the delta lambdas found here are smaller than those reported earlier was therefore expected. The differences found in the positions of the minima are more difficult to understand. Earlier reports have neither used the same luminance level at all wavelengths studied, nor have they always made adequate provision for the exclusion of stray light. Probably a combination of these contaminating influences led to the observed differences in location of the minima.

Obtaining consistent discrimination data in this region of the spectrum has proved to be more difficult than at longer wavelengths. The comparative brightness of the standard and variable stimulus fields was critical. Slight changes in the relative brightness led to substantial changes in color discrimination possibly because of the Bezold–Brücke effect. It was necessary, therefore, to equate the brightness of each of the variable stimuli to that of the standard. In spite of the care with which this was done, slight variations in the observational procedure, such as change of fixation, were possible and could have contributed to the increased variability noted in this part of the spectrum.

Fig. 5. Discrimination limens and standard deviations for observer J.K. from 410-500 mp. Dashed line indicates limens; solid line the standard deviations.

Fig. 6. Mean limens and standard deviations from 410-630 mp. Dashed line indicates limens; solid line the standard deviations.

Fig. 7. Comparison of some reports on color discrimination as a function of wavelength. Curve a represents the data of Wright and Pitt, Curve b the data of Laurens and Hamilton, and Curve c the data of the present study together with the data of Siegel and Dimmick.