mμ (*34*). It should be clear from Fig. 8 that a fused *B-G* mechanism would cross the *R* curve, or a fused *B-R* mechanism would cross the *G* curve, near these wavelengths.

The synchromias include not only limiting types such as those already discussed, but also intermediate conditions in which, though three visual pigments excite only two sensory channels, their proportions depart considerably from the average. These are the anomalous dichromats, just as trichromats in whom the distribution of color sensitivities departs widely from the average are the anomalous trichromats. They probably include all intergradations between the synchromias with normal luminosity function and the achromias. They appear nevertheless to form a minor category. Thus the "deuteranopes" of Figs. 12 and 13 include all those worked on by the authors cited, except for two intermediates measured by Hsia and Graham, and an unspecified few of Willmer's subjects.

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Appendix by W. S. Stiles: Foveal Threshold Sensitivity on Fields of Different Colors

George Wald's interesting measurements of increment thresholds by the two-color threshold method (*1*) are closely related to results I obtained in a comparable study, of which only certain salient features were published (*2, 3*). Wald kindly expressed a wish to refer to my data on the variation of the increment threshold with test wavelength when the retina is adapted to steady fields of different colors and brightness—the latter being generally lower than those Wald has used. These data (mean results) are summarized in Fig. 1, which shows curves for the 13 field conditions used. Each curve represents the variation of the logarithm of the reciprocal of the increment threshold, log ($1/N_\lambda$), with the wave number of the test stimulus, $1/\lambda$. To compress the curves into a single figure, a conveniently chosen constant (*C*), has been added to the values for each curve (see Fig. 1), so that the positions of the curves along the ordinate axis are significant only when allowance is made for *C*. The essential details of the measurement conditions are as follows.

The test stimulus was a circular light, 1 degree in diameter, that was flashed for 0.2 second once every 3 seconds. It was observed by monocular foveal vision, and each threshold was deter-

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mined from a frequency-of-seeing curve as the test intensity for a 50 percent chance of seeing. The adapting field was monochromatic, of wavelength μ, 10 degrees in diameter, with quantum intensity M_μ. Both M_μ and N_λ are expressed as the number of quanta per second entering the eye per square degree of adapting field or of test stimulus. Maxwellian view was used, with a virtual artificial pupil smaller than the eye pupil. For the adapting field the corresponding troland brightness, $(T)_\mu$, is obtained with the conversion formula:

$$\log T_\mu = \log M_\mu + \log 1/\mu + \log V_\mu + 11.651,$$

where V_μ is the relative luminous efficiency function, at wavelength μ, of the Commission Internationale de l'Eclairage (*4*). Four subjects were used in making these measurements (Fig. 1).

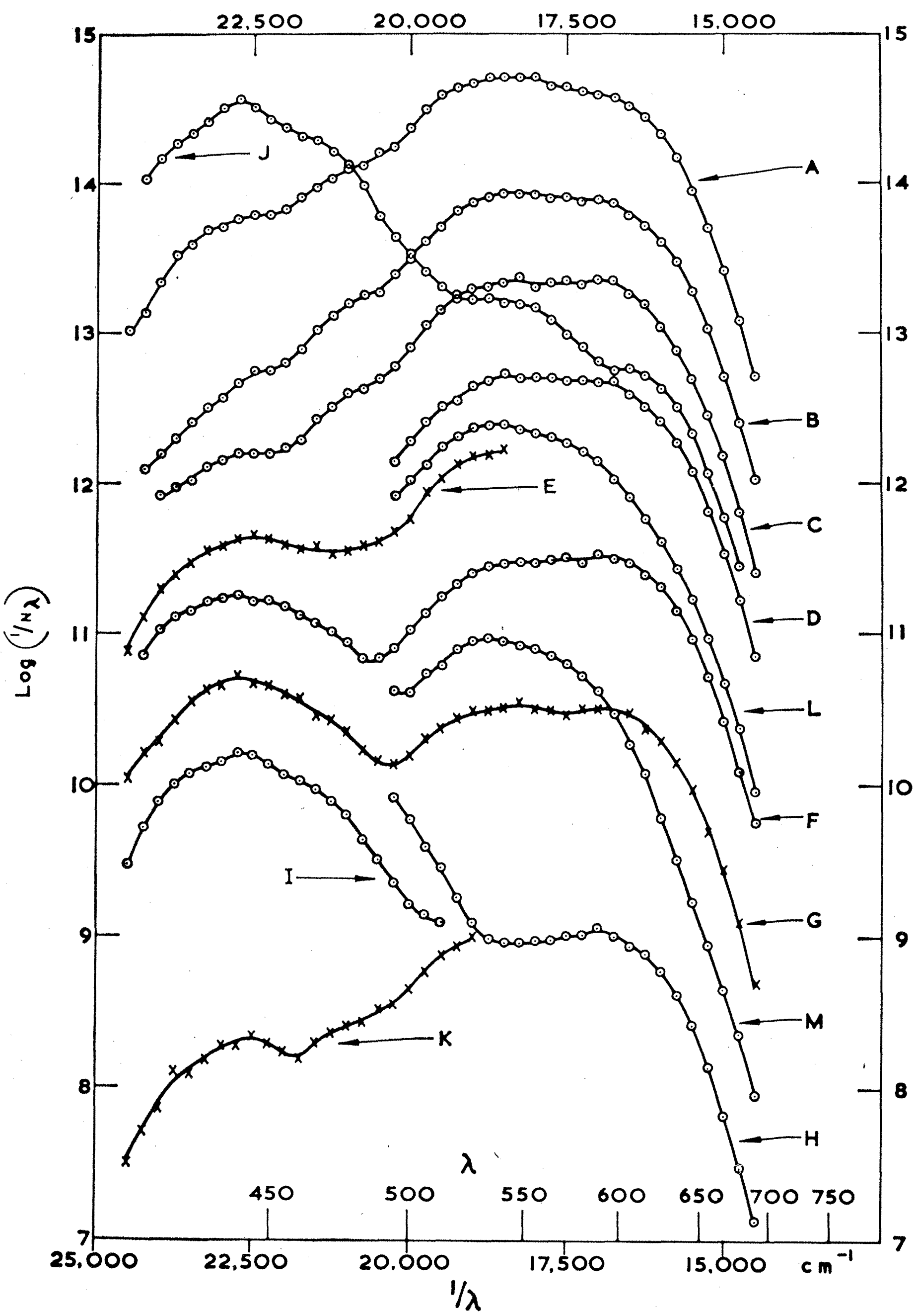

Fig. 1. Spectral sensitivity of the fovea measured with test fields superimposed on steady backgrounds of various wavelengths and brightnesses. The sensitivity is expressed as the logarithm of the reciprocal of the increment threshold in quanta per second entering the eye per square degree of test field. Mean results of determinations on a dark background (*A*) and on backgrounds of the following wavelengths and brightnesses: (*B*) 434.8 mμ, 12.0 trolands; (*C*) 470.6 mμ, 209 trolands; (*D, E, F*) 500.0 mμ, 42.8, 41.4, and 1552 trolands; (*G, H, I*) 548.0 mμ, 203, 90200, and 2790 trolands; (*J*) 588.2 mμ, 19320 trolands; (*K, L, M*) 666.7 mμ, 26.8, 29.2, and 2506 trolands. To bring the curves into a single chart, the following plotting constant (*C*) was added to each: (*A*) 20.0; (*B*) 19.9; (*C*) 20.2; (*D*) 18.8; (*E*) 18.2; (*F*) 18.9; (*G*) 17.0; (*H*) 18.2; (*I*) 16.8; (*J*) 21.5; (*K*) 14.8; (*L*) 18.0; (*M*) 17.8. Four subjects (S, K, B, and F) were used. Curves *C* and *K* show averaged measurements on subjects B and F; curves *E* and *G*, averages for subjects S and K; and the remaining curves, averages for all four subjects.

Because of the close spacing of the test wave numbers used, the curve for the complete test spectrum with a given field could not be measured in one session. Therefore, determinations were made, independently, of the curve for a range of longer wavelengths ($1/\lambda$ = 20250 cm^{-1} to the red end) or for a range of shorter wavelengths ($1/\lambda$ = 18500, 19000, or 19500 cm^{-1} to the blue end). Each subject made four, and in some cases eight, determinations of the curve for the shorter or longer wavelength range on different days. The mean values of log $1/N_\lambda$ for each subject were computed. As the main features of the curves recur for all subjects, who differ mainly in the absolute values of the increment thresholds, the means for the subjects were averaged to obtain the results given here. Where both longer and shorter wavelength ranges were studied for substantially the same field conditions, the two mean curves were combined into a single curve by raising one section slightly and lowering the other by the same amount, so as to give on the average the same values at the test wave numbers in the overlap range (20250 to 18500, 19000 or 19500 cm^{-1}). The shifts required were about 0.02 log unit.

Certain difficulties in interpreting curves of log ($1/N_\lambda$) against $1/\lambda$ in terms of spectral sensitivities of independent visual mechanisms (what I have called π mechanisms) I have already discussed (*3*). Wald makes some comparisons between these data and his new data, but I should like to defer further comment until the implications of recent work (*5*) on threshold summation have been evaluated.

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