

XIX. NEUROPHYSIOLOGY

Academic and Research Staff

Prof. Jerome Y. Lettvin
Prof. Stephen A. Raymond

Dr. Edward R. Gruberg
Michael H. Brill

Graduate Students

Michael J. Binder
Lynne Galler
Ian D. Hentall

Lynette L. Linden
Eric Newman
William M. Saidel

Don W. Schoendorfer
Susan B. Udin
Gregory Williams

A. MODULATION TRANSFER FUNCTIONS OF THE HUMAN VISUAL SYSTEM UNDER COLORED LIGHTS

National Institutes of Health (Grant 1 RO1 EY01149-01)
Bell Telephone Laboratories, Inc. (Grant)

Michael H. Brill

Despite the repeatability of just-noticeable difference measurements on the human visual system, these measurements have proven difficult to interpret, especially when they involve color phenomena. Stiles¹ presented evidence that a stimulus difference will be "just noticed" if its input to any of the three color channels exceeds a criterion value characteristic of that channel and its history. This implies that the eye's sensitivity to a given stimulus is determined by the channel most sensitive to that stimulus. Earlier findings of Silberstein and MacAdam² controvert this hypothesis. (Indeed, if it were correct, MacAdam's ellipses should be polygons in the chromaticity plane.) Like Silberstein and MacAdam, Stiles considered statistical rather than deterministic origins of threshold;³ such an alternative hypothesis allows all three color channels to contribute to a threshold at any given time.

We are examining these hypotheses in the light of ongoing psychophysical measurements of spatial modulation transfer functions using spectrally different illuminants. Our experiments make use of a photograph of a sinusoidally modulated grating whose spatial frequency increases with abscissa, and whose modulation depth increases with ordinate.⁴ Subjects are asked to view the grating under several illuminants from a fixed distance (30 cm), and to draw on a piece of clear plastic overlaying the photograph the boundary of the region in which they perceive the spatial inhomogeneity. Different illuminants are introduced by interposing filters between observer and display and by adjusting the distance of the source light from the display until its brightness matches that of the display with no interposed filters. Approximately 20 seconds are allowed to adapt to a new illuminant before a subject draws his threshold curve.

This method allows rapid data gathering without sacrificing repeatability and has

(XIX. NEUROPHYSIOLOGY)

given us some preliminary qualitative results. Under white light (a tungsten 60-W lamp at 100 cm), the threshold curve looks like Cornsweet's modulation transfer function for the human eye, preserving its bandpass shape. When an interference filter passing 448 nm light is interposed and compensations are made for brightness, subjects show a general reduction of sensitivity, with particular reduction at the high-frequency end of the chart. Although the low-frequency sensitivity is not appreciably reduced, the threshold curve still has a bandpass shape. Results for 601 nm, 573 nm, and 537.2 nm interference filters show a similar high-frequency cutoff, greater sensitivity in the middle frequencies than in blue light, and sensitivity commensurate with the blue at the low-frequency end of the chart. These curves were notably close to the white-light curve for all but the highest frequencies, at which the sensitivity was much greater with white light than with any other light we tried. This observation is confirmed by Navy reports that on misty days vision is best with no interposed filters.

A parallel processing scheme in which thresholds are determined by the most sensitive color channel clearly cannot account for such an observation. A statistical explanation is also difficult to invoke because the white sensitivity to high spatial frequencies so far exceeds sensitivity under colored lights.

We intend in the near future to further our investigation in the following ways:

- a. Rigorous standardization of the luminosity of the display under a variety of illuminants.
- b. Expansion of our repertory of subjects, possibly to include color-blind subjects.
- c. Examination of the effects of bleaching on the observed thresholds, especially with an eye to isolating color mechanisms.
- d. Extension of our study to modulation of color as well as intensity of light; this will be done by projecting in register one colored light through a slide of Cornsweet's grating (actually, Cornsweet obtained the grating from F. Campbell and J. Robson, unpublished), and another through a slide of its negative.
- e. Development of a model accounting for the observed thresholds.

References

1. W. S. Stiles, Proc. Natl. Acad. Sci. U. S. 45, 100 (1959).
2. L. Silberstein and D. MacAdam, J. Opt. Soc. Am. 35, 32 (1945).
3. G. Wyszecki and W. S. Stiles, Color Science (John Wiley and Sons, Inc, New York, 1967), Sec. 6.
4. T. Cornsweet, Visual Perception (Academic Press, Inc., New York, 1970), Chap. 12.