

This Week's Citation Classic

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MacAdam D L. Visual sensitivities to color differences in daylight.
J. Opt. Soc. Amer. 32:247-74, 1942.

[Research Laboratories, Eastman Kodak Company, Rochester, NY]

Over 25,000 color matches by a single normal observer were recorded and analyzed. The standard deviations in various directions at 25 locations in the international standard recommended by the Commission Internationale de l'Éclairage (CIE) chromaticity (color quality) diagram are represented as radii of ellipses. [The SCI® indicates that this paper has been cited in over 115 publications since 1961.]

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"This was the culmination of ten years of the first engineering application of color science.

"I and the first recording spectrophotometer simultaneously began working at the Massachusetts Institute of Technology in the fall of 1932. Teaching optics and photography laboratory courses, I was quickly involved with Hardy's spectrophotometer. I demonstrated it to hundreds of visitors from industries, universities, and government agencies. We had to teach them how to interpret the results, which is tricky: samples that have distinctly different spectrophotometric curves can look alike. Yellow materials reflect two-thirds of the visible spectrum, including all visible red and green wavelengths. Yellows as similar in color as the two sodium D lines are clearly distinguishable.

"On the basis of the science of color founded by Newton and advanced by Maxwell and Helmholtz, the CIE in 1931 recommended data representative of normal color

vision, use of which facilitates interpretation of spectrophotometric data. The results represent colors by points in a three-dimensional space, the equiluminous projection of which is a map-like representation of the qualities of colors. But equal distances between points in it that represent pairs of equiluminous colors do not indicate perceptually equal color differences. The discrepancy is as much as 20:1 in different locations and directions. Such discrepancies made evaluation of color differences exasperatingly anomalous.

"The problem had been studied in the Kodak Research Laboratories from its founding in 1912. After I moved there, the son of the first head of its physics department, P.G. Nutting, Jr., came to my laboratory early each morning, before our bosses got in, and later after a quick lunch, before they got back. We amassed over 25,000 observations on which my paper was based. I presented an oral report on the results to the Optical Society in 1940, when I was the first recipient of its Adolph Lomb Medal.

"After World War II, I extended the work into the third (lightness) dimension. My assistant then, W.R.J. Brown, received the Lomb Medal for his work on that problem. My Mattiello Memorial Lecture,¹ Hurter and Driffield Lecture,² and Ives Medal Lecture³ constitute my major reviews of subsequent developments in the subject. The latter is preceded by a list of my publications to 1974, mostly on that subject. My latest review is in my book.⁴ At its Stockholm meeting in September 1983, the Association Internationale de la Couleur plans to award me its Judd Medal "for important work in color science."

"I think the paper is cited because color is important in many industries and because the ellipses in Figures 23-48 were the first and for over 30 years the most frequently used guides to the interpretation of measured differences of color. The paper is also, of course, cited by doubters, by workers who attempt to supersede my ellipses, and by color-vision theorists who try to account for them."

1. MacAdam D L. Color measurement and tolerances. *J. Paint Tech. Eng.* 37:1487-531, 1965.

2. -----, Color science and color photography. *J. Photogr. Sci.* 84:229-50, 1966.

3. -----, Color essays. *J. Opt. Soc. Amer.* 65:483-92, 1975.

4. -----, Color measurement: theme and variations. New York: Springer-Verlag, 1981. 250 p.