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This Week's Citation Classic

De Valois R L, Abramov J & Jacobs G H. Analysis of response patterns of LGN cells. *J. Opt. Soc. Amer.* **56**:966-77, 1966.
[Dept. Psychol., Indiana Univ., Bloomington, IN]

Quantitative analysis of a population of cells in macaque LGN provides evidence for four types of spectrally opponent cells, and two types of non-opponent cells. Non-opponent cell responses agree quantitatively with behavioral measures of luminosity; spectrally opponent cells account for the perception of different hues. [The *SCI*® indicates that this paper has been cited over 100 times since 1966.]

R.L. De Valois
Department of Psychology
University of California
Berkeley, CA 94720

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"This paper has been widely quoted and has had considerable impact on the field of vision. Considering why this is so, we can perhaps discern four reasons.

"(a) This paper summarizes the evidence (which I, with various colleagues and students, had published in several earlier papers) that our color vision is based on the activity *of* spectrally opponent cells which fire to some wavelengths and inhibit to others. Such an organization had been proposed a century earlier by Hering, and argued by several psychophysicists in succeeding years. But until the contrary physiological evidence was obtained, the overwhelming majority of visual scientists had believed in the opposing Helmholtzian notion that the output of the three cone types fed straight through in independent channels to the brain.

"(b) This paper was perhaps the first —and still is one of the few —attempts to answer the question of the number of functional cell types in a nucleus by a quantitative analysis of data rather than by the experimenter's fiat. The paper actually had its inception in 1963, by which time my students, Israel Abramov and Gerald Jacobs, and I had collected extensive records of the responses of geniculate cells to flashes of different wavelengths of light. Trying to make sense of the data, with its enormous variability from cell to cell as is typical of physiological data, we had long, bickering (and occasionally screaming) arguments about how many different types of color cells there were. We finally decided to try to settle the question by a massive statistical analysis of the data we had collected. Since this was before the days of computers we had to count spikes from innumerable individual oscilloscope photographs. From this work we concluded that there were four separate types of spectrally opponent cell: + R-G (red excitatory, green inhibitory), +G-R, +Y-B, + B-Y, as well as two types of non-opponent cells.

"(c) This paper was one of the first attempts to compare systematically and quantitatively single cell physiological data with data from perceptual experiments. In other experiments we had shown that macaques and humans have virtually identical color vision. Here we demonstrated how the responses of the various cell types could account for a variety of behavioral observations, e.g., hue naming and saturation discrimination. Equally important, we pointed out certain other visual phenomena which could not be accounted for and must thus reflect processing at later levels.

"(d) Finally, this paper offers a simple, coherent account of the subcortical processing of color and luminance information. In subsequent years various contradictions and complications have been pointed out by ourselves and others (in particular, it is clear that opponent cells also carry brightness information). I would not now, 15 years later, want to bet very much on the validity of the model we put forth. However, as has often been noted, a theory is historically overthrown not by contrary data but only by a better, more comprehensive theory; since neither we nor others have yet presented one, our original paper still tends to be widely quoted."