The Life and Times of Roy G. Biv

Last year a television crew came to my town to film part of a program on color. The director had the bright idea of filming me lecturing about color to grade-school children. Never having taught pupils so young, I only reluctantly agreed to take part in this scheme.

The students were carefully selected from the academic fast lane. So that I would not face a completely unknown audience, I asked to meet them while the cameramen were setting up their paraphernalia. I confessed to the students that I was at a disadvantage by not knowing what they knew about color. This prompted one of the teachers in the room to beam proudly and assert, "They know all about Roy G. Biv." "Humph," was my unguarded response, "he ought to be shot." And so, with this inauspicious beginning, I did my best to convince the students that, although Roy G. Biv might be a useful device for remembering color order, the seven letters of his name did not exhaust the gamut of colors.

Newton: Roy G. Biv's Father

Newton, like all geniuses, is quoted (inaccurately) vastly more often than read. It seems that Roy G. Biv was born illegitimately on the pages on Newton's *Optiks* (1704), where in Prop. II Theor. II we find that "Rays...appear tinged with this Series of Colours, violet, indigo, blue, green, yellow, orange, and red, *together with all their immediate Degrees of a continual Succession perpetually varying. So that there appeared as many Degrees of Colours, as there were sorts of Rays differing in Refrangibility*" [emphasis added]. Failure to read or heed the emphasized words has led to the notion that Newton believed the number of colors to be seven. But what he really did was to rattle off a string of color names and stopped at seven. Why he settled on seven is likely a consequence of the occult powers long attributed to this number, which Francisco L. Urquizo in *Símbolos y Números* (1965) describes as "the cabalistic number par excellence which is encountered in numerous aspects of life." He then devotes five pages to the many roles of seven: seven musical notes, seven wonders of the world, seven days of the week, seven plagues of Egypt, seven deadly sins, and so on. Given this ubiquity of the number seven, it is compelling to seek seven colors. But Newton had to dig deep. For the life of me, I could not identify an indigo object if I were to see one, and I have yet to encounter anyone who could.

How Many Colors Are There?

In one colorimetry book I consulted, color space was divided into sectors labeled green, bluish-green, blue-green, greenish-blue, blue, purplish-blue, bluish-purple, purple, reddish-purple, red-purple, purplish-pink, pink, purplish-red, red, orange-pink, reddish-orange, orange, yellowish-orange, yellow, greenish-yellow, yellow-green, and yellowish-green. Even resorting to Serbo-Croatian, a language distinguished by words with world-record strings of consonants, I could not construct from these color names a suitable acronym to be dutifully memorized by children.

Aren't there only three colors—the primary colors red, green, and blue—from which all others can be obtained by superposition? In a sense, this is closer to the truth but still far from it. It is indeed true that by superposing varying amounts of light from red, green, and blue lamps one can create a large gamut of colors. But no set of real (as opposed to mathematical) lamps covers the entire gamut.

Although the number of colors is indeterminate, the number of color names is finite, and the subset in everyday use comprises about half a dozen, which is all we need (unless we are artists or paint formulators).

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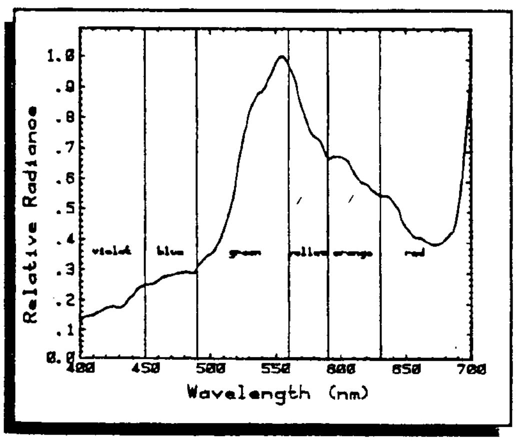
A Study in Misconceptions

Faulty explanations of colors in nature are the rule rather than the exception. In a book by a doctor of physics I learn that "a leaf looks green because it is absorbing all the colors of the spectrum except green, which it is reflecting." Although statements like this are as common as dirt, they are refuted once and for all by a radiance spectrum of grass (see figure), which epitomizes greenness, taken for me by Michael Churma.

This spectrum has been divided into regions corresponding to various perceived colors, although I would not defend their boundaries with my life. Note that all colors are present and that there is more yellow, orange, and red light than some of the greens. So much for green grass or leaves being a source of only green light—the G in Roy G. Biv.

Yellow can be obtained by mixing red and green light. Following the logic of the putative explanation of the greenness of leaves cited previously, I could say—with tongue in cheek—that a lemon looks yellow because it is absorbing all the colors except green and red, which it is reflecting.



Well, green is dominant in the spectrum of grass, isn't it? So why not just stretch the truth and say that only green light is present? Unfortunately, even physical dominance of a wavelength does not ensure that light will be perceived as the color evoked by that wavelength. A good example is skylight, the radiance of which can be slightly higher in the violet than in the blue, despite which the blue sky is still explained more often than not by saying that air molecules scatter only blue light. Perceptually, of course, the sky is blue, but not because it is composed of only blue light or even because the peak radiance lies in the blue. We are not spectrophotometers. When presented with a colored object, we give it a color name but are powerless to determine the relative amounts of all the component wavelengths. This is a human limitation, and cannot be evaded by saying that green objects are sources of only green light, red objects of only red light, and so on.

What should children be taught about color? It is easier to specify what they should *not* be taught. Color is not a synonym for wavelength. Nor should color be used as a sugar coating to sweeten the bitterness of truth. Frequently, well meaning but misguided authors, shrinking from terrifying their readers with wavelengths, distort reality by referring to absurdities such as colors we cannot see or colors of infrared light. Yet, to divorce color from the human observer is to reduce it to a needless synonym for wavelength, when in reality it is a much richer concept.

Like Alfonso X, I feel that "had I been present at the creation, I would have given some useful hints for the better ordering of the universe." I would have suggested that all colored objects be sources of monochromatic light. Redesigning the universe strikes me as a far easier task than stamping out the nearly universal misconceptions about color. ■

Letters

continued from page 3

the orange in question, CIE Publication No. 76 reports an orange with a maximum chroma of 168. The chroma contrast is thus 168%, assuming a white with 0 chroma.

How does the "hunter's orange" generate this high contrast? Bohren's description of the fluorescence process, again, is correct. Under overcast, north sky daylight (correlated color temperature of 6500 to 7500K), a non-fluorescent orange vest will have a maximum absolute reflectance of 0.90. On the same scale, our fluorescent orange vest will have an apparent reflectance of 2.5 or higher. The high radiant efficiency, cited by Bohren, occurs because in nearly all fluorescent colorants, the excitation and emission spectra overlap. The "hunter's orange" absorbs not only near UV radiance, but all available visible radiance up to about 600 nm, and then emits the radiance in the 600-750 nm range. While it is in the literature, this spectral overlap seems to be one of the least known of all spectroscopic phenomena. Fluorescent orange is still fluorescent, even in the incandescent light of automobile head lamps.

The two figures illustrate the effects. Figure 1 is a chromaticity diagram showing the spectral locus of maximum object colors (generated by David MacAdam). Figure 2 shows the excitation, emission, and total radiance factor spectral curves (generated by F.W. Billmeyer, Jr. and Franc Grum).

Danny C. Rich, Lawrenceville, N.J.

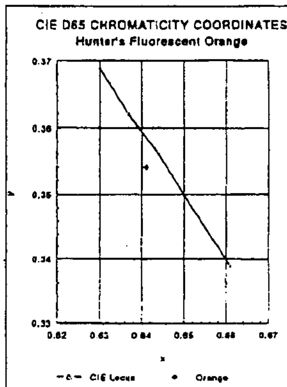


Figure 1. Chromaticity diagram.

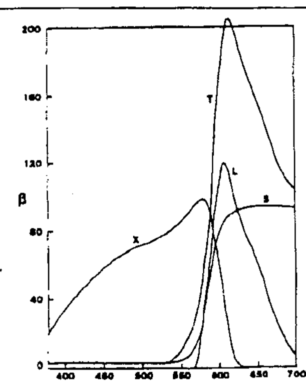


Figure 2. Spectral radiance factor (T) and its components for Blaze Orange: reflected radiance factor (S), luminescent (or fluorescent) radiance factor (L), and excitation spectrum (X).