Did your primary school teacher lie to you about color?

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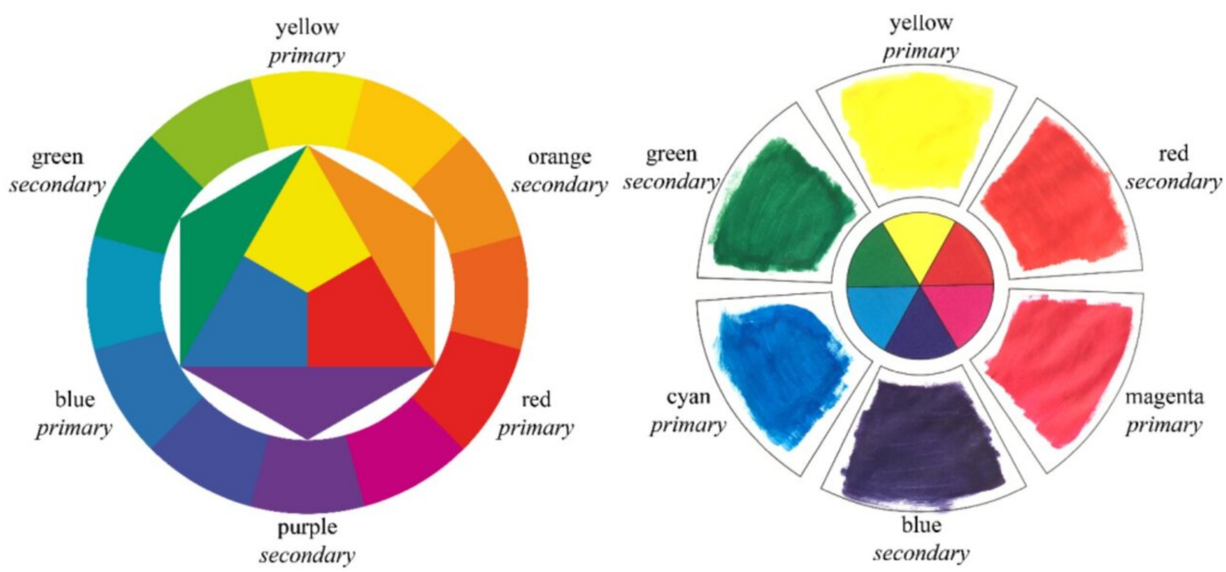

Credit: Victoria University of Wellington

At primary school you were taught that there are three primary colors: red, yellow and blue, and that you can mix these to make all other colors. This is not true. Or rather, it is only a rough approximation to the truth. My recent article, published in the *Journal of Perceptual Imaging*, digs into the history of color wheels and color mixing to find that the truth is more complex and more interesting.

The idea that there are three primary paint colors was discovered in the seventeenth century. Different artists used different shades, which were roughly reddish, yellowish and bluish. This theory was consolidated in the 1950s by Johannes Itten, the influential painter, teacher and theorist associated with the Bauhaus. Itten created the color wheel that is today taught in most art classes and primary schools.

Itten has a red-yellow-blue triad of primary colors. But Itten's primary triad is strongly tied to the way we use language rather than to the physically correct colors for mixing. The correct colors for mixing are magenta, yellow and cyan, the colors of ink that you buy for your color printer. Yellow is common to both sets. Cyan is a green-blue. Magenta is somewhere between red, purple and pink. And in that explanation of cyan and magenta lies the linguistic problem. Neither cyan nor magenta is a basic color term, whereas red, purple, green, blue, pink, and yellow all are. Itten's primaries are basic color terms and Itten uses the language of color to define the primaries that he uses.

In the late 1960s, Brent Berlin and Paul Kay proposed the theory that there are basic color terms in all languages. These are the terms that you teach small children and which produce categories of color that are irreducible, that is, all other color terms are considered, by most speakers of the language, to be variations on these basic color terms. In English, and most other European languages, there are eleven basic color terms: red, orange, yellow, green, blue, purple, pink, brown, black, gray, and white. As an example of the irreducibility of these basic terms, consider how difficult it is to convince a child that brown is really dark orange or that pink is light red. You may teach a particular child or student to make finer distinctions, as between cyan, azure, indigo, and turquoise, but there is a cultural push toward teaching and agreeing on the eleven basic color terms, and there is demonstrated effect of these basic categories on the ability to perform color discrimination.

The language of color strongly influenced Itten. In Itten's seminal writing on the color wheel, The Elements of color, he writes: "…a person with normal vision can identify a red that is neither bluish, nor yellowish; a yellow that is neither greenish, nor reddish; and a blue that is neither greenish, nor reddish… The primary colors must be defined with the greatest possible accuracy." There is no freedom here to allow red to be magenta, because magenta is a red that is distinctly bluish, nor is there freedom to allow blue to be cyan, because cyan is a blue that is distinctly greenish.

My analysis of color models shows that Itten's approach, while deeply appealing, is physically incorrect. Just because we can all agree linguistically on the prototypical basic red, yellow and blue does not mean that these are the correct colors to have as your primaries. Physical analysis of color shows that magenta, cyan and yellow give the best primaries for mixing the maximum range of colors. My paper shows that all of the technical color models broadly agree on this, and that Itten's color model is an outlier. My conclusion is that this is because he puts special emphasis on the colors that are linguistically and culturally determined to be somehow basic.

Now this is not necessarily a bad thing, but there is a challenge for educators. When students start their technical training, at university or in an apprenticeship, we need to teach them to forget what they have known since primary school about color. We need to take them deeper into the physical and psychophysical properties of color. We find this a challenge firstly because people are very attached to what they learned in the early years of their lives and secondly because we do not ourselves necessarily understand why the red-yellow-blue color wheel is technically incorrect. My work helps us to understand how it developed and, in understand that, we are better able to transition students to the more accurate technical explanation of color mixing.

More information: Neil A. Dodgson. What is the "Opposite" of "Blue"? The Language of Color Wheels, *Journal of Perceptual Imaging* (2019). DOI: 10.2352/J.Percept.Imaging.2019.2.1.010401

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