Secondary colours

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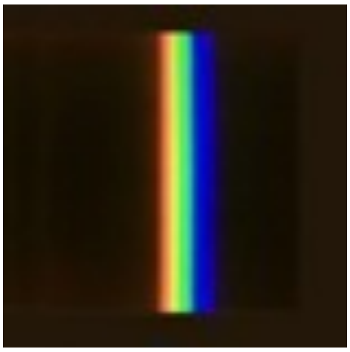
When I look at a white line on a back iPad screen through a direct vision prism I see red, green and blue. Red, green and blue are the colours of the there phosphors on the iPad screen that match the three sets of colour sensors on my retina. They and are called *primary* colours.



The red is shifted left by the prism, the blue is shifted right and the green is left where is was.

Dad asked me to look at a black line on a white iPad screen with the same direct vision prism.

I was surprised when I did that. The black line split into three odd unexpected colours: sort of bluish on the left, sort of pinkish in the middle, and a clear yellow on the right. I had no idea how that could happen: I had to ask.

What are these odd colours?

The white screen emits all wavelengths of light. All three colour sensors (red, green and blue) in our eyes are active and the brain gives us what we call white. The black line is a "hole" in the white screen that emits no light. There are no colour sensors sensors active on the retina and the brain gives us what we call black.

The prism does to the *whole white screen* what it does to the thin strip of white on a black monitor: red is shifted left, blue is shifted right and green is left where it is. *Picture this in you mind*. The odd blueish colour on the left is where the hole in the red has been shifted to. The yellow on the right is where the hole in the blue has been shifted to. The odd pinkish/purple colour in the middle is the hole in the green that is left where it was.

The odd colour on the left is *cyan*: a mixture of green and blue.
The odd colour in the middle is *magenta:* a mixture of red and blue.
The colour on the right is *yellow*: a mixture of red and green.

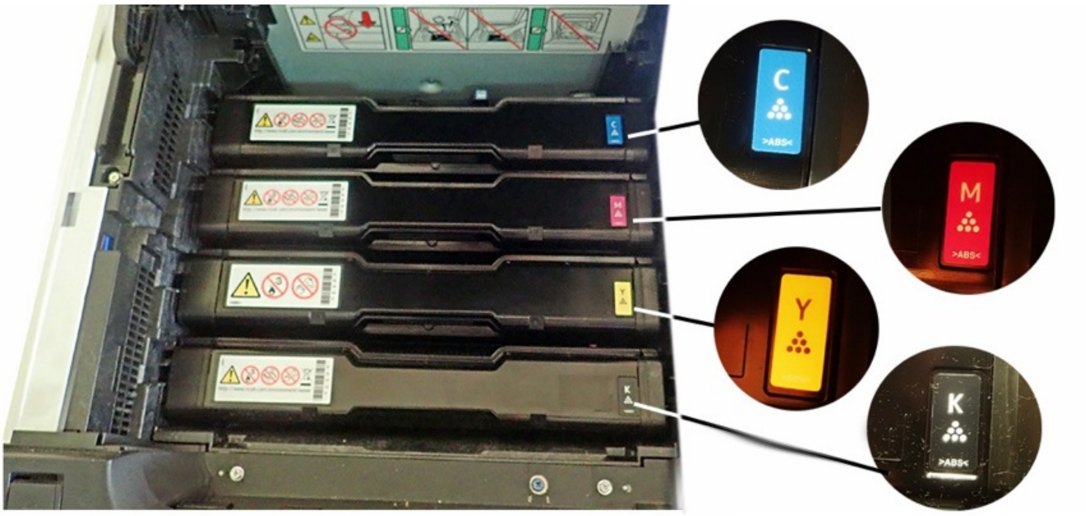
Red, green, and blue are primary colours for us because the brain gives us red, green or blue when just *one set* of our colour sensors is active.

Cyan, magenta and yellow are secondary colours for us because we "see" cyan, magenta or yellow when one set of our colour sensors is *not active*.

Elephants have just two sets of colour sensors. For elephant scientists there would be two primary colours and no secondary colours.

Inks and paints

Printers layer the *secondary colours*: cyan, magenta and yellow to print in full colour. Because the dyes they use are not perfect (they leak a bit in other wavelengths) they add black-ink image to improve the final effect.



Cyan, magenta, yellow, and black ink cartridges in our printer.

The paints used by artists are secondary colours too. For instance, yellow paint reflects red and green wavelengths, both the red and green sensors in our eyes become active, and the brain gives us yellow.

Deep confusion arises because artists call their yellow paint a *primary* colour. By that they mean: one of the three colours they start with, (what they call red, yellow and blue), from which they can mix all the colours they want. The confusion gets deeper because what artists call ‘red’ and ‘blue’ are the secondary colours magenta and cyan.

Yellow is what we see when only our blue sensors are not active.

Cyan is what we see when only our red sensors are not active.

Remember: a monitor screen emits three primary colours red, green and blue. Inks and paints are secondary colours. Suppose we mix artist’s yellow (with no blue reflection) with what they call blue (with no red reflection). That leaves only our green sensors active. We see green.

Image inversion (swapping the wavelengths emitted for wavelengths absorbed with a computer) can be used to flip between primary and secondary colours. The yellow (secondary colour) tortoise beetle in our garden is on a green leafy background (primary colour).

Inverting the top image flips primary green to secondary magenta (the absence of green). At the same time secondary yellow (the absence of blue) is flipped to primary blue …. and black becomes white.