Color Perception Experiments for Children

Experiments in color combinations can be both pretty and interesting to do with a youngster. This short series of experiments leads to a better understanding of color perception and its use in producing TV images. And they can be done at home.

Before starting the experiments, prepare three flashlights so that one emits blue light, one red, and one green. I found full sized flashlights available for less than $2 each. The color can be easily produced by coloring the clear plastic window on the front of the flashlight with colored ink. The ink from water-based markers will stick on some flashlights; ink from permanent markers such as "Sharpee" pens, which comes off with alcohol, will also work well. If you cannot find a pen with ink that will stick, apply a very thin layer of white glue to the plastic piece, then apply the ink after it dries.

You will also need three glasses; red, blue, and green liquid food coloring; preferably three more flashlights; waxed paper; access to the Sunday comics; a television; and permission from a youngster to try some experiments together. To start, I asked my daughter Jamie if she knew how colors are produced on a TV. She hadn't any idea, but we noted that it surely could not involve paint, since the TV displays a wide variety of colors that change very quickly. I told her these experiments would help explain how these colors are produced.

First, we directed the three flashlight beams on a white ceiling at night, noting the pretty deep blue, red, and green beams. Then we combined all three beams on one spot. Jamie was surprised to see the essentially white light. We tried combinations of just two beams, and also tried blocking some of the light from one or more of the flashlights to adjust the amount of each color. We did the blocking simply by covering part of the clear plastic with a finger; this still yields an adequately uniform source.

I explained to my daughter that light is usually composed of many wavelengths, which we perceive as separate colors. For example, in a rainbow the raindrops spread the light from the sun into its wavelength components, creating what is called a spectrum. Although most light one sees contains many wavelengths, the eye perceives it as one color. In this experiment, we were combining lights that were mostly blue, mostly red, and mostly green, to yield a light that was perceived as white even though it was not quite the same as the original light a flashlight might have given. (With a very young child, I would not try to offer the above explanation; a simple observation of the effect is educational by itself.)

We then checked to see if the same effect occurred when three uncolored flashlight beams are directed through each of three glasses of water filled with food coloring. In a dark room, we lined up three glasses near a white wall so that we could aim the three flashlights to create one combination beam on the wall. Around each glass was a single layer of waxed paper to create a sufficiently uniform beam. We were once again able to produce white from all three beams, yellow from red plus green, purple from red plus blue, etc.

I let my daughter fool around with various effects: what happens when you use colored flashlights through the colored glass; when the waxed paper is removed (the resulting pattern is beautiful); and when you run one beam through two glasses. I pointed out that when you use the three beams, you are combining colored light on the wall to make essentially white light. When you run one nearly white beam through a glass with red dye, for example, you are removing—or absorbing—much of the blue and green light so that primarily red remains.

An interesting effect can be created by diluting the red-dyed water with a considerable amount of water. The combination of the three beams through the three glasses (with waxed paper) yields a light red spot on the wall. In order to turn this spot from light red to white, you must then add red dye. It was surprising to Jamie that she would have to add red dye to make the combination beam less red, but she figured out that the additional dye meant less of the red light got through.

At this point we went in to the TV and viewed it from a range of a few inches. Jamie could see the individual red, blue, and green elements. (We older folks may need reading glasses or a magnifier to see this.) In the regions of a TV screen showing the image of a person's face, we could see primarily the red and green elements. In regions of blue, such as water, we could see the blue components glowing. We observed for a while what combinations of the three colors were used to produce the different colors. You can give youngsters some control over this by allowing them to change the color adjustment on the TV. I told Jamie that each color is produced by a phosphor, which is a material that glows when electrons hit it, and that the TV controls which of the colored components are lit.

I next showed Jamie that you needn't use red, blue, and green to cause the eye to perceive another color. In the comics, they use a limited number of dyes, then add small dots of color to give a still wider range of colors. "Calvin's" hair is orange ink with tiny red dots. His dad's dark green chair is created with green dye plus black dots. A light green lamp next to the chair is created with green dye plus white dots. Jamie and I went back and cleaned up the flashlights, and tried using orange, purple, and green pens to show that—like red, blue, and green— they can be combined into many different colors.

I told Jamie that, in general, when something appears to be a certain color, you can't be certain what wavelengths are actually being emitted or reflected. I measured the reflectance of a yellow rose petal once at school, and was

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amazed to find that it had almost no reflectance of yellow light; yet the eye combined its reflected colors so that it appeared yellow. The TV colors are an example of a very clever use of this phenomenon. (Knowing the emittance curve of the source irradiating an object, and the reflectance curve of the object, one can compute its apparent color, in terms of hue and saturation. I felt that this was beyond the level that I could successfully convey to a child.)

You can never tell for sure how kids will react to this sort of thing. My teenage son had too much homework to participate in the project this time, but he came in while I was busy trying out various possible experiments. "Cool! What are you doing?" When I told him, he took up the red flashlight, saying in a deep, drawn out voice, "I am your father, Luke." Quickly trading it for the blue flashlight: "Luke...feel the force, Luke!"

Part of the key to kids' enjoyment is letting them play around as they experiment with optical effects.