Lots of Dots: Pointillist Paintings and Optical Mixing

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For those of us lucky enough to perceive the world visually, color is a very important aspect of life. Seasons, festivals, the myriad forms of nature around us, and even human emotions - they can all be uniquely associated with certain colors. Colors conjure up vivid pictures of the world we live in and it is very difficult to imagine living in a black-and-white world, completely devoid of color. It is strange then to realize that in reality, color is a property of light and that objects do not have a color of their own. They only reflect a certain wavelength of light back to our eyes. White light when viewed through a prism, is composed of seven different colors (the colors of the *Indradhanush*/rainbow): red, orange, yellow, green, blue, indigo and violet. Each color is a different, reflected wavelength of light. When light strikes a ball painted red, all the colors of the rainbow shine on it, but red is the only color we see. This is because only the red wavelength of light is reflected from the ball back to our eyes which then send a message of red to the brain. All other colors are mostly absorbed by the red ball. We see white when all colors are reflected from a surface and black when all colors are absorbed by it.

To make life more complicated, the same color can look very different depending on the lighting conditions. For example, the same grass can appear gray in the early morning and bright green at noon. Those of you who have performed on stage, will have noticed how costumes seem one color when seen under the floodlights in the theater, and a totally different color when seen outside in natural light. Colors also appear to change according to their surroundings. You can see this by looking at the color squares below - the red outline box is the same color in all the examples, but looks a different shade because of the contrast with each differently colored square.

It has long been known by scientists and artists alike, that only a few "primary" colors (red, green and blue) are required to produce all the other colors the human eye can differentiate. Mixed together, the primary colors produce all the other colors. There are different ways the primary colors can be mixed, depending on the materials used for the mixing. When pigments like inks or paints are mixed, the mixed colors are formed by the colors that are reflected by the pigments. This is called subtractive mixing, since the other colors are absorbed or subtracted from the light hitting the object painted. When lights are mixed, they produce colors by the colors that the light sources emit. This is called additive mixing, since the colors from the different light sources are added together. The colors on a computer screen are produced using this method of additive mixing.

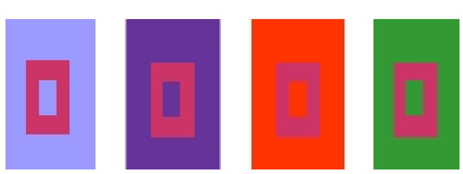

FIG. 1: The same red box looks a different color when viewed against differently colored backgrounds.

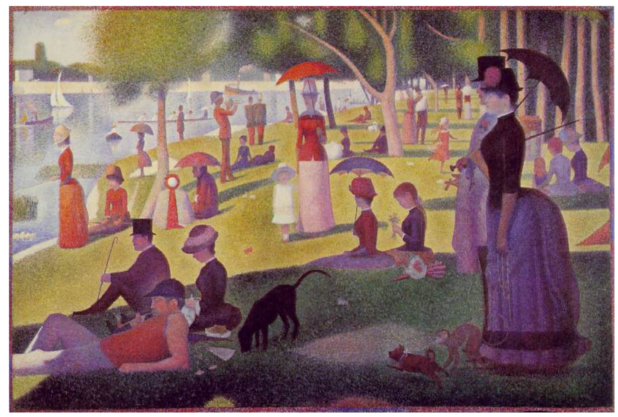

FIG. 2: "La Grande Jatte" (1884-86): Seurat's first Pointillist painting.

In the 1800s, French painters like Georges Seurat and Paul Signac used a third way of mixing the primary colors, by tricking the eye to create the illusion of color. They created paintings using only dots of primary colors. Seurat placed pure colors side by side by applying tiny dots and dashes to the surface of the canvas. When seen from a distance, the tiny strokes blend in the eye and are perceived as secondary colors. Seurat theorized that putting dots of yellow and blue side by side on the canvas would produce a brighter green than if he mixed yellow and blue paint together on the palette first. And he was right! He took two years to complete his first painting, dot by painstaking dot. The painting called "La Grande Jatte", is set in a Parisian park in the daytime. When you step away from the painting, you are able to see the composition in its entirety, and appreciate how different the texture of the women's gowns looks as opposed to the wood of the trees. However, when seen in close up, the entire painting is just a jumble of primary color dots - daubed onto the canvas dot by dot with extreme precision. When you again step back the appropriate distance, the illusion of the thousands of subtle colors reappears, created by optical mixing in your brain!

This technique is called "optical color mixing" and the

FIG. 3: "Port St. Tropez": a Pointillist painting by French painter Paul Signac.

paintings created using this method are called "Pointillist" paintings. Another example of a Pointillist painting by Paul Signac is shown in the next figure. He distributed dots of primary colors in a pattern on the paper, and depending on the quantity of a certain dot in a specific area, a specific color is seen by the viewer. The Pointillist painters with their dot paintings, thus confirmed the color theories of physicists like Newton, Young, Helmholtz, and Maxwell.

Modern news printing uses the same techniques to produce colors. If you use a magnifying glass to look very closely at the cartoon section of your Sunday newspaper, you'll find that the rainbow of colors you see is actually made up of tiny bits of just a few colors. When you back up and look from a distance, the bits appear to blend together to form varied colors and tones again. This then is optical mixing: blending that takes place in the viewer's eye rather than on the page or the canvas.

Many examples of color illusions have been discovered by other people as well. In 1894, Mr. C.E. Benham a toymaker, discovered that a spinning disk with a particular pattern of black and white marks could cause people to see colors where there were none! Benham's Spinning Top has puzzled scientists for over a 100 years, and many theories have been formed to explain it. One theory says that the black and white pattern appears to have colored rings because the different color receptors in your eyes respond at different rates. However, just why people see colors when the disk spins is still an unresolved question and to have fun with it, try making your own illusion toy, by following the procedure given below!

1. Get an old CD or a round, plastic lid (of a biscuit tin for example). Heat a 25 Paise coin and insert it halfway into the center of the CD hole so that the coin is *perpendicular* to the CD. The hot coin will melt two slots on each side of the center CD hole and will stick in the middle of the CD when it cools down. Alternatively, poke a very small hole in the middle of the plastic lid and stick a matchstick or toothpick halfway through it. Your spinner is now ready - twist the coin (or the toothpick) to spin the spinner.

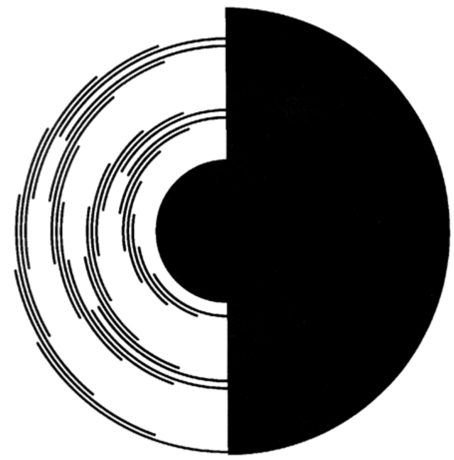

FIG. 4: Black and white pattern on Benham's disk.

2. Print or draw the black and white patterns shown in the figure, onto a sheet of paper and cut it out in a circular shape. Make a small slit in the center of the circular pattern and fit the paper onto the coin or toothpick so that the pattern lies flat on the CD (or plastic) spinner.

3. Spin the spinner in sunlight and see if you can observe the colors!

4. Change the conditions of the experiment: spin the spinner clockwise and then anticlockwise, change the lighting from sunlight to fluorescent, and make your own pattern using a black pen to draw a series of arcs. Record your results and reach your own conclusions.