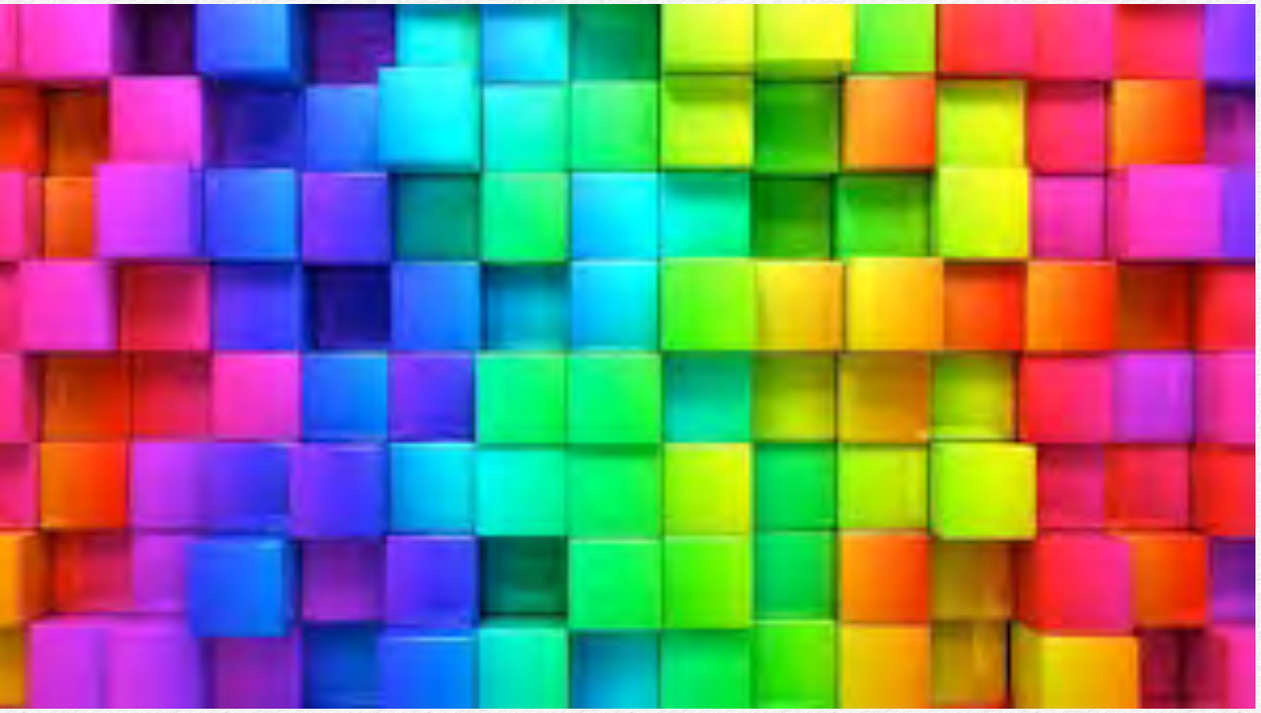
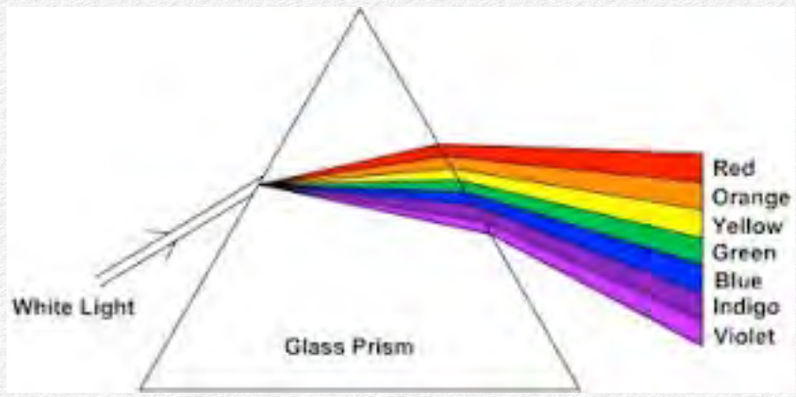
Color Theory





COLOR

Color is a “human phenomenon” . There is a measurable, physical difference in wavelength. “Visible” light is between 4000Angstroms and 7000Angstroms. The human eye perceives 4000 Angstroms as blue/violet light and 7000 Angstroms as deep red. Color is the response of the eye to certain wavelengths of light.

Our eyes have two types of cells: cones provide color perception and rods provide value perception. Visual abnormalities occur. Color blindness, especially red/green colorblindness is most common and most common in men - aprox. 5/100.

The eye perceives wavelengths as color - this has only to do with light. Pigment has no color without light. Color perception is one of the most precise determinations our senses can make - the average eye can distinguish between aprox 7,500,000 hues. White light is a combination of all wavelengths - prism

Color is produced when light hits an object. The object will absorb some of the wavelengths of light and depending on it’s “color” will reflect wavelengths corresponding to that color.

Terms:

Hue: that property of a color which distinguishes it from a grey of the same brilliance. ex red, blue, green etc.

Saturation/ CHROMA: Freedom from mixture with white.refers to the amount or percentage of a hue in a color mixture

Brightness/ Value: difference from black

The human eye is not uniformly sensitive to all wavelengths. Our eye works best in the yellow green area of the spectrum. Our eyes have difficulty focusing in the blue - violet range of the spectrum.

A little history of color

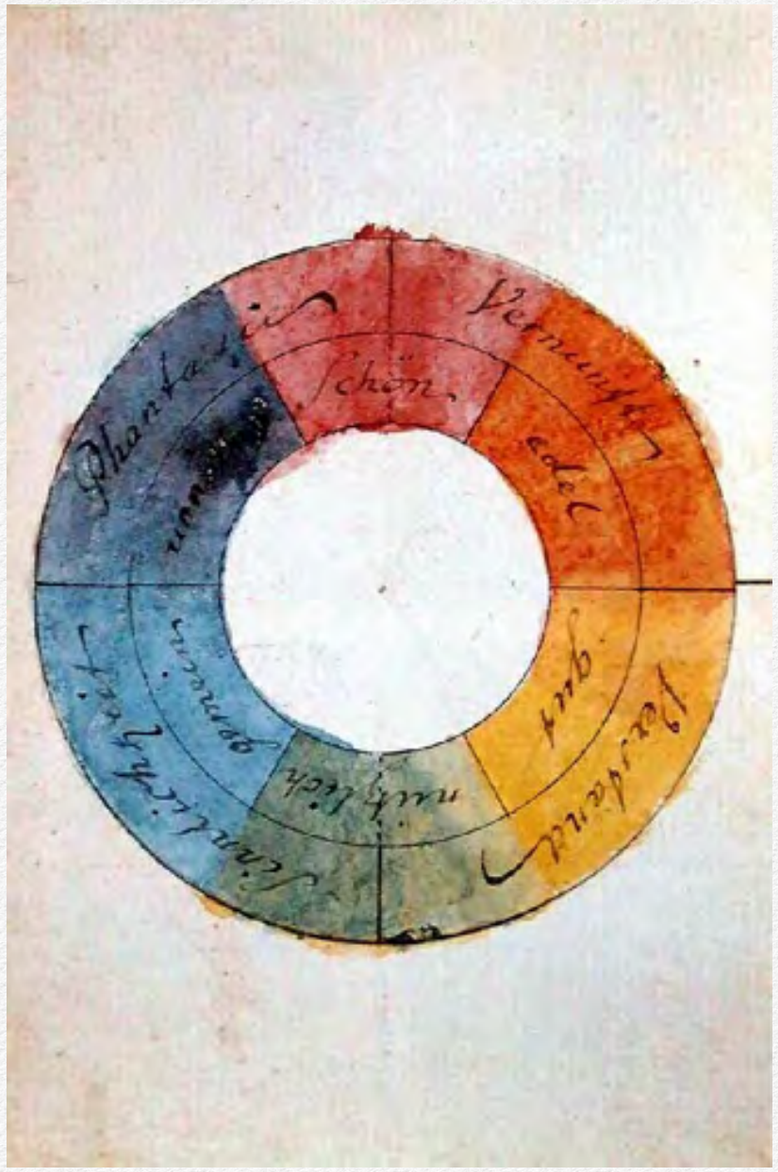
Issac Newton spent lots of time thinking about color and studying the light spectrum. In 1704, he writes" Opticks, or a Treatise of rhe Reflections, Refractions, Inflections and Colors of Light"

Newton realized that colors like purple and magenta exist in Nature but are not part of the natural spectrum. He found they could be generated by overlapping the opposite ends of two color spectra. Newton joins the two ends of a spectral line to produce his color circle.

Newton used his color circle to produce a geometry of color mixing. Conceptually, white is at the center. This is a revolutionary idea.

Newton's Color Circle

Around 1810, Goethe experiments with color and afterimages - created by staring at a color and then looking at a blank white surface. He was very interested in the oppositions inherent in color and their psycological effects. Studies the color of shadows and the complimentary colors.

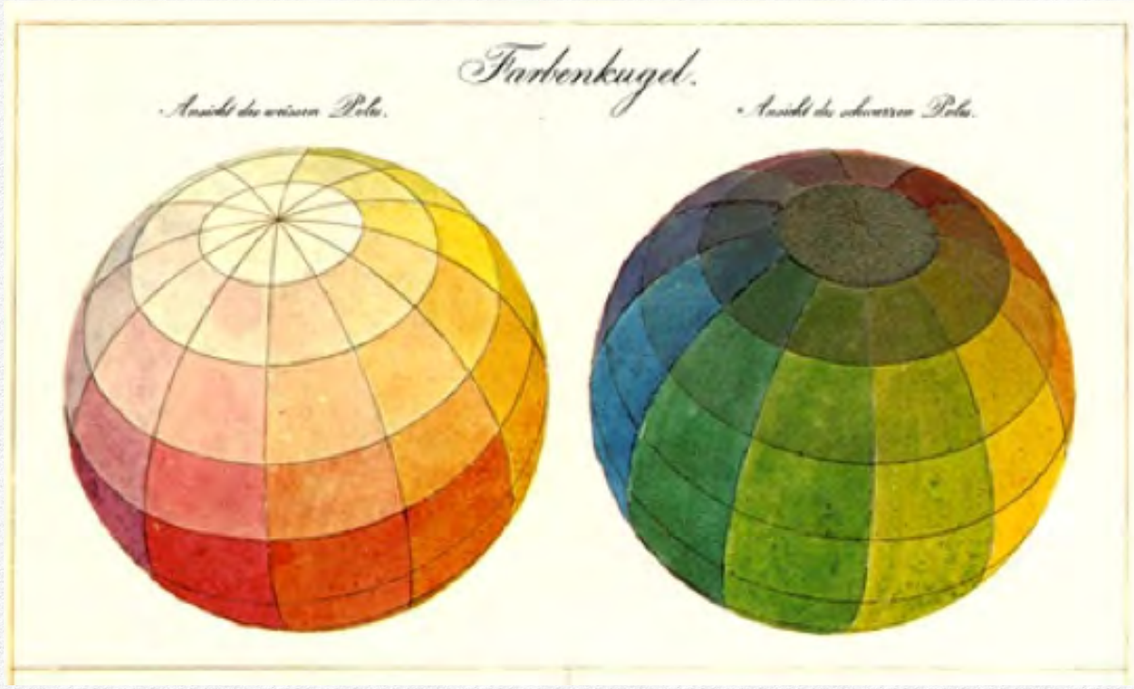


Goethe's Color Wheel

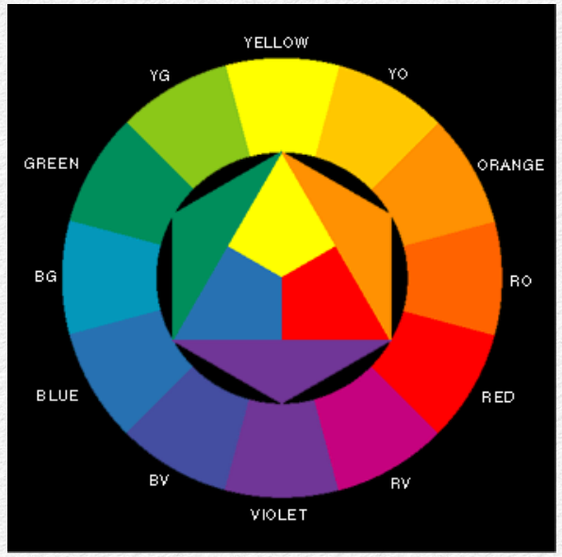
His studies and theories had a profound impact on painters like Turner:

William Turner (1843) “LIGHT AND COLOR(Goethe’s Theory) The Morning After the Deluge”

German Romantic painter, Otto Runge (1777-1810) struggles to quantify color and color relationships and creates a representation of colors on a sphere:



Perhaps the most common color wheel is based on the theories by Louis Prang in 1876. This color wheel is commonly known as the Artists, or Prang Color Wheel.

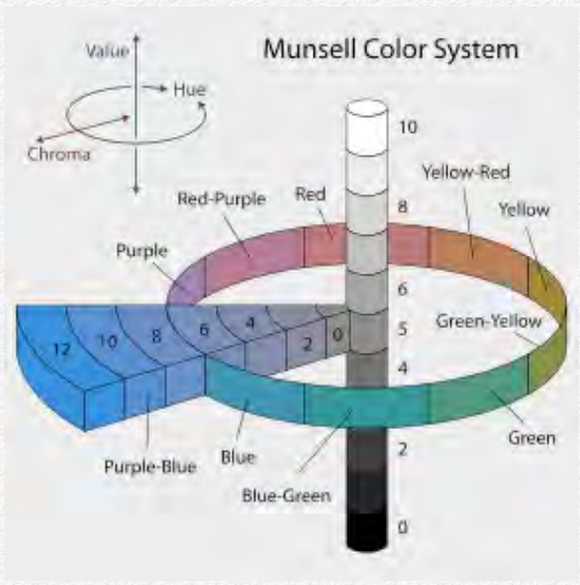


Prang was a printer and developed a 4 color printing process (chromolithography -1860's) and became known as the father of the Christmas Card. Today, process color (CMYK or Cyan, Magenta, Yellow and black)is used in printing. This process uses overlapping dots of various sizes which optically mix.

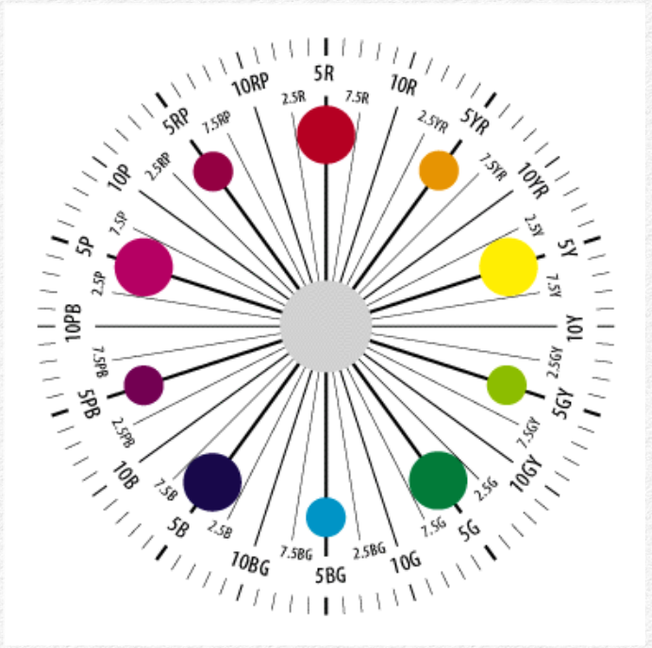
Munsell color system

This color system was created to numerically represent colors based on chroma, hue and value. Tried first by making a sort of globe. Then created a more sophisticated, three dimensional representation.

A BALANCED COLOR SPHERE



Colors are given numbers which allows for accurate duplication. Was used by paint, ink and colored paper manufacturers. Also used by US Bureau of Standards. Under the Munsell system, the primaries are: red, purple, blue, green and yellow.



The Ostwald color system was created in 1917 by German Nobel Prize winning chemist. This system was about understanding the harmonious relation-ships of color. Is more subjective and personal than previous systems. Primaries are: Yellow, red, Ultramarine blue, sea green. Secondaries are: Leaf green, orange, purple and turquoise.

These systems all pre-dated and inevitably led to digital colorometry, Pantone and RAL systems in wide use today.

Color dealing with pigment is called subtractive color mixing - this is the type most people are familiar with.

Primary colors are red, yellow and blue.

Secondary colors are orange, green and violet. mixing yields black.

As colors of pigments are mixed, more wavelengths are absorbed or *subtracted* out.

Subtractive Color Mixing

Color dealing with light is called **additive color mixing**.

Primary colors for additive color mixing are: red, green and blue.

Secondary colors are straw, magenta and cyan. mixing these yields white.

in additive color mixing - you are *adding* wavelengths as you are mixing.

In the theatre, we normally use filters to produce colored light. Starting with essentially white light, a filter absorbs all wavelengths except those of the desired color. Theatre lighting typically uses colored light as one of the tools to help tell the story of the play. Colored light on colored surfaces may create un-expected results and any designer should communicate well and proceed with caution.

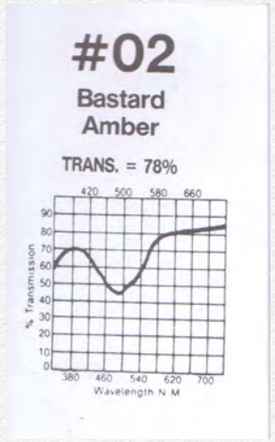
Different filter strategies have been used over time and have evolved greatly throughout history.

First attempts to color light: colored liquid in glass containers There are extant formulas for creating liquids of different colors for different effects from Serlio's 1545 book.

Stretched silk panels to bounce light off were introduced by Phillip de Loutherburg in 1770. As the light "bounced off" only the wavelengths of light that were the color of the silk were reflected.

Gelatine "gel" was the next step in coloring light. This was a very thin sheet of colored gelatine, dried in a baking sheet - the 20"X24" size sheet we still use today. Gel was available in a variety of colors with the first numbering system created in the 1930's. Gelatine gels were available until at least 1975, but as lamps grew hotter, gel was unable to stand up to the heat from the instruments.

Acetate based materials first start appearing in the 1950's as newer, more compact lamp filaments are introduced - roscolene (example). These "new"materials were more heat resistant and the dyes used were more colorfast. Still had a tendency to burn under intense lighting - especially if the color is dense.



Mylar is one of the first space age plastics (1950s) and becomes the basis for new gel materials.

Polycarbonate/ polyester mix, introduced to cope with high heat concentrations created by the then new to theatre, Tungsten halogen lamps. - (roscolux) along with:

Deep dyed polyester -(GAM) and surface dyed polyester - (Lee, Apollo) are all currently available gel types. Colors today are more stable and reliable than in the beginning and there are hundreds of different colors. Most swatch books come with a sheet like the one shown here for each color. They have the color name, number, light transmission and a graph of which wavelengths are passed.

Dichroic filters are metal coatings on glass. The spacing of the metal particles allows wavelengths of light to pass through. An interference pattern is created by the two sides of the filter - resulting in very pure wavelengths of light. These filters absorb very little light energy and reflect "un-used" light back towards the source. (as a compliment of the the color of the filter). Dichoic filters are permanent but fragile (glass), very heat resistant, but expensive. Used for some intelligent lighting systems and architectural applications.

In theatre gel comes in 20X24 sheets. This size is a throwback to gelatin days of a standard size baker's sheet. The film industry usually uses rolls 24" or 48" wide X 50' long. this allows windows and whole sets to be covered to "correct" light color temperature.

Color is also produced through the use of LED fixtures. The LEDs produce light in a very narrow range of wavelengths - colors are pure and vibrant. this is pure additive color mixing.It was originally thought that theoretical color mixing (RGB) would allow any color to be created. The rgb method was then augmented by rgb&a (amber). As LED's got bright enough to be taken truly seriously and more of the long term color problems were solved, a study was initiated by USITT which led to the creation of the Selador fixture. The Selador fixture (now owned by ETC) uses 7 different colors of LEDs to achieve color mixing. (red, red/orange, amber, green, cyan, blue and indigo) Even with this expanded pallette of colors to mix with, there are still some wavelength "holes" making some color matching difficult.

some additional information:

http://www.leefilters.com/lighting/technical-list.html

https://www.rosco.com/filters/

http://www.apollodesign.net/color-filters.html

rosco gam filters

http://www.leefilters.com/lighting/gel-converter.htmlwww.leefilters.com/architecture/arch-dl.htm