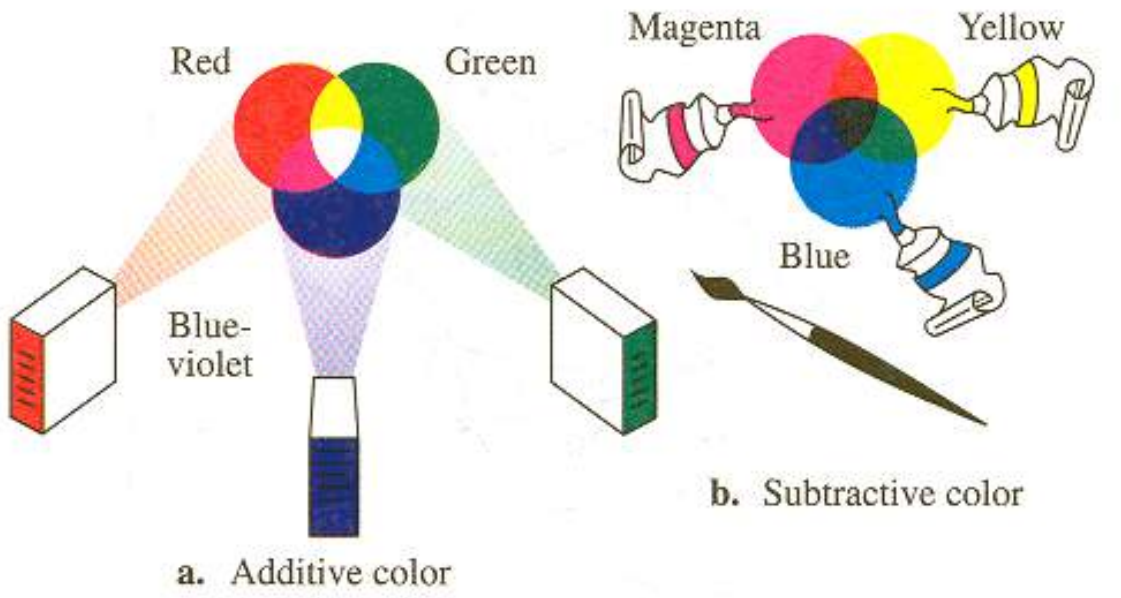
Color Theory 101

In the visual arts, **color theory** is a body of practical guidance to color mixing and the visual impacts of specific color combinations. Although color theory principles first appear in the writings of Leone Battista Alberti (c.1435) and the notebooks of Leonardo da Vinci (c.1490), a tradition of "colory theory" begins in the 18th century, initially within a partisan controversy around Isaac Newton's theory of color (*Opticks*, 1704) and the nature of so-called primary colors. From there it developed as an independent artistic tradition with only superficial reference to colorimetry and vision science.

Color abstractions

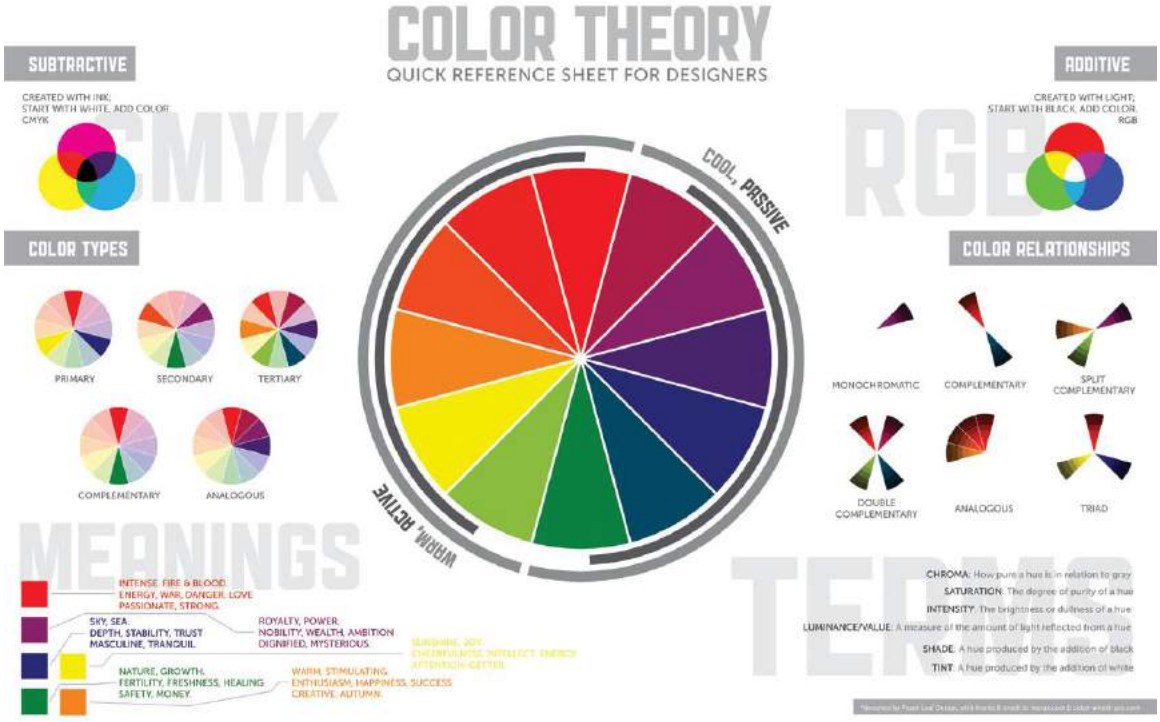
The foundations of pre-20th-century color theory were built around “pure” or ideal colors, characterized by sensory experiences rather than attributes of the physical world. This has led to a number of inaccuracies in traditional color theory principles that are not always remedied in modern formulations.



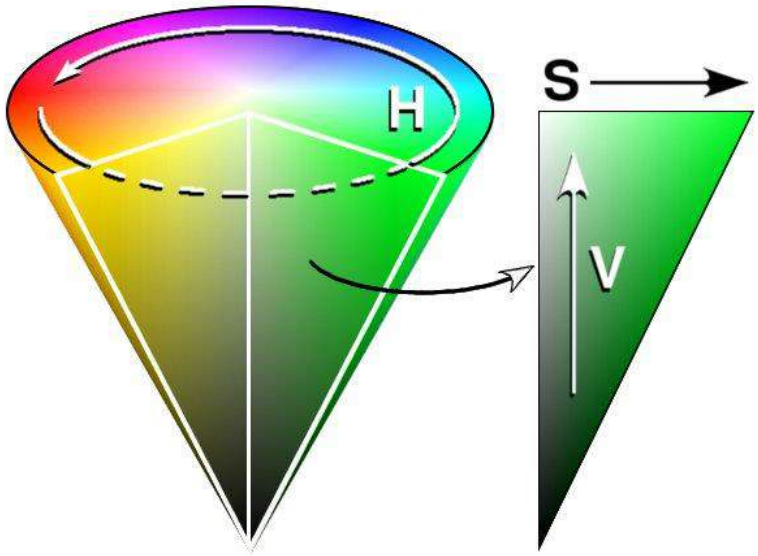
The most important problem has been confusion between the behavior of light mixtures, called additive color, and the behavior of paint or ink or dye or pigment

mixtures, called subtractive color. This problem arises because the absorption of light by material substances follows different rules from the perception of light by the eye.

A second problem has been the failure to describe the very important effects of strong luminance (lightness) contrasts in the appearance of surface colors (such as paints or inks) as opposed to light colors; "colors" such as grays, browns or ochres cannot appear in light mixtures. Thus, a strong lightness contrast between a mid valued yellow paint and a surrounding bright white makes the yellow appear to be green or brown, while a strong brightness contrast between a rainbow and the surrounding sky makes the yellow in a rainbow appear to be a fainter yellow or white.



A third problem has been the tendency to describe color effects holistically or categorically, for example as a contrast between "yellow" and "blue" conceived as generic colors, when most color effects are due to contrasts on three relative attributes that define all colors:



lightness (light vs. dark, or white vs. black),

saturation (intense vs. dull), and

hue (e.g., red, orange, yellow, green, blue or purple).

Thus, the visual impact of "yellow" vs. "blue" hues in visual design depends on the relative lightness and intensity of the hues.

These confusions are partly historical, and arose in scientific uncertainty about color perception that was not resolved until the late 19th century, when the artistic notions were already entrenched. However they also arise from the attempt to describe the highly contextual and flexible behavior of color perception in terms of abstract color sensations that can be generated equivalently by any visual media.

Many historical “color theorists” have assumed that three “pure” primary colors can mix *all possible colors*, and that any failure of specific paints or inks to match this ideal performance is due to the impurity or imperfection of the colorants. In reality, only imaginary “primary colors” used in colorimetry can "mix" or quantify all visible (perceptually possible) colors; but to do this the colors are defined as lying outside the range of visible colors: they cannot be seen. Any three real “primary” colors of light, paint or ink can mix only a limited range of colors, called a gamut, which is always smaller (contains fewer colors) than the full range of

colors humans can perceive.

Historical background

Color theory was originally formulated in terms of three "primary" or "primitive" colors—red, yellow and blue (RYB)—because these colors were believed capable of mixing all other colors. Printers, dyers and painters, had long known this color mixing behavior but these trades preferred pure pigments to primary color mixtures, because the mixtures were too dull (unsaturated).

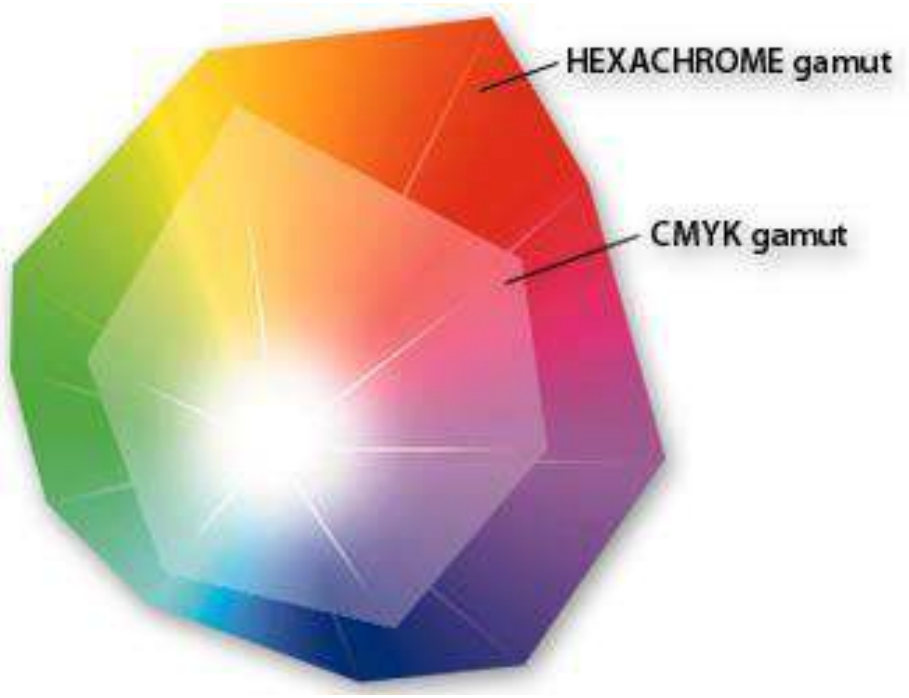
The RYB primary colors became the foundation of 18th century theories of color vision, as the fundamental sensory qualities that are blended in the perception of all physical colors and equally in the physical mixture of pigments or dyes. These theories were enhanced by 18th-century investigations of a variety of purely psychological color effects, in particular the contrast between "complementary" or opposing hues that are produced by color afterimages and in the contrasting shadows in colored light. These ideas and many personal color observations were summarized in two founding documents in color theory: the *Theory of Colours* (1810) by the German poet and government minister Johann Wolfgang von Goethe, and *The Law of Simultaneous Color Contrast* (1839) by the French industrial chemist Michel Eugène Chevreul.

Subsequently, German and English scientists established in the late 19th century that color perception is best described in terms of a different set of primary colors—red, green and blue

violet (RGB)—modeled through the additive mixture of three monochromatic lights. Subsequent research anchored these primary colors in the differing responses to light by three types of color receptors or *cones* in the retina (trichromacy). On this basis the quantitative description of color mixture or colorimetry developed in the early 20th century, along with a series of increasingly sophisticated models of color space and color perception, such as the opponent process theory.

Across the same period, industrial chemistry radically expanded the color range

of lightfast synthetic pigments, allowing for substantially improved saturation in color mixtures of dyes, paints and inks. It also created the dyes and chemical processes necessary for color photography. As a result three-color printing became aesthetically and economically feasible in mass printed media, and the artists' color theory was adapted to primary colors most effective in inks or photographic dyes: cyan, magenta, and yellow (CMY). (In printing, dark colors are supplemented by a black ink, known as the CMYK system; in both printing and photography, white is provided by the color of the paper.) These CMY primary colors were reconciled with the RGB primaries, and subtractive color mixing with additive color mixing, by defining the CMY primaries as substances that *absorbed* only one of the retinal primary colors: cyan absorbs only red (−R+G+B), magenta only green (+R−G+B), and yellow only blue violet (+R+G−B). It is important to add that the CMYK, or process, color printing

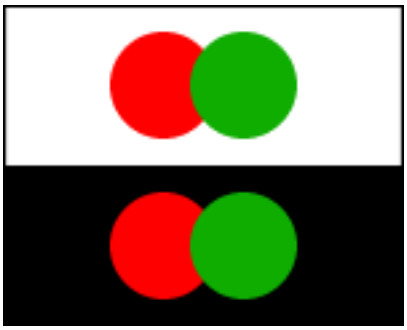


is meant as an economical way of producing a wide range of colors for printing, but is deficient in reproducing certain colors, notably orange and slightly deficient in reproducing purples. A wider range of color can be obtained with the addition of other colors to the printing process, such as in Pantone's Hexachrome printing ink system (six colors), among others.

For much of the 19th century artistic color theory either lagged behind scientific understanding or was augmented by science books written for the lay public, in particular *Modern Chromatics* (1879) by the American physicist Ogden Rood, and early color atlases developed by Albert Munsell (*Munsell Book of Color*, 1915, see Munsell color system) and Wilhelm Ostwald (Color Atlas, 1919). Major advances were made in the early 20th century by artists teaching or associated with the German Bauhaus, in particular Wassily Kandinsky, Johannes Itten, Faber Birren and Josef Albers, whose writings mix speculation with an empirical or demonstration-based study of color design principles.

Contemporary color theory must address the expanded range of media created by digital media and print management systems, which substantially expand the range of imaging systems and viewing contexts in which color can be used.

Traditional color schemes



Complementary color scheme

Colors that are opposite each other on the color wheel are considered to be complementary colors (example: red and green). The high contrast of complementary colors creates a vibrant look especially when used at full saturation. This color scheme must be managed so that it is not jarring.

Complementary color schemes are tricky to use in large doses, but work well when you want something to stand out.

Complementary colors are really bad for text.

Warm vs. cool colors

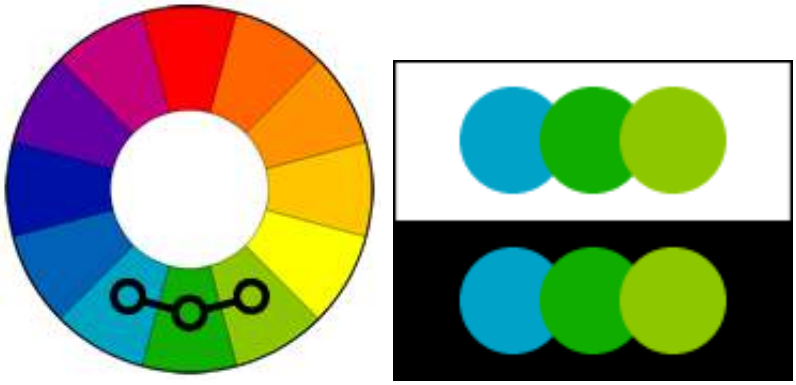
The distinction between *warm* and *cool* colors has been important since at least the late 18th century but is generally not remarked in modern color science or colorimetry. The contrast, as traced by etymologies in the Oxford English Dictionary, seems related to the observed contrast in landscape light, between the "warm" colors associated with daylight or sunset and the "cool" colors associated with a gray or overcast day. Warm colors are often said to be hues from red through yellow, browns and tans included; cool colors are often said to be the hues from blue green through blue violet, most grays included.

There is historical disagreement about the colors that anchor the polarity, but 19th century sources put the peak contrast between red orange and greenish blue. This concept is related to the color temperature of "visible light", an important consideration in photography, television and desktop publishing. The determination of whether a color appears warm or cool is relative. Any color can be made to appear warm or cool by its context with other colors.

Color theory has ascribed perceptual and psychological effects to this contrast. Warm colors are said to advance or appear more active in a painting, while cool colors tend to recede; used in interior design or fashion, warm colors are said to arouse or stimulate the viewer, while cool colors calm and relax. Most of these effects, to the extent they are real, can be attributed to the higher saturation and lighter value of warm pigments in contrast to cool pigments.

Analogous color scheme

Analogous color schemes use colors that are next to each other on the color wheel. They usually match well and create serene and comfortable designs.

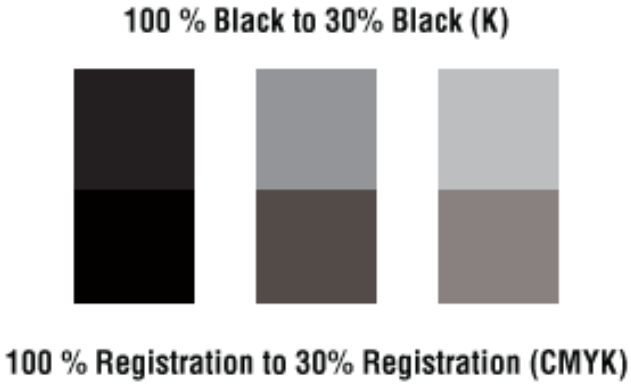


Analogous color schemes are often found in nature and are harmonious and pleasing to the eye. Make sure you have enough contrast when choosing an analogous color scheme.

Choose one color to dominate, a second to support. The third color is used (along with black, white or gray) as an accent.

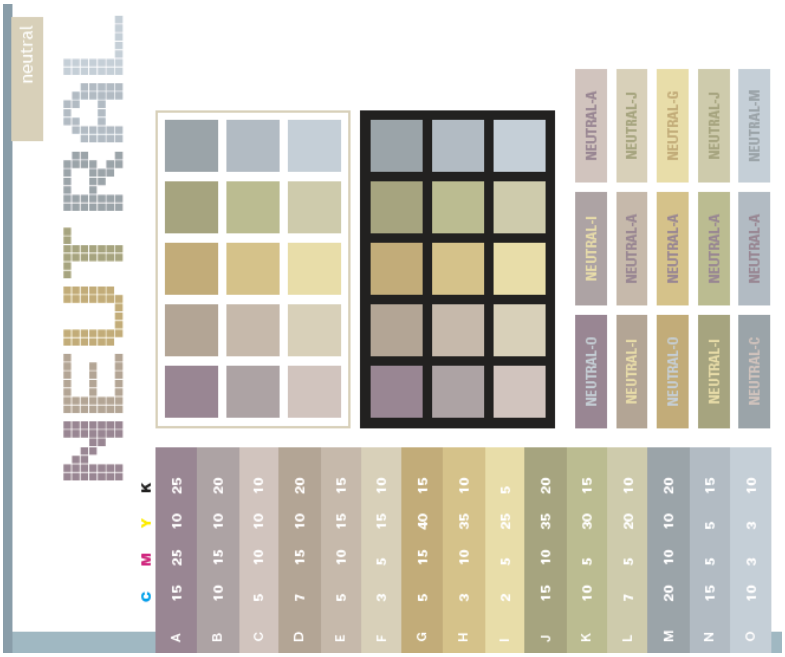
Gray Vs Grey

Earlier on we discussed how a 50% mix of two complimentary colors results in a (G-R-E-Y) grey not a (G-R-A-Y) gray, which is made simply by mixing black and white in different percentages.



Achromatic colors scheme

Any color that lacks strong chromatic content is said to be *unsaturated*, *achromatic*, or near *neutral*. Pure achromatic colors include black, white and all grays; near neutrals include browns, tans, pastels and darker colors. Near neutrals can be of any hue or lightness.

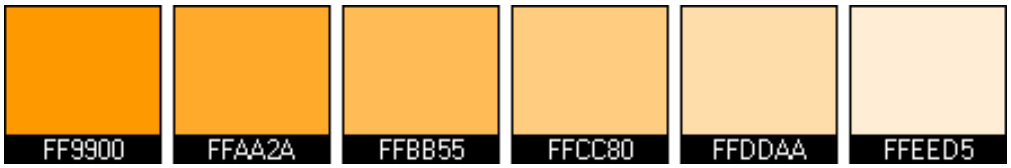


Neutrals are obtained by mixing pure colors with either white or black, or by mixing two complementary colors. In color theory, neutral colors are colors easily modified by adjacent more saturated colors and they appear to take on the hue complementary to the saturated color. Next to a bright red couch, a gray wall will appear distinctly greenish.

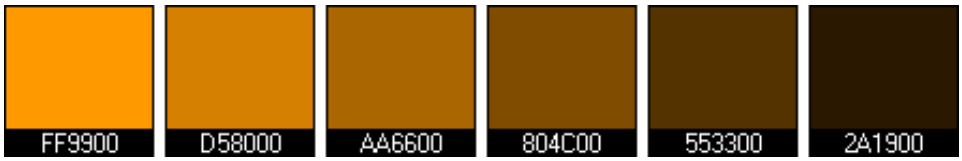
Black and white have long been known to combine well with almost any other colors; black increases the apparent *saturation* or *brightness* of colors paired with it, and white shows off all hues to equal effect

Tints and shades

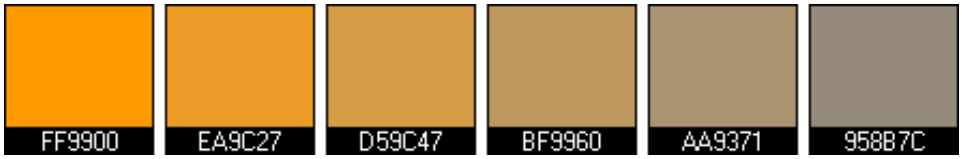
Tints - adding white to a pure hue:



Shades - adding black to a pure hue:



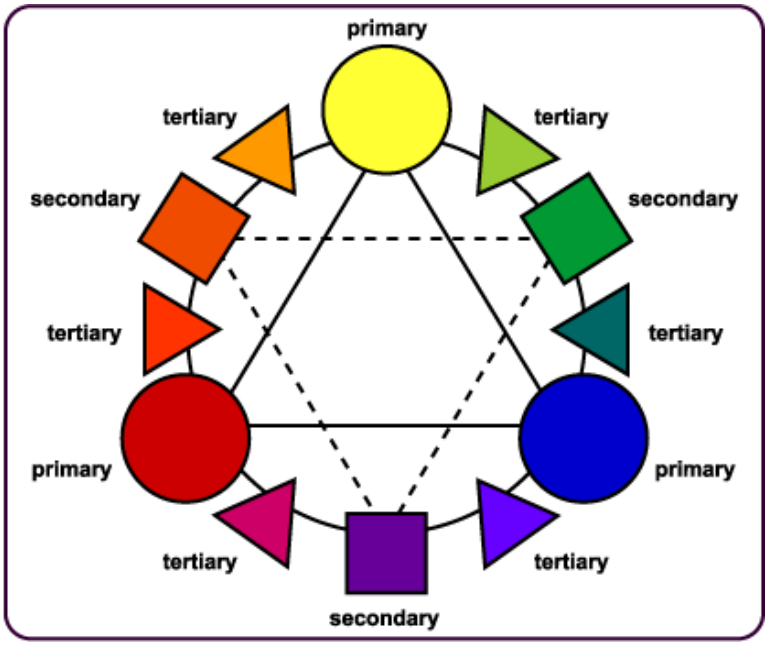
Tones - adding gray to a pure hue:



Secondary & Tertiary Colors

A secondary color is a color made by mixing two primary colors in a given color space, this works for both light and print.

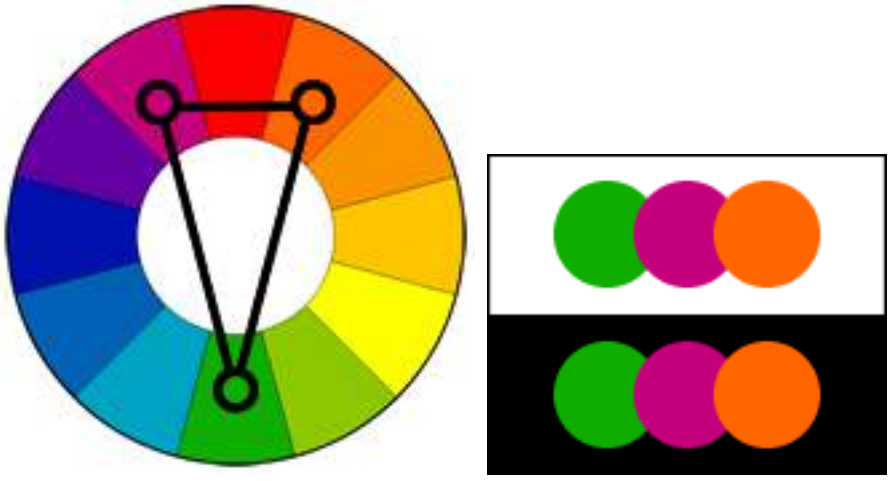
Tertiary colors are colors made by mixing one primary color with one secondary color, in a given color space such as RGB or CMYK. Unlike primary and secondary colors, these are not represented by one firmly established name, but by putting together the names of both the parent colors e.g.: blue-green or orange-yellow.



Split-Complementary color scheme

The split-complementary color scheme is a variation of the complementary color scheme. In addition to the base color, it uses the two colors adjacent to its complement.

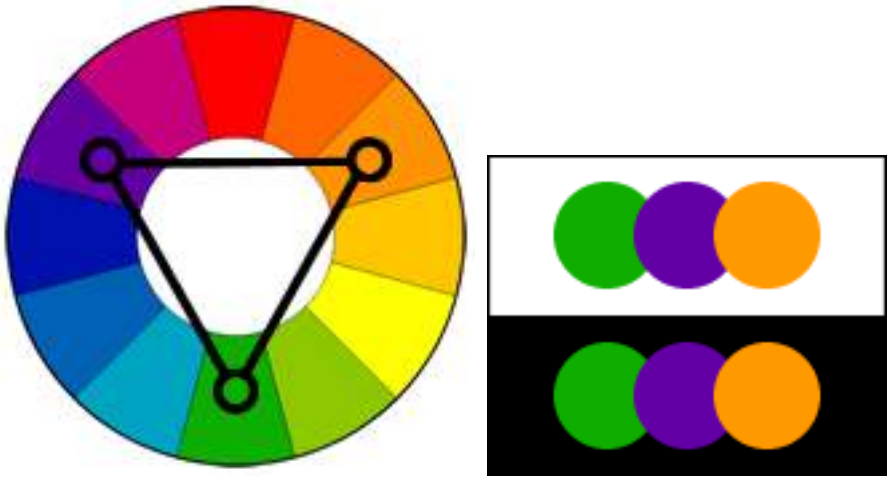
This color scheme has the same strong visual contrast as the complementary color scheme, but has less tension.



The split-complimentary color scheme is often a good choice for beginners, because it is difficult to mess up.

Triadic color scheme

A triadic color scheme uses colors that are evenly spaced around the color wheel.

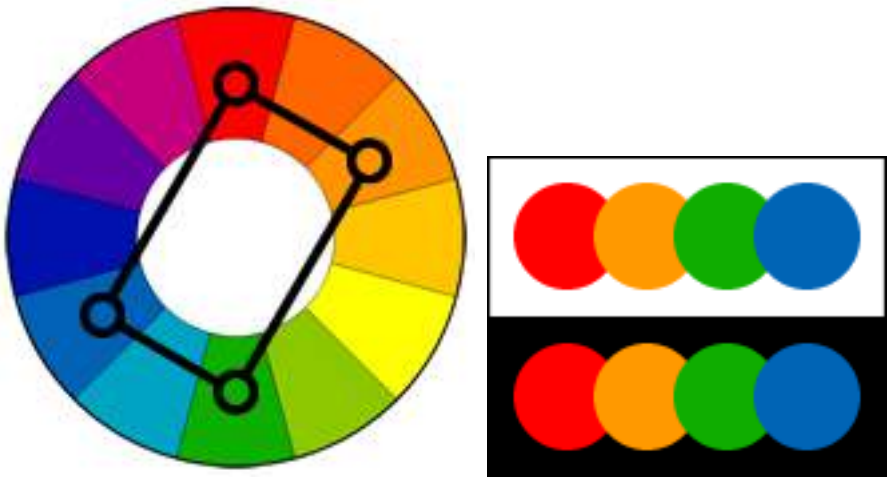


Triadic color schemes tend to be quite vibrant, even if you use pale or unsaturated versions of your hues.

To use a triadic harmony successfully, the colors should be carefully balanced - let one color dominate and use the two others for accent.

Tetradic color scheme

The rectangle or tetradic color scheme uses four colors arranged into two complementary pairs.



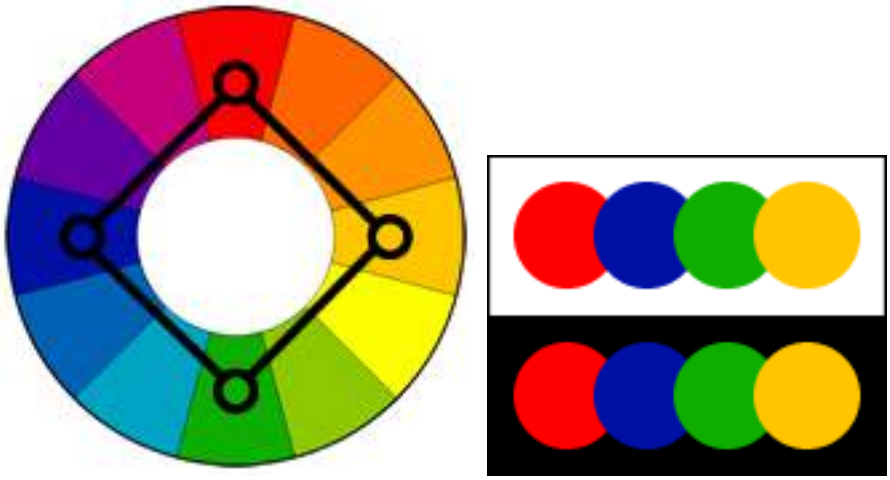
This rich color scheme offers plenty of possibilities for variation.

Tetradic color schemes works best if you let one color be dominant.

You should also pay attention to the balance between warm and cool colors in your design.

Square color scheme

The square color scheme is similar to the rectangle, but with all four colors spaced evenly around the color circle.



Square color schemes works best if you let one color be dominant.

You should also pay attention to the balance between warm and cool colors in your design.

Vibration in color

After selecting your first color make sure that you shift the hue and select your next color. This will ensure that the value of both colors will remain the same.

When both these colors are placed side by side the edge of both colors will produce a vibrating effect.

Stay away from using vibrating color when it comes to your typography it can make your communication unreadable.

Color harmony and color meaning

It has been suggested, "Colors seen together to produce a pleasing affective response are said to be in harmony". However, color harmony is a somewhat misleading notion in that responses to color can be influenced by a range of different factors including individual differences (age, gender, etc); cultural and social differences; as well as contextual, temporal and perceptual factors. In addition, given that humans can perceive over 2.8 million different hues, it has been suggested that the number of possible color combinations is virtually infinite thereby implying that predictive color harmony formulae are fundamentally unsound. Despite this, many color theorists have devised formulae, principles or guidelines for color combination with the aim being to predict or specify positive aesthetic response or 'color harmony'. Color wheel models have often been used as a basis for color combination principles or guidelines and for defining relationships between colors. Some theorists and artists believe juxtapositions of complementary color will produce strong contrast, a sense of visual tension as well as 'color harmony'; while others believe juxtapositions of analogous colors will elicit positive aesthetic response. Color combination guidelines suggest that colors next to each other on the color wheel model (analogous colors) tend to produce a single-hued or monochromatic color experience and some theorists also refer to these as 'simple harmonies'. In addition, split complementary color schemes usually depict a range of analogous hues plus a key complementary color. A triadic color scheme adopts any three colors approximately equidistant around a color wheel model. Feisner and Mahnke are among a number of authors who provide color combination guidelines in greater detail.

Color combination formulae and principles may provide some guidance but have limited practical application. This is because of the influence of contextual, perceptual and temporal factors which will influence how

color/s are perceived in any given situation, setting or context. Such formulae and principles may be useful in fashion, interior and graphic design, but much depends on the tastes, lifestyle and cultural norms of the viewer or consumer.

As early as the ancient Greek philosophers, many theorists have devised color associations and linked particular connotative meanings to specific colors. However, connotative color associations and color symbolism tends to be culture-bound and may also vary across different contexts and circumstances. For example, red has many different connotative and symbolic meanings from exciting, arousing, sensual, romantic and feminine; to a symbol of good luck; and also acts as a signal of danger. Such color associations tend to be learned and do not necessarily hold irrespective of individual and cultural differences or contextual, temporal or perceptual factors. It is important to note that while color symbolism and color associations exist, their existence does not provide evidential support for color psychology or claims that color has therapeutic properties.

Download “Color Wheel Calculating Programs” from the net for your particular OS. (http://www.sessions.edu/Design-Career-Center/Design-Tools/Color-Calculator.asp)