Color Glossary A-C

A B C [D E F G H I J K L M N O P Q R S T U V W X Y Z]

Version 1.0, 03/18/2003

The following glossary lists and explains color and visual perception terms which are relevant for graphic and Web design as well as usability. The information was taken from several sources and adapted to the needs of this glossary. See References for more information.

In this version, some ISO definitions have been added.

Accomodation

ISO Definition: Adjustment of the focus of the eye, normally spontaneous, for the purpose of attaining maximum visual acuity at various distances. (Source: ISO 8995 (1989-10-00) ISO/TC 159)

Achromatic Colors

The "hueless" colors black, gray, and white, that is, the whole range of gray levels between black and white.

ISO Definition: Perceived colors devoid of hue. The color names white, gray and black are commonly used or, for transmitting objects, colorless and neutral. (Source: ISO 9241-8 (1997-10-00) ISO/TC 159)

Figure: Achromatic "colors".

Adaptation (visual)

ISO Definition: Process by which the state of the visual system is modified by previous and present exposure to stimuli that may have various luminances, spectral distributions and angular subtenses. (Source: ISO 9241-8 (1997-10-00) ISO/ TC 159)

Adaption

ISO Definition: The process which takes the luminance and/or the colour of the visual field or the final state of this process. (Source: ISO 8995 (1989-10-00) ISO/TC 159)

Additive Color

Synonym for the RGB (red, green, blue) color space that uses the projected red, green and blue light as primary colors to produce the full spectrum of colors. See also Color Mixture -> Additive Color Mixture.

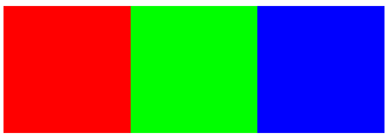


Figure: The primaries of additive color mixing are red, green, and blue.

Additive Color Mixture

See Color Mixture -> Additive Color Mixture.

Afterimages

Afterimages result from localized adaptation of the photoreceptors in those parts of the retina exposed to the stimulus.

Monochrome Afterimages

If a black object on a white background (or vice versa) is being focused on for several seconds, and then a white area is being focused on, a negative afterimage is perceived. The afterimage may last for one to two minutes.

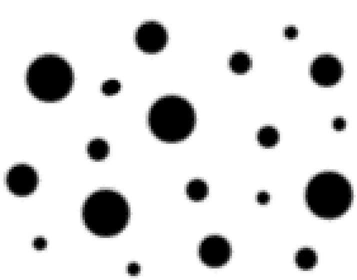


Figure: Monochrome afterimage - glare at the dots for several seconds and you will begin to see a negative afterimage, i.e. white dots

Color Afterimages

If a colored area is being focusd on for a longer time (at least for about half a minute), and then a white area is being focues on, an afterimage of the complementary color is perceived. The afterimage may last for one to two minutes.

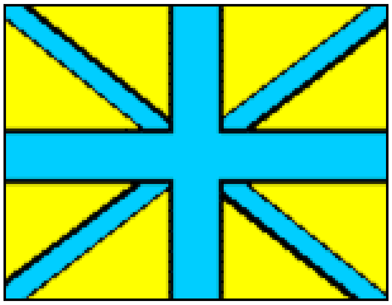


Figure: Color afterimage - gaze at the center of the image for about 30 seconds and then look away to a neutral area - an afterimage of the Union Jack will be seen.

-> Large areas of bright color should be avoided on screens because of the disturbing afterimages that can result.

Aliasing

Makes individual pixels visible, especially along diagonal lines and curves. Also known as staircasing or Jaggies because of the steps that appear. Lines and text look more jagged than smooth.

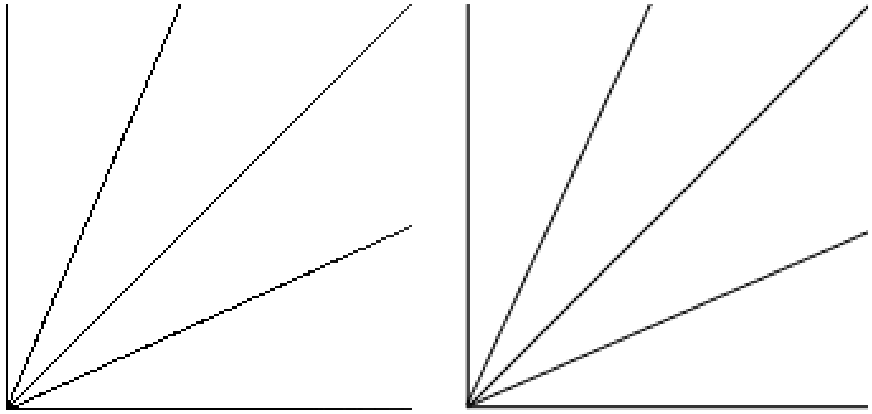


Figure: Aliased (normal) lines (left) vs. anti-aliased (smoothed) lines (right)

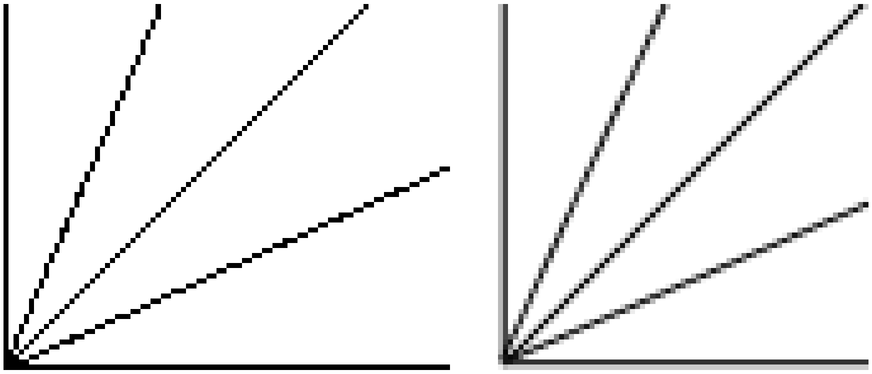


Figure: Enlarged sections of the image above

See [Anti-Aliasing.](#)

Anti-Aliasing

A process that filters or softens the hard stair-stepped edge (and thus removes the Jaggies) in bitmapped images by creating a series of gradually blending pixels.

Figure: Aliased (normal) text (left) vs. anti-aliased (smoothed) text (right)

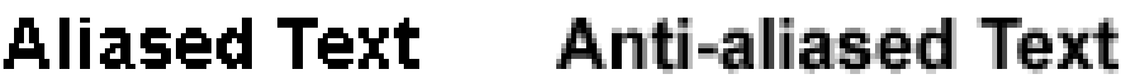


Figure: Enlargement of the image above

Note: Anti-aliasing increases the number of colors in a digital image. Therefore, Web designers sometimes prefer aliased text in order to keep the file size small.

See Aliasing.

BMP

See Image File Formats.

Brightness

Brightness is the *perceived intensity* of light coming from the image itself, rather than any property of the portrayed scene. Brightness is sometimes defined as *perceived luminance*. (From Adelson, MIT)

Brightness Assimilation

Reverse effect of brightness contrast, seems to depend on cognitive factors like knowledge about the appearance of objects.

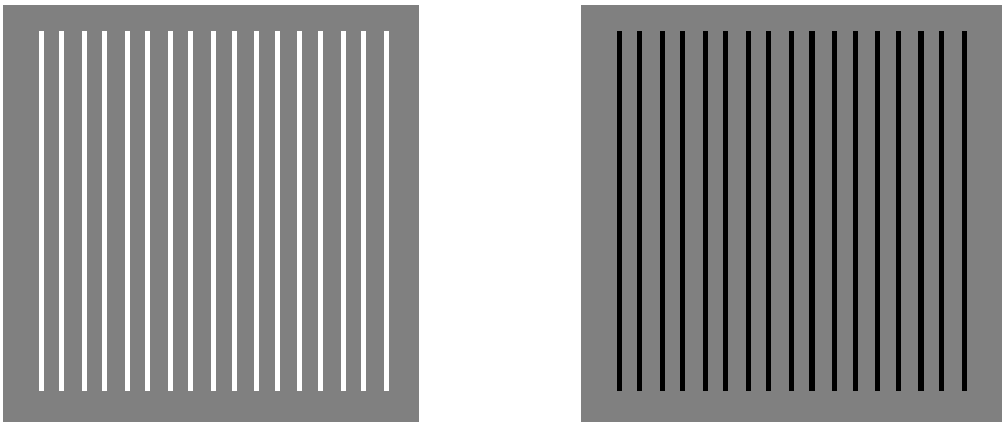


Figure: The gray under the white stripes appears lighter than the same gray under the black stripes due to brightness assimilation

See also Color Assimilation.

Brightness Contrast

See Simultaneous Contrast -> Simultaneous Contrast (Black and White).

See also Simultaneous Contrast -> Simultaneous Color Contrast.

Chroma

Synonym for Saturation.

Chromatic Colors

The "colorful" colors like, red, green, blue, yellow, purple, etc.

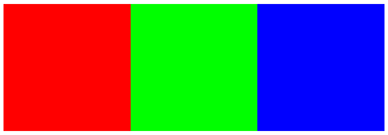


Figure: The chromatic primaries of additive color mixing are red, green and blue.

Chromatic Induction

Synonym for Hue Induction.

Chromostereoopsis

Red and blue colors are perceived at different depths. This effect is due to the chromatic aberration of the eye (light of different wavelengths is refracted differently).

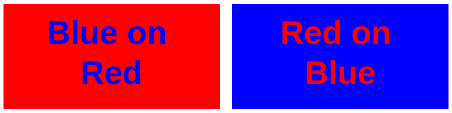


Figure: Foreground and background color combinations to avoid!

Because chromostereoopsis can be quite disturbing visually, avoid displaying both vivid red and blue together.

CIE

Commission Internationale de l'Eclairage - this commission determines standards for color and lighting. It developed the Norm Color system and the Lab Color Space (also called Lab Color System, or CIELAB Color System).

CMYK

See Color Space -> CMYK (see also RGB, HSL/HSV/HSB, Lab).

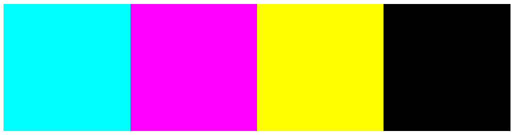


Figure: The primaries of the CMYK color space are cyan, magenta, yellow, and black

Color After Images

See After Images -> Color After Images.

Color Assimilation

Color assimilation (also known as the Von Bezold spreading effect or Bezold-Brücke effect) is the opposite of Color Contrast: Colors take on the hue of the surrounding color, whereas color contrasts moves it into the direction of the Complementary Color.

Example: The white squares on the red background in the figure below look reddish, and those on the blue background look bluish. Thus, the white squares tend to take on their background's colors.

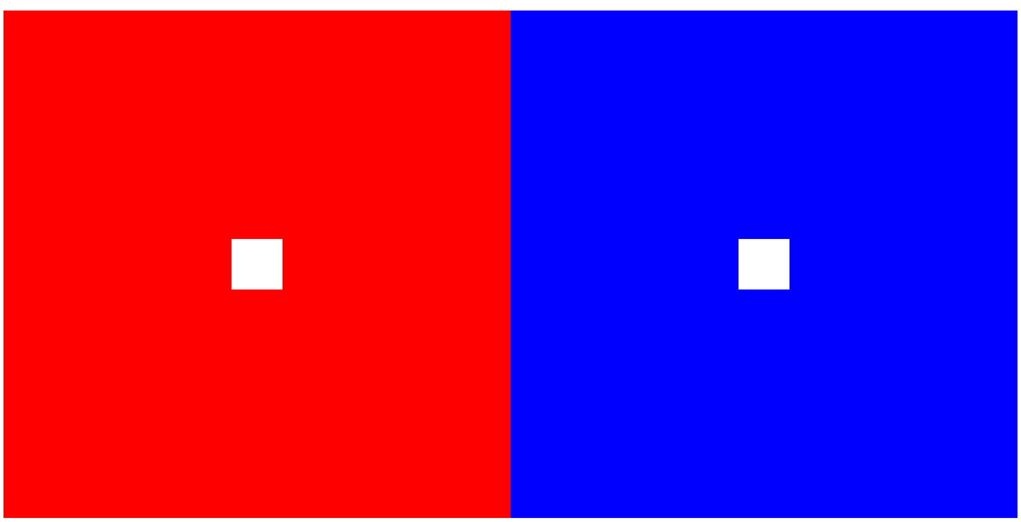


Figure: The white central square shifts its hue into the direction of the surrounding color.

While the physiological mechanisms for brightness and color contrast phenomena are well understood, the conditions how and when the assimilation occurs are not. However, as with the brightness assimilation, the spatial frequency (coarseness) of the image seems to be an important factor.

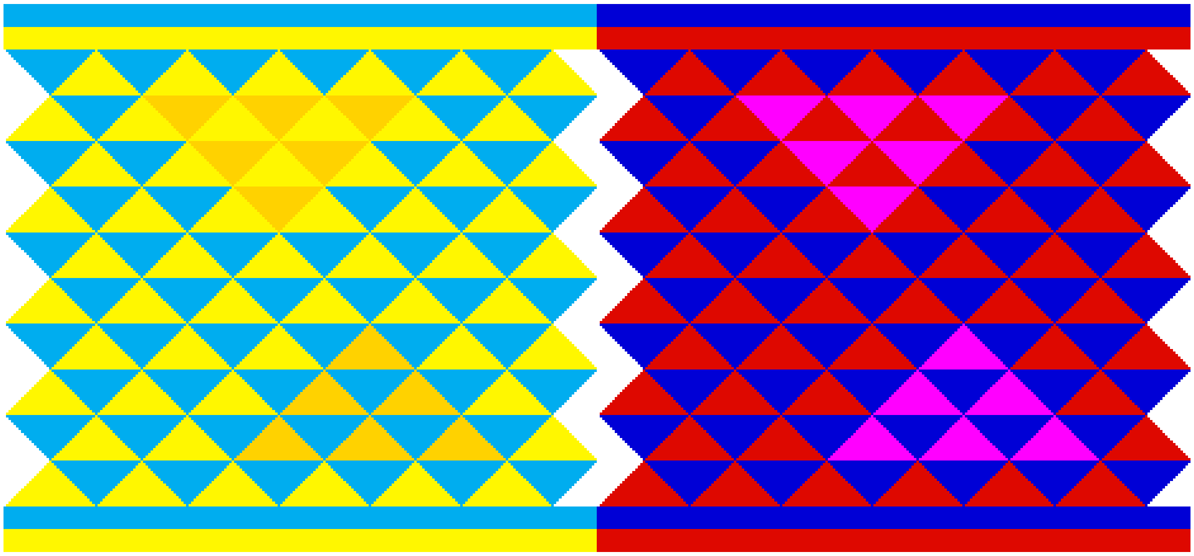


Figure: Animated demonstration of color assimilation; look how the same color looks differently depending on the surrounding colored triangles.

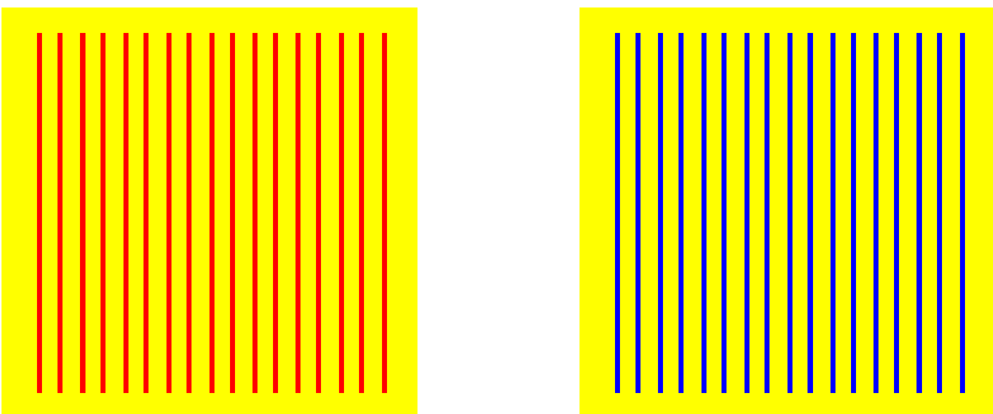


Figure: Image comparable to the image for brightness assimilation - the yellow under the red stripes appears warmer than the same yellow under the blue stripes due to color assimilation

The contrast and assimilation phenomena are also found for brightness and darkness (Brightness Contrast and Brightness Assimilation).

See also the Illusion Forum Website for animated demonstrations of many effects.

Color Blindness

See Color Deficiencies; see also Visual Impairments.

Color Circle

Newton's color circle is a convenient way to summarize the additive mixing properties of colors (see second figure below). R, G, B are thought of as the additive primary colors, and their complementary colors are placed across from them on the circle. The colors then fall on the circle in the order of the wavelengths of the corresponding spectral colors. Magenta (purple) is not a spectral color.

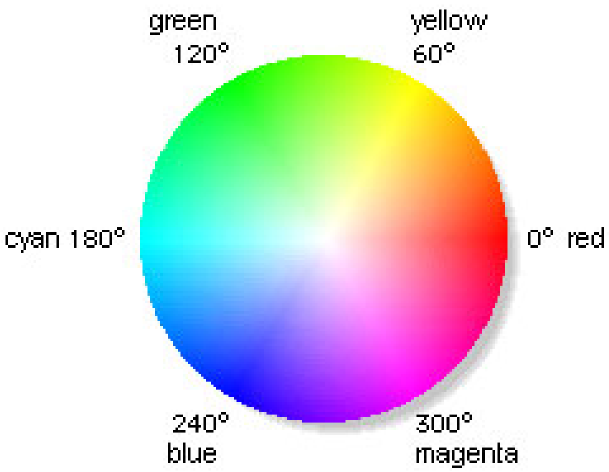


Figure: A color circle (from Apple Macintosh)

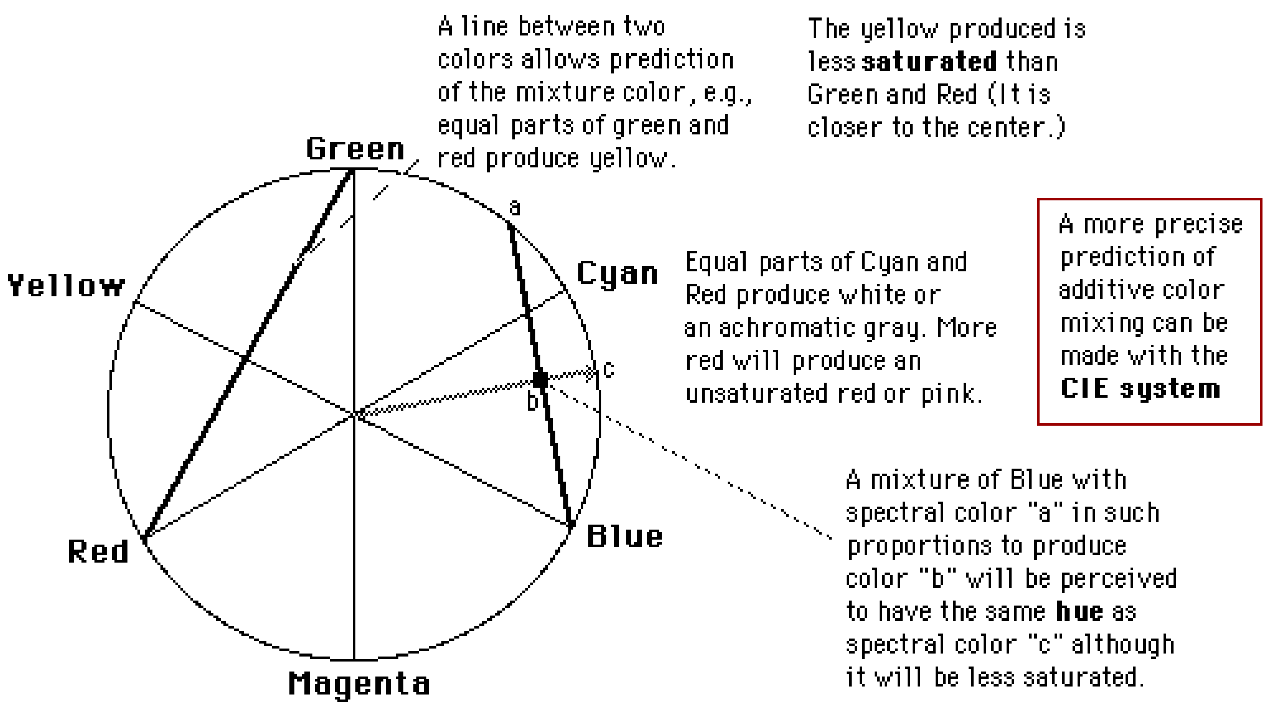


Figure: Using the color circle to predict the outcomes of additive color mixing (adapted from *Hyperphysics*)

Saturation (purity of the color) can also be described by the color circle: colors become less pure or desaturated as you move into the center of the circle; colors become purer or saturated as you move towards the perimeter.

Quantifying the circumference of the circle in terms of hue and its radius in terms of saturation leads toward one of the formal color systems, the Munsell System. (Adapted from *Hyperphysics* Website)

Color Constancy

The human ability to maintain the percept of a particular hue throughout variations in the quality of the luminance or reflectance properties of the surface pigment. (Adapted from *Sensation and Perception*)

Color Contrast

See Simultaneous Contrast -> Simultaneous Color Contrast.

Color Deficiencies

Some individuals show drastic deficiencies in their ability to discriminate colored stimuli - these people are called colorblind, although this term is too strong for most of the deficiencies. According to the trichromatic color theory there are five types of color deficiencies to be distinguished:

- **Monochromats**
  - *Monochromats I*: people with no functioning cones; people with this deficiency have problems with daylight, because it is too bright for them; they also lack visual acuity
  - *Monochromats II*: people with only one variety of the cones functioning in addition to the rods; both types of monochromats see colors only as variations in intensity, that, is analog to black-and-white or unicolored images
- **Dichromats**: People with only one malfunctioning cone system
  - *Protanopia*: malfunctioning in the red cone system; typically only two (yellow, blue) or three colors (yellow, blue, purple) can be distinguished - yellow comprises red, orange, yellow, and green, blue coincides with blue and purple
  - *Deuteranopia*: malfunctioning in the green cone system; green cannot be distinguished from certain combinations of red and blue; this is the most common type of color deficiency
  - *Tritanopia*: malfunctioning of the blue cone system; longer wavelengths appear as red and the shorter ones as bluish-green; this color deficiency is very rare

Mild instances of color deficiencies are called "anomalous trichromatism" and are fairly common; typically these people do not act exactly like a dichromat, but need more red (protoanomaly) or green (deuteranomaly) than a color-normal individual to match colors. More than 8% of the male and about 0.04% of the female population have some sort of color anomaly or deficiency. (Adapted from Sensation and Perception)

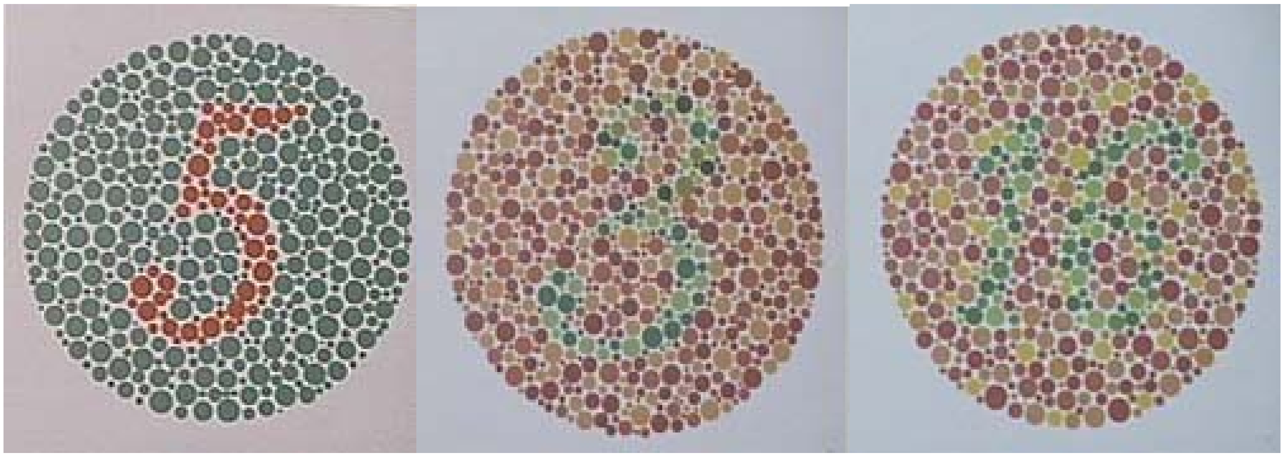


Figure: Ishihara color blindness test charts (from *Allendale Eyecare* Website)

See also www.visibone.com/colorblind. Test your color vision at Michael Bennett's Website (http://home.sc.rr.com/mikebennett/colorblind.html). Visicheck offers a color deficiency simulator (http://www.vischeck.com/)

For visual impairments in general, see Visual Impairments.

Color Induction

See Hue Induction (also called chromatic induction).

Note: The term *color induction* is used with different meanings.

Color Mixture

Additive Color Mixture

Additive color mixing describes how different wavelengths of light mix to make colors in the mind. This color mixing is explained through the combinations of the "primary" colors red, green, and blue (RGB). Color mixtures are usually demonstrated by shining overlapping beams of light through different color filters onto a white (colorless) surface (as in the diagram below), or by patches of pure colored paper or paint on a rapidly spinning disk (a "color top" or "Maxwell disk," so named because James Clerk Maxwell used it to study color mixing in around 1855, although it was first used for that purpose by Ignaz Shiffermüller in the 1760's).

Figure: Additive color mixing using light sources (from www.linocolor.com)

Any color can be produced by adding the colors of the three color channels RGB (Red, Green, and Blue). If the colors of two of the color channels are mixed in equal proportions, new base colors are created. Blue and green add up to a bright, light blue called cyan. Magenta, a bright pink, is made by mixing red and blue. Red and green together make yellow. If red, green, and blue light are mixed equally together at full power, you get white light. (Adapted from www.linocolor.com)

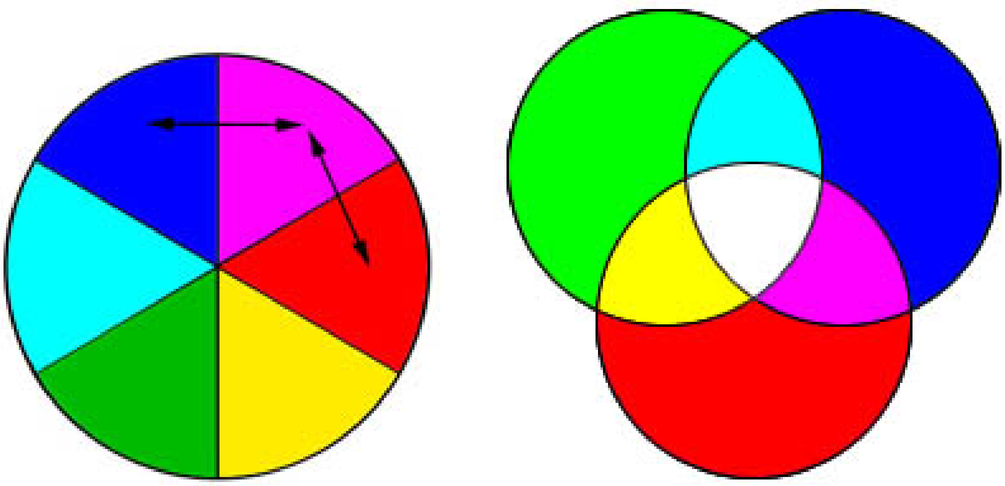


Figure: Mixing two colors additively leads to a lighter color; if red, green, and blue light are mixed equally together at full power, you get white light (from www.mica.edu)

Monitors

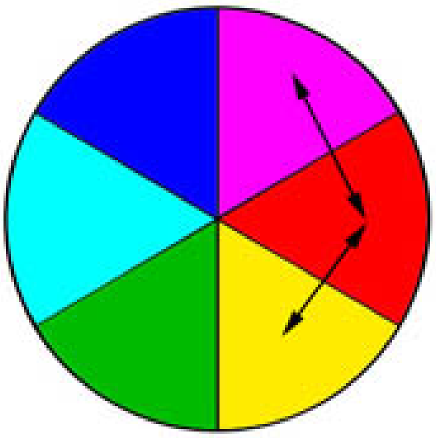
Monitors and televisions produce color by using electromagnetic waves that correspond to red, green and blue. However, screens aren't able to display the full range of colors which are visible to the human eye. Their range of color is limited. (From www.linocolor.com)

See also the Hyperphysics Website.

ISO Definition: Stimulation that combines on retina the actions of various color stimuli in such a manner that they cannot be perceived individually. (Source: ISO 9241-8 (1997-10-00) ISO/TC 159)

Subtractive Color Mixture

The opposite of additive color mixing, subtractive color mixing describes how the light absorbing properties of paints mix to make colors in reflected light. This color mixing is explained through combinations of the three subtractive "primary" colors cyan, yellow and magenta (CYM), and is usually demonstrated by placing multiple color filters over a single beam of light, or by physically mixing paints (i.e. inks or pigments that reflect light of a certain color). That is, the subtractive primary colors result when a section of the visible spectrum corresponding to a single additive primary color is absorbed from reflected white light. (Adapted from www.linocolor.com)



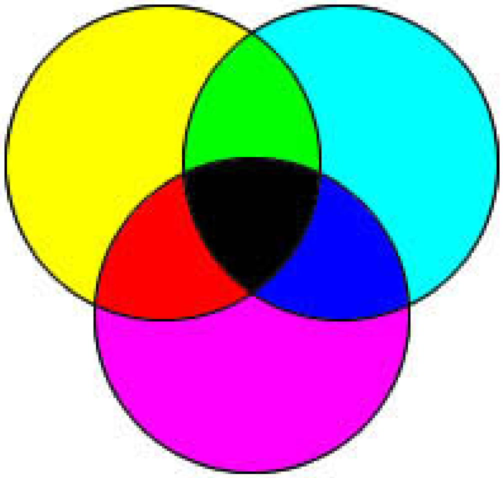


Figure: Mixing colors subtractively leads to a darker color (from www.mica.edu)

How Colors Are Printed

Printed colors differ from monitor colors in that they are produced by overlaying ink pigments on paper instead of by combining different wavelengths of light. If you tried to print red, green, and blue on top of one another, however, you could not produce many colors. You would not be able to make yellow, for instance. That is why printing uses subtractive instead of additive color mixing. (From www.linocolor.com)

Figure: Printing with RGB (from www.linocolor.com)

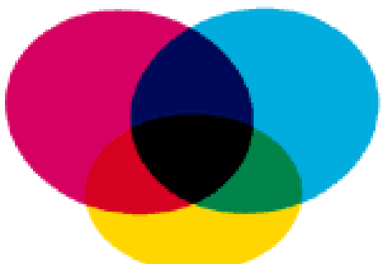


Figure: Printing with CMYK (from www.linocolor.com)

Why the K?

Theoretically, if we were to print a surface with equal parts of cyan, magenta and yellow, we would see black, because all colors would be absorbed and none reflected. In practice, however, this black looks more like a muddy green or brown. That is why four colors are generally used in printing ("four-color print"). Black (K) is used as the fourth color in order to achieve a real black. (From www.linocolor.com)

Color Model

System that describes colors for objective color production, as the Norm Color and CIELAB systems.

See Color Space.

Color Space

System that describes colors for objective color production, as the Norm Color and CIELAB systems; also called color model.

The Color Space

To integrate brightness into the picture, the color triangle must be transformed from a two-dimensional triangle into a spatial body known as color space. The color space is a three-dimensional system with coordinates for red, green and blue:

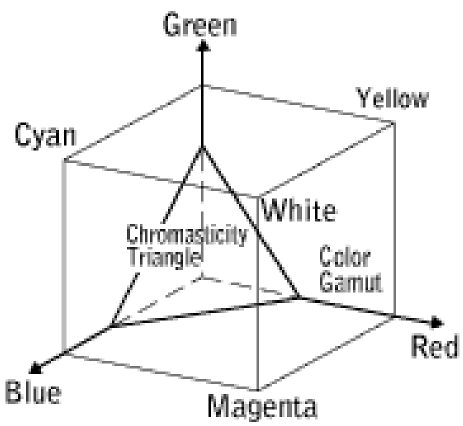


Figure: The color space extends the color triangle into three dimensions

The further the color loci of the primary colors from the origin, the greater the volume of the cuboid color gamut which is formed and thus the higher the quality of any color reproduction system which is based on it.

All colors lying inside the color gamut can be reproduced by a reproduction system based on the primary colors (for example a color monitor). Colors outside the color space cannot be reproduced.

In other words: the primary colors of a color space are determined by the equipment which generates them. (From www.linocolor.com)

RGB

Color space based on the three primary colors red (**R**), blue (**B**) and green (**G**) used for additive color mixing. Televisions and computer monitors use RGB to reproduce color.

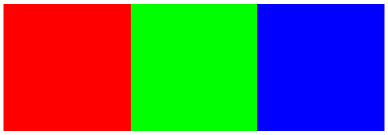


Figure: The three primaries of the RGB color space are red, green and blue

CMYK

Color space based on the three primary colors cyan (**C**), yellow (**Y**) and magenta (**M**) used for subtractive color mixing, plus the achromatic color black (**K**). The four process colors used in four-color printing.

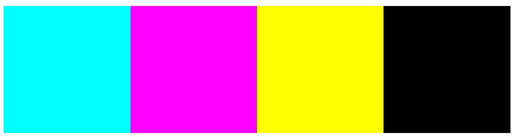


Figure: The four primaries of the CMYK color space are cyan, magenta, yellow and black

HSL, HSV, HSB

Hue, **S**aturation, **L**uminance (also known as **Hue**, **S**aturation, **V**alue or Hue, **S**aturation, **B**rightness): A system for describing the physical perception of color, in terms of tint (hue, color tone), perceived narrowness of the spectrum (saturation, chroma), and luminance (brightness, value).

Hue determines the position on the color wheel or color circle, Saturation is the purity of the color, and Luminance the range of lightness to darkness of the color.

Application of the Model

In the HSL color space it is easy to change hue, saturation and luminance alone without changing the other two characteristics; this is hard to achieve in the RGB color space that is offered by most graphic programs.

Hue can be changed by moving the position on the color circle:

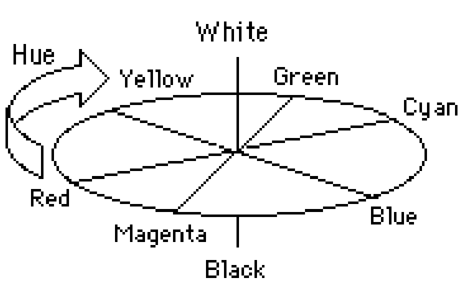


Figure: Hue changes by moving the position on the color circle (from *Hyperphysics*)

Saturation: If, for example, blue is gradually added to a yellow, mixed from red and green, the yellow goes through steps of decreasing purity, each "less chromatic."

#FFFF00	#FFFF40	#FFFF7F	#FFFFBF	#FFFFFF

Figure: Demonstration of adding blue in steps of 25% to yellow, represented as a mixture of 100% red and 100% blue

Colors of different saturation retain their original hue since the relationship between the color values of red and green are not changed. In the color triangle, they move along the straight connecting line from the yellow color locus towards blue, whereas in the color circle increasing saturation corresponds to a radial outward movement:

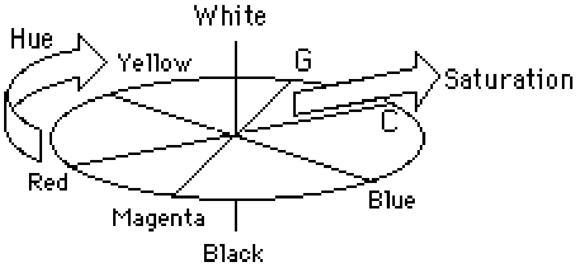


Figure: Saturation increases by moving outwards on the color circle (from *Hyperphysics*)

Brightness

If all three color components are reduced simultaneously -- while retaining their mixing ratio -- the hue remains unchanged. The color decreases in brightness. If the components of all three primary colors are reduced to zero, the resulting color will be black. Like white, black has a saturation level of zero.

#0000FF	#0000BF	#000080	#000040	#000000

Figure: Demonstration of decreasing the brightness of pure blue in steps of 25%

See also Lightness, Luminance.

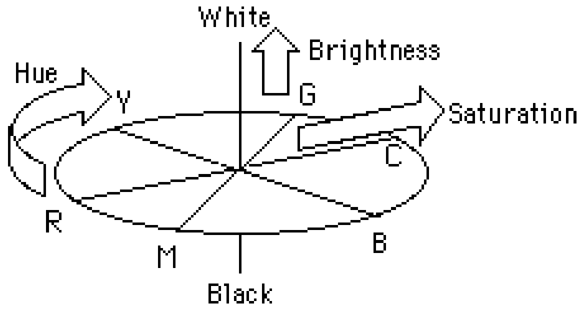


Figure: All three dimension in the color circle (from *Hyperphysics*)

Norm Color System

In 1931 the CIE (Commission Internationale de l'Eclairage) developed the XYZ color system, also called the "norm color system." This system is often represented as a two-dimensional graphic which more or less corresponds to the shape of a sail.

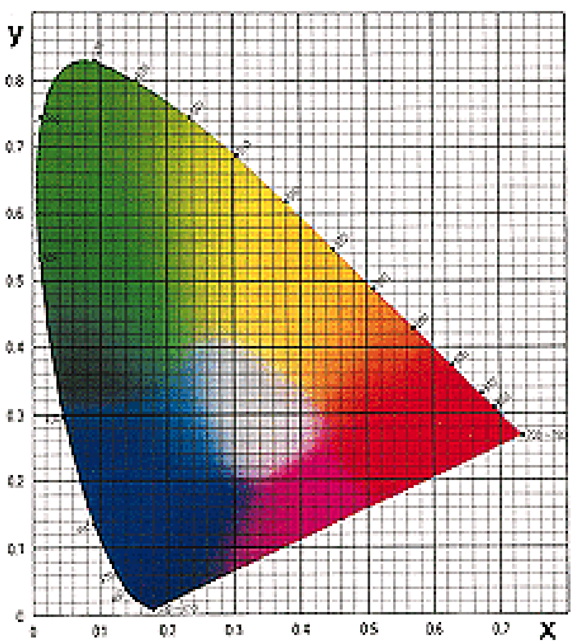


Figure: The XYZ color space defined by the norm color system (from www.linocolor.com)

The red components of a color are tallied along the x (horizontal) axis of the coordinate plane and the green components along the y (vertical) axis. In this way every color can be assigned a particular point on the coordinate plane. Colors on the left tend toward gray, which means that their spectral purity is decreased.

What is not taken into consideration in this graph is brightness (the z axis). If it were, the figure would look like a flat sack. (From www.linocolor.com)

Color spaces can be drawn for different devices (eyes, printer, screen) for comparisons.

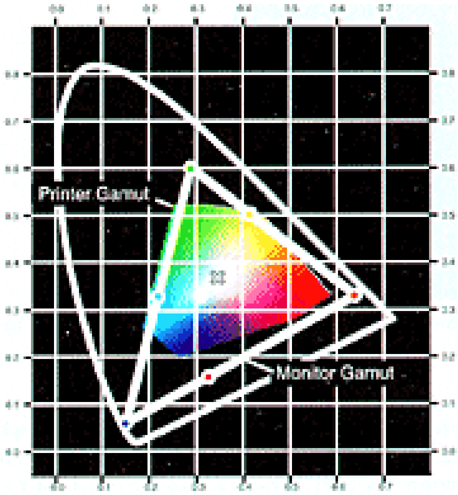


Figure: Relative gamuts of additive (monitor display) and subtractive (printed) color; the larger area on the graph represents all visible colors. Click on the graph to see a more detailed version of the chart. (from *projectcool* Website)

See also Color Triangle.

CIELAB, Lab, L*a*b

Color space defined by the CIE, based on one channel for Luminance (lightness) (**L**) and two color channels (**a** and **b**).

One problem with the XYZ color system, is that colorimetric distances between the individual colors do not correspond to perceived color differences. For example, in the figure above, a difference between green and greenish-yellow is relatively large, whereas the distance distinguishing blue and red is quite small. The CIE solved this problem in 1976 with the development of the three-dimensional Lab color space (or CIELAB color space).

In this model, the color differences which you perceive correspond to distances when measured colorimetrically. The *a* axis extends from green (-a) to red (+a) and the *b* axis from blue (-b) to yellow (+b). The *brightness* (L) increases from the bottom to the top of the three-dimensional model. (From www. linocolor.com)

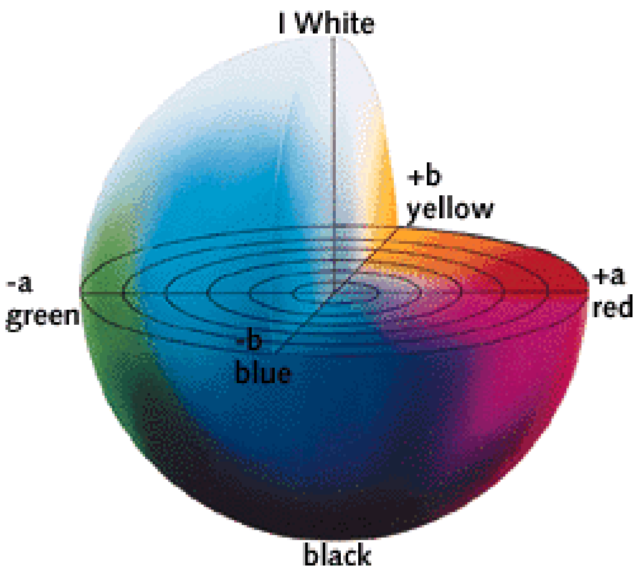


Figure: The CIELAB color space (from www.linocolor.com)

This color space is better suited to many digital image manipulations than the RGB space, which is typically used in image editing programs. For example, the Lab space is useful for sharpening images and the removing artifacts in JPEG images or in images from digital cameras and scanners.

Color Triangle

Any three non-collinear points plotted on a chromaticity diagram determine a color triangle. Since the points are non-collinear, they correspond to basic, or primary hues. All of those colors on the chromaticity diagram which fall within the triangle determined by the three points may be produced by addition of the three hues.

Colors in the chromaticity triangle are defined by hue and saturation (chroma) only, not by brightness. There can be any amount of brightness in the chromaticity triangle.

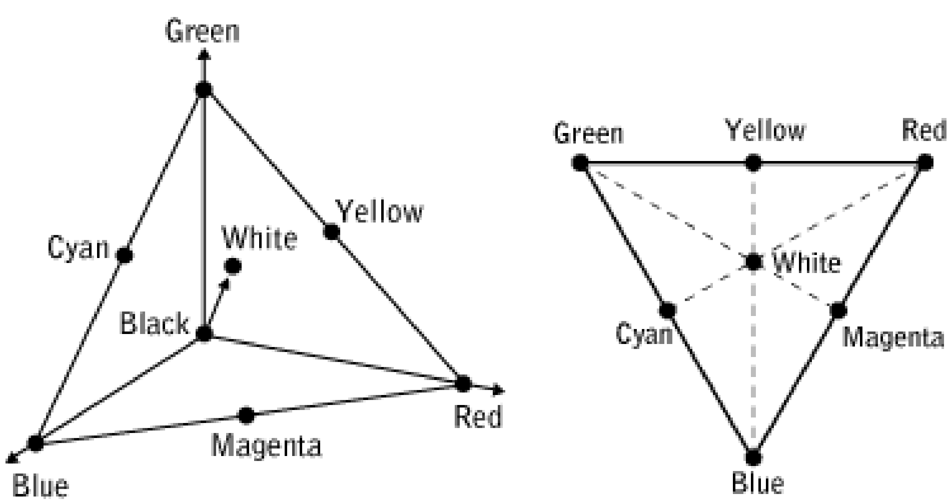


Figure: A basic color triangle (left); using the color triangle for demonstrating relations between colors (right)

All colors which can be produced by additive mixing of the three primary colors red, green and blue lie in the area enclosed by this color triangle. The further a color lies from the center of the triangle the higher its saturation (chroma). A mixed color has a high saturation level if it has only a small amount of its third component. A maximum saturation is found in colors mixed from only *two* primary colors.

If the amount of the third primary color is increased until all three primaries are present in equal components, white is the result - the saturation level is equal to zero, and the achromatic point lies in the middle of the color triangle (see color triangle above).

#FFFF00	#FFFF40	#FFFF7F	#FFFFBF	#FFFFFF

Figure: Adding blue in steps of 25% to yellow, represented as a mixture of 100% red and 100% blue, eventually leads to white

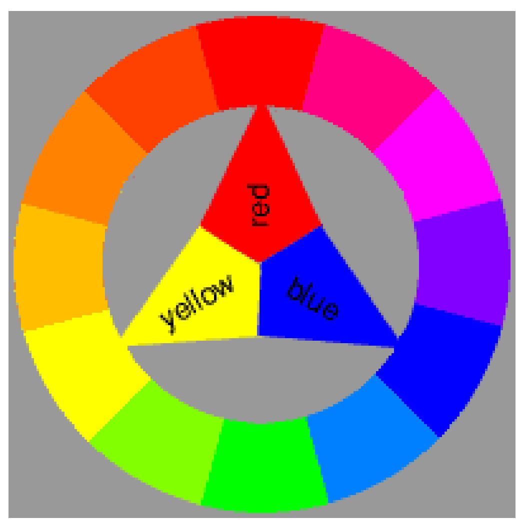
Color Wheel

A color wheel arranges colors around the edges of a circle. Primary colors are in the middle. Three common color wheels are the artist's wheel, the subtractive wheel, and the additive wheel (see below). A standard color wheel has 12 distinct hues, but does not have any visual information about saturation or value. These 12 hues can be classified in:

- **Primary colors** - the defining colors of the wheel; in the color wheels below, they appear in the center as well as equally spaced around the circle
- **Secondary colors**- the three colors that are equal distant from the primary colors
- **Tertiary colors** - the colors between each primary and secondary color

The Artist's Color Wheel

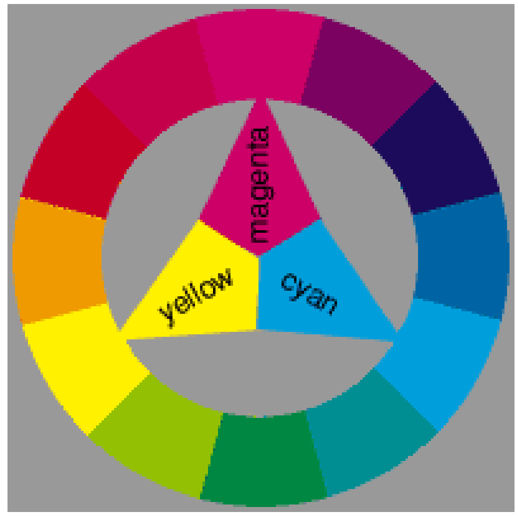
This color wheel is used for mixing paints. It uses red, yellow, and blue as primary colors. Violet, green, and orange are secondary colors, and red-violet, blue-violet, blue-green, yellow-green, yellow-orange, and red-orange are tertiary colors.



The Subtractive Color Wheel

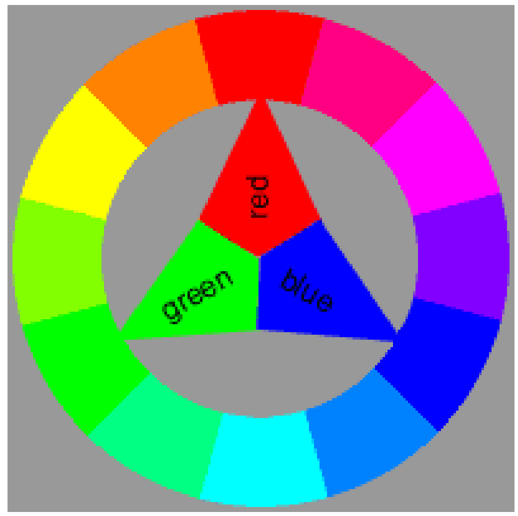
This color wheel uses the printing inks cyan, magenta, and yellow as primary colors.

Note: Because cyan (C), magenta (M), and yellow (Y) inks do not combine to make black, the printing process adds black as a fourth ink (K).



The Additive Color Wheel

This color wheel displays the additive colors used for projected light. When mixed together the additive primaries form white. The primaries are red, green and blue. These colors are extremely bright because light that is projected can be far more intense than printed color.



(Adapted from *projectcool* Website)

Complementary Colors

Colors that add to white when mixed adaptively. Complementary colors reside at opposite ends of the Color Circle or Color Wheel.

Examples: Magenta-green, blue-yellow, red-cyan

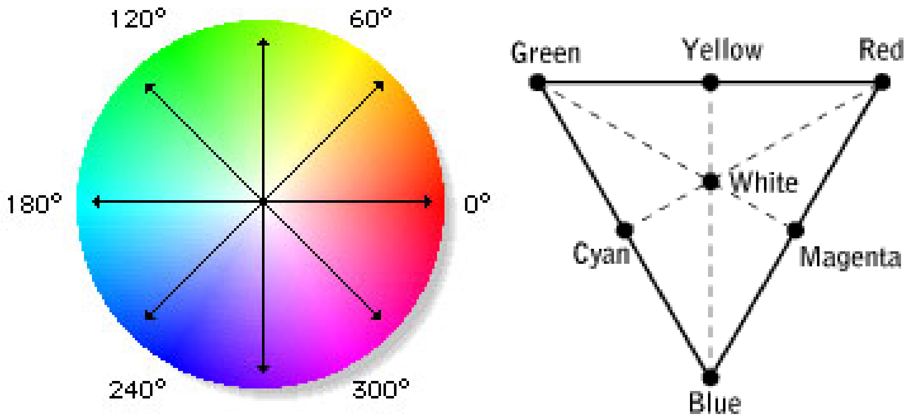
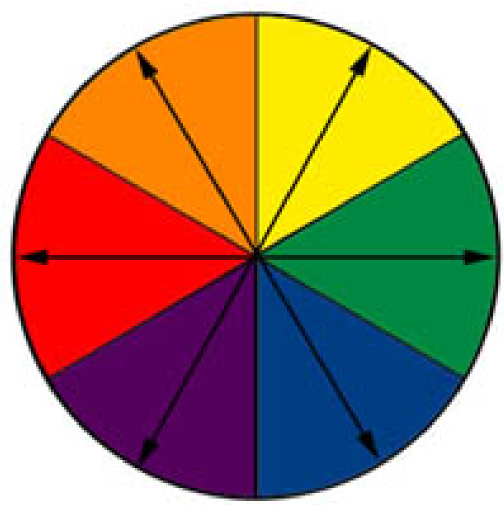


Figure: Complementary colors reside at opposite ends of the color circle (left) or color triangle (right)

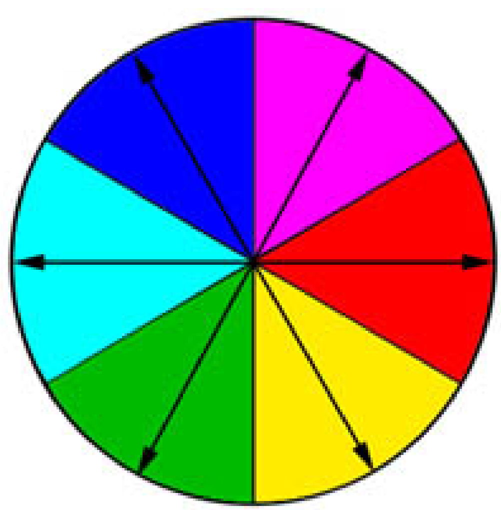
Complementary Colors - The Traditional Color Wheel

Complementary colors are those that are situated across from each other on the color wheel. There is a unity inherent in using complementary colors since any color has as its complement the sum of the other two primary colors. The complement of yellow, for instance is purple, made by mixing the other two primaries, red and blue. The complement of red is green, a combination of yellow and blue. Compositions created using complementary color schemes tend to feel complete and pleasing to the eye. Complementary colors will desaturate each other if mixed. (From www.mica.edu)



Complementary Colors - The Scientific Color Wheel

In the scientific color wheel, the symmetry or unity of the relationships of complements is even more evident. These six colors show both the pigment primaries of cyan, magenta and yellow along with the pigment secondaries of red, blue-violet and green. The complement of a primary pigment color turns out to be a primary light color. We could just as easily call this a color wheel for light (an additive wheel) with the primaries being red, blue-violet and green and secondaries of cyan, magenta and yellow. (From www.mica.edu)



Constancies

See [Color Constancy] and [Size Constancy].

Contrast Sensitivity

The contrast sensitivity function for **red** and **green** is greatest for 10 point text (spatial frequency = 1 line pair/mm = 8 Hz/degree) at normal viewing distance (46 cm) and about 14 point text at arm length (65 cm).

For blue the greatest sensitivity is around a spatial frequency of 1 Hz/degree The sensitivity itself is about one tenth of that of red and green. This is due to the scarcity of blue cones in the retina and to the absence of a local yellow-blue opponent mechanism. (From Jackson et al.)

Blue	Blue	**Red**	Red	**Green**	Green
Blue	Blue	**Red**	Red	**Green**	Green

Figure: The primaries blue, red and green in normal face and bold face on white and black backgrounds

Cultural Variations in the Meaning of Colors

Overview

Culture	Red	Blue	Green	Yellow	White
USA, Europe	Danger	Manliness, sweet, calm, Authority	Safety, safe, sour	Caution, Cowardice	Purity
France	Nobility	Freedom, Peace	Criminality	preliminary	Neutrality
Egypt, Arab Nations	Death	Virtue, Faith, Truth	Fertility, Strength	Happiness, Welfare or Wealth	Joy
India	Life, Creativity		Welfare or Wealth, Fertility	Success	Death, Purity
Japan	Anger, Danger	Shame, Despicableness	Future, Youth, Energy	Grace, Dignity, Nobility, childish, joyful	Death

China	Happiness, Joy, Festivity	Sky, Clouds	Ming dynasty, royal, Honor	Birth, Wealth, Strength or Power	

(from different sources)

Color Associations

These associations are valid for western cultures only (see table above for differences). (from Jackson et al.)

The Achromatics

White

- **Positive**: Snow, Purity, Innocence, Peace, Lightness, Cleanliness
- **Negative**: Cold, Clinical, Vulnerability, Deathly pallor, Surrender, Sterility

Black

- **Positive**: Night, Coal, Power, Stability, Formality, Solidity
- **Negative**: Fear, Void, Death, Secrecy, Anonymity, Evil

Gray

- **Positive**: Intelligence, Maturity, Wealth, Dignity, Dedication, Restraint
- **Negative**: Confusion, Decay, Concrete, Shadow, Depression, Boredom

The Chromatic Primaries

Red

- **Positive**: Victory, Passion, Love, Strength, Energy, Sexuality
- **Negative**: Blood, War, Fire, Danger, Anger, Satan

Yellow

- **Positive**: Sun, Summer, Serenity, Gold, Harvest, Innovation
- **Negative**: Cowardice, Treason, Jealousy, Hazard, Illness, Folly

Green

- **Positive**: Vegetation, Nature, Spring, Fertility, Hope, Safety
- **Negative**: Decay, Inexperience, Envy, Greed, Escapism, Bad luck

Blue

- **Positive**: Sky, Sea, Spirituality, Stability, Peace, Unity
- **Negative**: Cold, Depression, Melancholy, Obscenity, Mystery, Conservatism

Color Preferences

Eysenck's "universal" order of colors for Western adults:

(1) Blue, (2) Red, (3) Green, (4) Purple, (5) Yellow, (6) Orange

References

Compiled and edited by Christine Wiegand and Gerd Waloszek (Product Design Center)

top

Source: Color Glossary

Color Glossary D-Z

[A B C] D E F G H I J K L M N O P Q R S T U V W X Y Z

Version 1.0, 03/18/2003

The following glossary lists and explains color and visual perception terms which are relevant for graphic and Web design as well as usability. The information was taken from several sources and adapted to the needs of this glossary. See References for more information.

In this version, some ISO definitions have been added.

Dither, Dithering

A process of placing different-colored pixels next to one another to create the illusion of additional colors. The eye sees the two adjacent colors, and the mind blends them into a third color. (From *Looking Good in Color*)

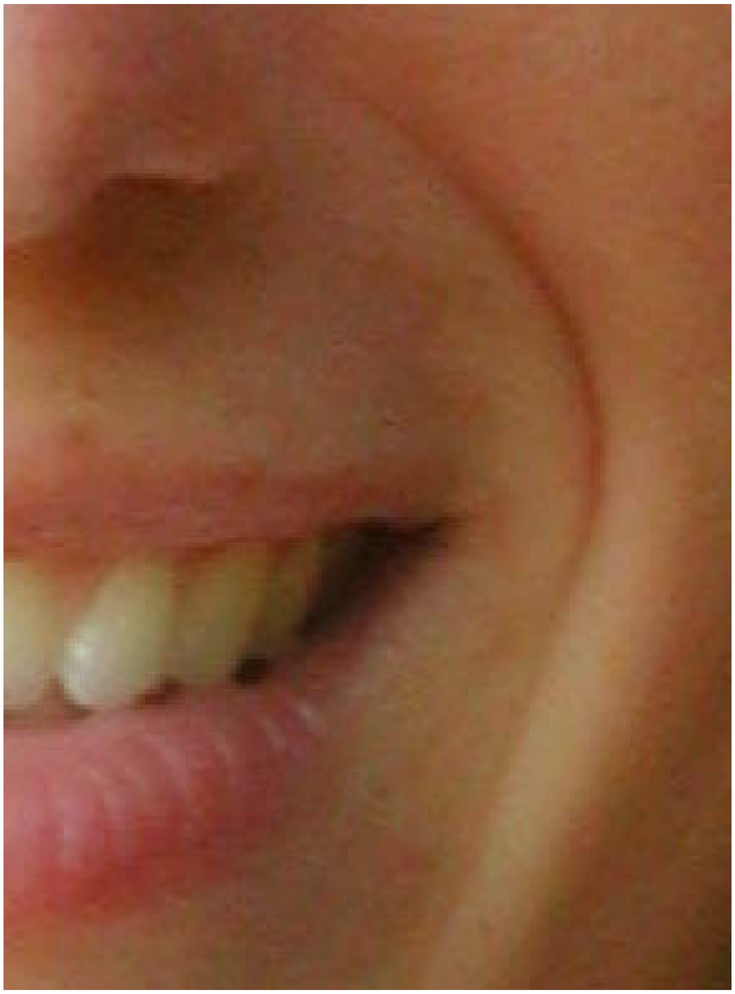


Figure: Original continuous tone photo for the demonstration of dithering (200% enlargement)

Figure: Dither pattern (left) and diffusing dithering (irregular pattern, right) for creating intermediate colors (200% enlargement)

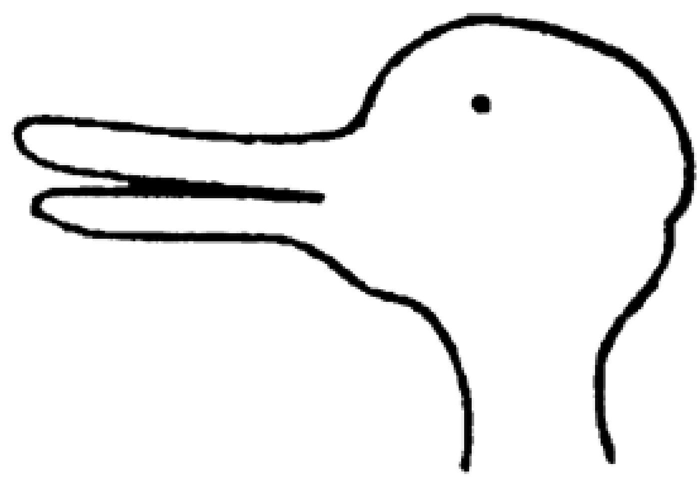
Figure-Ground Phenomenon

The figure-ground phenomenon, also called figure-ground separation, refers to the human ability to separate figures or "foreground" information from a surrounding background or noise information. This phenomenon is often demonstrated with ambiguous images, where you can see only one of two possible interpretations of a scene at a time.

Old or young woman?

Sax player or woman?

Faces or bird bath?



Rabbit or hare?

Figure: Different figures demonstrate the figure-ground or foreground-background phenomenon

Although there can be a number of perceptual attributes listed that distinguish figures from ground, we are still far away from fully understanding the stimulus factors and psychological processes that distinguish figures from ground. One of these is, for example, the smaller the stimulus the more likely it is seen as figure.

Figure-ground phenomena also lead to the perception of subjective contours.

Foreground-Background

See Figure-Ground Phenomenon

Gamut

The gamut is the set of possible colors within a color system. No one system can reproduce all possible colors in the spectrum. Thus, it is not possible to create every color in the spectrum with either additive or subtractive colors. Both systems can reproduce only a subset of all visible colors. While those subsets generally overlap, there are colors which can be reproduced with additive color and not with subtractive color and vise-versa. (©1998 ACM)

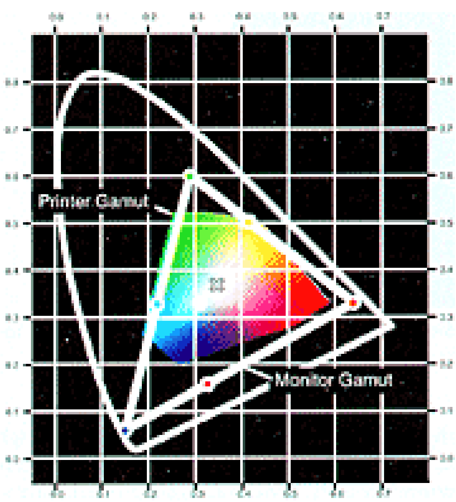


Figure: Relative gamuts of additive (monitor display) and subtractive (printed) color; the larger area on the graph represents all visible colors. Click on the graph to see a more detailed version of the chart. (From *projectcool* Website)

The colors that can be created by each system are called a "gamut". The ACM diagram to the left, shows the relative gamuts of additive (monitor display) and subtractive (printed) color. The larger area on the graph represents all visible color. Click on the graph to see a more detailed version of the chart. (From *projectcool* Website)

Gestalt Laws

The Gestalt psychologists approached lightness perception, and perception generally, in a different manner from the Hering or the Helmholtz schools. They emphasized the importance of perceptual organization, much of it based on mechanisms that might be characterized as mid-level. The key concepts include *grouping*, *belongingness*, *good continuation*, *proximity*. (From Adelson, MIT)

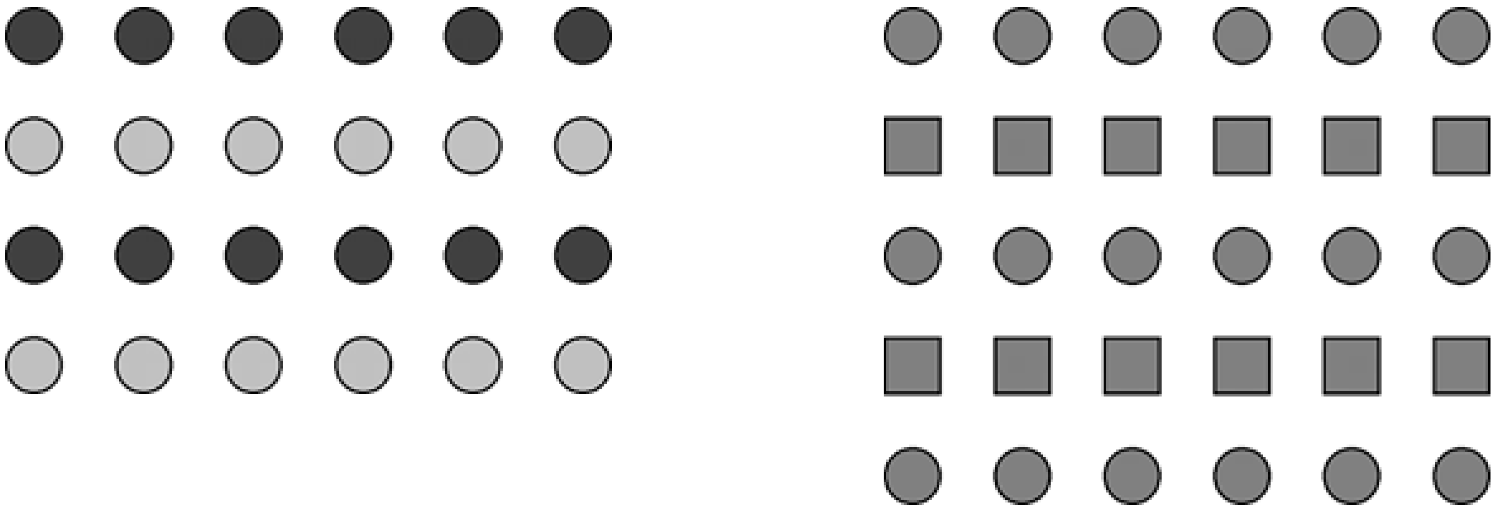


Figure: Grouping by color (or gray level, left) and form (right)

See also the guest editorial in *Perception* 11/1997 (vol. 26)"Colour in a larger perspective: the rebirth of Gestalt psychology"

GIF

See Image File Formats.

Halftone

The process of converting a continuous-tone image into a series of one-color dots of varying sizes. The larger and closer together the dots, the darker the image. The finer and aparter the dots, the lighter the image. (From lgc)

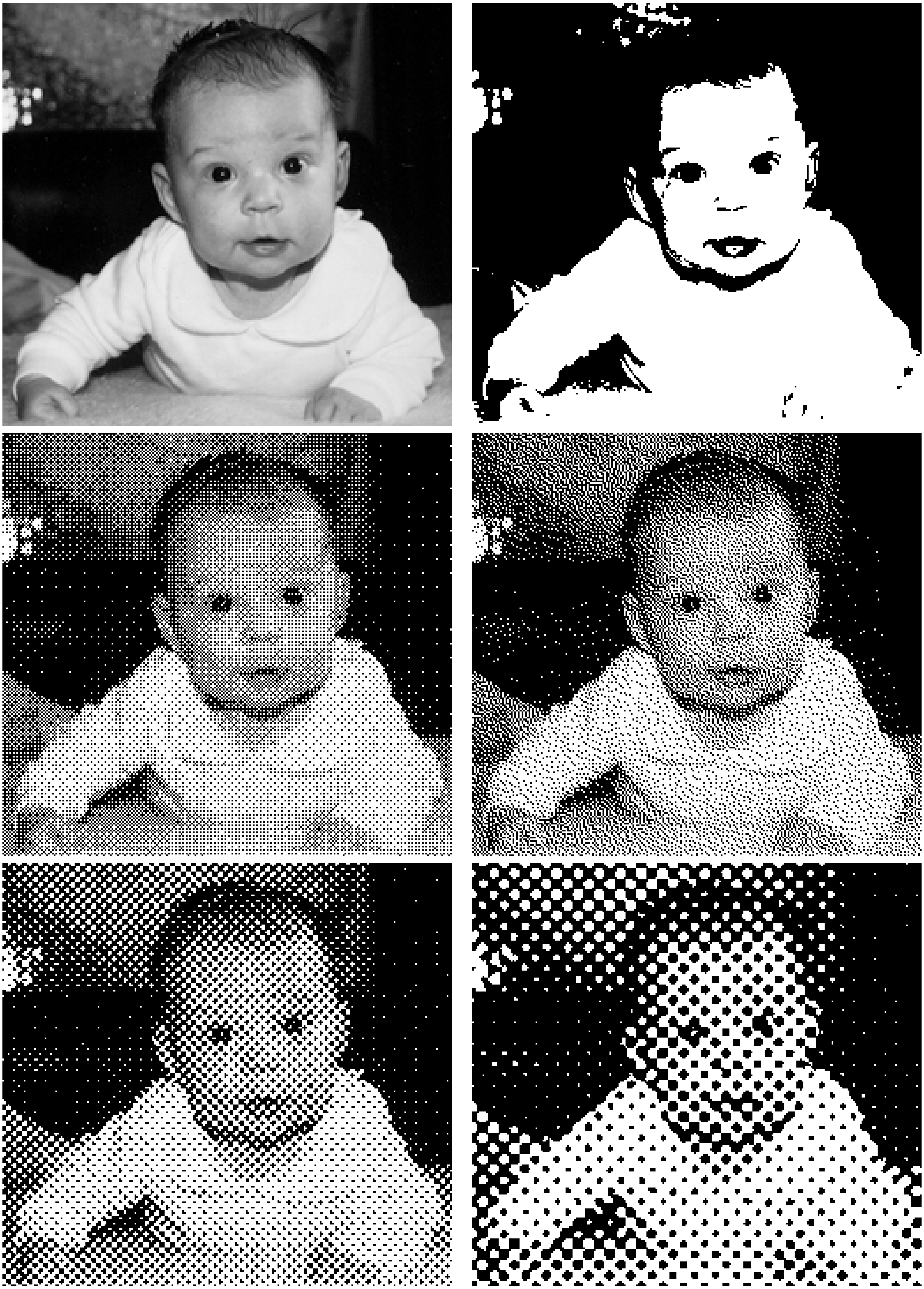


Figure: Continuous tone image (upper left) as it is possible on computer screens and a pure black and white version of the image created by a threshold process (upper right) in comparison to different halftone processes for printing: patterned dither (middle left),diffusion dither (mezzotint, middle right), dots at an angle of 45 degree (screened halftone, lower left) and the same image with a coarser dot pattern (lower right). Click the lower right image to see an even larger version and to see the computer simulation of the dots in detail.

HSL, HSV, HSB

See Color Space -> HSL/HSV/HSB (see also RGB, CMYK, Lab)

Hue

Hue, along with saturation and brightness make up the three distinct attributes of color (as defined in the HSL color space). The terms "red" and "blue" are primarily describing hue. Hue is related to *wavelength* for spectral colors (see Light). It is convenient to arrange the saturated hues around a Newton Color Circle. Starting from red and proceeding clockwise around the circle below to blue proceeds from long to shorter wavelengths. However, not all hues can be represented by spectral colors since there is no single wavelength of light which has the magenta hue - it may be produced by an equal mixture of red and blue.

There are many different mixtures of wavelengths which can produce the same perceived hue. The achromatic line from black to gray to white through the center of the circle represents light which has no hue.

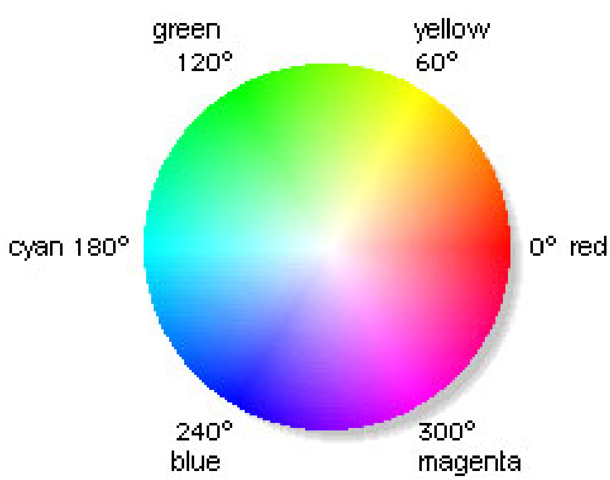


Figure: The color wheel (left) shows spectral and non spectral hues; the color circle (right) also shows different levels of saturation

Hue Induction

Hue induction (chromatic induction, color induction) refers to the change of hue when colors are perceived in the context of other colors.

Hue Induction through Simultaneous Contrast

The target color seems to be tinged with the complementary color of the surround (most noticeable with a gray target).

Note: Hues in the red to blue range are most stable, i.e. are least affected by chromatic induction.

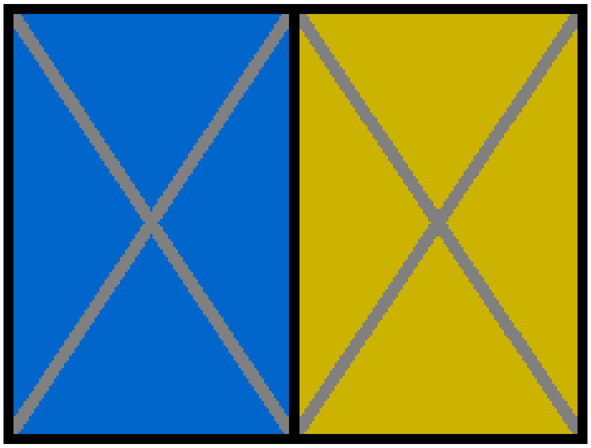


Figure: Hue induction makes the gray look different.

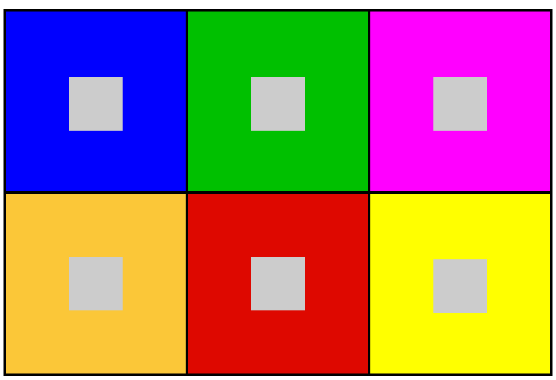


Figure: Depending of the color of the surrounding square the central neutral (gray) square gets a slight tint in the direction of the complementary color.

Hue Induction through Color Assimilation

When the areas of color in a pattern subtend very small angles to the observer (less than about a third of a degree), an effect opposite to simultaneous contrast occurs: Colors appear to become more like their neighbor instead of less like them.

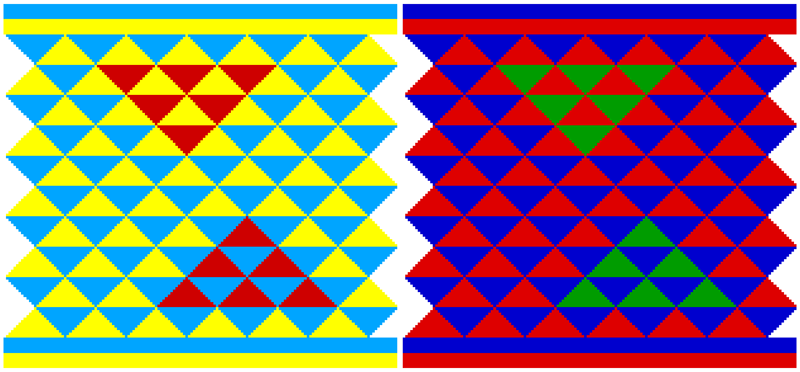


Figure: The Bezold-Brücke effect (hue induction) makes the red (left) and green (right) assimilate their neighboring colors; see also an animated example

Consequences of hue induction:

- same colors appear to be different
- different colors appear to be the same

Fore more examples see Simultaneous Contrast -> Simultaneous Color Contrast.

Effect of Surrounding Color

Colorfulness of a target is also affected by the surround. In general colors look most colorful against another color in lower lightness, particularly gray.

Image File Formats

Below we list the mostly used image file formats, their characteristics, and uses.

BMP

Native bitmap file format (BMP = bitmap) for Microsoft Windows and OS/2 (slightly different). Files can be in 8-bit or 24-bit format and may utilize a lossless LZW compression.

Used throughout Microsoft Windows and OS/2 for bitmap files.

GIF

GIF = Graphic Interchange Format, 8-bit file format (or lesser bit depths, that is, 256 or less colors) developed specifically for the Internet by Compuserve. Offers automatic lossless compression (LZW, but best suited to horizontal patterns) and one transparency color.

Used for Web graphics which require only 256 or less colors, like graphics, text, screen dumps etc.

JPEG, JPG

24-bit file format with lossy compression. Offers variable degrees of compression: Higher compression rates result in smaller file sizes but also increase compression artifacts. Basically the compression is based on the reduction of the number of colors. When the image is compressed, colors may change slightly.

Used for Web graphics which require more then 256 colors, like photos, graphics with smooth gradations etc.

PICT

Native bitmap and object-oriented file format for the Apple Macintosh (comparable to WMF in Windows).

Used on the Apple Macintosh for bitmapped, vector-oriented and mixed files.

PNG

PNG = Portable Network Graphics, developed as a licence-free successor to the GIF file format. Offers 8 bit and 24 bit color depths, lossless compression and an 8-bit transparency mask for smooth transitions between foreground and background images.

Currently not widely supported and used on the Web.

TIFF, TIF

TIFF = Tagged Image File Format, platform independent bitmap file format (there are slight differences between Motorola-based systems (Apple Macintosh) and Intel-based systems (Microsoft Windows). Offers different bit depths, lossless LZW compression, alpha channels and more.

Used for exchanging images between different computer platforms.

WMF

Native bitmap and object-oriented file format for Microsoft Windows (comparable to PICT on the Apple Macintosh).

Used on Microsoft Windows for bitmapped, vector-oriented and mixed files (format of the clipboard).

Intensity

Light waves vary in *intensity* and *wavelength* (frequency). Intensity is proportional to the square of the *amplitude* of a light wave.

See also Light.

Jaggies

A term for "jagged" or stair-step effect found in enlarged bitmapped images. Anti-aliasing and higher resolution minimizes jaggies. (From lgc)

See also Aliasing and Anti-Aliasing.

JPEG, JPG

See Image File Formats.

Lab

See Color Space -> Lab (see also RGB, CMYK, HSL/HSV). See further CIE which introduced the Lab color system.

Lateral Inhibition

The combined effect of the summation of adjacent excitatory and inhibitory signals causes us to perceive an increased contrast at luminance boundaries (edges), but little or no contrast in uniform fields.

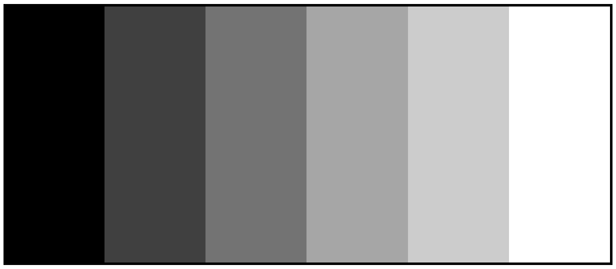


Figure: The Mach-band effect is caused by lateral inhibition

Figure: Simultaneous contrast (black and white) is also caused by lateral inhibition; it lets the same gray in the middle of the lager squares appear differently.

Light

Electromagnetic radiation emanating from light sources or reflected from non-radiating objects. Perceived by our *eyes* and processed in the *brain*.

- Physical dimensions: Frequency (wavelength), intensity (amplitude)
- Perceptual dimensions: Brightness - related to intensity; hue (tone, tint) - related to frequency (wavelength), lightness
- Psychological dimensions: warmness/coldness, moods induced by colors, color associations, cultural differences

The visible light spectrum lies between 380 nm (violet) and 760 NM (red).

Light travels at a constant velocity of 300.000 km/s; it takes 1,25 sec to the moon, and nearly 8 minutes to the sun.

Lightness

Lightness is the perceived *reflectance* of a surface. It represents the visual system's attempt to extract reflectance based on the luminances in the scene. (From Adelson, MIT)

ISO Definition: Brightness of an area judged relative to the brightness of a similary illuminated area that appears to be white or highly transmitting. (Source: ISO 9241-8 (1997-10-00) ISO/ TC 159)

See also Brightness, Intensity, Luminance.

Luminance

Luminance is the amount of visible light that comes to the eye from a surface.

Illuminance is the amount of light incident on a surface. Reflectance is the proportion of incident light that is reflected from a surface.

Luminance, illuminance, and reflectance, are *physical* quantities that can be measured by physical devices.

There are also two *subjective* variables:

- Lightness is the perceived *reflectance* of a surface. It represents the visual system's attempt to extract reflectance based on the luminances in the scene.
- Brightness is the perceived *intensity* of light coming from the image itself, rather than any property of the portrayed scene. Brightness is sometimes defined as perceived luminance.

(From Adelson, MIT)

ISO Definition: The physical measurement of the stimulus which produces the sensation of brightness, in terms of the luminous intensity in a given direction [epsilon] (usually towards the observer) per unit area of an emitting, transmitting or reflecting surface. It is the luminous intensity of the light emitted or reflected in a given direction from an element of the surface, divided by the area of the element projected in the same direction. Unit: candela per square metre (cd/m2)

Note: The luminance L, in candela per square metre, of a perfectly matt surface is given by the formula [see formula in the standard] where E is the illuminance, in lux; [rho] is the reflectance of the surface considered. (Source: ISO 8995 (1989-10-00) ISO/TC 159)

Moiré

Moiré is a repetitive box-like pattern that results when two screens overlap and are out of register. This effect occurs when scanning screened originals due to the overlapping influence of more than one screen - the scan screen of the scanner and the print screen of the original. Small stars or lines in the image make it appear as if it were made of fabric. (From www.linocolor.com and lgc)

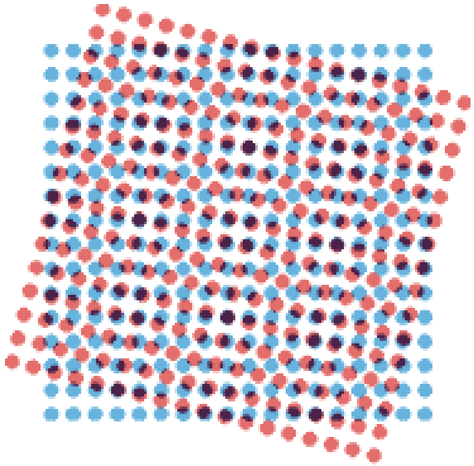


Figure: A moiré pattern

Munsell System (Munsell Color Space)

The Munsell color system is based on the HSL color space and is used for calibrating color systems. It matches colors to a set of standard samples (typically color charts), with adjacent samples based upon equal perceived differences in color. It divides hue into 100 equal divisions around a color circle. This is similar in approach to the Newton Color Circle except that the circle is distorted by assigning a unit of radial distance to each perceptible difference in saturation (called units of chroma). Since there are more perceptible differences for some hues, the figure will bulge outward to 18 values for some hues compared to only 10 for another. Perpendicular to the plane formed by hue and saturation is the brightness scale divided into a scale of "value" from 0 (black) to 10 (white). A point in the color space so defined is specified by hue, value, and chroma in the form H V/C. (Adapted from *Hyperphysics*)

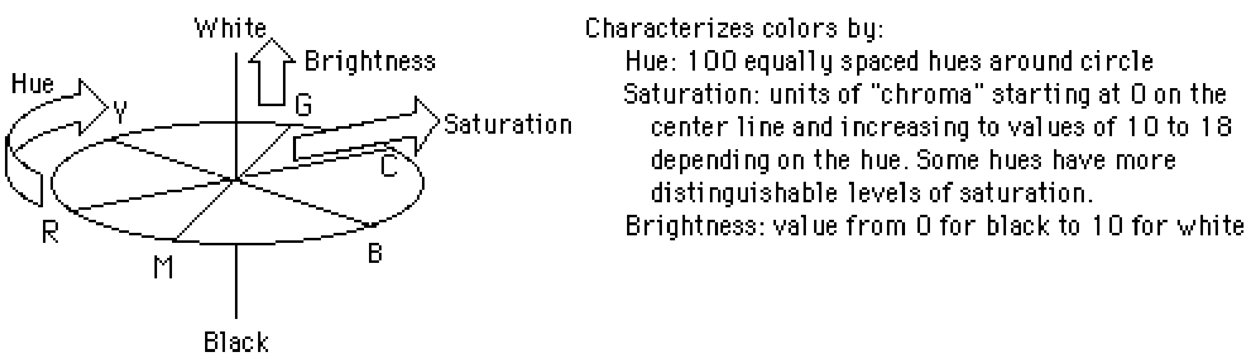


Figure: The Munsell color system (from *Hyperphysics*)

Optical Illusion

Optical illusions define illusions in perception. They can be attributed to physiological (due to the construction and functionality of the human eye) as well as psychological factors (due to misinterpretations while seizing and comprehending the perceived objects and situations). There are various types of optical illusions: Geometrical-optical illusions, illusions concerning motion, contrast, perspective etc.

See also "Goodie" Optical Illusions in the *Resources* section of the *SAP Design Guild* for detailed information.

Parallax

ISO Definition: Difference in the apparent relative positions of objects when viewed from different points (Source: ISO/FDIS 9241-9 (1999-10-07) ISO/TC 159)

Perception

ISO Definition: Psychophysiological process occurring in the central nervous system, the product of which is knowledge about the environment. Perception is a dynamic process and is not determined merely by the parameters of the signals which initiated it. As a consequence, it is possible that the information obtained may be incomplete, uncertain, or incorrect. Knowledge may be based on one or more of the following levels of perception: detection, identification, and interpretation. Detection is the perceptual process by which the operator becomes aware of the mere presence of a signal. Identification is the perceptual process by which the detected signal is distinguished from other signals. Interpretation is the combination of perceptual and cognitive processes by which the contents and significance of the identified signal are recognised. (Source: EN 894-2 (1997-02-00) CEN/ TC 122)

PICT

See Image File Formats.

Pixel

ISO Definition: the smallest element that is capable of generating the full functionality of the display (Source: prEN ISO 13406-2 (1997-07-00) ISO/TC 159)

PNG

See Image File Formats.

Primary Colors

Primary colors theoretically cannot be mixed from any other colors. The RGB primary additive colors (red, green, blue) can be mixed in varying combinations to produce millions of additive colors. The subtractive colors red, yellow and blue or magenta, yellow, cyan can be mixed as printer's ink or artist's pigment to produce thousands of colors.

Primary colors are: red, green, blue (additive color mixture), red, yellow, blue (arts, subtractive color mixture for paints) or cyan, magenta, yellow (subtractive color mixture for print).

Note: Often the colors cyan, magenta, yellow are called blue, red and yellow (like the primary colors for arts). Note however, that the secondary colors which are created by mixing the primaries are different if the first set or the second set is used. Be careful and consult the respective illustrations in order to not get confused by this ambiguity.

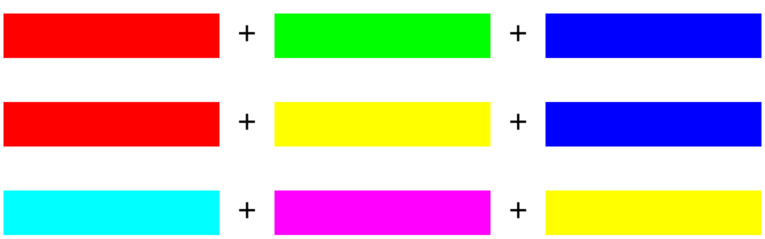


Figure: Different triples of primary color - red, green, blue (additive color mixing), red. yellow - blue (arts, subtractive color mixing), and cyan, magenta, yellow (subtractive color mixing, print)

Process Colors

A term that is a synonym for CYMK (cyan, yellow, magenta, black), the four inks used by printers to produce full-color printing. Also referred to as four-color printing.

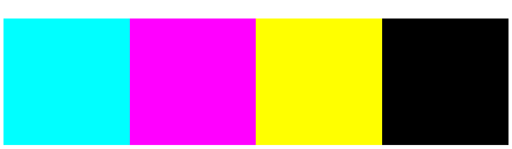


Figure: The four primaries of the CMYK color space cyan, magenta, yellow and black

Psychological Effects of Colors

Colors do not have only sensorial but also psychological effects and may affect people's moods:

- **Cool**: blue, turquoise, violet
- **Warm**: yellow, orange, red, brown
- Achromatic colors (white, gray, black) may take on either a warm or a cool character with just a hint of color.
- Green and magenta are marginal, depending on which colors surround them - they will tend to the opposite.

Warm hues act stimulating, while cool hues act relaxing. These effects are, for example, taken into account when decorating the interior of buildings.

Reflectance

Reflectance (of a surface) is the proportion of incident light the surface reflects.

ISO Definition: The ratio of the luminous flux reflected from a surface on it. The reflectance depends on the direction of the incident light, except for matt surfaces, and on its spectral distribution. (Source: ISO 8995 (1989-10- 00) ISO/TC 159)

RGB

See Color Space -> RGB.

Saturation

Saturation is related to how much white content is in the stimulus - it describes the purity of colors.

As used in HSL, HSV, or HSB it refers to the presence or lack of chroma or color pigment. A color that is 100 percent saturated contains no white (monochromatic colors). A color that has 0 percent saturation is white.

ISO Definition: chromaticness, or colorfulness, of an area judged in proportion to its brightness (Source: ISO 9241-8 (1997-10-00) ISO/TC 159)

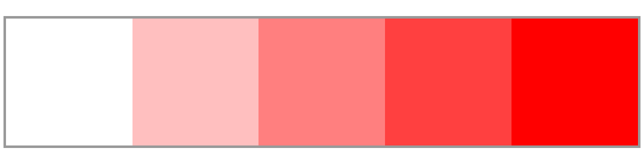
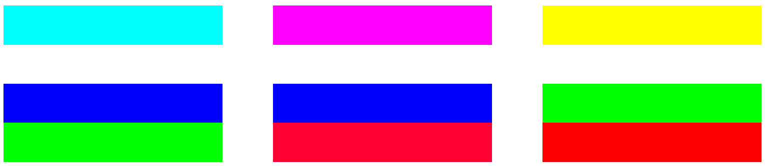


Figure: A red changing from 0% saturation to 100% saturation in steps of 25% each

Secondary Colors

The three colors which are created by mixing the three primary colors. Additively mixing the primary colors red, green and blue results in the following secondary colors: cyan (blue-green), magenta (blue-red), yellow (green-red).



Depending on the primary colors, other secondary colors are created. For instance, the primaries red, yellow and blue, which are used in arts (pigments, thus subtractive color mixing), produce the secondaries green (blue-yellow), orange (red-yellow), and violet (red-blue).

Simultaneous Contrast

Simultaneous contrast is caused by lateral inhibition and can be observed for black-and-white as well as for colored images.

Simultaneous Contrast (Black and White)

Simultaneous contrast lets the central gray square look differently, depending on the surrounding gray level, although all the central squares are composed of the same gray.

Figure: Simultaneous contrast (black and white)

Simultaneous Color Contrast

Simultaneous color contrast effects that

- colors shift their hues into the direction of the complementary color (the opposite effect of Color Assimilation, where colors tend to adopt similar hues)
- colors look lighter or darker with respect to the background color (essentially the same effect as with black and white)

The change in appearance of a central area is caused by the presence of a neighboring area. The effect is strongest when the inducing field completely surrounds the target area.

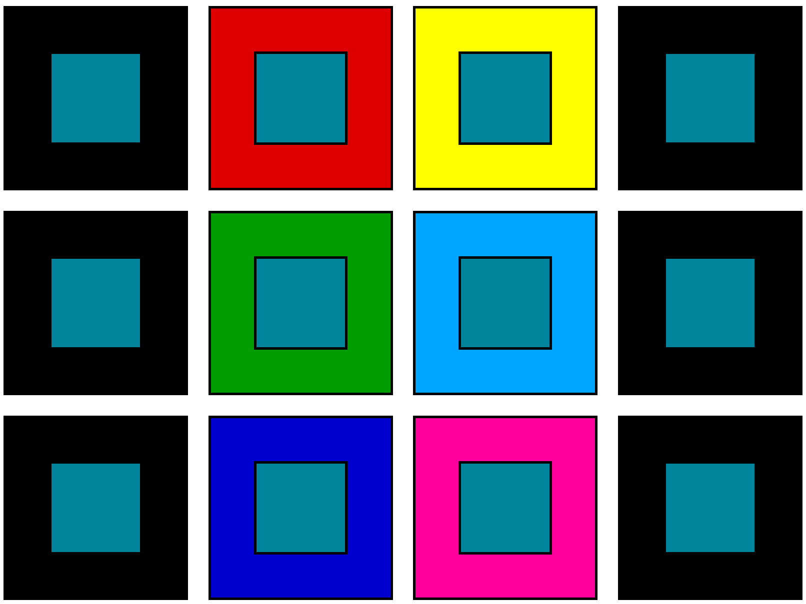


Figure: Simultaneous contrast makes the central blue look different

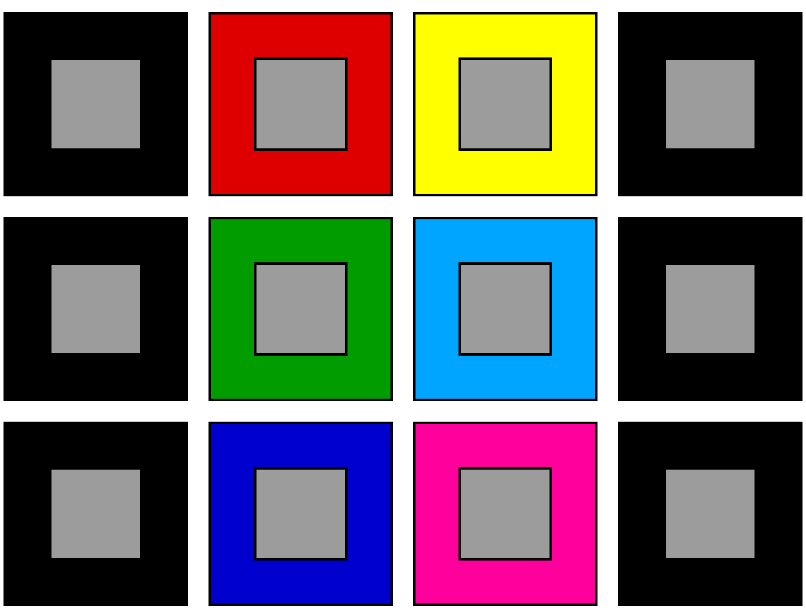


Figure: Simultaneous contrast makes the central gray adopt different hues (and brightnesses, depending on the brightness of the surrounding color)

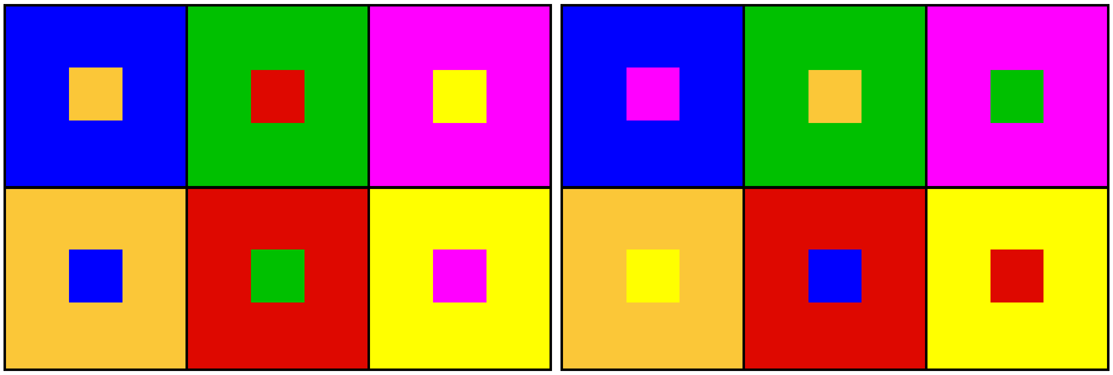


Figure: Color contrasts intensifies complementary colors (left); the same central colors look less intensive with other surrounding colors (confounded with brightness, therefore some colors still look intensive).

An Example

Color contrast and Color Assimilation or other effect of Hue Induction demonstrate that the perceived brightness/color of an object or region of a scene does not depend simply on its own brightness/color. There are basically two phenomena:

1. The same color may look differently
2. Different colors may lead to a similar color impression

Below are a few demonstrations of this, inspired by a book of Edward Tufte:

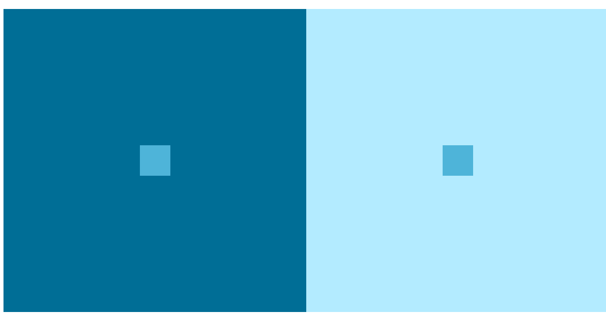


Figure: The same color looks differently depending on the surrounding color

Figure: Though the colors of the middle squares seem to look the same, they are different, as the next figure shows:

Figure: The colors of the central squares

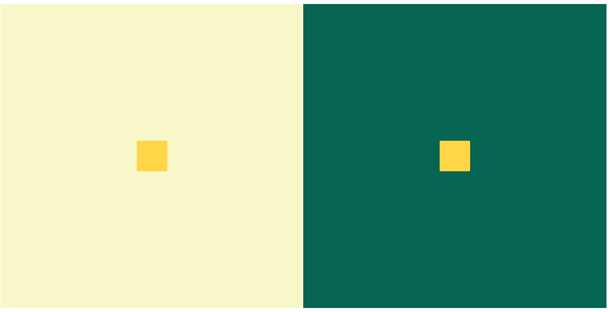


Figure: This is how the same color (the left color) looks depending on the two backgrounds

See also Chromatic Induction, Hue Induction

Size Constancy

Size constancy denotes the stability of perceived size despite changes in objective distance and retinal image size.

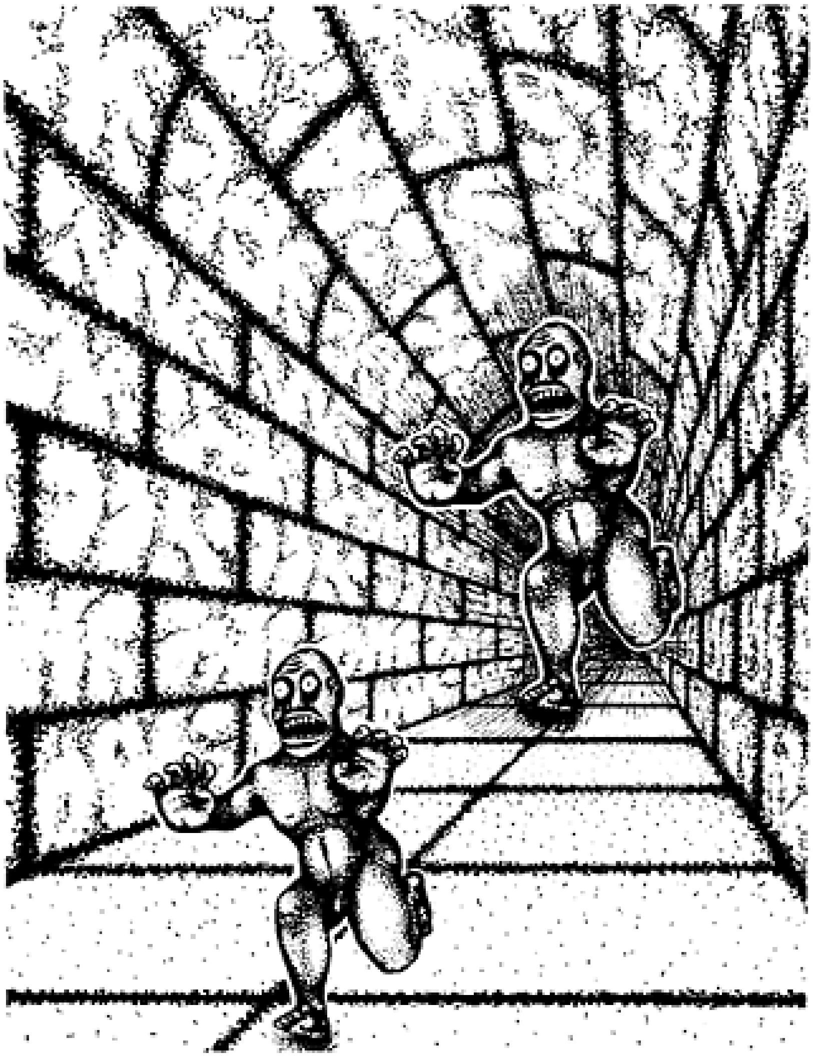


Figure: Size constancy lets the person to the right appear much larger than the one to the left, even though both are of the same physical size (from Shepard)

Stereopsis

ISO Definition: Binocluar, visual perception of depth or three dimensional space. (Source: ISO 9241-8 (1997-10-00) ISO/TC 159)

Subjective Colors

Colors which are perceived from moving, e.g. rotating, black-and-white images are called subjective colors. One such device is Benham's disk. It was invented by a nineteenth-century toymaker who noticed colors in a black-and-white pattern he had mounted on a top. Toy spinning tops with Benham's disks are still available in toy stores. The effects are, however, rather subtle.

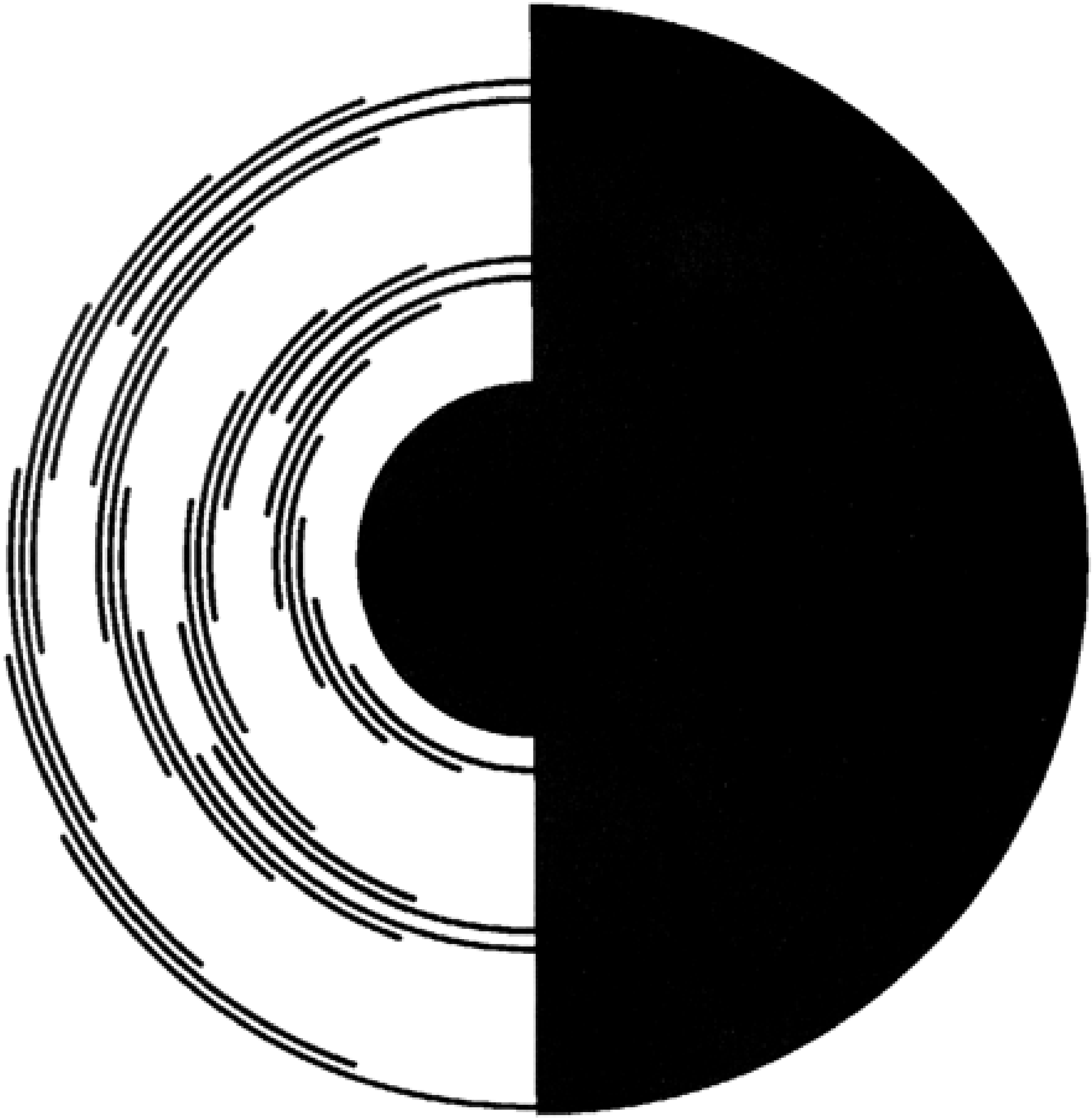


Figure: Benham's disk for inducing subjective colors

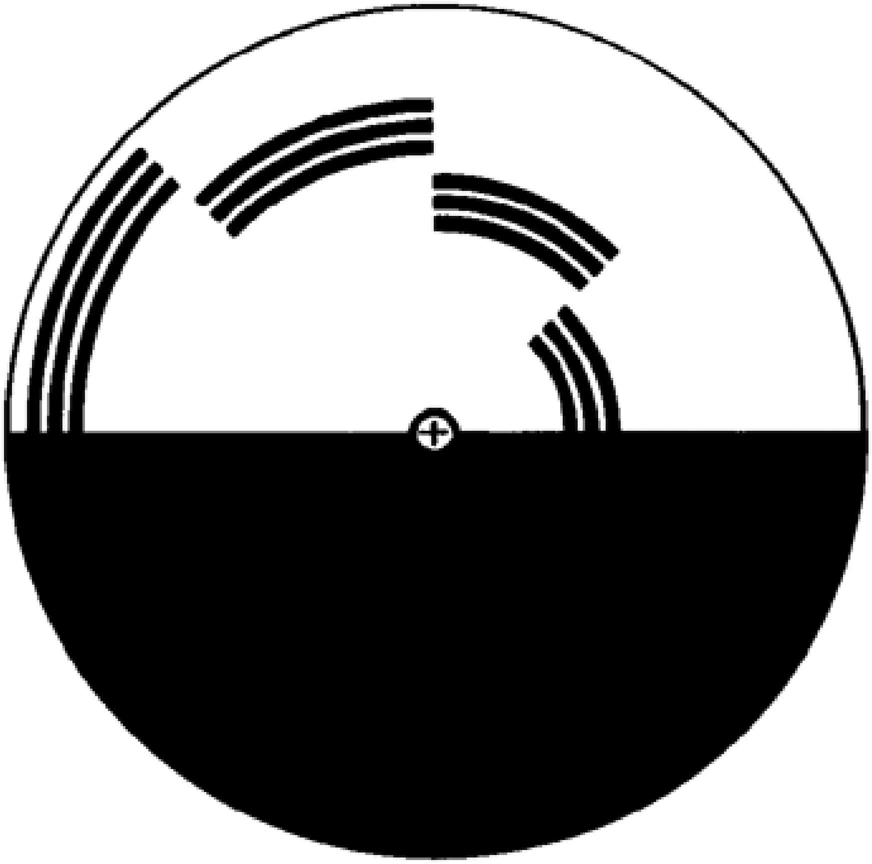


Figure: A variant of Benham's disk (from Sensation and Perception)

Subjective Contours

Subjective contours demonstrate that form can emerge through the use of depth cues in a two-dimensional array - the observer perceptually "creates" the contours defining a form. Coren (1972) suggested that subjective contours arise when we use depth cues within a configuration to help organize an otherwise meaningless array into a simpler, more meaningful figure. A typical such depth cue is *interposition*, that is, the occlusion of an object by another one. The occluded object is perceived as the more distant one (see figures below). The figure defined by the subjective contour acts remarkably like a "real" contour even to the extent that it can mask a real contour. (Adapted from Sensation and Perception)

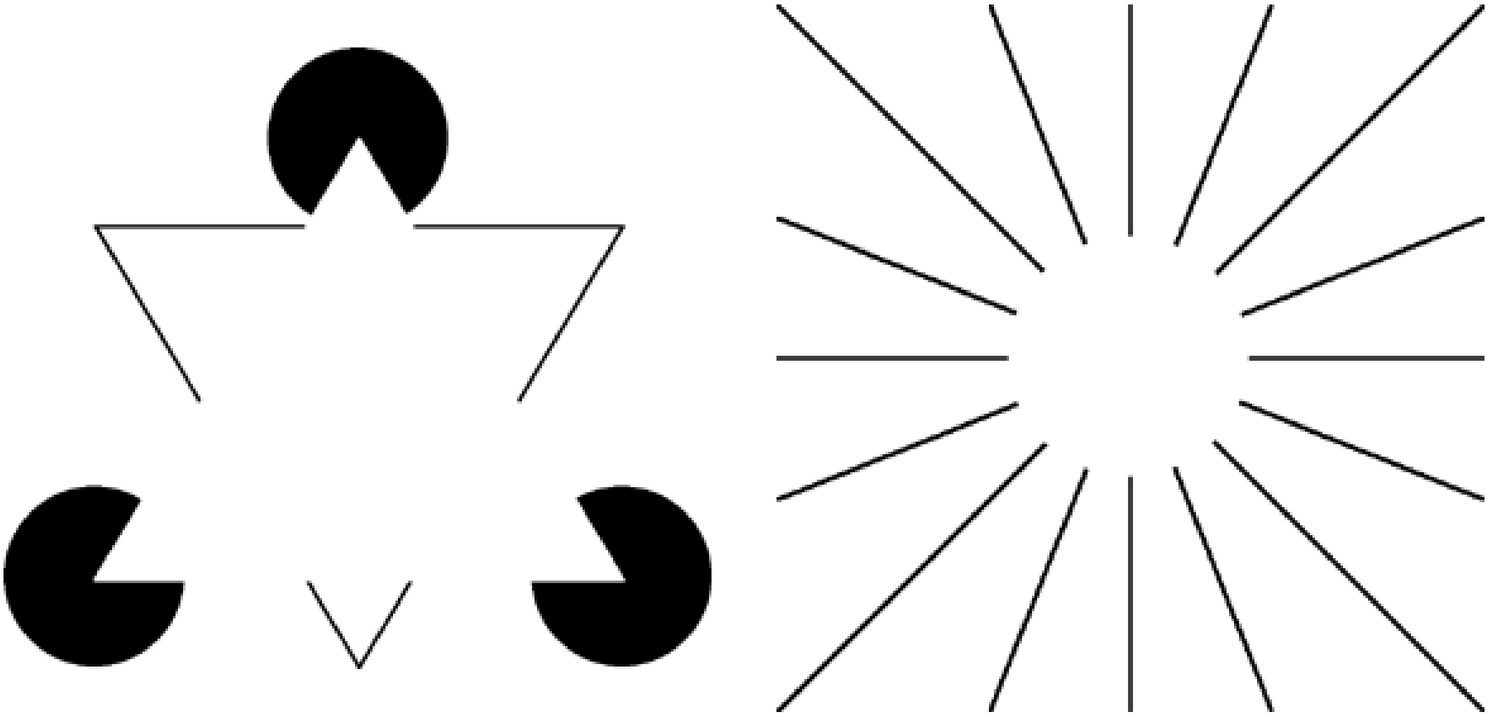


Figure: Examples for subjective contours (left: a triangle is perceived; right: a circle is perceived)

Subtractive Color

The opposite of additive color, subtractive color represents inks or pigments that reflect the light of a certain color. Its primaries are cyan, magenta and yellow. The primary colors of magenta, cyan and yellow can be mixed together to make up millions of colors. See CMYK and Color Mixture -> Subtractive Color Mixture.

Subtractive Color Mixture

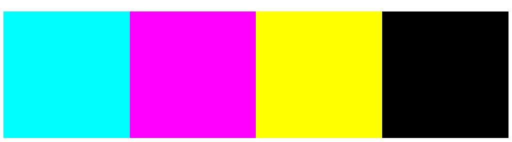


Figure: The primaries of subtractive color mixture for print are cyan, magenta, yellow, and black

See Color Mixture -> Subtractive Color Mixture.

TIFF, TIF

See Image File Formats.

Visual Impairments

Most visual impairments have physiological reasons. Some of them originate from the lens alone, some from its physical relation to the eye ball, others from the sensors, that is from malfunctions of rods or cones, or the neural pathways and processing.

The tables below provide an overview of the most common visual impairments. For more information on visual impairments, see Vision and Visual Disabilities - An Introduction in the *Editions* section of the *SAP Design Guild.*

Overview of Visual Impairments

The first table covers impairments that are related to malfunctions of sensors. The second table includes impairments caused by defects in the optical or neural system or by diseases.

Sensor-Related Impairments

	Loss of Central Vision	Loss of Peripheral Vision	Low Acuity	Night-Blindness	Day-Blindness	Color Deficiencies
Synonyms		Tunnel vision			Glare sensitivity	Color blindness
Affected Sensors	Cones	Rods	Cones	Rods	Cones	Cones (one or more types affected)
Syndromes	Macular degeneration (age-related or inherited) Inverse retinitis pigmentosa	Retinitis pigmentosa (RP) Usher syndrome (RP combined with hearing loss) See also Glaucoma	Coincides with loss of central vision	Retinitis pigmentosa	Monochromats (all cone types affected)	Dichromats: Protanopia Deuteranopia Tritanopia Monochromats

Table 1: Overview of sensor-related visual impairments

Visual Impairments Caused by the Neural or Optical System or by Diseases

	Sightnedness	Lens Clouding	Loss of Vision Field	Loss of Peripheral Vision	Focusing Problems, Distortions
Synonyms			Cortical blindness	Tunnel vision	
Remarks	Typically remedied by glasses or contact lenses	Can be remedied by lens surgery	Can include total loss of vision	Can lead to total loss of vision	Can lead to total loss of vision
Affected Parts	Lens, eye ball	Lens	Optic nerve (visual pathway), brain	Optic nerve (close to lens)	Blood vessels (arteries) in retina
Syndromes	Farsightedness Nearsightedness Astigmatism	Cataracts	Damages in the neural pathways or in brain regions dedicated to vision	Glaucoma	Diabetic retinopathy (caused by age-related diabetes)

Table 2: Overview of further visual impairments

WMW

See Image File Formats.

References

Compiled and edited by Christine Wiegand and Gerd Waloszek (Product Design Center)

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Source: Color Glossary