Perception to visualization II

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Characteristics of visual variables

Selective

is a change in just this variable enough to make a mark distinct?

Associative

can marks sharing this attribute be grouped despite other variables?

Quantitative

if two marks differ in this variable, can we extract a numerical relationship?

Order

can we order marks based on the values of this variable

Length

across how many changes in this variable are distinctions recognizable?

Eight Visual Variables

Position

Mark or **Glyph** or **Shape**

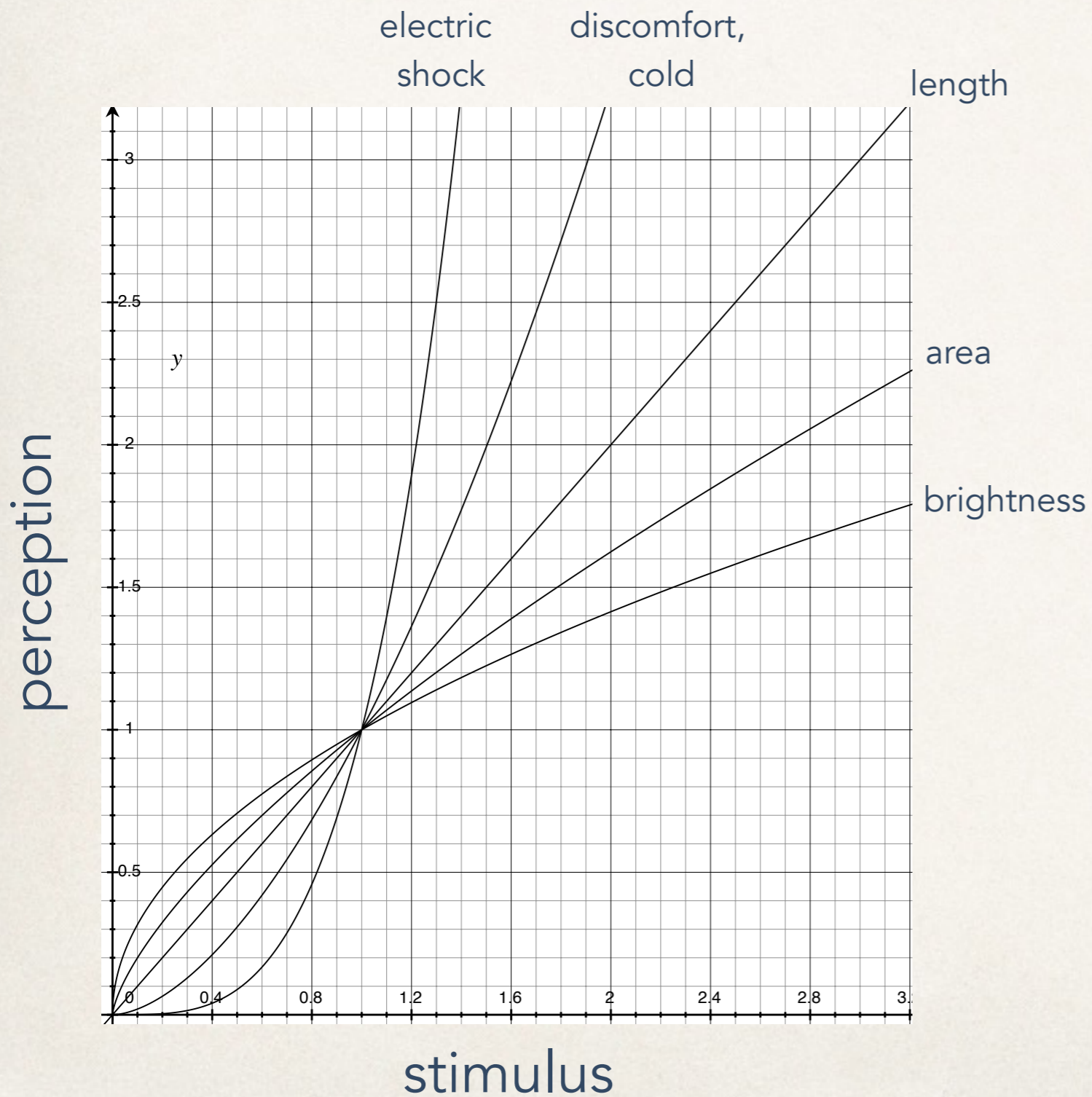**Size** (length, area, volume)

Brightness or **Luminance**

Color

Orientation

Texture

Motion

Steven's power law

$$\psi(I) = kI^a$$

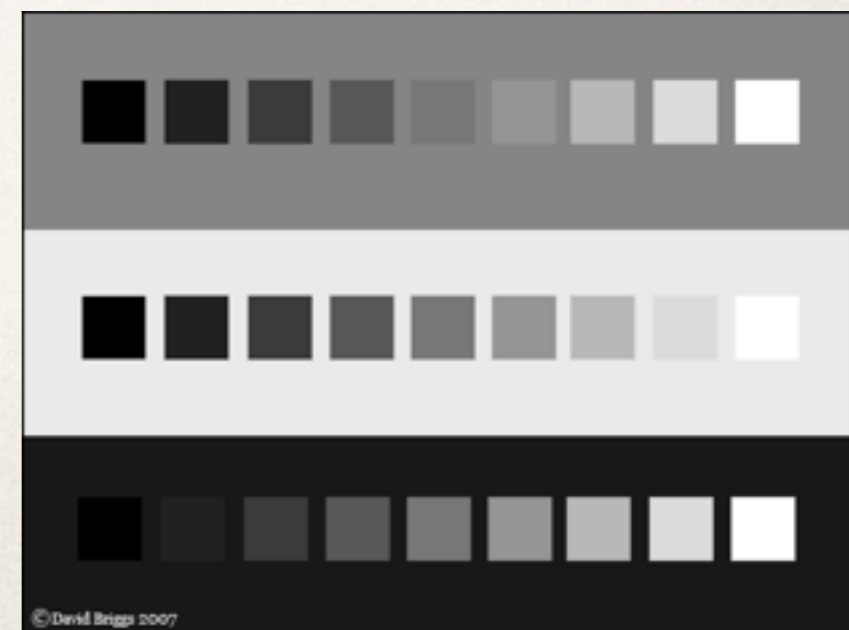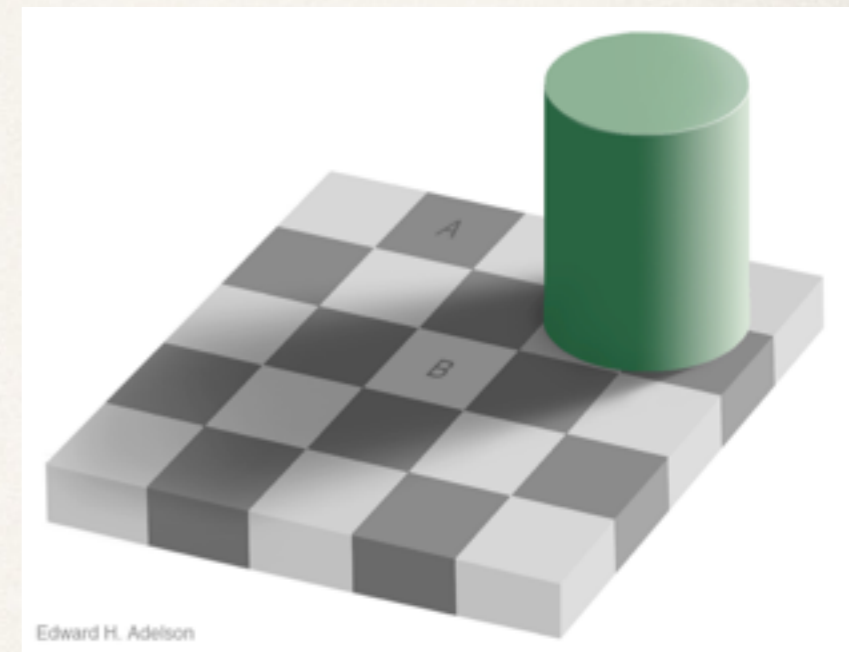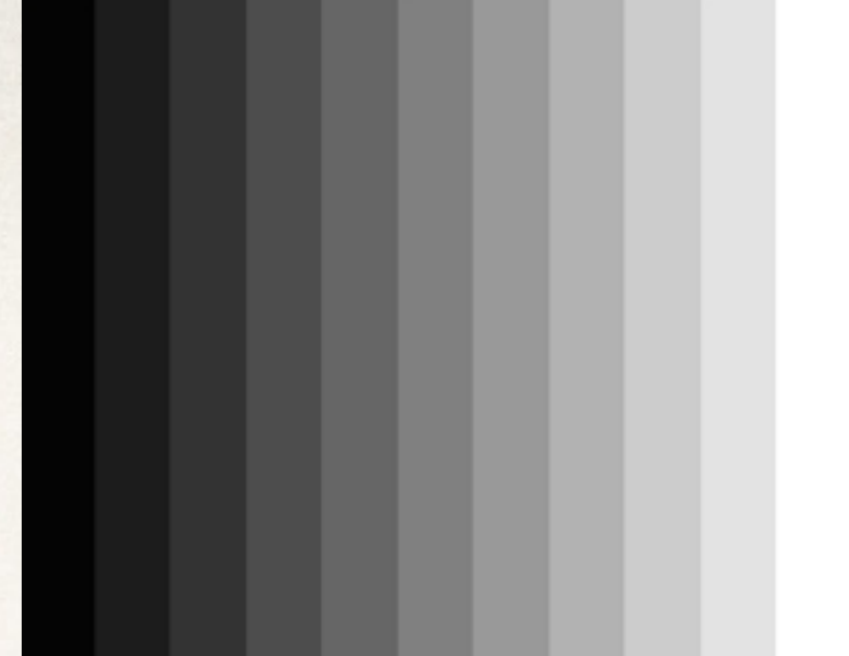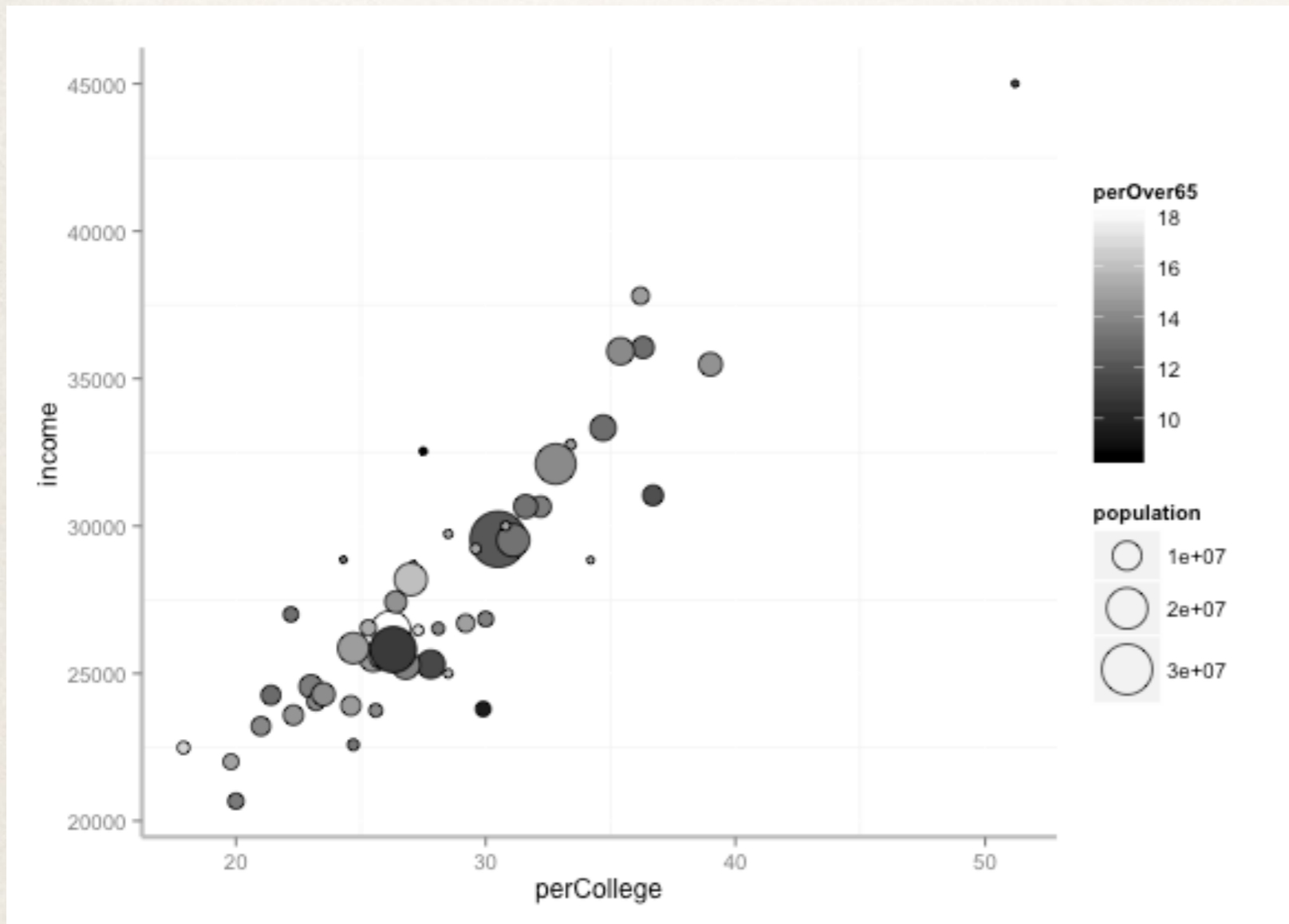| sensation	exponent
shock	3.5
discomfort, cold	1.7
length	1
area	0.7
brightness	0.5

Weber's Law

JNB - Just Noticeable Difference
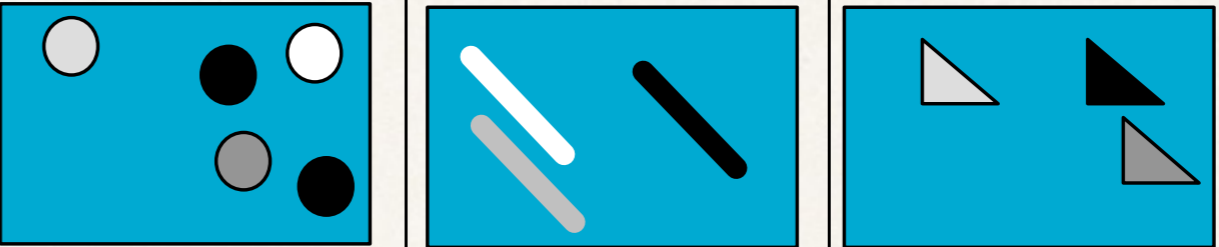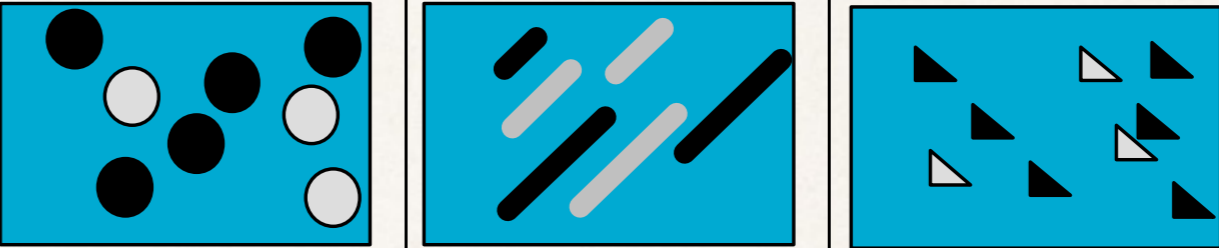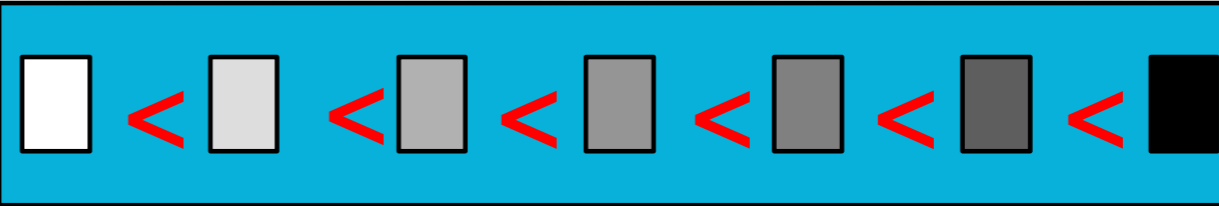
$$dp = k\frac{dS}{S}$$

The perceptible difference proportional to the ratio of the difference in stimulus and the current stimulus
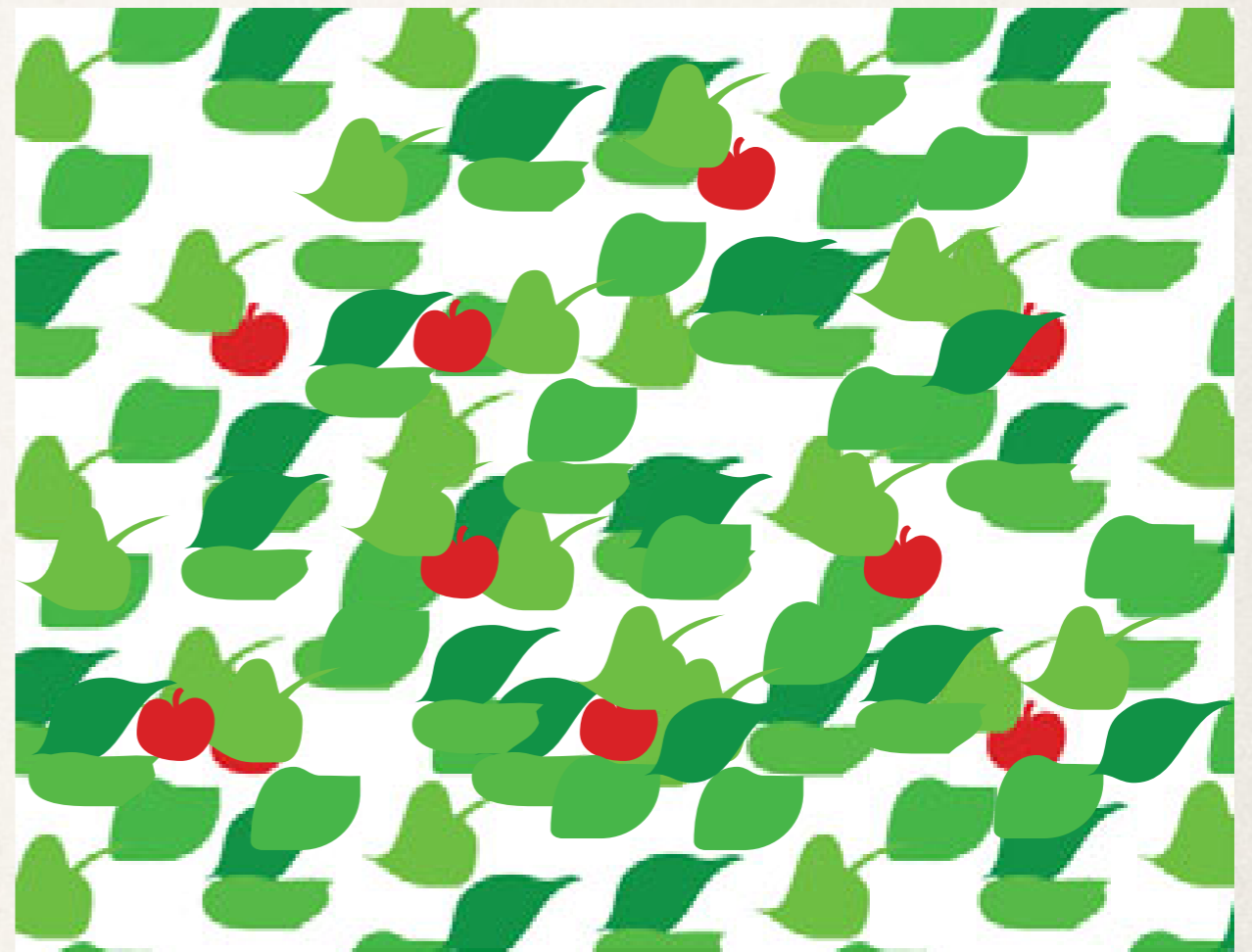
Brightness or Luminance

Luminance characteristics

		Visual Variable: Value		
✓	selective			
✓	associative			
≠	quantitative			
✓	order			
✓	length	• theoretically infinite but practically limited • association and selection ~ < 7 and distinction ~ 10		

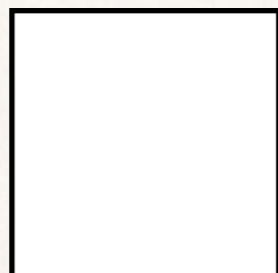Carpendale, "Considering Visual Variables as a basis for Information Visualization."

Color

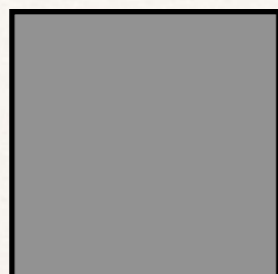# Color

Visual perception

Marshall *et al.,* 2007; Marshall and Oberwinkler, 1999
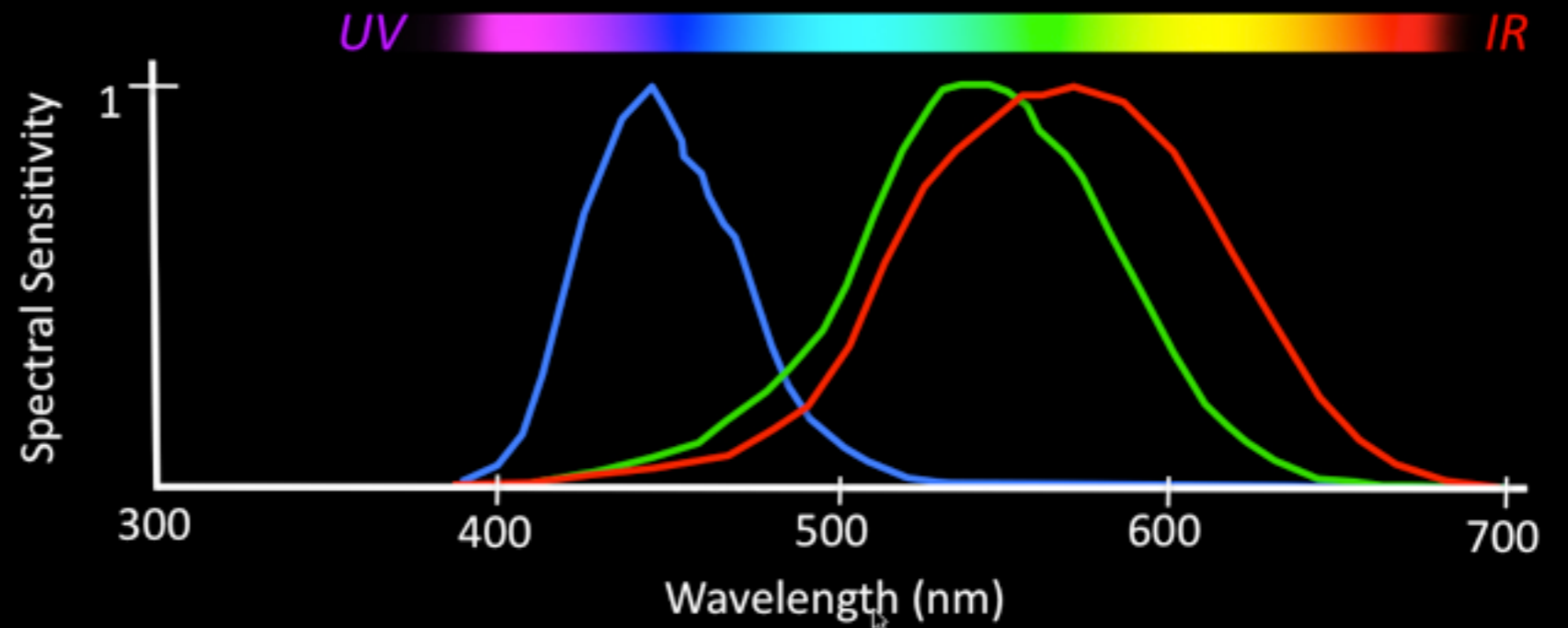
Universal (?) colors

white

grey

black
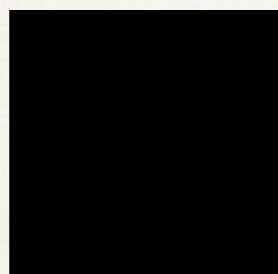
red
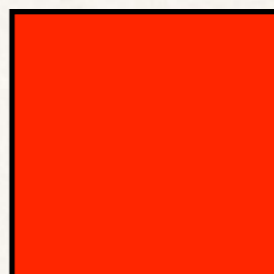
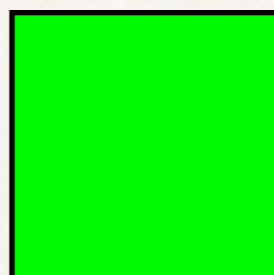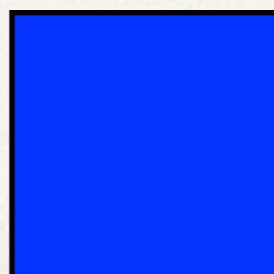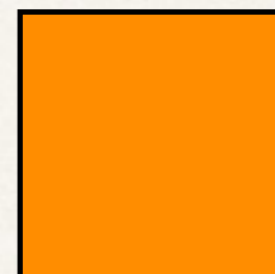yellow
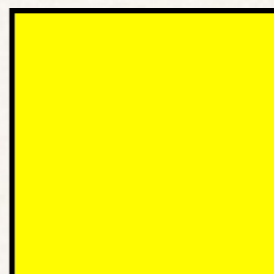
green

blue

pink
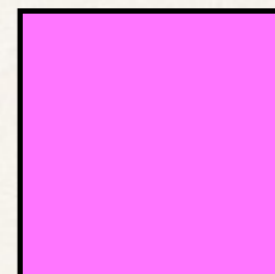
orange

brown
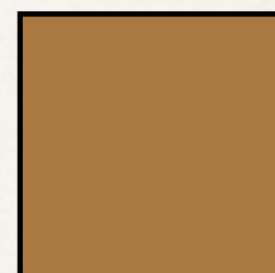
purple

Color names: XKCD survey

THIS CHART SHOWS THE DOMINANT COLOR NAMES OVER THE THREE FULLY-SATURATED FACES OF THE RGB CUBE (COLORS WHERE ONE OF THE RGB VALUES IS ZERO)
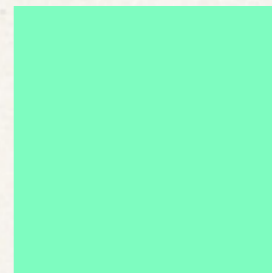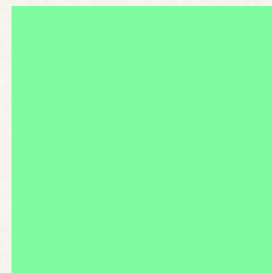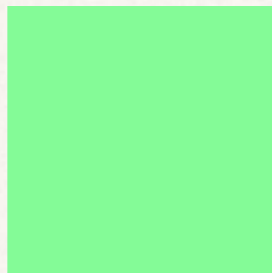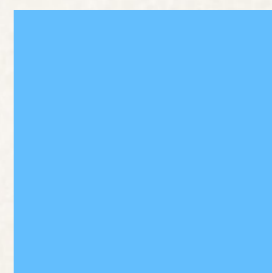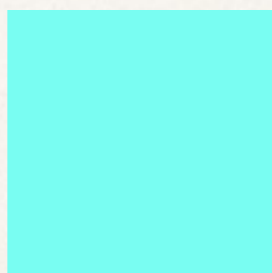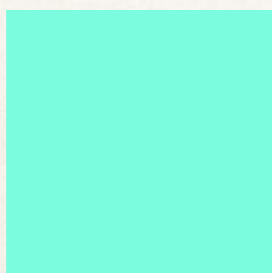
http://blog.xkcd.com/2010/05/03/color-survey-results/
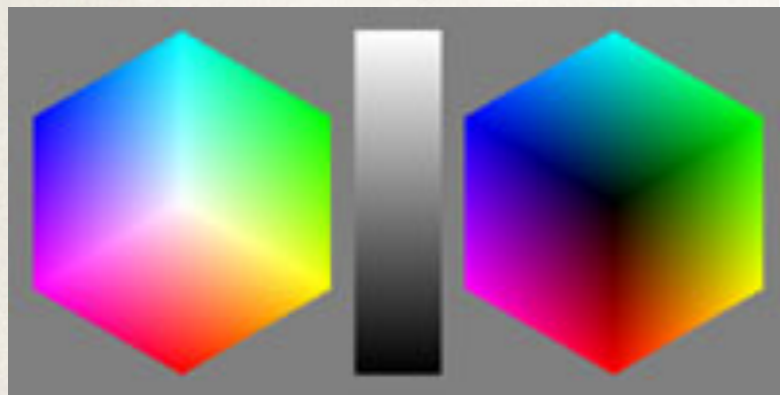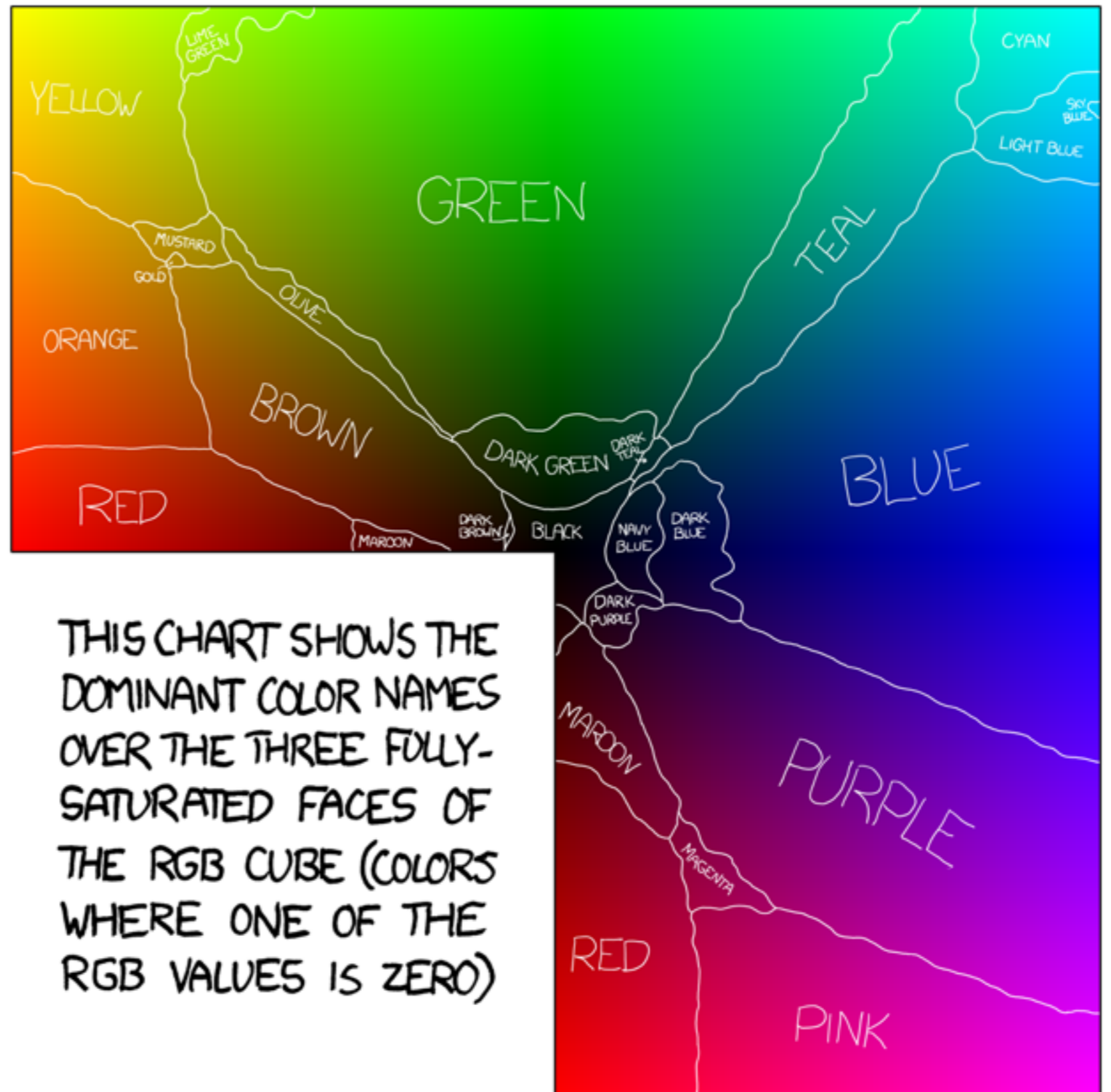
Color names
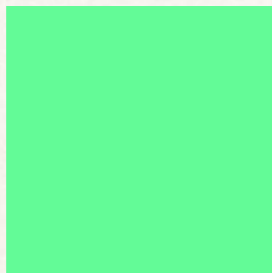
Greens

Blues

Opponent Process model

Long (red)

Med (green)

Short (blue)

\+ Luminance

\-

R-G

\-

Y-B
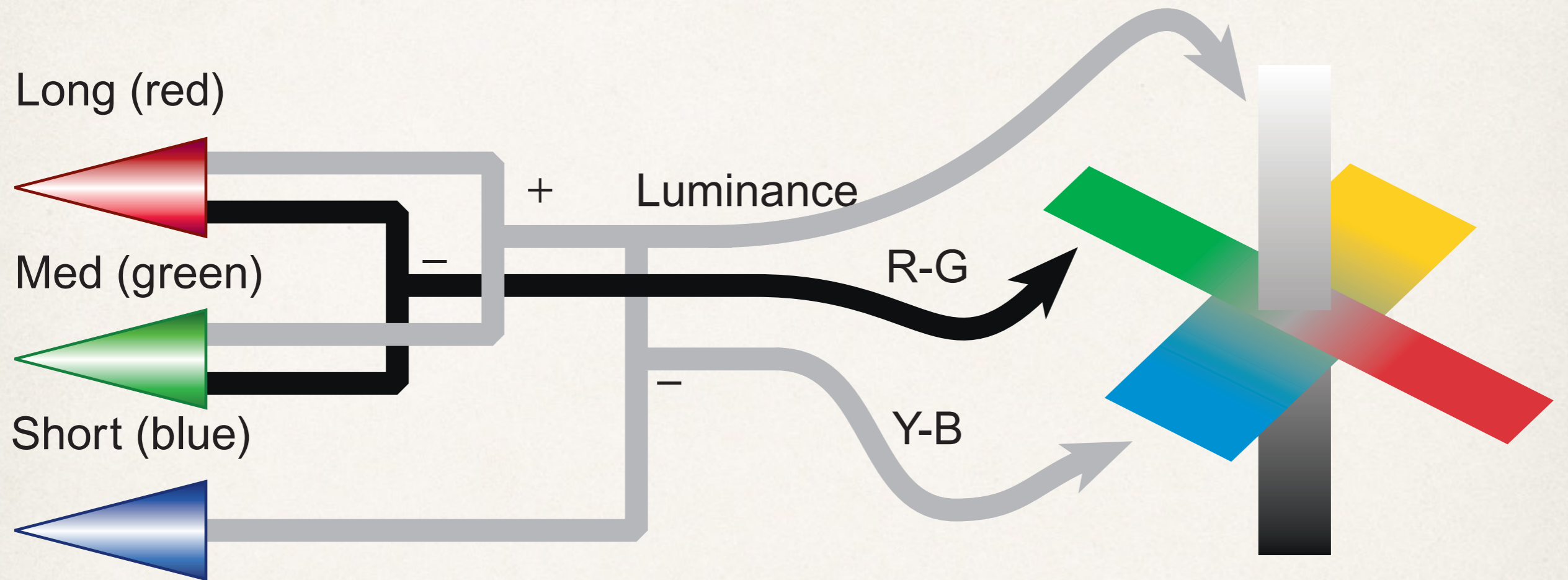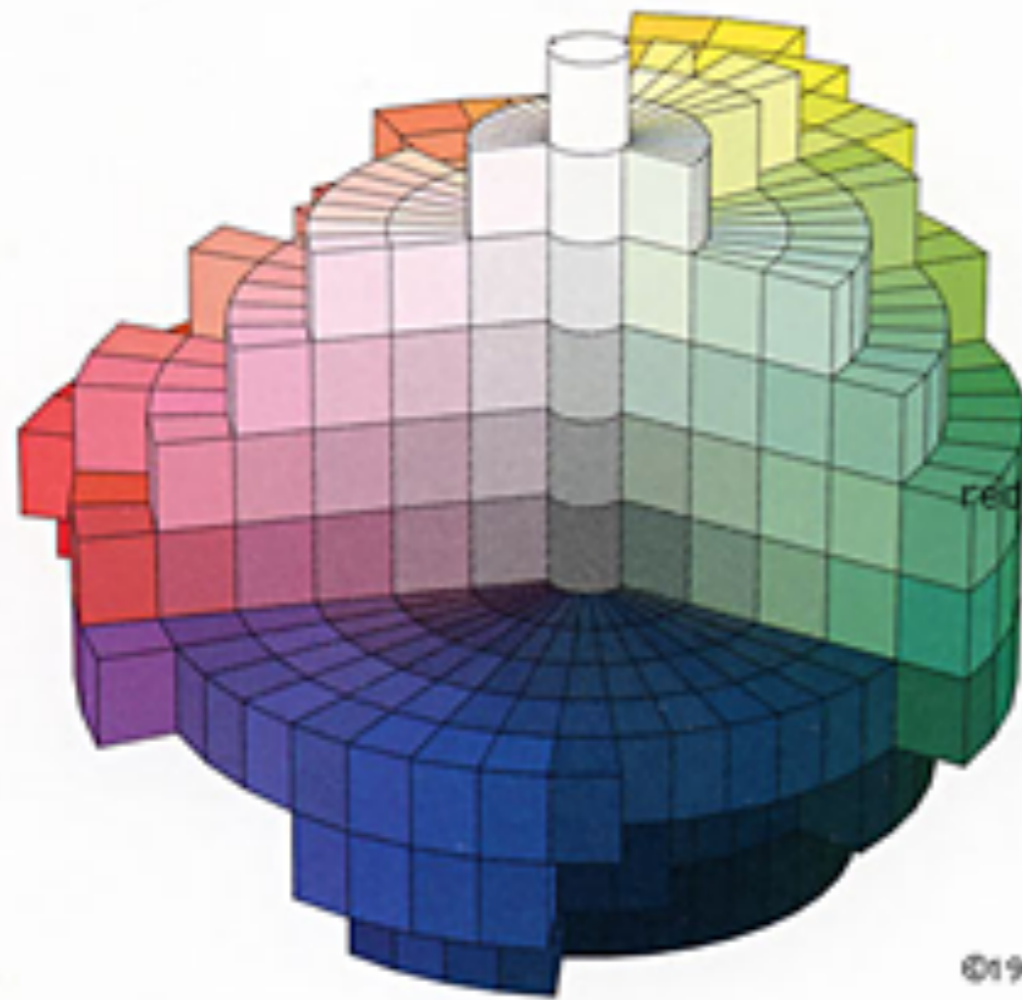
no "reddish-green" or "bluish-yellow"

Munsell's color system
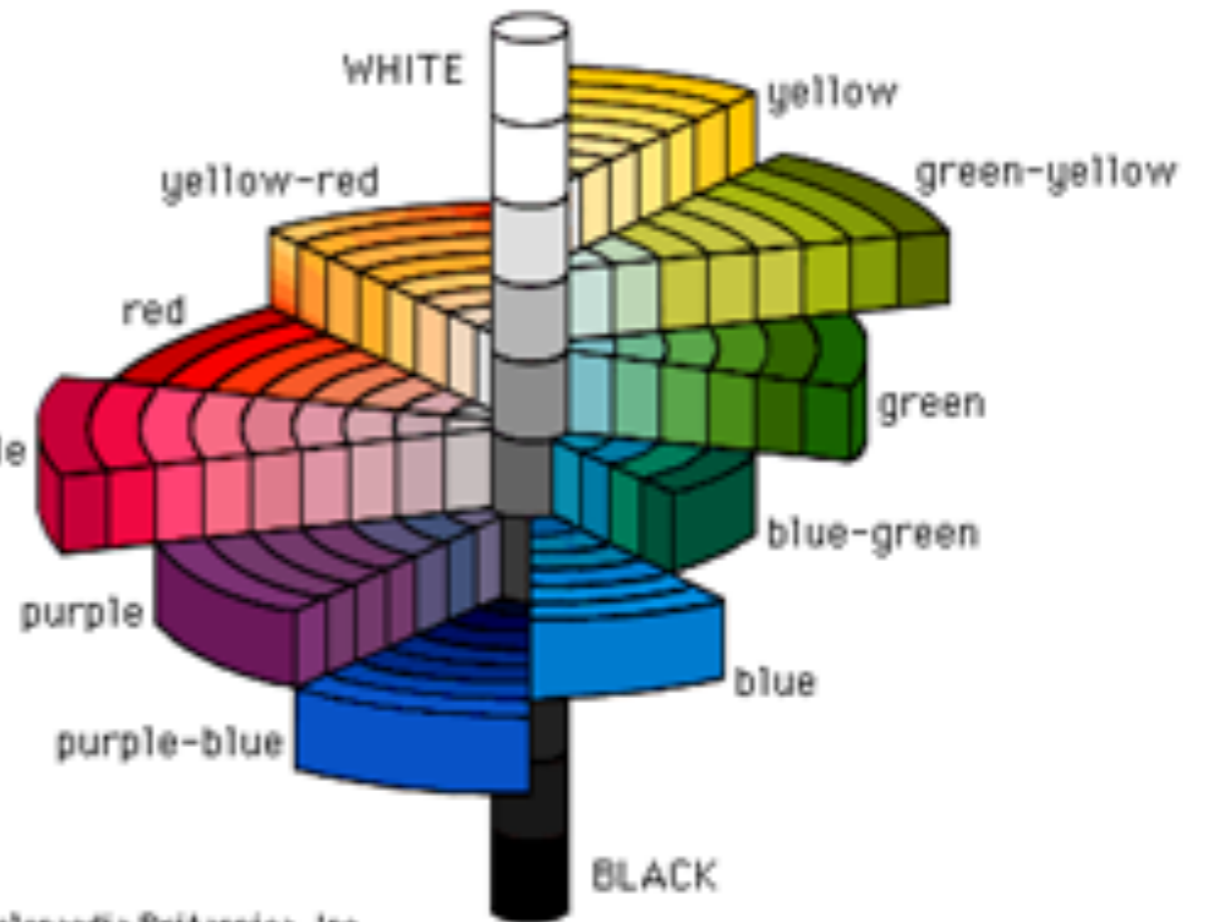
©1996 Encyclopaedia Britannica, Inc.

Hue, saturation, brightness/value/intensity
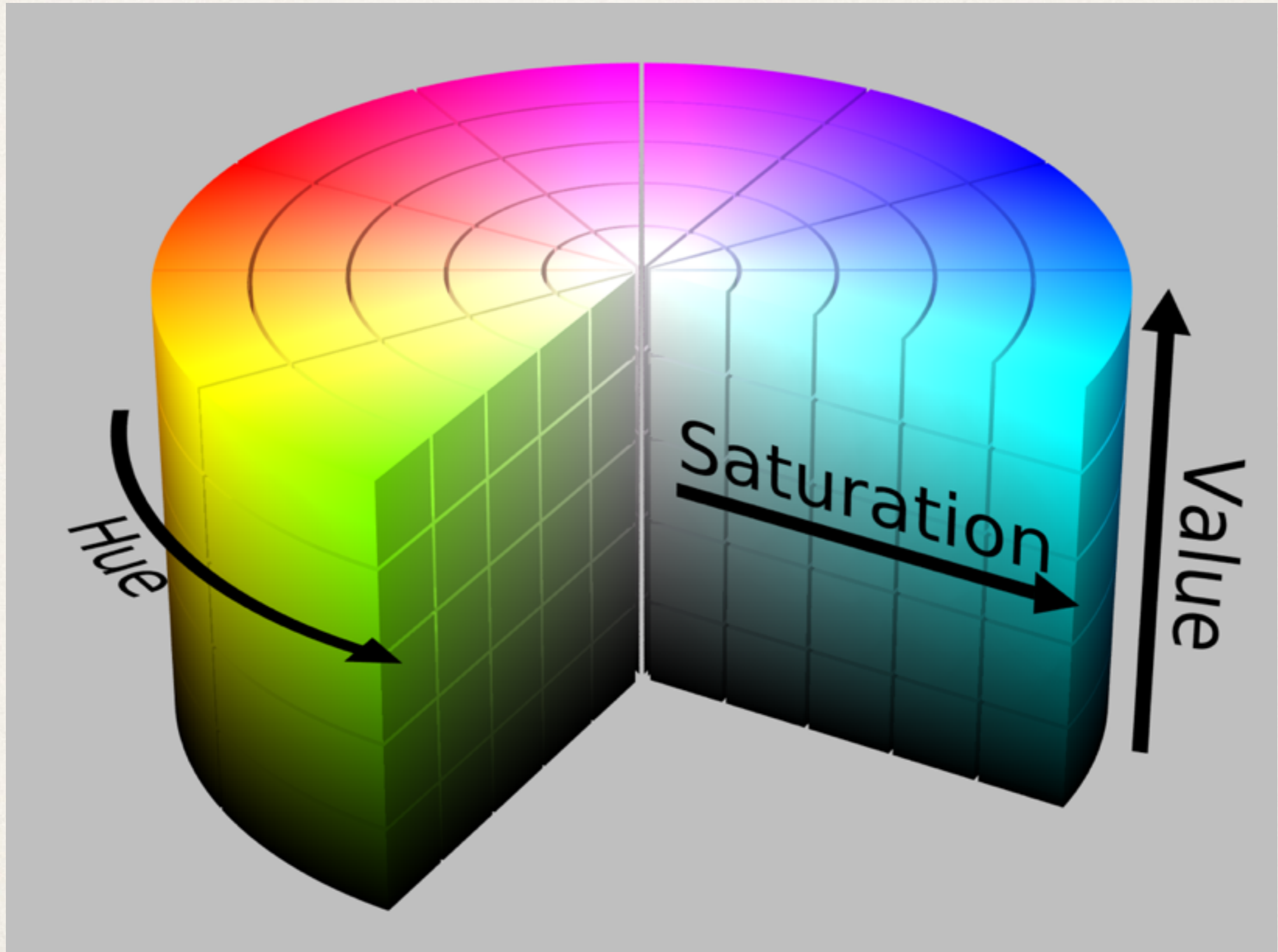
CIE XYZ
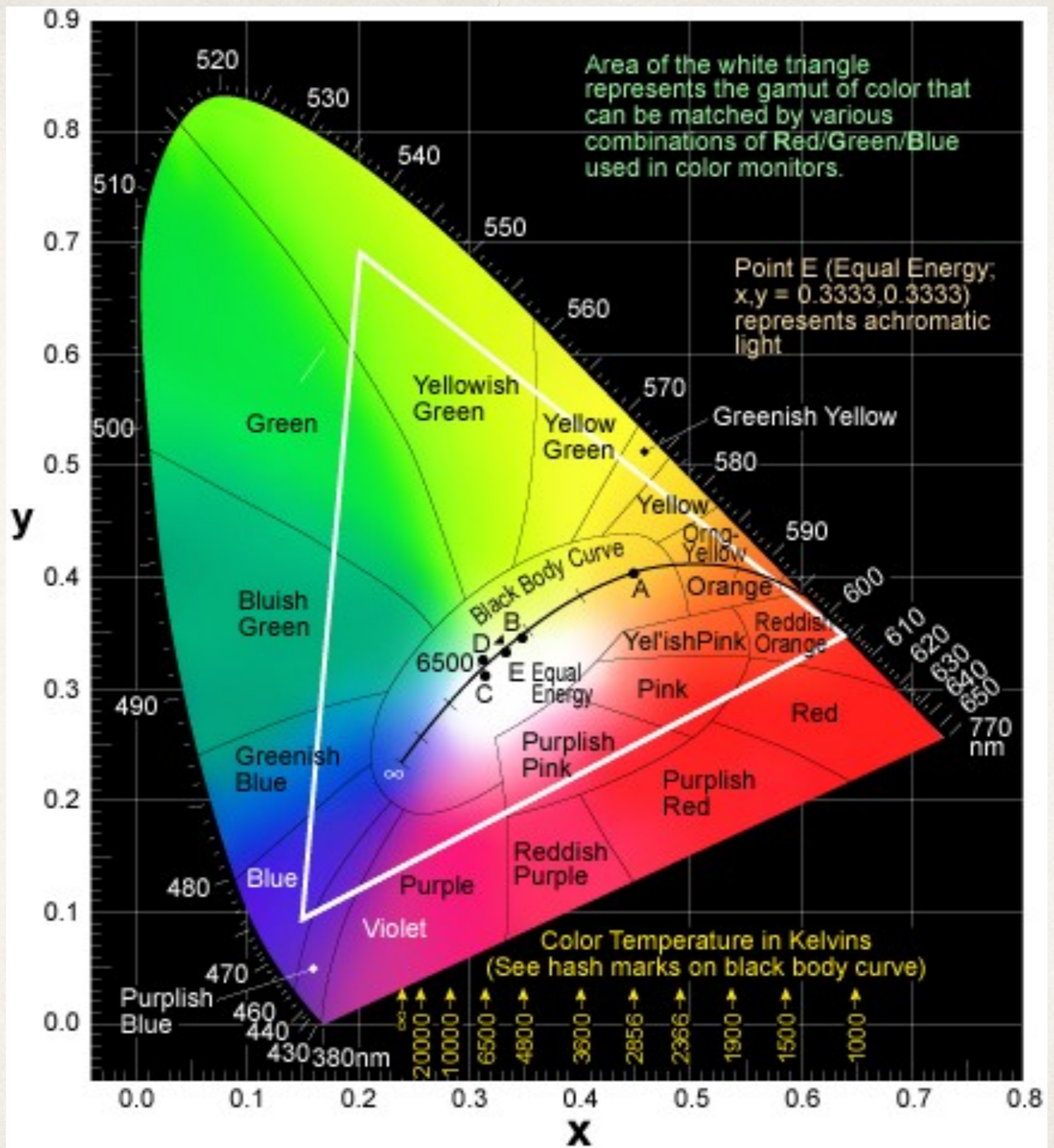
Color gamut

sRGB
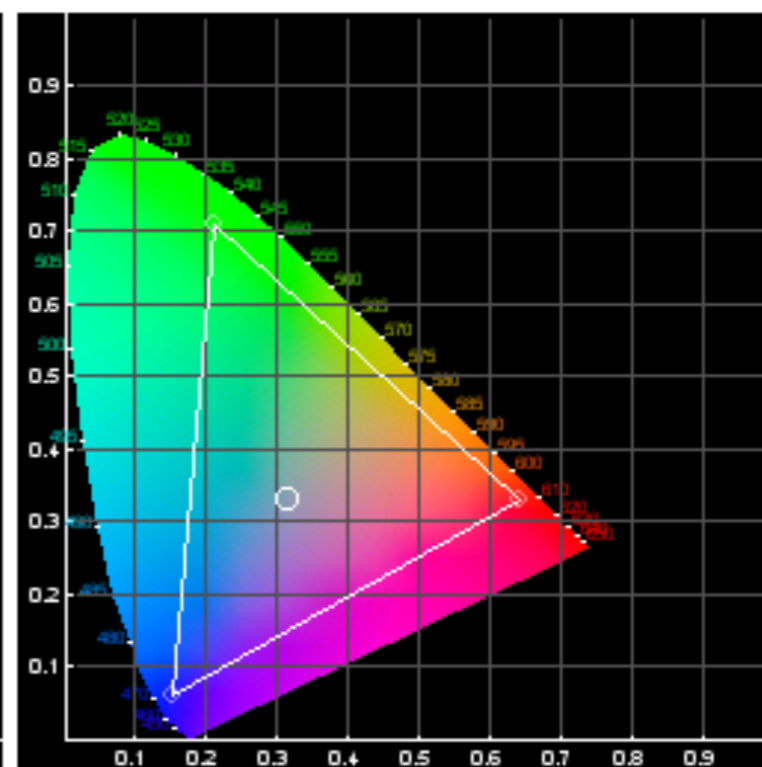
AdobeRGB

ProPhotoRGB
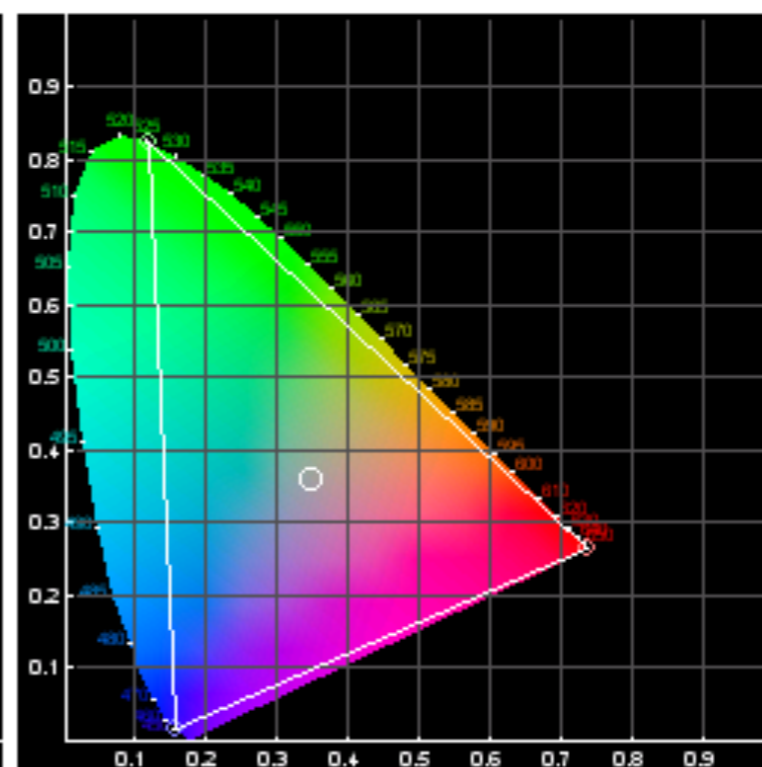
Wide Gamut RGB

Color blindness

Protanopia　　　Deuteranopia　　　Tritanopia

Color blindness

Complementary colors

Complimentary colors

The Cafe Terrace on the Place du Forum
Vincent van Gogh

Simultaneous contrast

Josef Albers

Simultaneous contrast

Josef Albers

Chromatic adaptation

Color Constancy

Chromatic adaptation
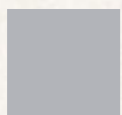
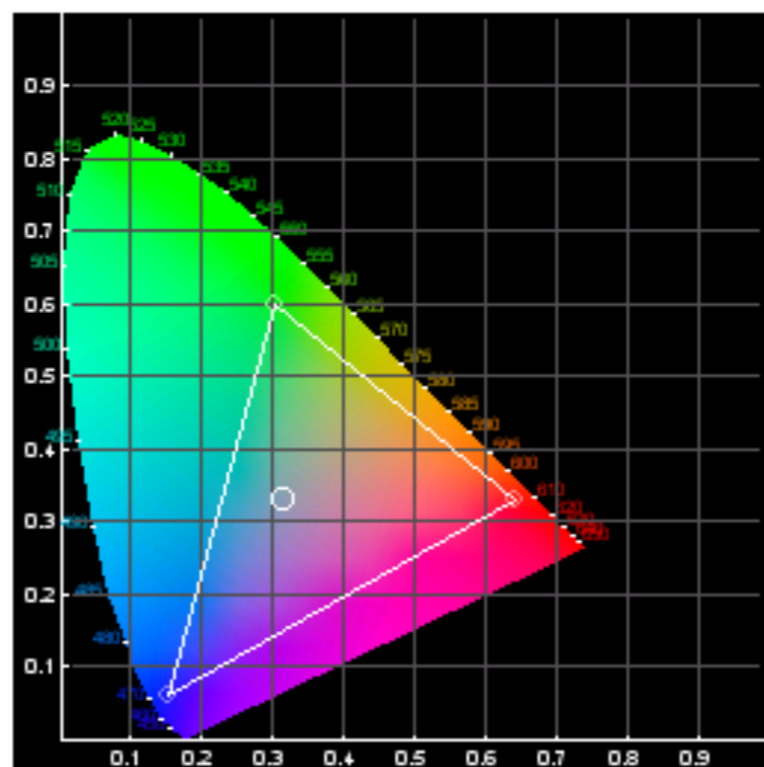Color Constancy

Chromatic adaptation

Color Constancy

210,177,137

178,180,185

253,189,44

242,196,44

Visual aggregation
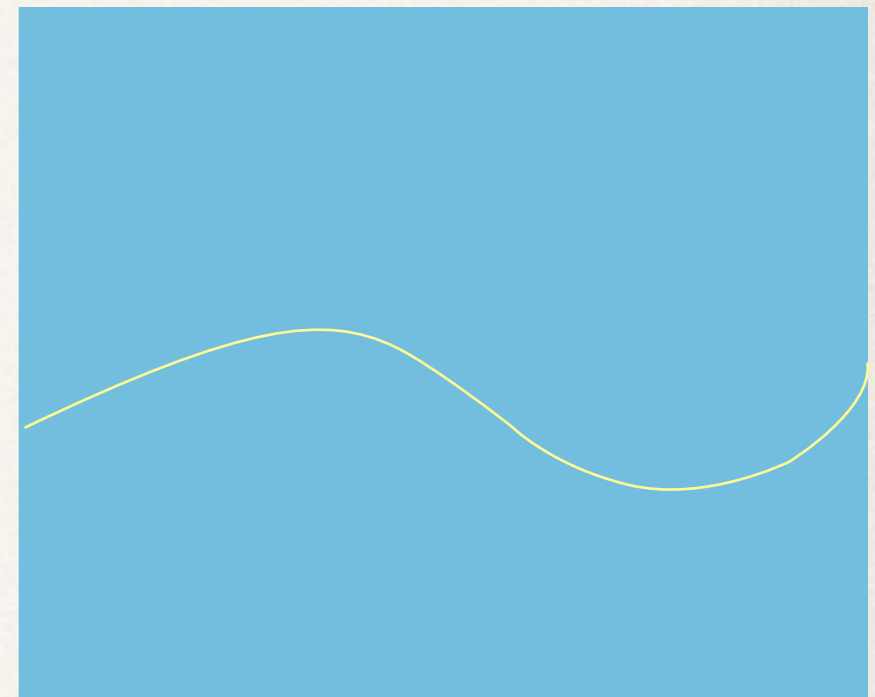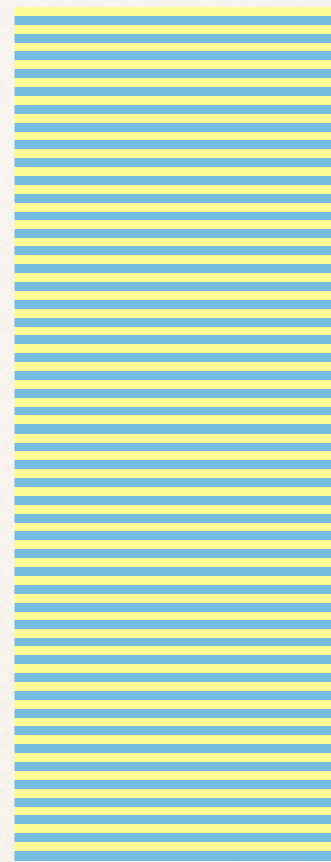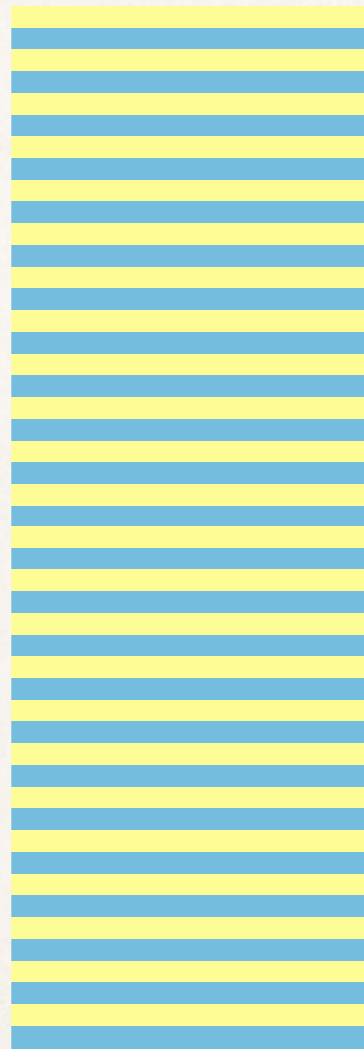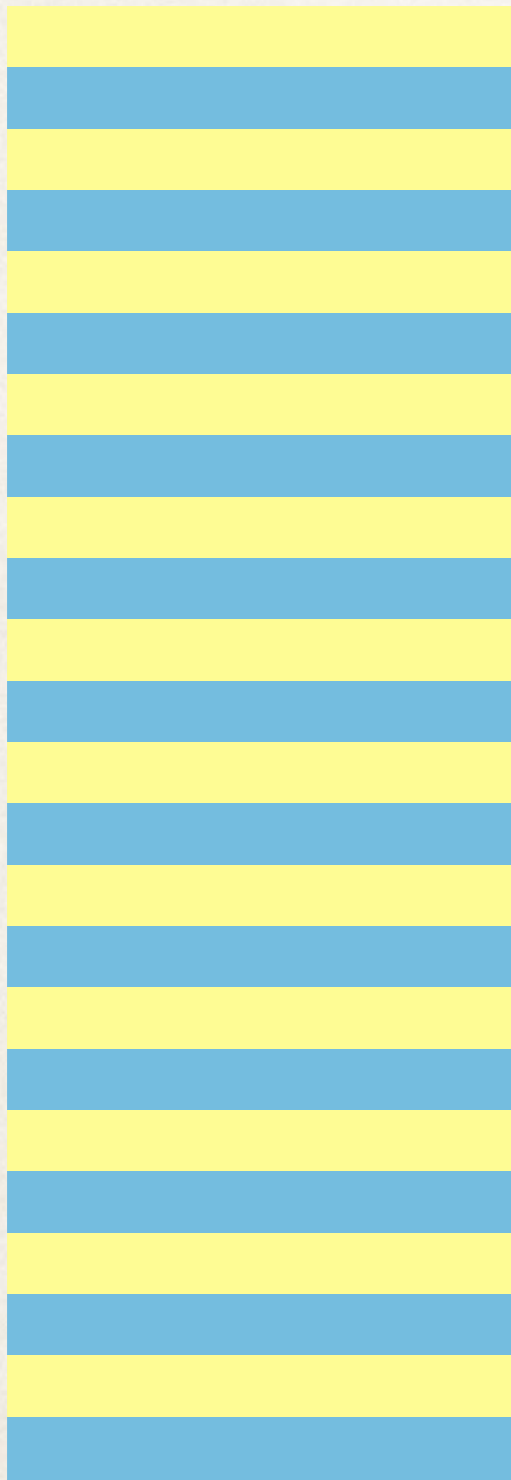
Chromostereopsis

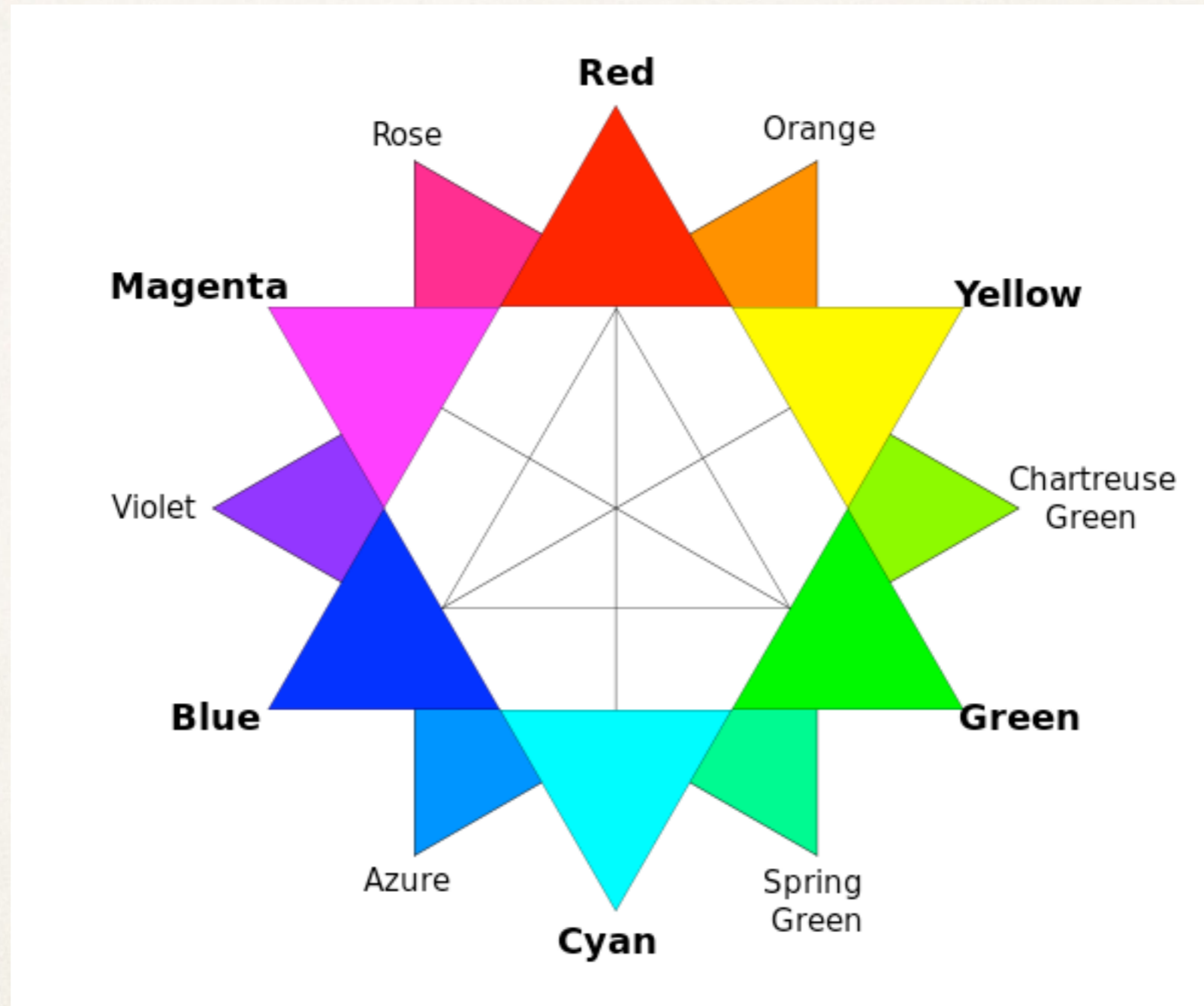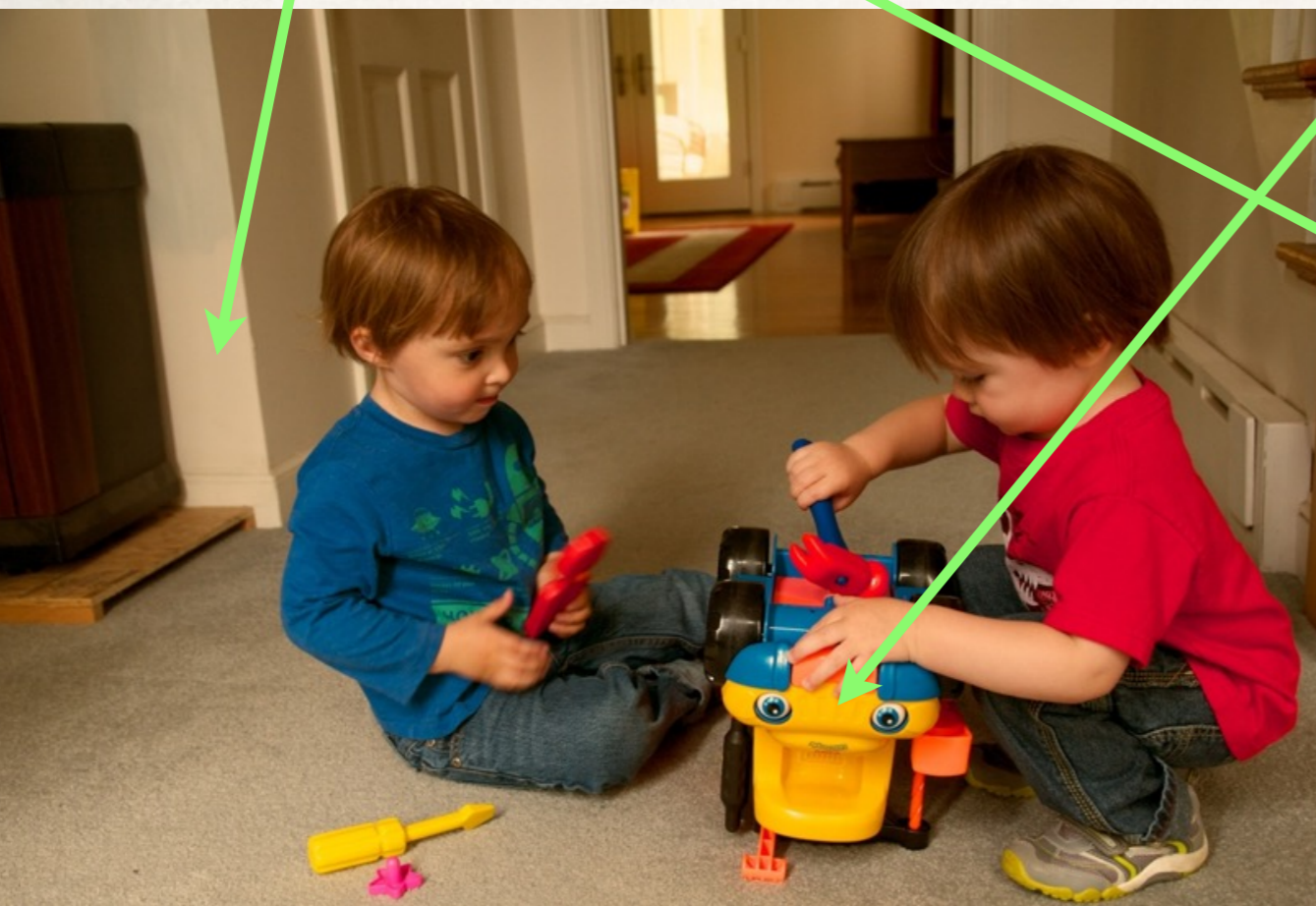Chromostereopsis is the illusion of depth caused by the interactions of two colors, usually red and blue. There are several theories as to what causes this, included chromatic aberration in the eye. Whatever the cause, just don't do it. My eyes will thank you.

Color vs contrast

While color is good for distinguishing between objects, it is important to note that color alone is not enough. If the luminance of two colors is the same, there is no contrast and it becomes very hard to distinguish between the two values.

Effects of size
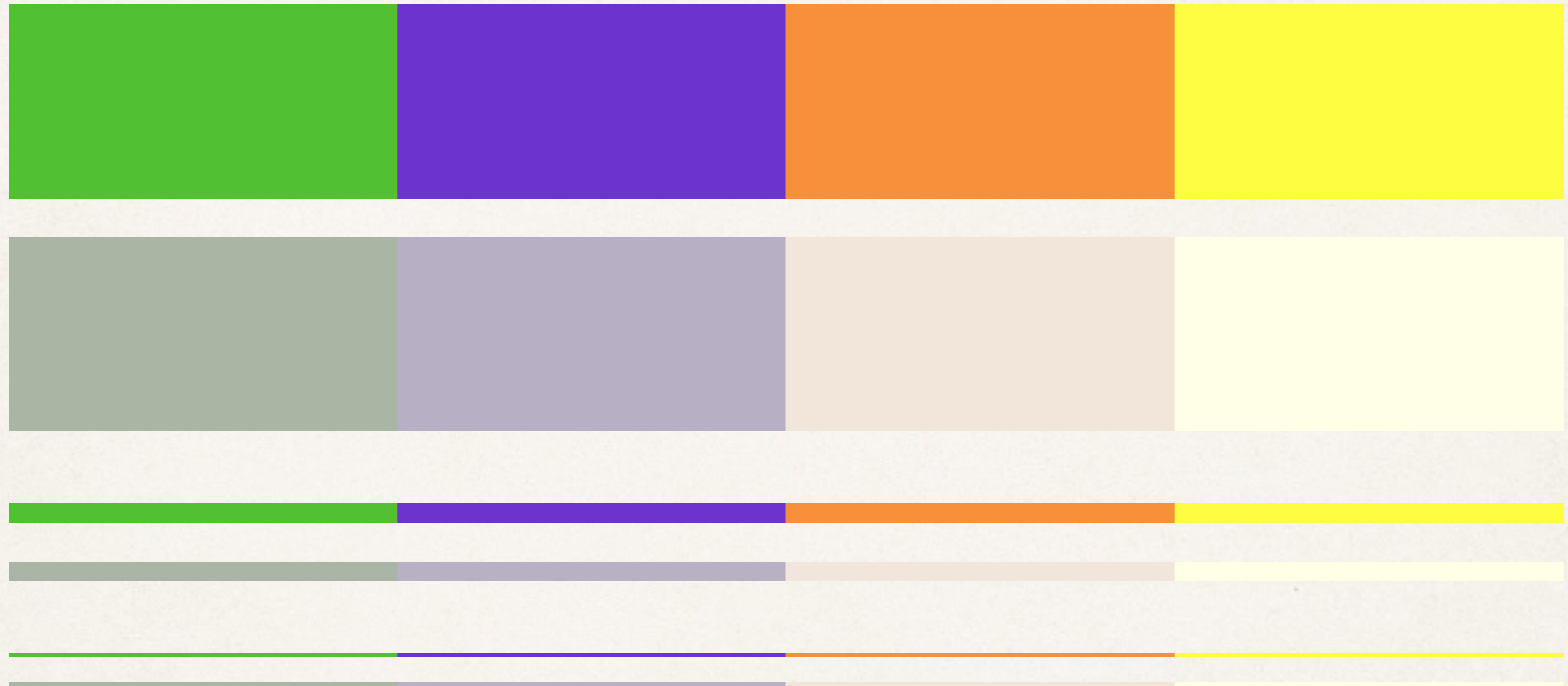
Cultural conventions
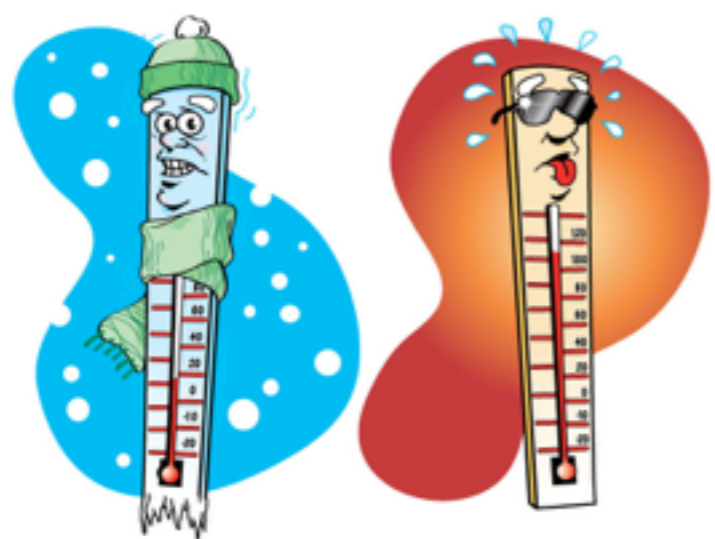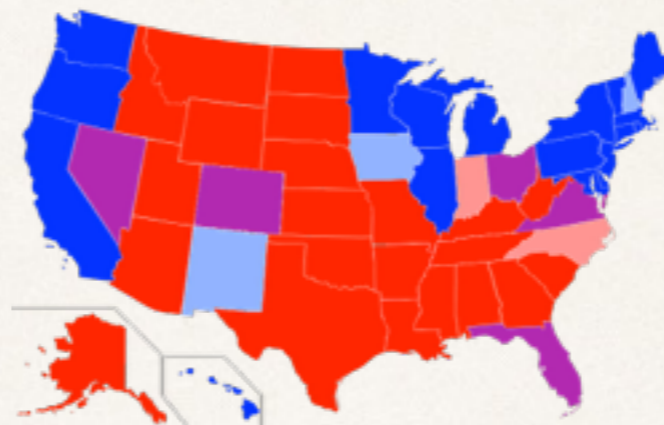
Thoughts about using color

Use only a few colors (~6)

Colors should be named and distinct

As objects get smaller, increase saturation

Make sure you have luminance contrast between figure and ground
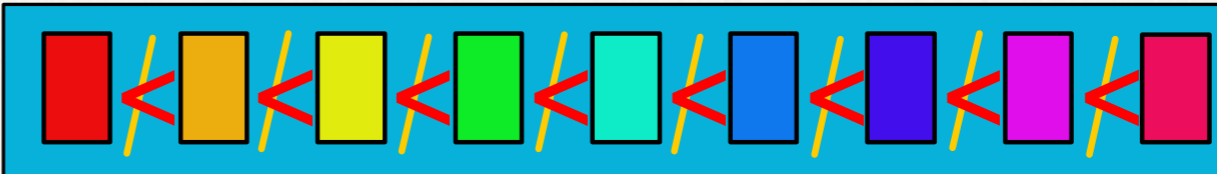
Don't assume color will be perceived the same in multiple contexts

Be attentive to cultural conventions and symbolism

Be aware of bad interactions (like red/blue)

Respect the color blind

Characteristics of color

Rainbow maps
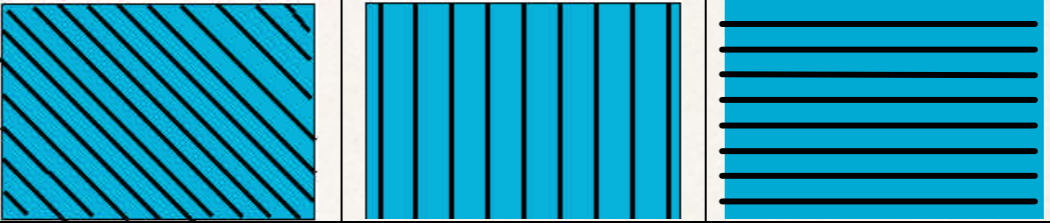
hue is periodic, not monotonic

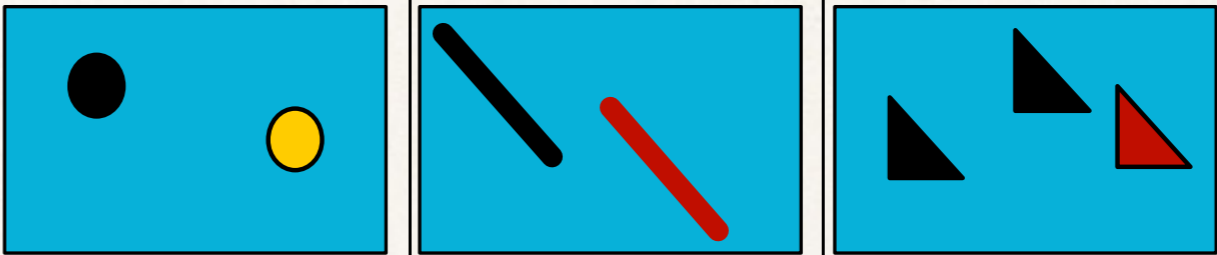# Orientation
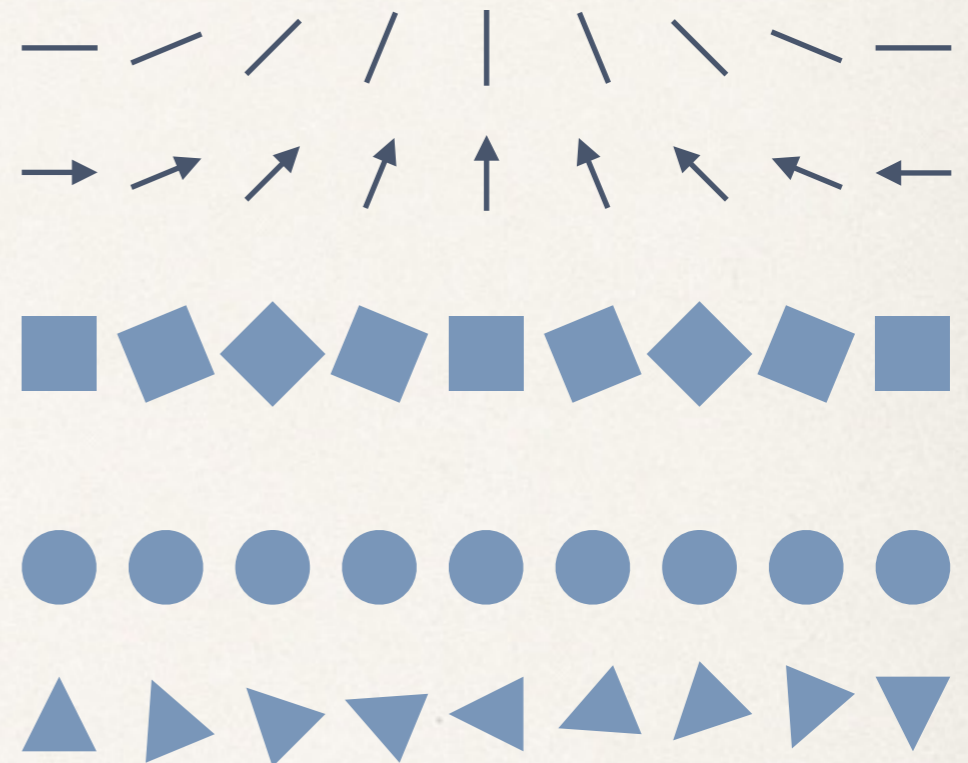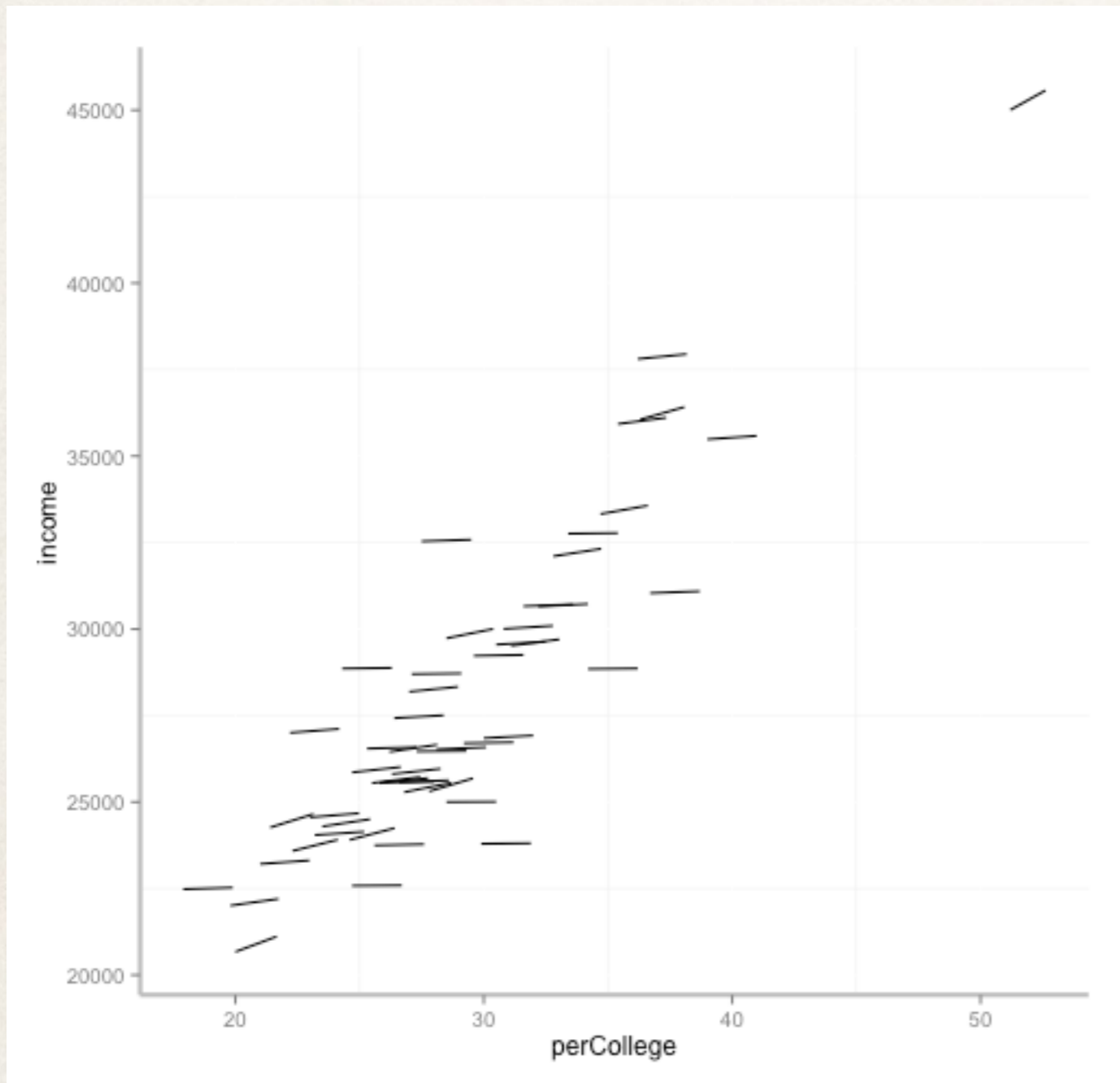
Orientation characteristics

		Visual Variable: Orientation	
✓	Selective		
✓	associative		
≢	Quantitative		
≢	Order		
✓	Length		

Carpendale, "Considering Visual Variables as a basis for Information Visualization."

Texture

Combination of other variables
marks
color
orientation
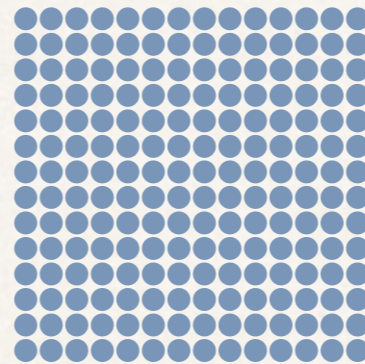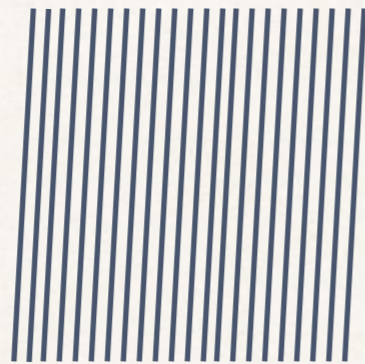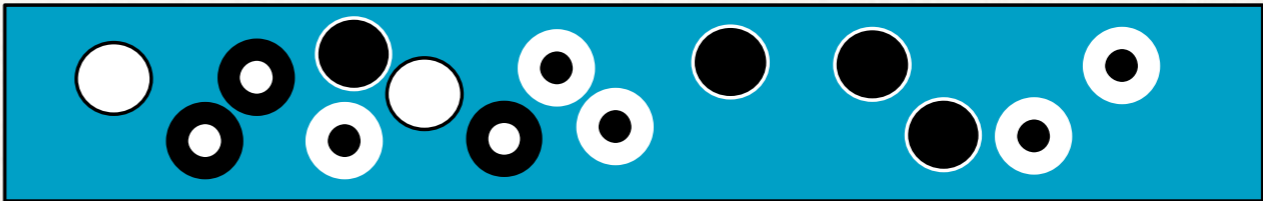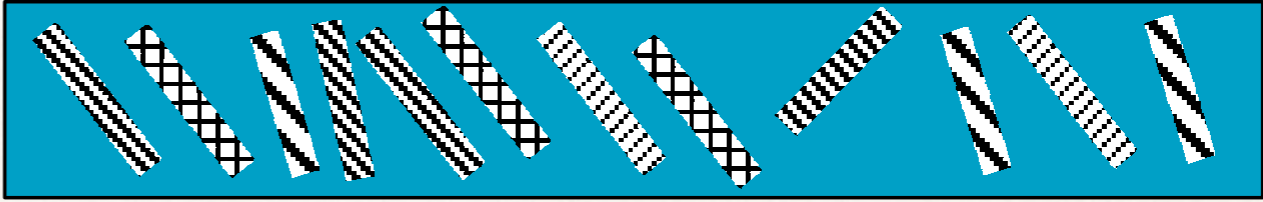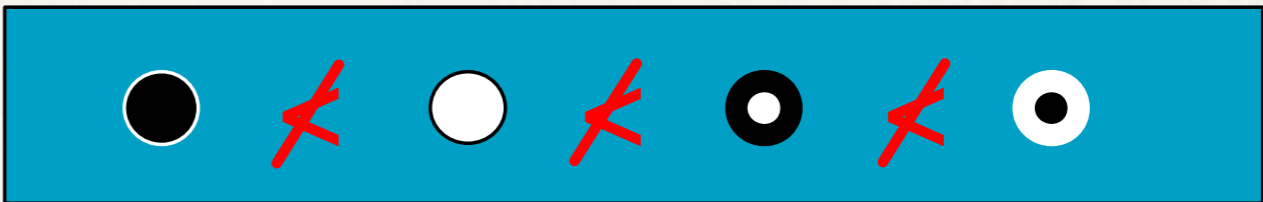
Texture characteristics

		Visual Variable: Grain
✓	Selective	
✓	associative	
≠	quantitative	● = ? ◉ = ?
≠	order	● ≠ ○ ≠ ◉ ≠ ◉
✓	Length	• theoretically infinite but practically limited association and selection ~ < 5

Carpendale, "Considering Visual Variables as a basis for Information Visualization."

Motion

Hans Rosling: The best stats you've ever seen
http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html
http://www.gapminder.org

Summary of characteristics

	selective	associative	quantitative	order	length
position	✓	✓	✓	✓	✓
shape	maybe	maybe	✗	✗	✓
size	✓	✓	maybe	✓	✓
brightness	✓	✓	✗	✓	✓
color	✓	✓	✗	✗	✓
orientation	✓	✓	✗	✗	✓
texture	✓	✓	✗	✗	✓

Picking an encoding

Principle of Consistency

The properties of the image (visual variables) should match the properties of the data

Principle of Importance Ordering

Encode the most important information in the most effective way

Quantitative estimation ranking

most accurate

least accurate

position, aligned scale

position, identical nonaligned scales

length

angle, slope

area, volume

color

Cleveland and McGill, 1984

Mackinlay's ranking of encodings

Quantitative	Ordinal	Nominal
position	position	position
length	density	hue
angle	saturation	texture
slope	hue	connection
area	texture	containment
volume	connection	density
density	containment	saturation
saturation	length	shape
hue	angle	length
texture	slope	angle
connection	area	slope
containment	volume	area
shape	shape	volume