CogSci109 Lecture 8

Mon, Oct. 15, 2007

More color theory, visualization, effective representation

Outline for today (Part I)

- Announcements
  - **Homework 2 grade back wed**
  - **Homework 3 is online**
    - Description
    - FAQ
- Quick review and remider of motivation

Outline for today (Part II)

- Visualization II - representing your data and communicating basic results effectively (part A)
  - **Being sensitive to perception**
    - Contrast tables
      - **How contrast tables can be used to improve how you communicate results**
    - Mach Banding
      - **Perceptual boundary phenomena and proper use**
    - Context-dependence of colors and lightness
      - **Use context of colors to emphasize differences or create subtle flow**

Outline for today (Part III)

- Visualization II - representing your data and communicating basic results effectively (Part B)
  - **Encoding information**
    - Color models
      - **RGB, CMY, HSV**
      - **Geometric representation**
    - False color representation and color maps to expose hidden info
      - **Typical color maps**
  - **Know your output media**
    - Color gamuts
      - **printers, displays, video, etc**
      - **relation to perceptual gamuts**
    - Strengths and weaknesses of display technologies

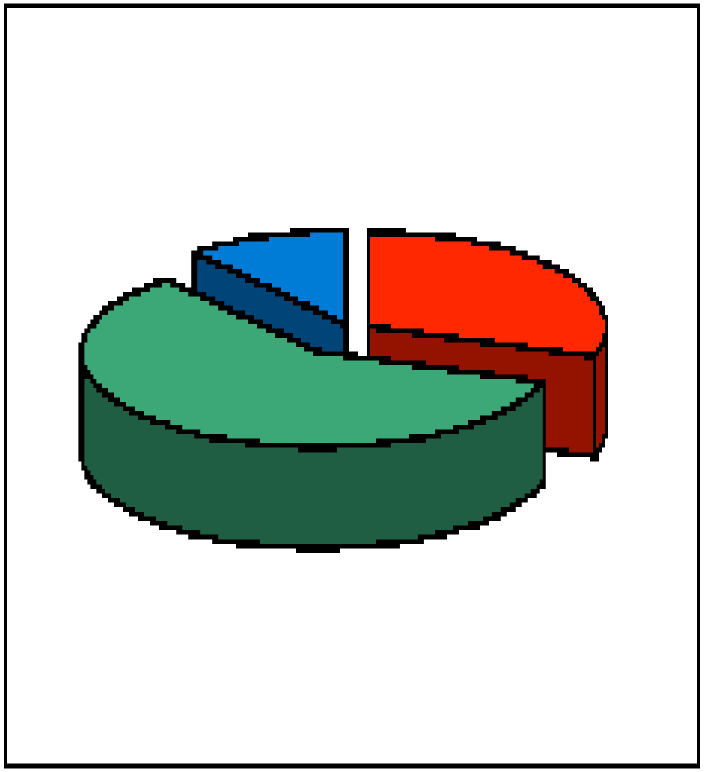
Quick reminder - why are we studying visualization?

- Human brain has trouble making sense of large amounts of data produced by computational modeling and experimentation
- As more computational methods are applied, more and more information is being created
- Scientific visualization is one way of making important information explicit and simple to process

Luminance equation reviewed

- Perceived intensity due to a color
  - Different contributions of red/green/blue components
  - Empirically determined

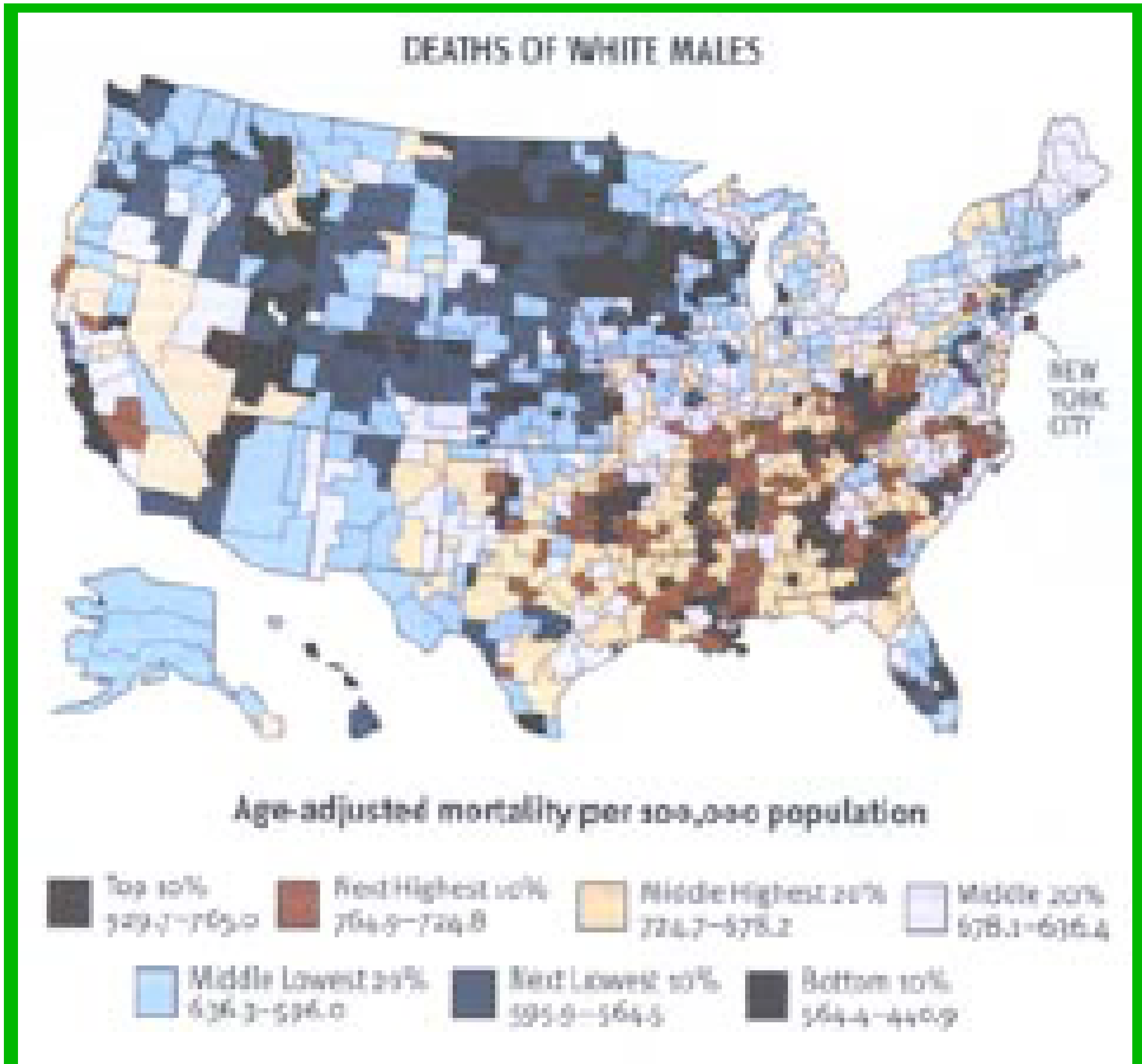
$$Y = .30*Red + .59*Green + .11*Blue$$



≈ Contrast Table

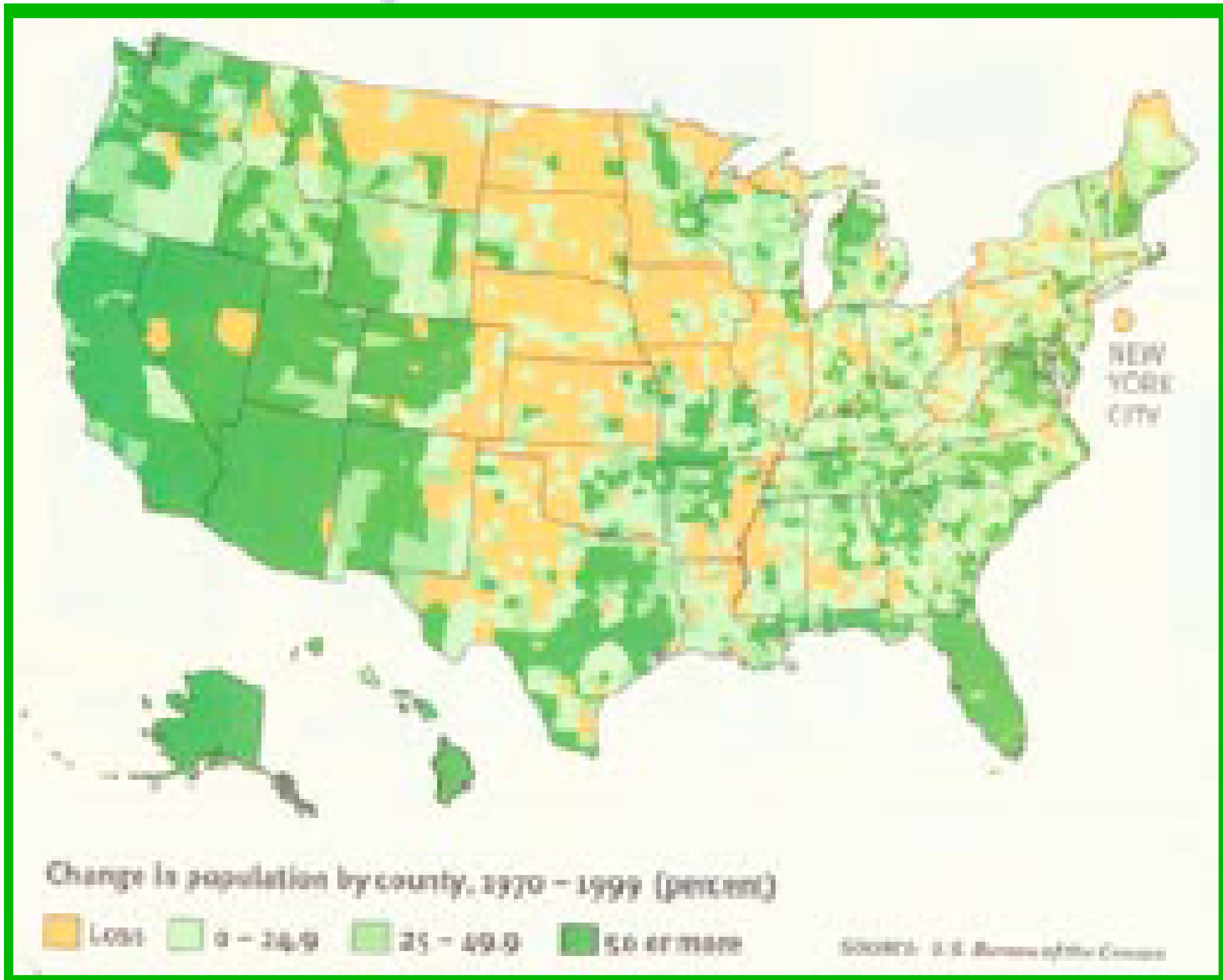
	Black	White	Red	Green	Blue	Cyan	Magenta	Orange	Yellow
Black	0.00	1.00	0.30	0.59	0.11	0.70	0.41	0.60	0.89
White	1.00	0.00	0.70	0.41	0.89	0.30	0.59	0.41	0.11
Red	0.30	0.70	0.00	0.29	0.19	0.40	0.11	0.30	0.59
Green	0.59	0.41	0.29	0.00	0.48	0.11	0.18	0.01	0.30
Blue	0.11	0.89	0.19	0.48	0.00	0.59	0.30	0.49	0.78
Cyan	0.70	0.30	0.40	0.11	0.59	0.00	0.29	0.11	0.19
Magenta	0.41	0.59	0.11	0.18	0.30	0.29	0.00	0.19	0.48
Orange	0.60	0.41	0.30	0.01	0.49	0.11	0.19	0.00	0.30
Yellow	0.89	0.11	0.59	0.30	0.78	0.19	0.48	0.30	0.00

What's Wrong with this Picture?



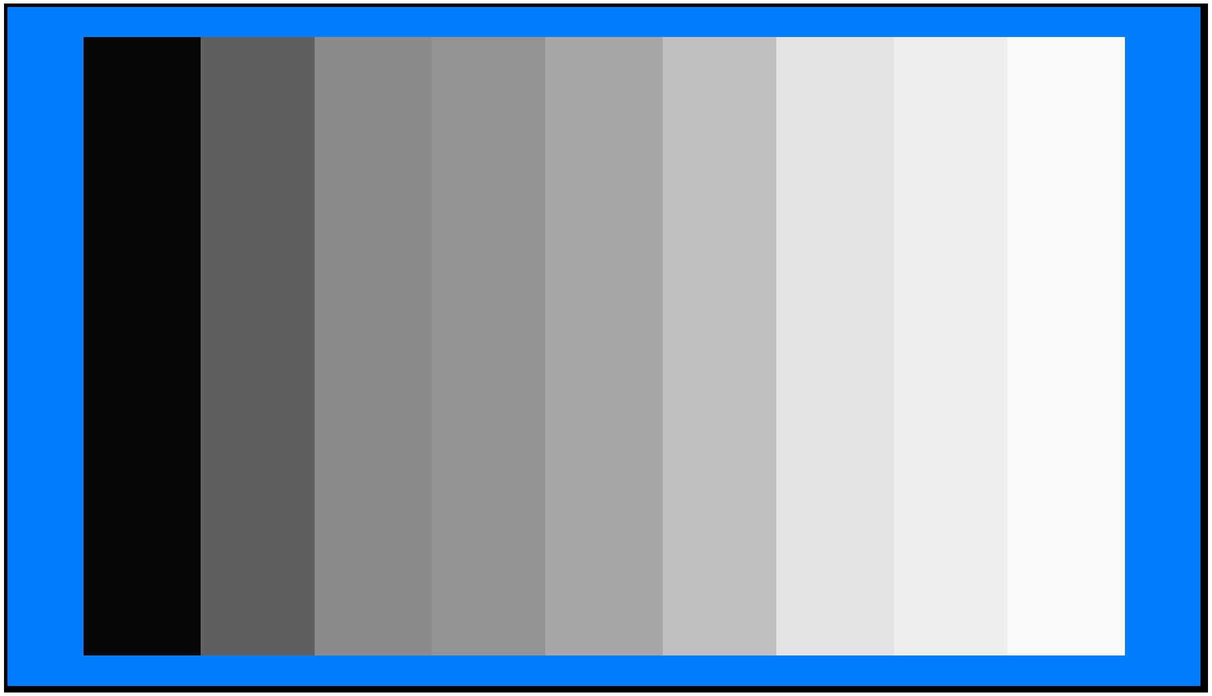
Source:
Scientific American,
June 2000

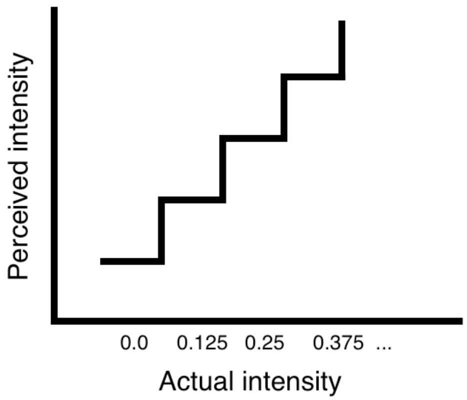
What's Right with this Picture?

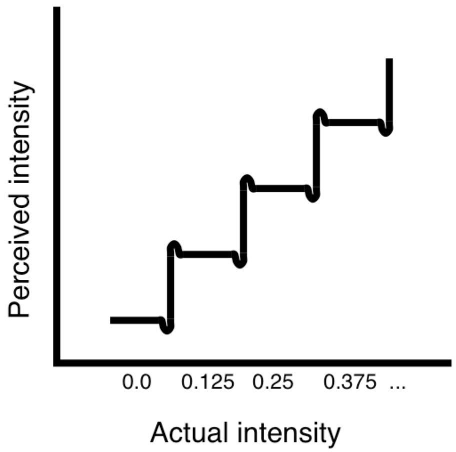


Source:
Scientific American,
August 2000

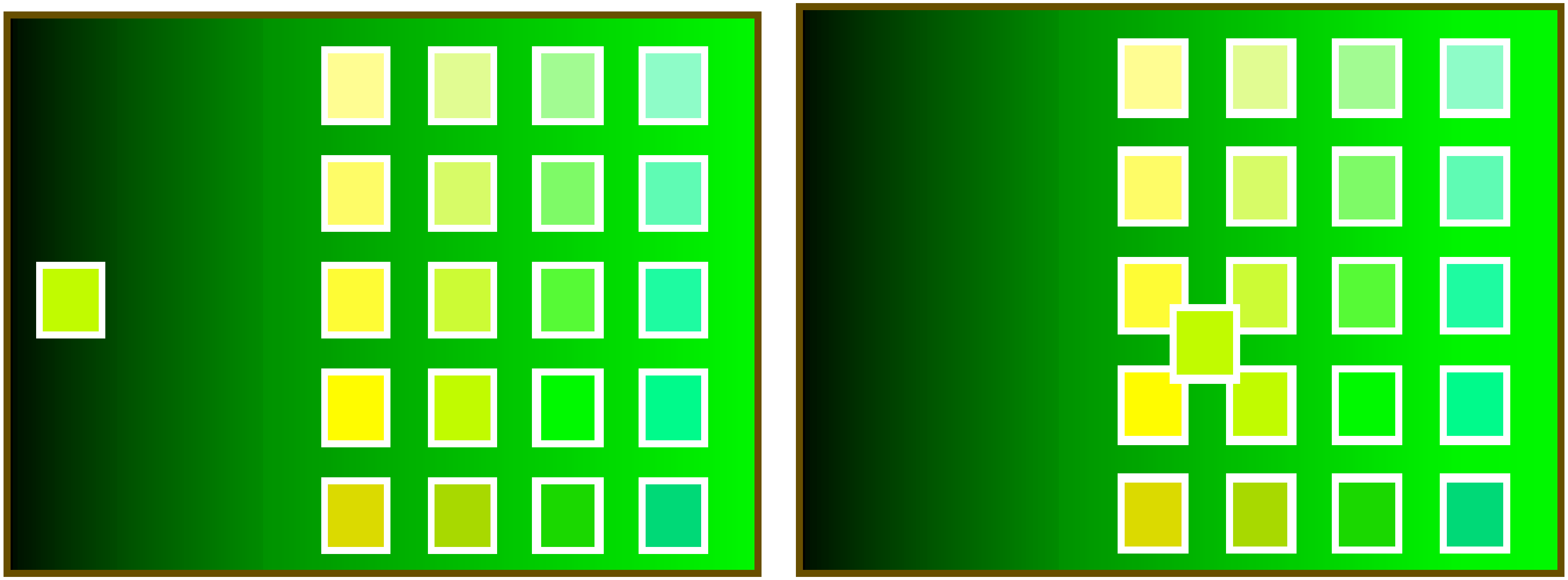
Beware of Mach Banding





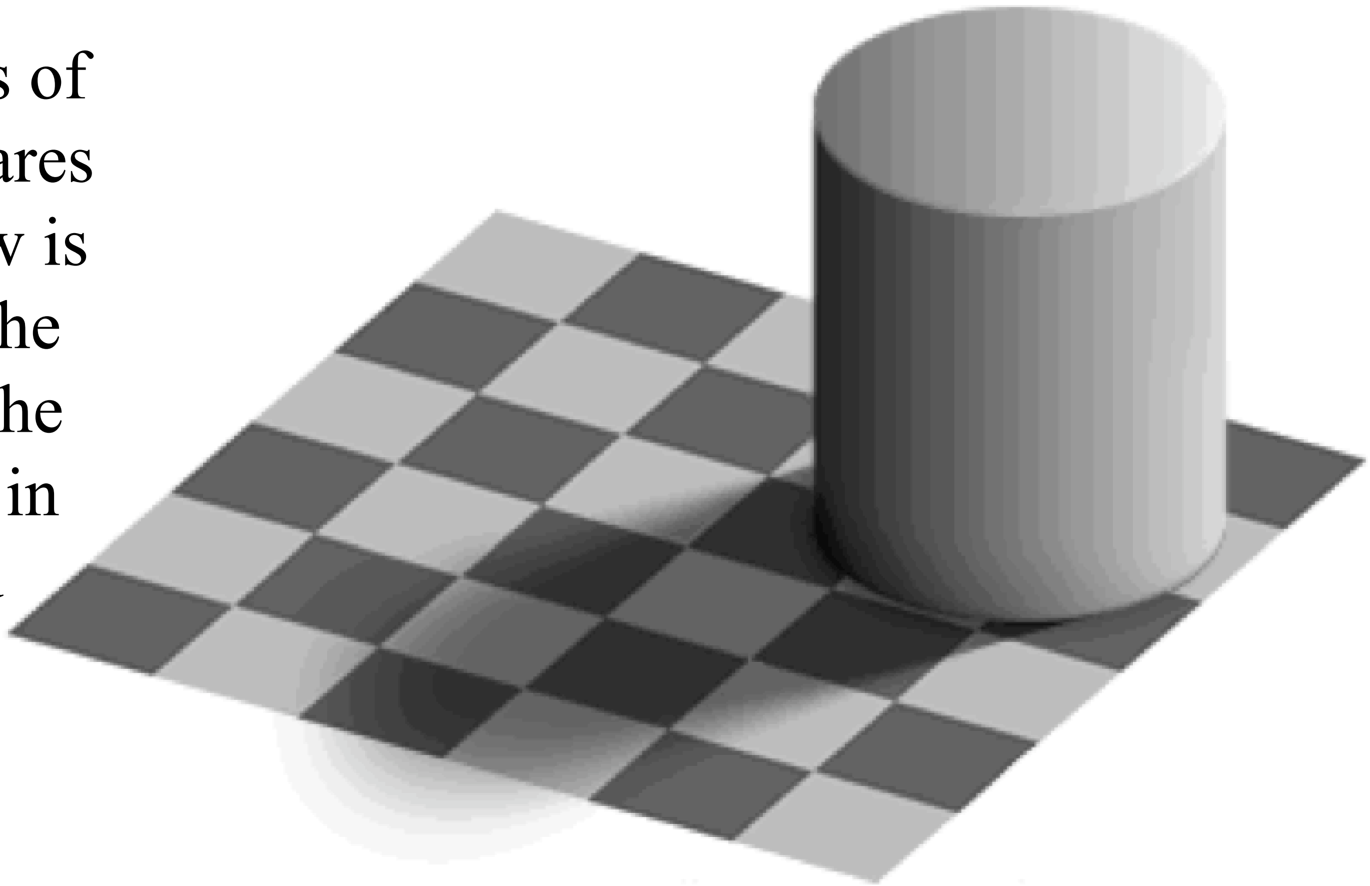


Recall that perceived color intensity is also context-dependent



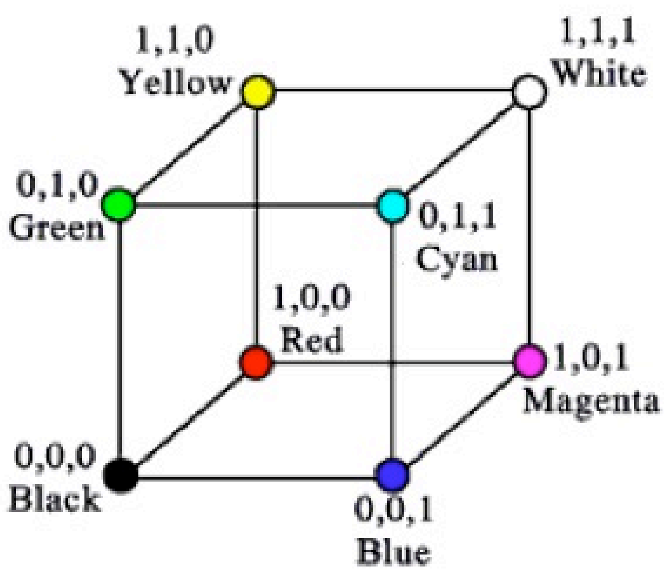
Perceived lightness is context-dependent as well

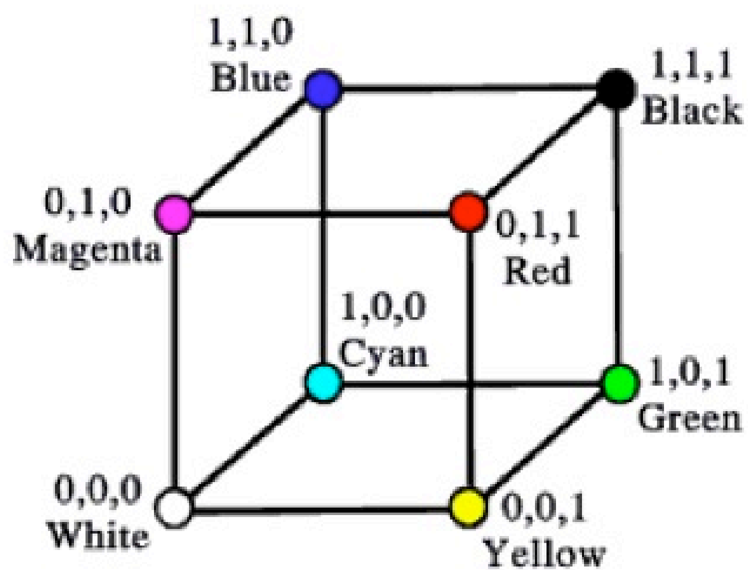
- The lightness of the light squares in the shadow is the same as the lightness of the dark squares in the unshaded region



RGB and CMY color cubes

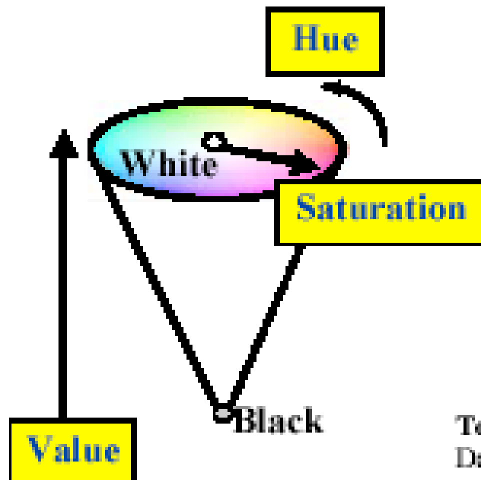
- Map (r,g,b)->(x,y,z) or (c,m,y)->(x,y,z)
- Combinations of primary color components (R, G, B) use to produce any desired color
- The two spaces are complements of each other





HSV color cone

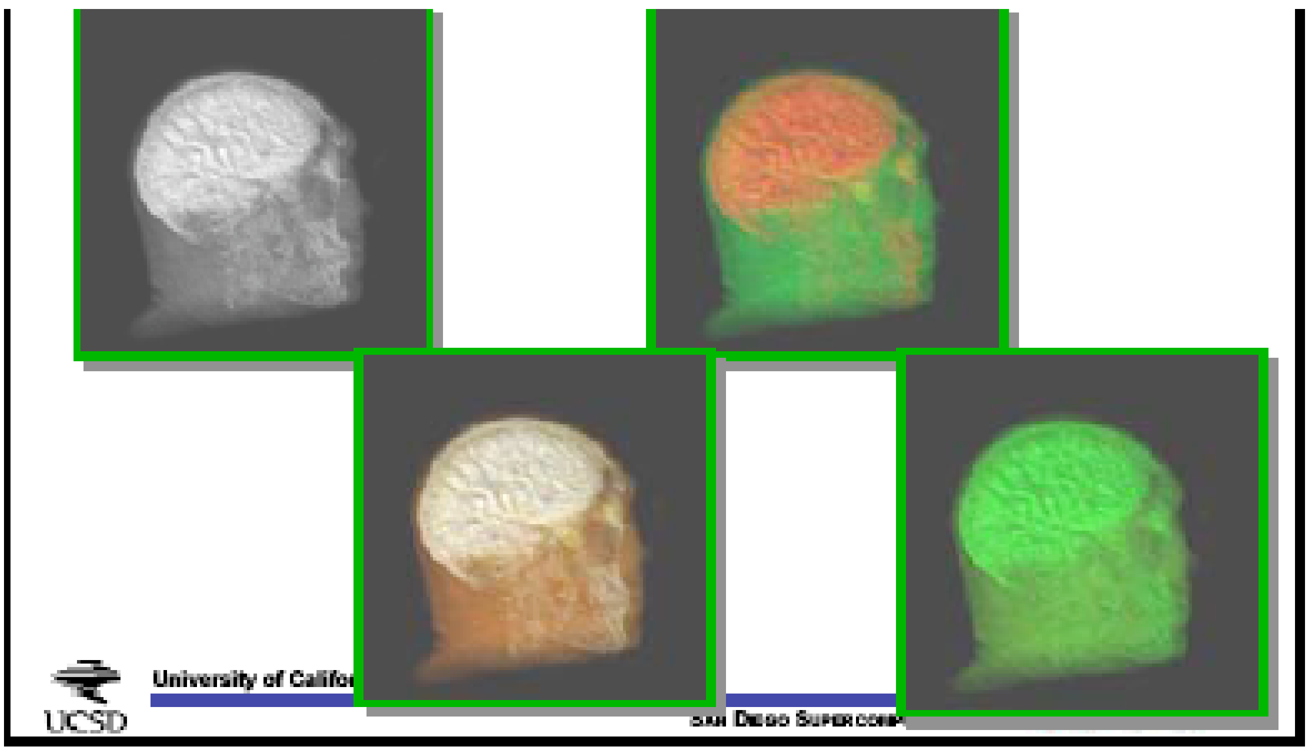
- Hue
  - **the various colors we perceive**
  - **Each has its own unique wavelength**
- Saturation
  - **Also called chroma**
  - **Comparison of color to neutral gray**
  - **Richness of color**
  - **100% - pure color, 0% gray**
- Value
  - **Lightness or darkness of a hue, or achromatic color**
  - **Lower when darker, higher when lighter**



To convert from HSV to RGB, see: Foley, Van Dam, Feiner, and Hughes, *Computer Graphics: Principles and Practices*, Addison-Wesley, 1990.

False color representation and color maps

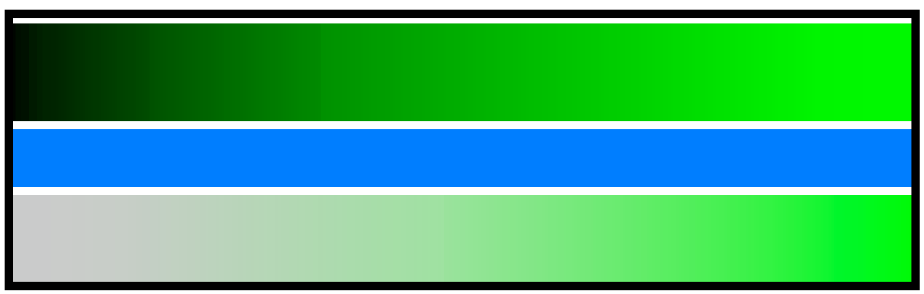
- Map values from any range to a map of colors
  - **(ie a matrix of 0-1 range -> white-black)**



Typical color maps

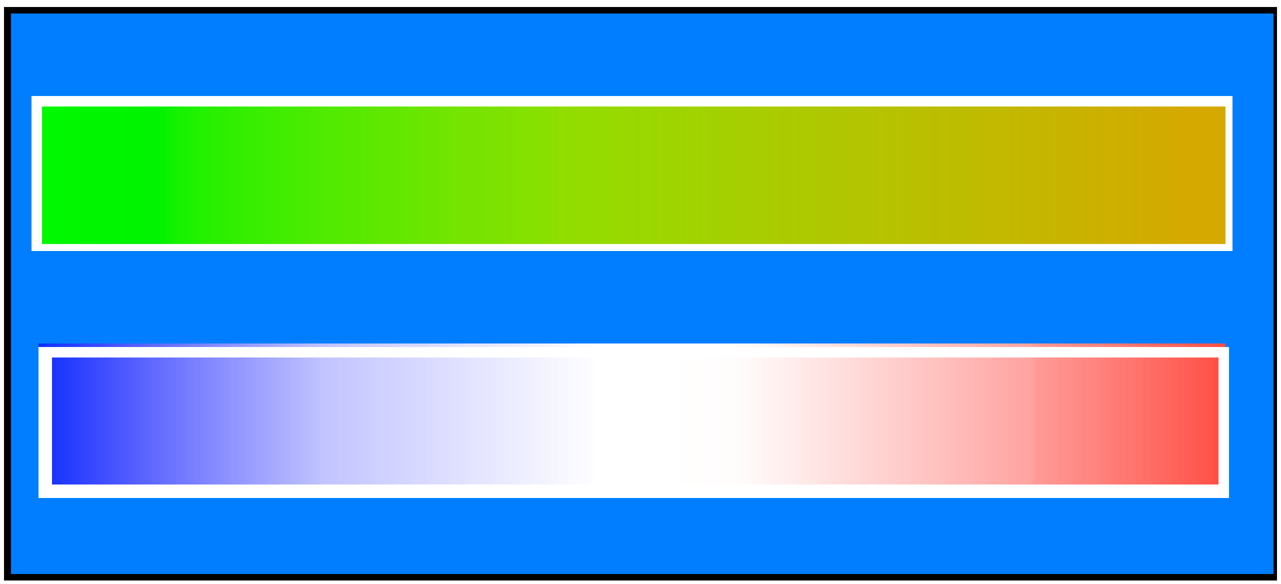
- **Gray scale** – get gray by setting all three color values to the same

- **Intensity and saturation color scales**- we often feel intuitively that black means nothing



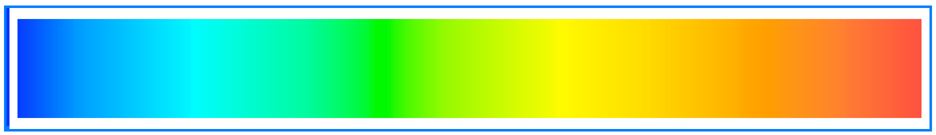
More color maps

•**Two color interpolation** – blue->red, interesting, bad visually, but strong meaning
•Generally you put white in center, otherwise magenta in middle means nothing



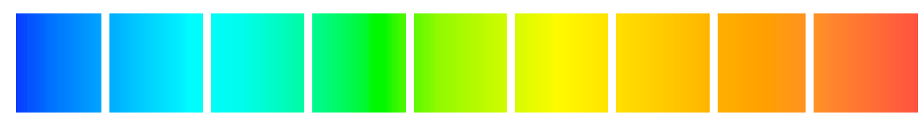
A few more color maps

- **Rainbow color scale** – magenta is not directly in the em spectrum



- **Heated object color scale** – intensity increases left -> right

- **Color scale contours**



Different display technologies have different limitations

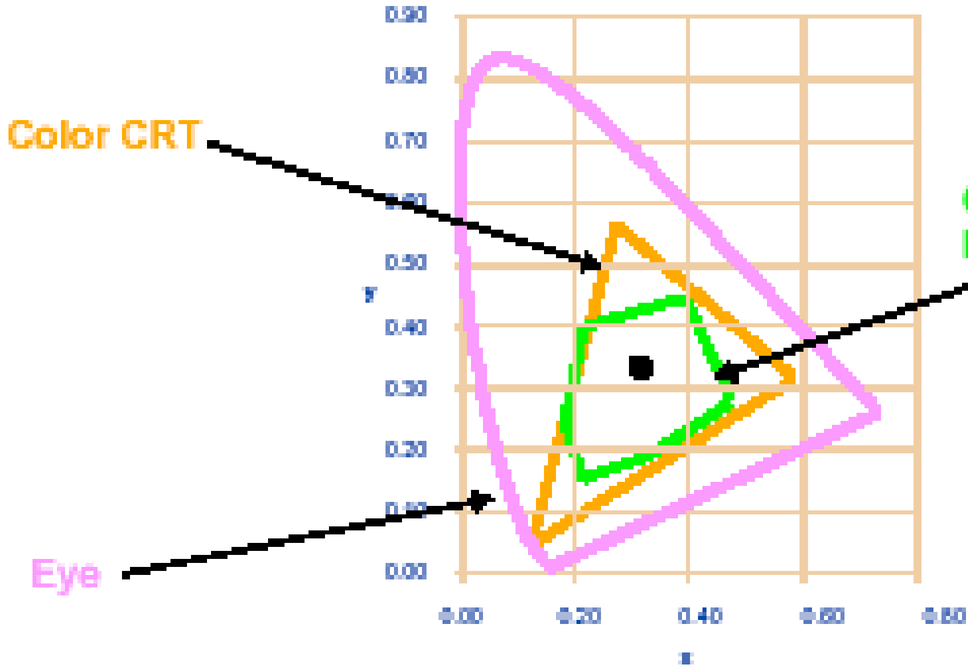
- CRT
  - Widest color gamut
  - Fast refresh for high performance VR applications
  - Still narrower gamut than human perception
  - Cheaper than LCDs
  - Multiple resolutions
- LCD
  - Slow response (‘refresh’)
  - Less colors than CRT typically, but improving
  - Tough
  - Not good for extreme temperatures
  - Multiple resolutions are interpolated, not true changes

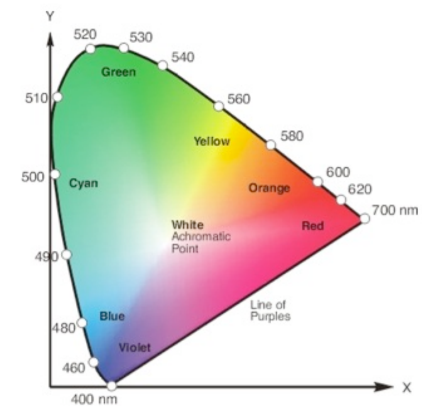
More on different displays

- Color printer
  - **Subtractive color**
  - **Narrow color gamut**
  - **Realize that you may have a $500 color printer with photorealistic detail IF you use the special paper, but others may not**
- NTSC TV
  - **Narrow color gamut, slow refresh, interlacing**
- Film
  - **Fairly wide color gamut**
  - **Good resolution typically**

Comparison of typical color gamuts

- Try to stay away from the regions which cannot be printed when creating images for papers, or convert them beforehand





Output

- If you are creating visualizations for multiple contexts (video, computer monitors, printed papers, faxes, etc) be aware of device limitations
- Use redundant encoding of information if you don't know what the output is or who will be looking at it
  - **Different fonts**
  - **Symbols**
  - **Fill pattern**
  - **Outline pattern**
  - **Outline thickness**

A final word about colors…

- Just because you *have* 2^{24} different colors
- Doesn't mean you have to use them all…