Luminance and Color Images

- Luminance
  - Monochromatic
  - Values are gray levels
  - Analogous to working with black and white film or television
- Color
  - Has perceptional attributes of hue, saturation, and lightness
  - Do we have to match every frequency in visible spectrum? No!

Reflectance

- Reflected light at each wavelength is the product of illumination and surface reflectance
- Surface reflectance can typically be modeled as having two components:
  - Lambertian reflectance: equal in all directions (diffuse)
  - Specular reflectance: mirror reflectance (shiny spots)

Color Mixing

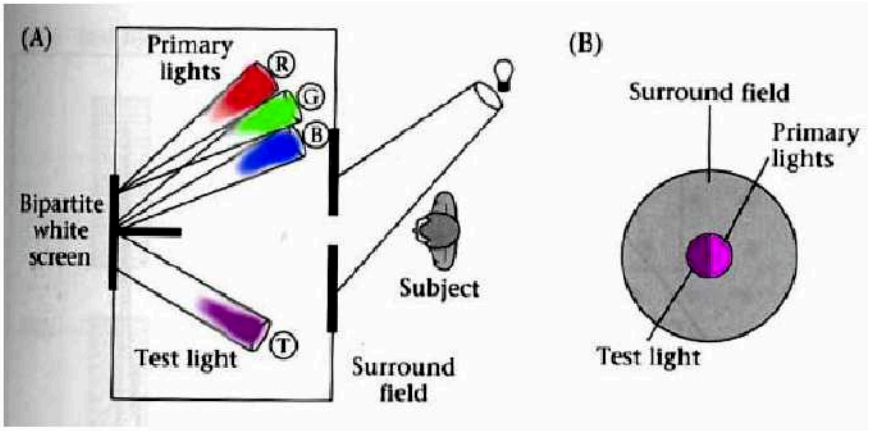
- Additive: When colors combine by adding their spectra. E.G. red and green make?
  - CRT/LCD monitors
  - Slide Film
- Subtractive/Multiplicative: When colors combine by multiplying their spectra. E.G. cyan and yellow make?
  - photographic film
  - paint
  - crayons

Additive and Subtractive Color

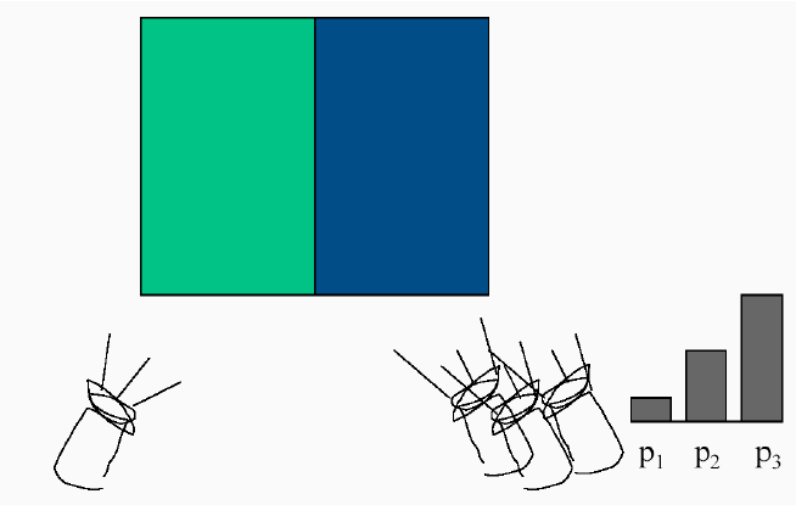
- Additive color
  - Form a color by adding amounts of three primaries
    - CRTs, projection systems, positive film
  - Primaries are Red (R), Green (G), Blue (B)
- Subtractive/Multiplicative color
  - Form a color by filtering white light with cyan (C), Magenta (M), and Yellow (Y) filters
    - Light-material interactions
    - Printing
    - Negative film

Color Matching Experiments

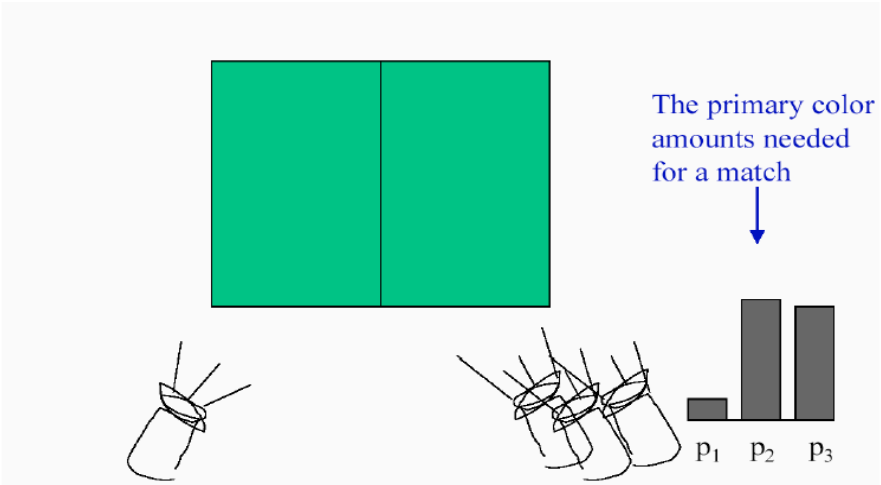
CREDIT: Many slides in this section from Jim Rehg and Frank Dellaert and much of the material is from David Lowe's course lecture 9.



Color Matching



Color Matching



Color Matching

- Many colors can be represented as a positive weighted sum of A, B, C

  M=a A + b B + c C

  where the = sign should be read as "matches"
- This is additive matching.
- Gives a color description system - two people who agree on A, B, C need only supply (a, b, c) to describe a color.

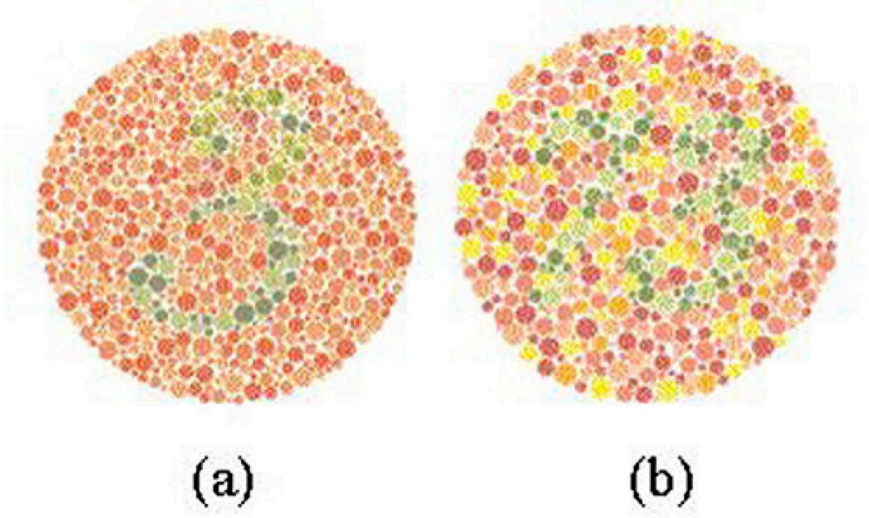
Subtractive Matching

- Some colors must be matched like this:
  M + a A = b B + c C
- This is subtractive matching.
- Interpret this as (-a, b, c)
- Problem for building monitors: Choose R, G, B such that positive linear combinations match a large set of colors

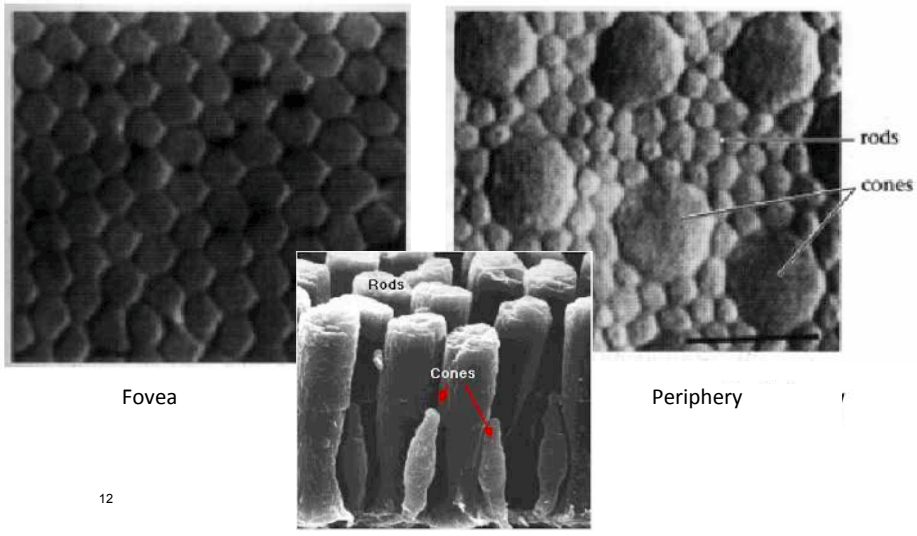
The principle of Trichromacy

- Three primaries will work for most people if we allow subtractive matching
  - Exceptional people can match with two or only one primary.
  - This could be caused by a variety of deficiencies.
- Most people make the same matches.
  - There are some anomalous trichromats, who use three primaries but make different combinations to match.

Color Blindness



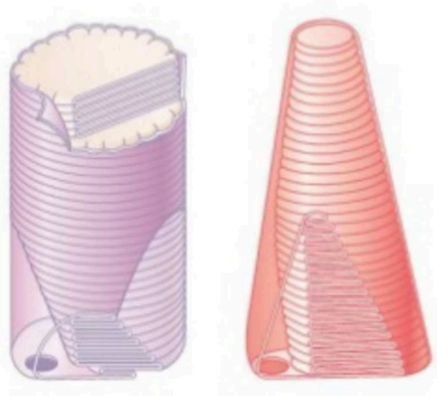
Human Receptors



Fovea

Periphery

Rods and Cones



Distribution of Rods and Cones

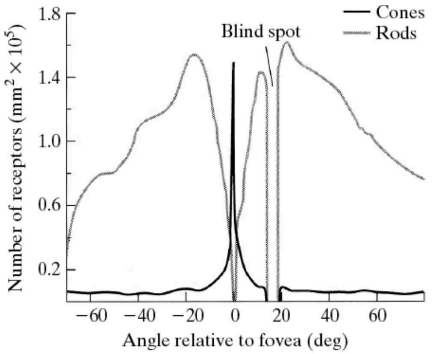
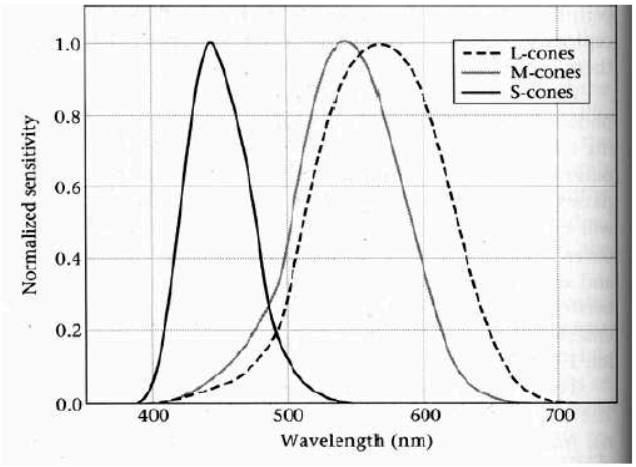
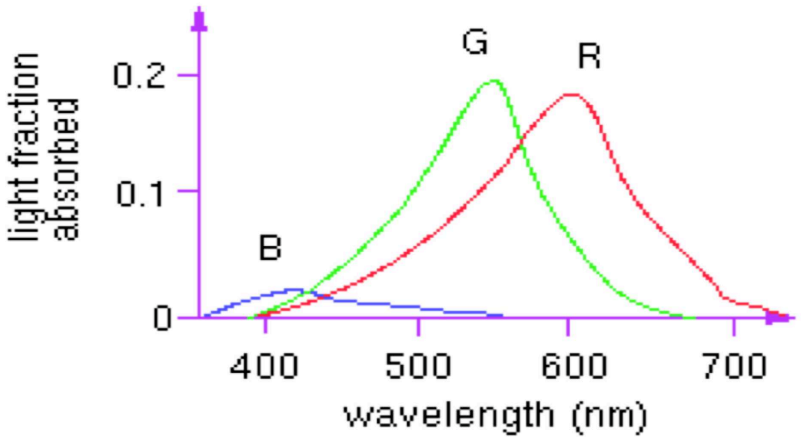


Figure 1.15 The distribution of rods and cones across the retina. *Reprinted from FOUNDATIONS OF VISION, by B. Wandell, Sinauer Associates, Inc., (1995). © 1995 Sinauer Associates, Inc.*

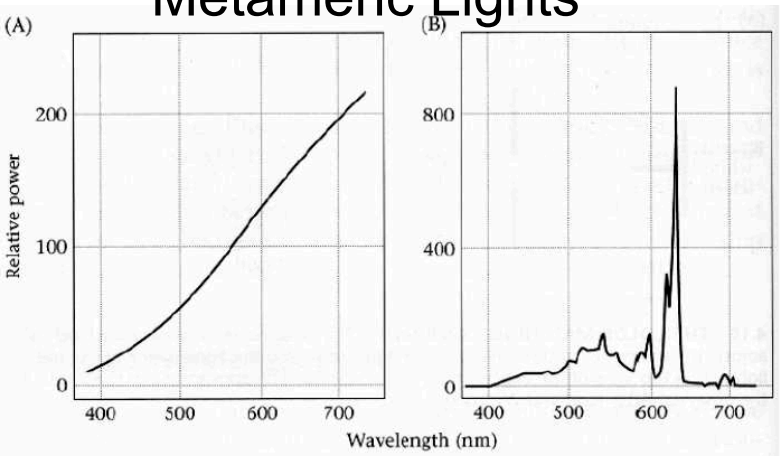
Sensitivities



Absolute Sensitivities



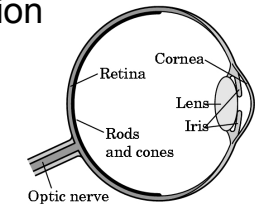
Metameric Lights



4.11 METAMERIC LIGHTS. Two lights with these spectral power distributions appear identical to most observers and are called metamers. (A) An approximation to the spectral power distribution of a tungsten bulb. (B) The spectral power distribution of light emitted from a conventional television monitor whose three phosphor intensities were set to match the light in panel A in appearance.

Three-Color Theory

- Human visual system has two types of sensors
  - Rods: monochromatic, night vision
  - Cones
    - Color sensitive
    - Three types of cone
    - Only three values (the *tristimulus* values) are sent to the brain



- Need only match these three values
  - Need only three *primary* colors