Visual Effects and Human Vision
Anatomy of the Eye

The Human Eye

Cornea, Iris, Pupil, Lens, Retina

Eye Muscle, Optic Nerve

Fovea (1/16”)
Color & fine detail

Figure 1
The Visual Brain

Figure 8. Visual input to the brain goes from eye to LGN and then to primary visual cortex, or area V1, which is located in the posterior of the occipital lobe. Adapted from Polyak (1957).
Cones and Rods

Light and Dark vision

Color Vision
Cone Cells in the Eye

Photomicrograph of human cone cells.
Color Vision Theories

- Aristotle — 400 BC
- Galen — 100 AD
- Newton, Goethe — 1600-1800s
- Young-Helmholtz — 1850s
- Hering — 1874

- Trichromatic Theory
- Opponent-Process Theory

- Today — Two stage process, still not completely understood — Composite Theory
Young & Helmholtz — 1850s

Trichromatic Theory

S
M
L
Color Receptors

- Rods — sensitive to light and dark
- Cones — color receptors
- 3 light-sensitive pigments
  - Red sensitive (L)
  - Blue sensitive (S)
  - Green sensitive (M)
Photopic Spectral Sensitivity Function

Notice how the photopic (daylight) sensitivity is largely a function of the M and L cones, and has a broad peak at 555 nm.
Trichromatic Theory of Vision

- Young-Helmholtz - 1850s

Cones with RGB receptors

- red message to brain
- blue message to brain
- green message to brain
Limitations of the Trichromatic Theory

- Not good at explaining
  "complementary afterimages"
Complementary Afterimages or “Successive Contrast”

- Stare at the center of the flag for 30 seconds

Observe the afterimage
Birds in a Cage

- Stare at the x on one of the birds for 30 seconds then shift your gaze to the cage.
- What color is the bird in the cage?
The ultimate afterimage

http://www.johnsadowski.com/big_spanish_castle.php
Four Color Vision Effects

- Successive contrast (afterimage)
- Simultaneous contrast of hue
- Simultaneous contrast of value
- Spatial effects of color
Simultaneous Contrast of Hue

- Do the two small purple rectangles appear to be the same color?

They are!
Simultaneous Contrast of Hue

- Are the small gray rectangles the same color?

Blue tint  Yellow tint

How about the blue ones?
Are the two pinks the same?
A close-up tells it all.

- This illusion can be found at

Other Optical Illusions
Optical Illusions on the Web

http://www.grand-illusions.com

http://www.michaelbach.de/ot/index.html
Simultaneous Contrast of Value

- Do both small rectangles appear to have the same value or intensity?

A dark background makes gray appear lighter.
A light background makes gray appear darker.
Spatial Effects of Color

Which color appears closer to you?

Which color appears closer to you now?
Color Blindness Studies

- **Trichromats** are people with “normal” color vision

- **Dichromatism** occurs when one of the three color receptors is missing
  - Red/green confusion (1-5% of males, <0.1% of females)
  - Blue/yellow confusion (rare)

- **Monochromatism** occurs when no color receptors are present. (extremely rare)
Color Blindness Test Plate

Random dots or number “32”?
How color-blind people see the world.

http://www.iamcal.com/toys/colors/

http://www.vischeck.com/examples/
Opponent-Process Theory

Achromatic System
black-white

Chromatic System
red-green
blue-yellow
Opponent-process Theory

- Hering - 1874

Cones

> R-G

(+) Stimulation = red message to brain

> B-Y

(-) Stimulation = green message to brain

R-G

(+/-) Stimulation = blue message to brain

Light

(-) Stimulation = yellow message to brain
Comosite Theory of Vision

- Modern view of vision
  Cones in retina (Trichromatic)
  Cells in thalamus (Opponent-process)

- (+) response = red message
- (-) response = green message
- (+) response = blue message
- (-) response = yellow message
Figure 16. Model for normal human colour vision.
Some websites on light and color

- www.grand-illusions.com
- www.micro.magnet.fsu.edu/primer/lightandcolor/index.html
- Interactive Color Program — a free Macintosh download from San Diego Supercomputer Center
  - www.sdsc.edu/sdsc.html