CPSC 599.28/601.28
Colour

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References

Effective Colour

What is Colour?

Physical World   Visual System   Mental Models

Lights, surfaces, objects   Eye, optic nerve, visual cortex   Red, green, brown
Bright, light, dark, vivid, colorful, dull
Warm, cool, bold, blah, attractive, ugly, pleasant, jarring

Illustrators, cartographers
Artists, designers
A few scientific principles
From: M. Stone

Perception and Cognition
From: M. Stone
Physical World

- Spectral Distribution
  - Visible light
  - Power vs. wavelength
- Any source
  - Direct
  - Transmitted
  - Reflected
  - Refracted

Colour

The Retina

photoreceptors: rods and cones

neurons (receptive fields): intermediate neural layers - image processing

http://www.ccrs.nrcan.gc.ca/ccrs/eduref/sradar/chap2/c2p2_g2e.html
Cone Response

- Encode spectra as three values
  - Long, medium and short (LMS)
  - Trichromacy: only LMS is “seen”
  - Different spectra can “look the same”


Effects of Retinal Encoding

All spectra that stimulate the same cone response are indistinguishable

Metamerism
Chromaticity Diagram

RGB Chromaticity

- R, G, B are points (varying lightness)
- Sum of two colors lies on line
- Gamut is a triangle
  - White/gray/black near center
  - Saturated colors on edges
Display Gamuts


Projector Gamuts

Opponent Colour

- **Definition**
  - Achromatic axis
  - R-G and Y-B axis
  - Separate lightness from chroma channels

- **First level encoding**
  - Linear combination of LMS
  - Before optic nerve
  - Basis for perception
  - Defines “color blindness”

Colour Blindness

- **Simulates color vision deficiencies**
  - Web service or Photoshop plug-in
  - Robert Dougherty and Alex Wade

- [www.vischeck.com](http://www.vischeck.com)
Colour Blindness

normal
protanope
deuteranope
tritanope

colorvisiontesting.com

Genes in Vischeck

B
C

B
C

B
C
2D Colour Space

Normal  Protanope  Deuteranope  Tritanope
Colour Blindness

small-field tritanopia
Colour Addition
- computer monitors
- red, green, and blue
- absence all three colors gives black,
- all three gives white.

Colour Subtraction
- printers ink
- cyan, magenta, and yellow
- absence all three colors gives white,
- all three gives black.

Colour Paint

primary

secondary

tertiary
Perceptual Color Spaces

- Unique black and white
- Uniform differences
- Perception & design

Munsell Atlas

Courtesy Gretag-Macbeth
Color Appearance

- colour constancy
- colour perception
Color Appearance

• More than a single color
  – Adjacent colors (background)
  – Viewing environment (surround)

• Appearance effects
  – Adaptation
  – Simultaneous contrast
  – Spatial effects

• Color in context

Simultaneous Contrast

• Add Opponent Color
  – Dark adds light
  – Red adds green
  – Blue adds yellow

These samples will have both light/dark and hue contrast
Bezold Effect

Spreading

- Spatial frequency
  - The paint chip problem
  - Small text, lines, glyphs
  - Image colors

- Adjacent colors blend

Redrawn from Foundations of Vision
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What makes colour effective?

- “Good ideas executed with superb craft”
  —E.R. Tufte

- Effective colour needs a context
  - Immediate vs. studied
  - Anyone vs. specialist
  - Critical vs. contextual
  - Culture and expectations
  - Time and money

Why Should You Care?

- Poorly designed colour is confusing
  - Creates visual clutter
  - Misdirects attention

- Poor design devalues the information
  - Visual sophistication
  - Evolution of document and web design

- “Attractive things work better”
  —Don Norman