Color

Susan Campbell and Sandro Fouché
Motivating Example
Motivating Example
Color Vision

- trichromatic receptors
  - blue
  - green
  - red
- combine into opponent channels
  - blue-yellow
  - red-green
Color Vision (2)

- afterimages
Color Vision (2)

- afterimages
• achromatic perception of contrast
• opponent colors more difficult to detect
Color Vision (4)

- color deficiency and color blindness
- sex-linked: red/green
- recessive: blue/yellow
Color Perception

• colors depend on context
• chromatic induction
• inferential processes
• memory affects perception
• lightness, hue, colorfulness
Checker-shadow illusion:
The squares marked A and B are the same shade of gray.

Perception Illusion
CIE Model
Display Technology

- Subtractive Color
- RGB - Three light-emitting elements
- Gamma - intensity of emissions per channel
  \( (\gamma = 1.6 - 2.5; 2.2 \text{ is somewhat standard}) \)
- Gamut - range of color possible on a display
Display Gamut
Primary Colors

Green

Red

Blue
Secondary Colors

- Yellow
- Cyan
- Magenta
Tertiary Colors
Color Models

- RGB
  - most straightforward,
  - perceptually non-uniform
  - device dependent luminance / hue color bias
HSV model

- **Hue**: chroma values
- **Saturation**: scale to white
- **Value / Brightness**: scale to black
Lab* color

- L : lightness
- a : chroma green to red
- b : chroma (blue to yellow)
Design Principles

- Association: visual similarity
- Differentiation: visual distinction
- Harmony / Discord

*Color* is one of the most effective visual attributes for *coding* information in displays and is capable, when used correctly, of achieving *powerful* and *memorable* effects.
Design Principles

• Association: visual similarity
• Differentiation: visual distinction
• Harmony / Discord
Design Principles

- Association: visual similarity
- Differentiation: visual distinction
- Harmony / Discord
Design Principles

- Association: visual similarity
- Differentiation: visual distinction
- Harmony / Discord
• luminance contrast
  • minimum of 3:1
  • ideal of 10:1 (blue on white)
  • color text or background, but not both
Information

• nominal variables: discriminability and memorability imply 5-7 colors maximum
• ordinal variables: graded sequence of colors
• include color key alongside figure
• see ColorBrewer example
Visualization

- Don’t use color that doesn’t support or add to the meaning of the information displayed.
- Use color to indicate changes of state.
- Use color saturation to depict depth layering and priority of object categories.
- In scientific visualization, use only enough color to create a realistic effect.
Imaging

- The most important criterion is to preserve the intended appearance of the image.
  - Always use a neutral gray background when displaying color images.
  - Put a narrow white border around an image to stabilize its color appearance.
  - Use color management software when accurate color reproduction is required.
Design Guidelines

• function
  • Treat color design as part of a user-centered design process.
  • Use color for association and differentiation of a design’s elements.

• aesthetics
  • Choose a harmonious palette of colors for use throughout an application.
  • Unify each design by using common thematic color(s).
Specific Guidelines

- Avoid adjacent areas of strong blue and strong red in a display to prevent unwanted depth effects (colors appearing to lie in different planes).

- Never use the blue channel alone for fine detail such as text or graphics. Do not use, for example, blue text on a black background or yellow text on a white background.

- Areas of strong color and high contrast can produce afterimages when the viewer looks away from the screen, resulting in visual stress from prolonged viewing.

- Do not use hue alone to encode information in applications where serious consequences might ensue if a color-deficient user were to make an incorrect selection.
Tools

- ColorBrewer
  http://colorbrewer.org/
- Web Color Picker
  http://the-light.com/colclick.html
- Color SynthAxis
- VisCheck
  http://www.vischeck.com/
Resources

• Color perception:

  http://webvision.med.utah.edu/Color.html#Introduction

• Color glossary:

  http://www.sapdesignguild.org/resources/glossary_color/index1.html

• Colorblindness:


• Munsell colors: