Color?
Using **Color** Effectively in Computer Graphics

Lindsay W. MacDonald, University of Derby, UK

presented by

Georg Apitz & Gleneesha Johnson
{geapi,gjohnson}@cs.umd.edu

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Color: Eye

The Human Eye

Aqueous Humour
Cornea
Iris
Lens
Optic Nerve
Fovea
Vitreous Humour

Color: Eye

Photoreceptors
Short Medium Long

Relative sensitivity
100
50
0

Wavelength (nm)
400
500
600
700

Neural channels
Achromatic (luminance)
Red-green
Yellow-blue
Avoid adjacent areas of strong blue and strong red in a display to prevent unwanted depth effects (colors appearing to lie in different planes).
Color: Background

- 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.

```
red:green:blue 40:20:1
```

```
this is some blue text
```

```
this is some yellow text
```
Color: Afterimages

- 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.
Color: TestScreen
Color: Afterimage
Color: Color Deficiency

- 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.

- Exists for all three base colors
  - Absence of the red pigment is known as protanopia
  - Absence of the green pigment is known as deuteranopia
  - Absence of the blue pigment is known as tritanopia
- Surrounding colors, field size, and viewing conditions can all change the appearance of colors.
Color: RGB

- Additive color model for computer displays
- Uses light to display color
- Colors result from transmitted light
- Red+Green+Blue=White
Color: CMYK

- Subtractive color model for printed material
- Uses ink to display color
- Colors result from reflected light
- Cyan+Magenta+Yellow=Black
Color: Comparison

RGB  CMYK
- Some colors may be impossible to reproduce exactly if they lie outside the display’s color gamut.
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Color: Design

- Use color in conjunction with other visual variables for effective presentation.

- Functional vs. decorative
- Get it right in black and white, then add color sparingly.
Use color for association and differentiation of a design’s elements.
Color: Associations

- Take advantage of the psychological associations of colors.

<table>
<thead>
<tr>
<th>Color</th>
<th>Positive Associations</th>
<th>Negative Associations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Passion, strength, energy, heat, love</td>
<td>Blood, war, fire, danger, anger, aggression</td>
</tr>
<tr>
<td>Green</td>
<td>Nature, spring, fertility, safety, environment</td>
<td>Inexperience, decay, envy, misfortune</td>
</tr>
<tr>
<td>Yellow</td>
<td>Sun, summer, gold, harvest, optimism</td>
<td>Cowardice, treason, hazard, illness, folly</td>
</tr>
<tr>
<td>Blue</td>
<td>Sky, sea, stability, peace, unity, depth</td>
<td>Depression, obscenity, conservatism, passivity</td>
</tr>
<tr>
<td>White</td>
<td>Snow, purity, peace, cleanliness, innocence</td>
<td>Cold, clinical, surrender, sterility, death, banality</td>
</tr>
<tr>
<td>Gray</td>
<td>Intelligence, dignity, restraint, maturity</td>
<td>Shadow, concrete, drabness, boredom</td>
</tr>
<tr>
<td>Black</td>
<td>Coal, power, formality, depth, solidity, style</td>
<td>Fear, void, night, secrecy, evil, anonymity</td>
</tr>
</tbody>
</table>
Color: Harmony

- Choose a harmonious palette of colors for use throughout an application.
- Unify each design by using common thematic color(s).
  - colorschemer.com
  - ColorBrewer
- Use strong color only in small details, such as icons and graphical indicators.

- Use color consistently.
  - internal
  - external

- Use a limited palette of colors and offer predefined harmonious combinations
- Ensure good legibility by providing adequate contrast between text and background.

- Avoid colored text on colored background
Color: Information

- Limit the number of colors in nominal coding to seven or fewer.
- Ability to discriminate colors.
- Ability to remember meanings.
- Use natural or application-related associations for ordinal coding.
- Always include a color key or scale with a color-coded display.
- Use bright colors to draw attention for short period of time.
Color: Visualization

- Use color saturation to depict depth layering and priority of object categories.
- In modeling applications, use only enough color to create a realistic effect.
Color: 5 Golden Rules

- Take account of human visual needs and expectations.
- Conform to the color conventions for the application.
- Design the screen layout considering all available visual variables.
- Be consistent in the use of color throughout all screens in an application.
- Use color sparingly, never more than is necessary for the task
Color: Questions

more on color @ http://www.color.org/
Color: Background matters
Color: Gestalt Principles

- Form Perception
  - Closure, area, symmetry
Color: Gestalt Principles

- Grouping
  - Proximity, similarity, continuity
Color: Perception

- The relative luminance of saturated colors follows the spectral luminous efficiency function, not the spectral hue order.

<table>
<thead>
<tr>
<th>Color</th>
<th>Primaries</th>
<th>Relative luminance (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>R G B</td>
<td>100</td>
</tr>
<tr>
<td>Yellow</td>
<td>R G</td>
<td>90</td>
</tr>
<tr>
<td>Cyan</td>
<td>G B</td>
<td>70</td>
</tr>
<tr>
<td>Green</td>
<td>G</td>
<td>60</td>
</tr>
<tr>
<td>Magenta</td>
<td>R B</td>
<td>40</td>
</tr>
<tr>
<td>Red</td>
<td>R</td>
<td>30</td>
</tr>
<tr>
<td>Blue</td>
<td>B</td>
<td>10</td>
</tr>
<tr>
<td>Black</td>
<td>—</td>
<td>0</td>
</tr>
</tbody>
</table>

![Graph showing relative sensitivity vs wavelength (nm)]