The Use of Color in User Interfaces

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SWE 432
Design and Implementation of Software for the Web
Color Topics

• The Eyes
• Color
• Guidelines
  – Physiological
  – Perceptual
  – Cognitive
The Eyes

Retina

Lens

Lens adjusted for green

Lens adjusted for red
The Eyes: Lens and Retina

- **Lens**: Use muscles to change shape to focus on colors
- **Retina**: Absorbs longer wavelengths better
- **Rods**: See shades of gray
- **Cones**: See color and detail
- **Chromostereopsis**: Cannot focus on different colors at the same time
Color

- **Hue**: What we usually see as color
- **Luminance**: Amount of light entering eye
- **Brightness**: Perceived amount of light
  (blue appears brighter than white)
- **Saturation**: Purity of color
- **Lightness**: Amount of light an object reflects
## Color Spectrum

<table>
<thead>
<tr>
<th>Color</th>
<th>Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purple</td>
<td>&lt; 430 nm</td>
</tr>
<tr>
<td>Blue</td>
<td>450 – 480 nm</td>
</tr>
<tr>
<td>Green</td>
<td>500 – 550 nm</td>
</tr>
<tr>
<td>Yellow</td>
<td>570 – 590 nm</td>
</tr>
<tr>
<td>Orange</td>
<td>610 – 630 nm</td>
</tr>
<tr>
<td>Red</td>
<td>&gt; 640 nm</td>
</tr>
</tbody>
</table>

See the Java Applet color wheel at:

http://www.ficml.org/jemimap/style/color/wheel.html
Color Wheel – Opposites
Notes on Human Eyes

• Lens are adjusted for **green** when relaxed

• **Reds** are easiest to discriminate

• **Blues** are hardest to discriminate

• The number of **hues** we can perceive **shrinks** as we age
Color Lightness

Wavelengths reflected by a ripe tomato
Color Contrast

• Relative brightness of signal over background

• Greater contrast – better perception

• Opponent colors yield better contrast – but may be ugly
  
  (yellow:blue, red:green)

• Dark on light yields better contrast than light on dark
  
  – This is true on paper and on screens
  
  – The effect is reversed when projecting

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Color Contrast

• Relative brightness of signal over background

• Greater contrast – better perception

• Opponent colors yield better contrast
  (yellow:blue, red:green)

• Dark on light has better contrast than light on dark
  – This is true on paper and on computer screens
  – This effect is reversed when projecting
Color Guidelines

- Physiological
- Conceptual
- Cognitive
Physiological Guidelines (1)

1. Avoid using highly saturated opponent colors at the same time (except as BG / FG)
2. Do not use blue for text, thin lines, and small shapes
3. Do not use adjacent colors that only differ in the amount of blue
4. Older users need higher brightness levels
5. Use dark on light when printing and on-screen, and light on dark when projecting
Physiological Guidelines (2)

6. As light levels change, color perception changes
7. The amount of detectable change in color is different with different colors
8. Try not to put red and green on the sides of large displays (those cones are centered in our eyes)
9. Opponent colors give strong contrast
10. Adjacent colors should have different levels of brightness
Perceptual Guidelines (1)

1. Hue changes perceived brightness
2. Different hues have different saturation levels
3. Not all colors are as readable as others
4. Use brighter, spectrum-centered colors for text
5. Hues will look different with different intensity and background color
Perceptual Guidelines (2)

6. Do not require color discrimination in small areas
7. Avoid using hue to indicate numeric information
8. Use greater intensity for hues that indicate larger amounts
9. Use two different background colors to split screen
Cognitive Guidelines (1)

1. Do not use too much color
2. Group related elements by using a common background color
   • Use color to indicate “regions” in web sites
3. Use similar colors to imply similar meanings
4. Brightness and saturation draw attention
Cognitive Guidelines (2)

5. Warm and cold colors can indicate action levels
6. The same color may have different meanings in different cultures
7. Use redundant coding of shape and color
Color in HTML

Color is defined as \#RRGGBB

Some predefined colors:

<table>
<thead>
<tr>
<th>Color Name</th>
<th>Hex Value</th>
<th>Color Name</th>
<th>Hex Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqua</td>
<td>#00FFFF</td>
<td>Navy</td>
<td>#000080</td>
</tr>
<tr>
<td>Black</td>
<td>#000000</td>
<td>Olive</td>
<td>#808000</td>
</tr>
<tr>
<td>Blue</td>
<td>#0000FF</td>
<td>Purple</td>
<td>#800080</td>
</tr>
<tr>
<td>Fuchsia</td>
<td>#FF00FF</td>
<td>Red</td>
<td>#FF0000</td>
</tr>
<tr>
<td>Gray</td>
<td>#808080</td>
<td>Silver</td>
<td>#C0C0C0</td>
</tr>
<tr>
<td>Green</td>
<td>#008000</td>
<td>Teal</td>
<td>#008000</td>
</tr>
<tr>
<td>Lime</td>
<td>#00FF00</td>
<td>White</td>
<td>#FFFFFF</td>
</tr>
<tr>
<td>Maroon</td>
<td>#800000</td>
<td>Yellow</td>
<td>#FFFF00</td>
</tr>
</tbody>
</table>
# Usable Color Combinations

<table>
<thead>
<tr>
<th>Background</th>
<th>Best Colors</th>
<th>Worst Colors</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Black, Blue</td>
<td>Cyan, Yellow</td>
</tr>
<tr>
<td>Black</td>
<td>Yellow, White</td>
<td>Blue</td>
</tr>
<tr>
<td>Red</td>
<td>Black</td>
<td>Blue, Magenta</td>
</tr>
<tr>
<td>Green</td>
<td>Black, Red</td>
<td>Cyan</td>
</tr>
<tr>
<td>Blue</td>
<td>Red, White, Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Cyan</td>
<td>Blue, Red</td>
<td>Green, White, Yellow</td>
</tr>
<tr>
<td>Magenta</td>
<td>Black, Blue</td>
<td>Cyan, Green</td>
</tr>
<tr>
<td>Yellow</td>
<td>Black, Blue, Red</td>
<td>Cyan, White</td>
</tr>
</tbody>
</table>
An Effective Use of Colors

Borland C++ 3.1 used six colors to categorize textual content:

1. Reserved words – white
2. Identifiers – yellow
3. Macros – green
4. Literals – cyan
5. Comments – gray
6. Syntax errors – red
Conclusions

• Color can greatly enhance the usability of interfaces
• Color can (and often is!) greatly over-used
• When using color:
  – be gentle
  – be thoughtful