Color

SE 444
Color Topics

• Color perception
• Using color in interaction design
• Color concerns for interaction design

Color Reference
Color Perception - A Physics Review

- A light source emits light waves at visible frequencies that strike an object
  - The object absorbs and or reflects different frequencies
    - The object may be opaque, transparent, or translucent
- The reflected frequencies determine the object’s color
  - Black if all frequencies absorbed
  - White if all frequencies reflected
  - Other combinations produce the color spectrum
- The perceived color varies based on light source properties and viewing conditions
Color Systems

- Primary colors – basic colors from which all other colors are derived
- Light – Red, Green, Blue (RGB)
- Print – Cyan, Magenta, Yellow and (Black)
Color Perception

- The human visual system (rods and cones)
  - The **cones** prevalent in the central retina are **sensitive to color**
    - Sensitive to **red, green, and blue**
  - The **rods** prevalent on the retina periphery are **sensitive to motion and low-light environments**

- Visual limitations
  - Color **perception is weak** in our **peripheral vision**
  - **Eyes** are **most sensitive** to the middle frequencies, **green and yellow**
Color Deficiencies

- Photoreceptors vary greatly from person to person.
- People with photoreceptors that **do not respond to certain frequencies** do not perceive those colors in the same way that other people do; **“color blindness”**
  - 8% of male individuals
  - 0.4% of female individuals
- The most common form is a reduced sensitivity to green, known as deuteranomaly
  - 5% of male individuals
  - 95% of color deficiencies in female individuals
Types of Color Blindness

Protanopic color vision, no ability to perceive red

Normal trichromatic color vision

Deuteranopic color vision, no ability to perceive green

Color Blindness Simulator
Color Perception

- Factors affecting color perception:
  - Culture
  - Age
  - Fatigue
  - Emotions
  - Ambient light
  - Light sources
  - Blood oxygen levels

- Color can evoke:
  - An expectation, preferences
  - Emotion – aesthetic appeal – “warm” versus “cold” colors
  - Localization – differences by culture or commercial context (logo color) in the meaning and emotion of color
Using Color in Interaction Design

- Clarification, Relation, and Differentiation
- Searching
- Comprehension, Retention, and Recall
- Task Performance
- Redundant Coding
- Color Concerns for Interaction Design
Clarification, Relation, and Differentiation

- Color can be used to **clarify differences** and **similarities** and **communicate relationships**

- Color codes can be used to support a logical information structure; e.g., multi-variable graph
Searching

- Color can be used to **catch the attention** of the user
  - Keywords, string types

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style="text-align:left; width:100%;">
<thead>
<tr>
<td style="vertical-align:top; text-align:center;">
 &nbsp;&nbsp;When Netscape Navigator 7.1 displays the source code of a web page, it colors the element names purple, the attribute names black, the attribute values blue, the comments green and character entities orange.
</td>
</tr>
</tbody>
</table>
```
Comprehension, Retention, and Recall

- Color can enable us to **comprehend patterns** in complex data structures

- Color can aid in **remembering and recalling** information
Task Performance and Redundancy

- Studies show color improves task performance for:
  - Recall
  - Search-and-locate
  - Retention
  - Decision judgment

- Redundancy – color alone is not enough
  - A clear HCI structure and presentation must already be present before color is introduced
  - Use multiple sensory cues (e.g. color and shape)
  - Don’t use color to delineate shapes – contrast issues
Color Concerns for Interaction Design

- **Limitations** in the perception of **subtle color differences**

- **Number and choice of colors**
  - To aid in color recognition and recall, **use only a few distinct colors**
    - Red, green, blue, and yellow are best
    - Five to nine colors for coding information
  - Don’t **distract** the user or **compete** with content
  - Keep color **perception limitations** in mind
    - E.g., we see green and yellow best, so avoid small blue objects
  - **Avoid saturated colors** – can cause visual fatigue
Color Concerns - Contrast

- **Incompatible differences** - some specific color combinations cause unique problems:
  - **Colors at opposing ends of the spectrum** such as red and blue
  - **Positive contrast** makes characters appear to glow (Halation)

<table>
<thead>
<tr>
<th>Color Combination</th>
<th>Color Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated yellow and green</td>
<td>Saturated yellow on green</td>
</tr>
<tr>
<td>Yellow on white</td>
<td>Yellow on white</td>
</tr>
<tr>
<td>Blue on black</td>
<td>Blue on black</td>
</tr>
<tr>
<td>Green on white</td>
<td>Green on white</td>
</tr>
<tr>
<td>Saturated red on blue</td>
<td>Saturated red on blue</td>
</tr>
<tr>
<td>Saturated red on green</td>
<td>Saturated red on green</td>
</tr>
<tr>
<td>Magenta on green</td>
<td>Magenta on green</td>
</tr>
<tr>
<td>Saturated blue on green</td>
<td>Saturated blue on green</td>
</tr>
<tr>
<td>Yellow on purple</td>
<td>Yellow on purple</td>
</tr>
<tr>
<td>Red on black</td>
<td>Red on black</td>
</tr>
<tr>
<td>Magenta on black</td>
<td>Magenta on black</td>
</tr>
</tbody>
</table>
Foreground-Background Color Contrast

- Color Backgrounds
  - An object’s **perceived color** is affected by the **background color**