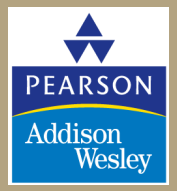
Chapter 9: Color

The Resonant Interface
HCI Foundations for Interaction Design
First Edition

by Steven Heim



Section III – Facets of Interaction

Chapter 9 Color

- The Human Perceptual System
  Presented by Anne
- Using color in Interaction Design
  Presented by Peter
- Color Concerns for Interaction Design
  Presented by Rakib
- Technical Issues Concerning Color
  Presented by Josiah

The Human Perceptual System

- Color Perception
- Color Deficiencies
- Individual and Cultural Issues

Color Perception

- Human color perception depends on the way in which light waves interact with objects in the environment
- Some light waves are absorbed some pass through
  - Opaque
  - Translucent
  - Transparent

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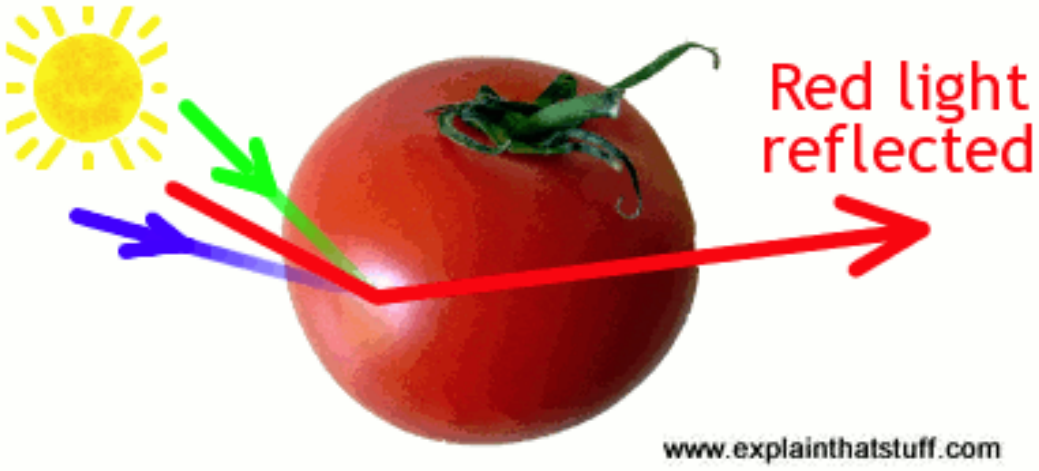
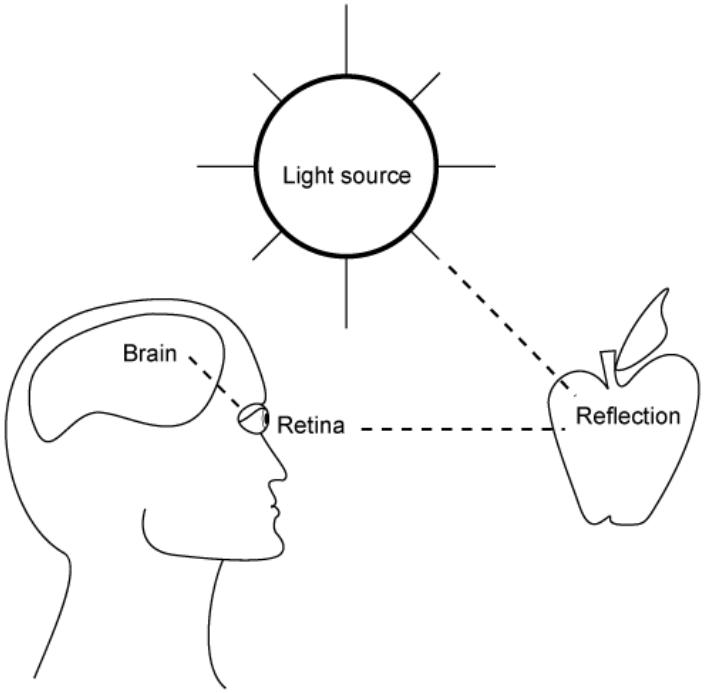
Color Perception

- When light hits an object some of the waves that are not allowed to pass through are absorbed and some of them are reflected



Color Perception

- The frequencies of the reflected waves determine the color we perceive



Color Perception

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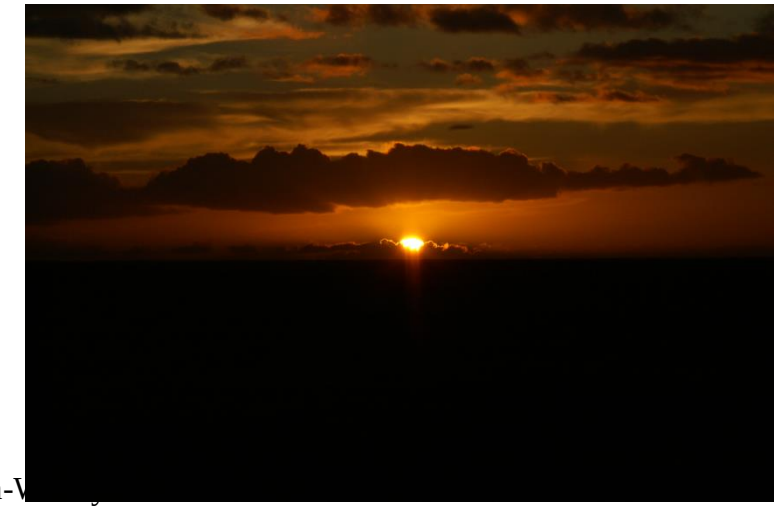
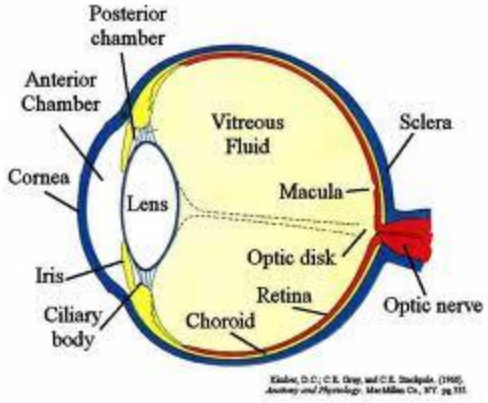
The perceived color of an object can change drastically under different lighting situations

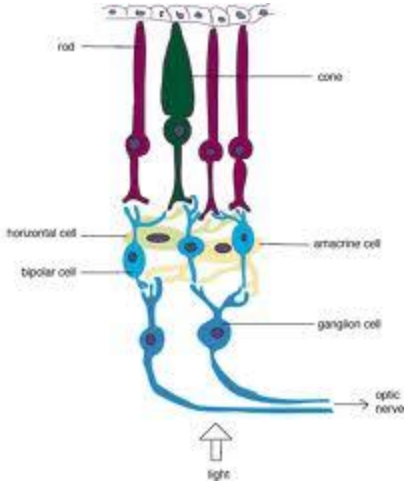
- The color of an object depends on the light source and the nature of the light it emits
  - Metamerism



Color Perception

- The Human Visual System (Rods and Cones)
  - The cones are sensitive to color and are more prevalent in the central part of the retina
  - The rods are situated mostly in the periphery of the retina and are sensitive to motion and low-light environments





Color Perception - *Visual Limitations*

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Avoid using blue for text and small screen elements

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Our ability to distinguish color is directly related to the size of an object

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Color perception is weak in our peripheral vision

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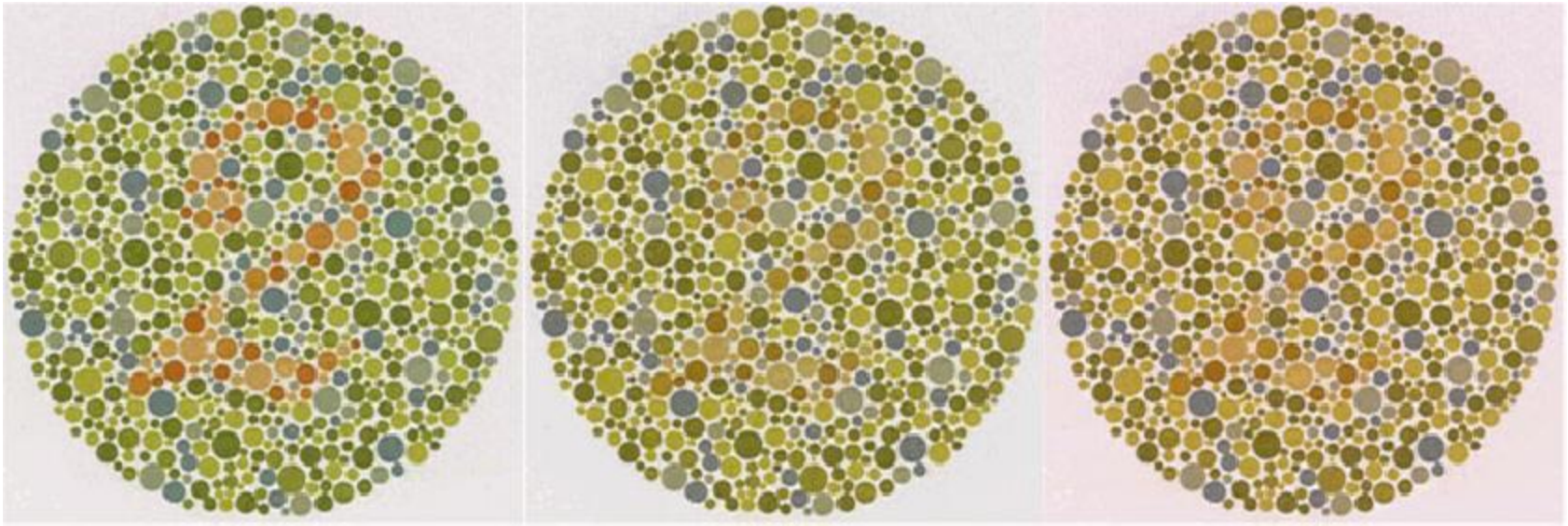
Do not rely only on color to delineate shape

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
  - 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



Color Deficiencies - *Types of Color Blindness*

- Anomalous trichromatic vision results when all cones are present but some are misaligned:
  - **Protanomaly:** Diminished sensitivity to red
  - **Deuteranomaly:** Diminished sensitivity to green
  - **Tritanomaly:** Diminished sensitivity to blue
- Dichromatic vision anomalies occur when one of the cone types is missing:
  - **Protanopia:** No ability to perceive red
  - **Deuteranopia:** No ability to perceive green
  - **Tritanopia:** No ability to perceive blue

Color Deficiencies - *Types of Color Blindness*

Protanopic color vision. Normal trichromatic color vision. Deuteranopic color vision.

PhotoShop Plug-in

http://www.vischeck.com/downloads/

Online version

http://www.vischeck.com/vischeck/vischeckImage.php

Color Deficiencies - *Types of Color Blindness*

Normal color vision

Deuteranopic color vision

Color Deficiencies - *Types of Color Blindness*

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Color deficiency and human subjectivity must be considered important factors in interaction design

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

Individual and Cultural Issues

- Ask a person to name a favorite color and what it reminds him of, then ask another person about the same color

- Some colors carry natural associations that are universally consistent.
  - We should stick to these common associations when we find them

Individual and Cultural Issues

- Preference and Expectations

Inappropriate Colors

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It is important to understand the target user's color associations and expectations

Individual and Cultural Issues

- Emotional Response

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Color can evoke emotional responses

"Light warm red has a certain similarity to medium yellow, alike in texture and appeal, and gives a feeling of strength, vigour, determination, triumph. In music, it is a sound of trumpets, strong, harsh, and ringing" (Kandinsky, 1977, 40)

Individual and Cultural Issues

Mexico #282

Mexico #268

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Individual and Cultural Issues

- Globalization—Localization
  - **Emotions**: Associations with yellow range from grace and nobility in Japan, to cowardice and caution in the United States, to happiness and prosperity in Egypt (Russo & Boor, 1993)
  - **Age**: People of different generations have observable and often contrasting preferences in color
  - **Gender**: In most cultures gender can greatly influence color decisions
  - **Physical Appearance:** Mail box colors

Individual and Cultural Issues

- Globalization—Localization
  - **Industrial or professional communities:**
    - **Academic robes**

– **Corporate identity and product recognition:**
  - **Coca-Cola**
  - **American Express**
  - **UPS**

Using Color in Interaction Design

- Clarification, Relation, and Differentiation
- Searching
- Comprehension, Retention, and Recall
- Tasks and Performance
- Redundant Coding

Using Color in Interaction Design

- Clarification, Relation, and Differentiation

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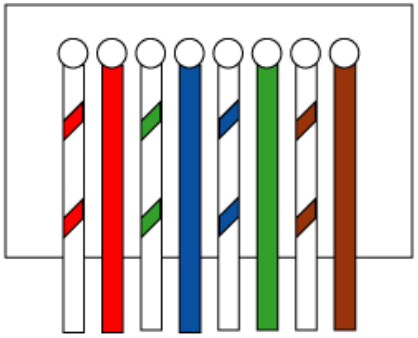
Color can be used to clarify differences and similarities and communicate relationships

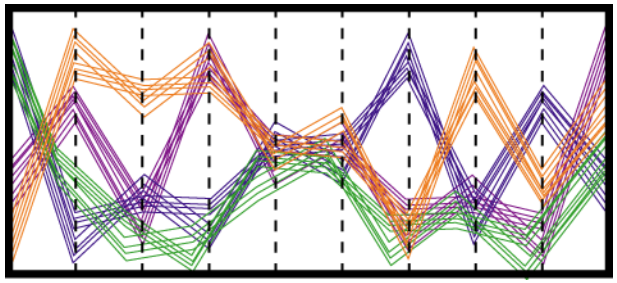
- Color codes can be used to support a logical information structure.

Using Color in Interaction Design

- Clarification, Relation, and Differentiation



Ethernet wires



Parallel coordinate plot.

Map of the

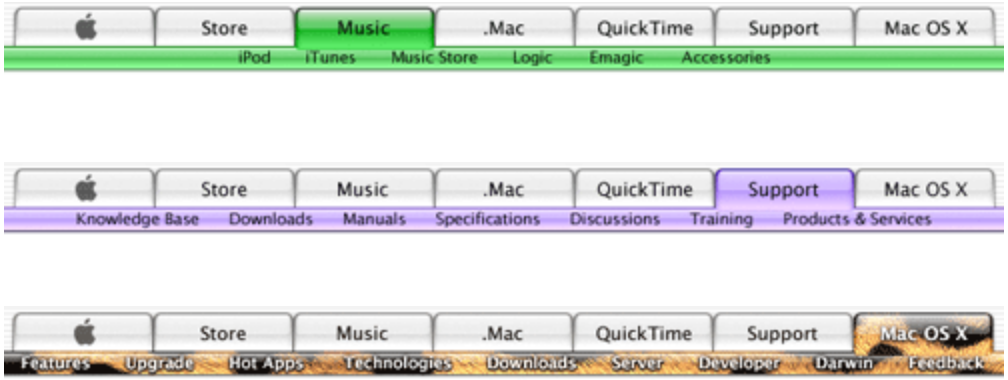
Boston subway system

Another clarification example

Here, the use of color can speed up the users decision!

Another relation/differentiation example

Here, color is related with a menu tab



Using Color in Interaction Design

- Clarification, Relation, and Differentiation
  - The spectrum has been shown to be an intuitive means of presentation.

Color code alert system

Using Color in Interaction Design

- Searching

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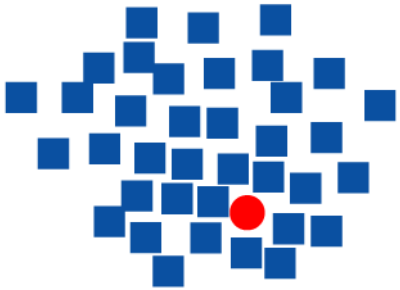
Color can be used to catch the attention of the user

Blue squares and a blue circle



Blue squares and a red circle

Using Color in Interaction Design

Searching

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style="text-align:left; width: 100%;">
<tbody>
<tr>
<td style="vertical-align:top; text-align:center;">

  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>
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Using Color in Interaction Design

- Comprehension, Retention, and Recall

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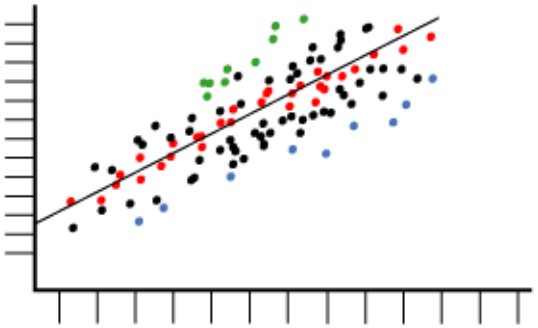
Color can enable us to comprehend patterns in complex data structures



Color-coded scatter plot

Using Color in Interaction Design

- Comprehension, Retention, and Recall

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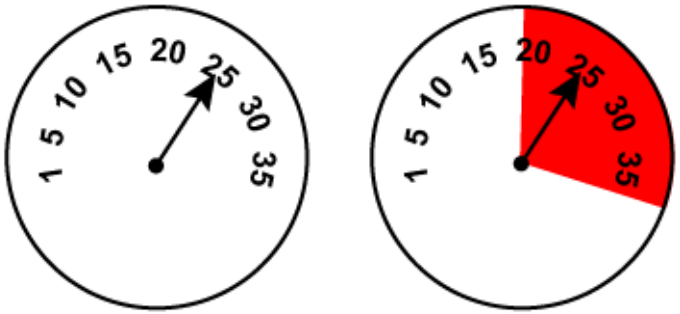
Color can aid in remembering and recalling information



Color-coded dials

Using Color in Interaction Design

- Tasks and Performance
- Color improves performance in the following tasks: (Hoadley)
  - Recall task
  - Search-and-locate task
  - Retention task
  - Decision judgment task

We usually see this…

So what happens when we see this?

Using Color in Interaction Design

- Redundant Coding

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A clear structure and presentation must already be present before color is introduced

- Studies have shown that people are better at search tasks when the targets of the search are coded using more than one parameter, for instance, color and shape (Thorell & Smith, 1990)

Color Concerns for Interaction Design

- Indistinguishable Differences
- Optimal Colors
- Number of Colors
- Incompatible Differences
- Color Backgrounds

Color Concerns for Interaction Design

- Indistinguishable Differences

- Even though there are millions combination of colors, our eyes can only identify about 10.
- Our color receptors are not always able to detect subtle changes in color Picking poor color can degrade user performance.

Our ability to perceive subtle changes varies from color to color

http://www.youtube.com/watch?v=Rab5l5SDm3I

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Our ability to perceive subtle changes varies from color to color

Similar colors in close proximity :

Color Concerns for Interaction Design

- Number of Colors
  - To remember a color and then recognize it later, we should use only a few distinct colors
  - To be able to tell the difference between two adjacent color-coded objects, we can use more colors
  - A structured approach to color selection is essential

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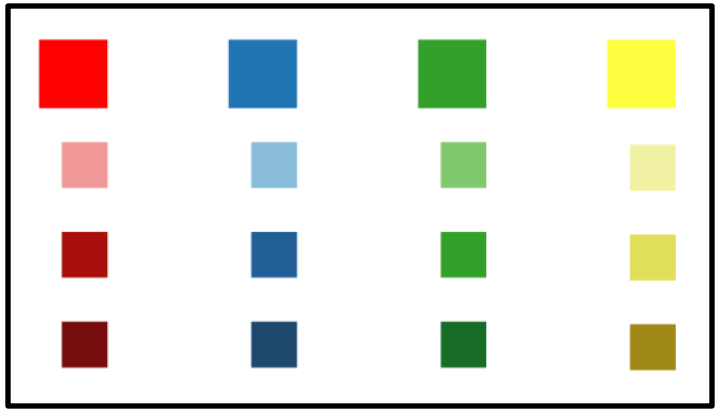
Interface colors should never distract the user or compete with content

Color Concerns for Interaction Design

- Optimal Colors
  - It has been found that the colors red, blue, green, and yellow are the most beneficial in learning environments. (Thorell & Smith, 1990)
  - Choices can be grouped based on colors.



Color code using red, blue, green, and yellow

Color Concerns for Interaction Design

- Some specific color combinations cause unique problems:
  - Colors at opposing ends of the spectrum such as red and blue require the eye to use two different focal lengths
  - Positive contrast makes characters appear to glow (Halation)

Some color combinations create optical effects that are distracting

Color Concerns for Interaction Design

- Incompatible Differences

Color Combinations to Avoid:

Problematic Color Combinations

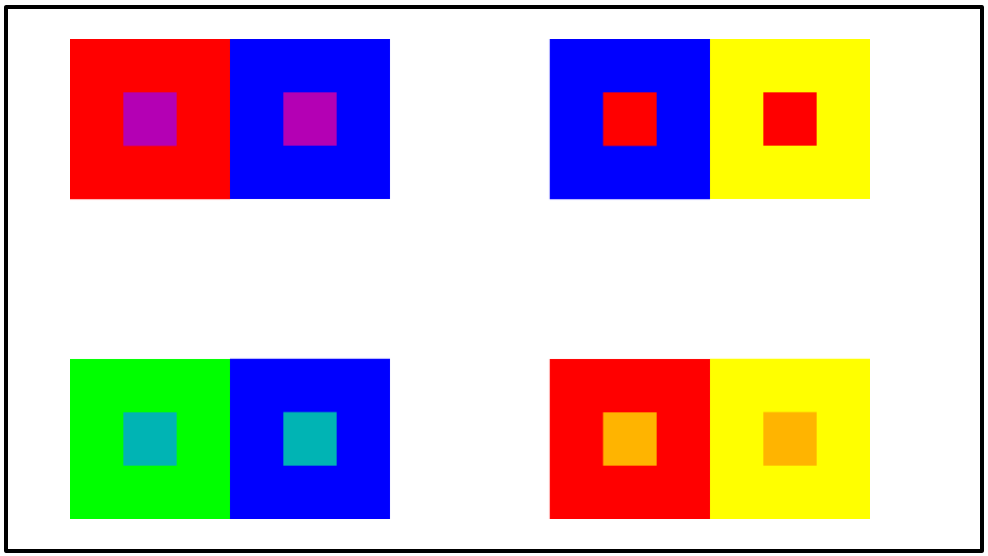
Colors at opposing ends of the spectrum such as red and blue require the eye to use different focal lengths

Saturated yellow and green	Saturated yellow on green
Yellow on white	Yellow on white
Blue on black	Blue on black
Green on white	Green on white
Saturated red on blue	Saturated red on blue
Saturated red on green	Saturated red on green
Magenta on green	Magenta on green
Saturated blue on green	Saturated blue on green
Yellow on purple	Yellow on purple
Red on black	Red on black
Magenta on black	Magenta on black

Color Concerns for Interaction Design

Color perception is affected by context

- **Color Backgrounds**



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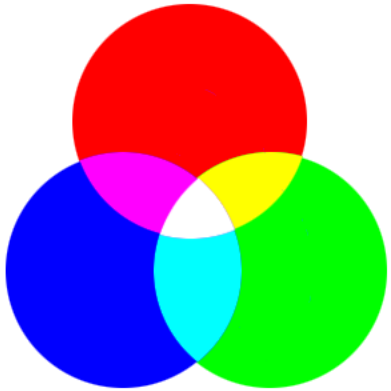
The perceived color of an object is affected by the color of its background

Technical Issues Concerning Color

- Color Displays
- Computing Environment
- Color Systems
- Color Contrast
- Color Space
- Web-Based Color
- The Color Picker

Technical Issues Concerning Color

- Color Displays
  - Computer screens create color by mixing red, green, and blue (RGB) light
  - This is an additive process



- We must work within the limitations of the human perceptual system and within the limitations of computer screen technology
- Some LCD monitors can only display 262,000 colors

Technical Issues Concerning Color

- Computing Environment

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Monitors vary widely in the colors they display

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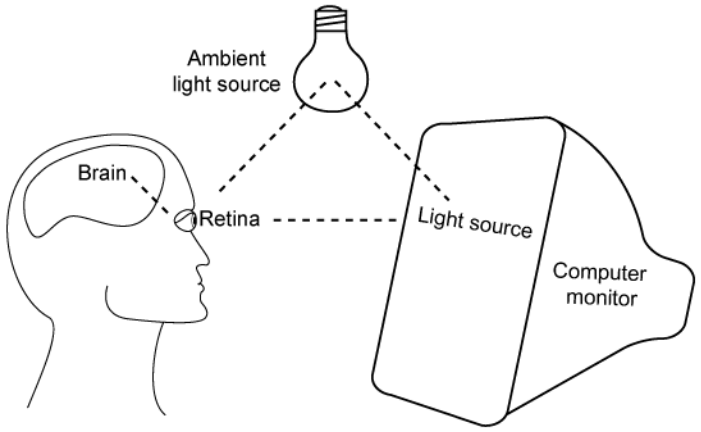
High levels of ambient light cause colors to lose their vibrancy



Technical Issues Concerning Color

- Computing Environment
  - It is important to know where your interface will be used
  - There are many factors to consider:
    - Ambient light
    - Screen type
    - Screen glare
    - Screen calibration
    - Printed output

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Designs should be tested in as many different environments as possible

Technical Issues Concerning Color

- Color Systems
  - Munsell divided color into three basic elements: hue, value, and chroma:
    - The difference in our perception of the colors red, green, and blue is determined by changes in *hue*.
    - Shades of color can be defined as the result of changes in *value*, such as the difference between light blue and dark blue.
    - The pureness of a color is determined by *chroma*. Changes in chroma can make a color change from a vibrant color to a muted or muddy color.

Technical Issues Concerning Color

- Color Systems
  - Other terms are sometimes used to express these properties:
    - Hue
    - Value/luminance/brightness
    - Chroma/saturation
  - This text uses the terms hue, saturation, and brightness

Technical Issues Concerning Color

- Brightness refers to the amount of white or black that is present in a color

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Altering brightness makes the color appear lighter or darker

Light Blue Dark Blue

Technical Issues Concerning Color

- Saturation describes the “gray-to-hue” ratio of a color

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Decreasing saturation by adding a greater percentage of gray makes colors muted

Technical Issues Concerning Color

- Hue - If we change the proportions of the colors we mix together, we affect the hue

Dark sea green

143, 188, 143

R G B

Teal

62, 189, 144

R G B

Technical Issues Concerning Color

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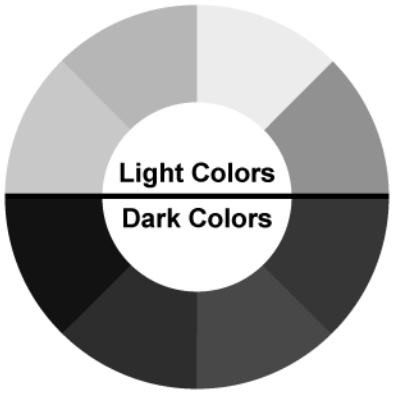
Colors with the same brightness levels can appear lighter or darker than each other

Light and dark colors



Light and dark colors—grayscale

Technical Issues Concerning Color

- Color Contrast

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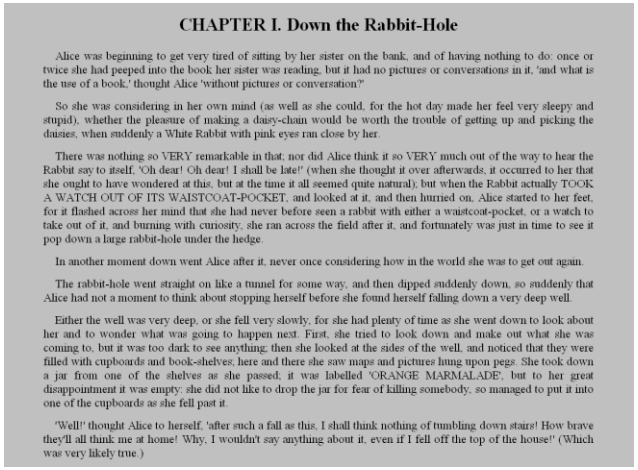
Positive contrast becomes tedious and annoying after extended periods of use



CHAPTER I. Down the Rabbit-Hole

Alice was beginning to get very tired of sitting by her sister on the bank, and of having nothing to do: once or twice she had peeped into the book her sister was reading, but it had no pictures or conversations in it, 'and what is the use of a book,' thought Alice 'without pictures or conversation?'

So she was considering in her own mind (as well as she could, for the hot day made her feel very sleepy and stupid), whether the pleasure of making a daisy-chain would be worth the trouble of getting up and picking the daisies, when suddenly a White Rabbit with pink eyes ran close by her.

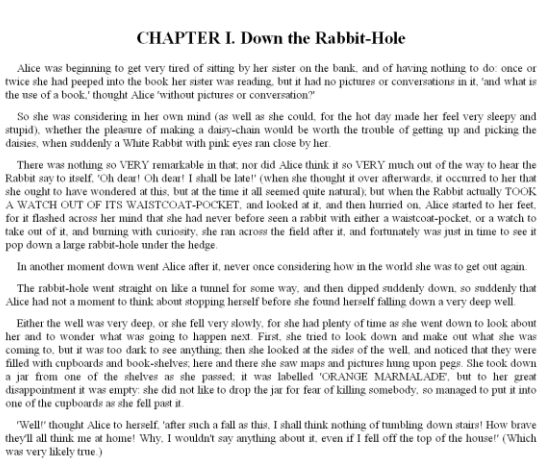
There was nothing so VERY remarkable in that; nor did Alice think it so VERY much out of the way to hear the Rabbit say to itself, 'Oh dear! Oh dear! I shall be late!' (when she thought it over afterwards, it occurred to her that she ought to have wondered at this, but at the time it all seemed quite natural); but when the Rabbit actually TOOK A WATCH OUT OF ITS WAISTCOAT-POCKET, and looked at it, and then hurried on, Alice started to her feet, for it flashed across her mind that she had never before seen a rabbit with either a waistcoat-pocket, or a watch to take out of it, and burning with curiosity, she ran across the field after it, and fortunately was just in time to see it pop down a large rabbit-hole under the hedge.

In another moment down went Alice after it, never once considering how in the world she was to get out again.

The rabbit-hole went straight on like a tunnel for some way, and then dipped suddenly down, so suddenly that Alice had not a moment to think about stopping herself before she found herself falling down a very deep well.

Either the well was very deep, or she fell very slowly, for she had plenty of time as she went down to look about her and to wonder what was going to happen next. First, she tried to look down and make out what she was coming to, but it was too dark to see anything; then she looked at the sides of the well, and noticed that they were filled with cupboards and book-shelves; here and there she saw maps and pictures hung upon pegs. She took down a jar from one of the shelves as she passed; it was labelled 'ORANGE MARMALADE', but to her great disappointment it was empty: she did not like to drop the jar for fear of killing somebody, so managed to put it into one of the cupboards as she fell past it.

'Well!' thought Alice to herself, 'after such a fall as this, I shall think nothing of tumbling down stairs! How brave they'll all think me at home! Why, I wouldn't say anything about it, even if I fell off the top of the house!' (Which was very likely true.)



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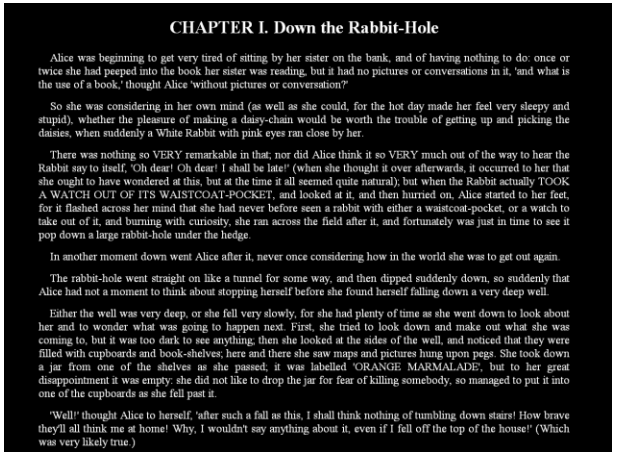

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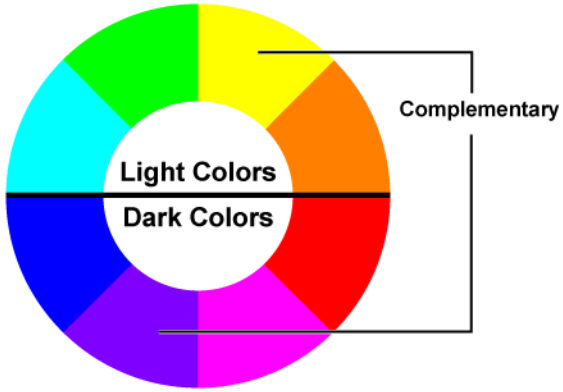
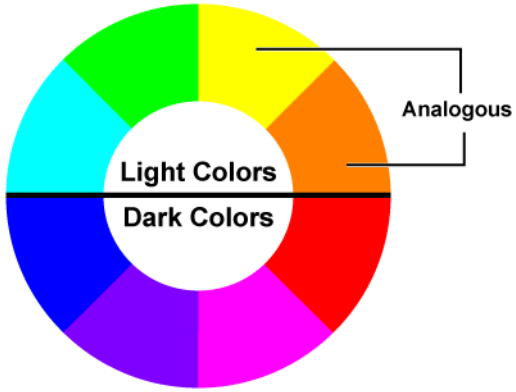
Technical Issues Concerning Color

- Complementary Color Scheme



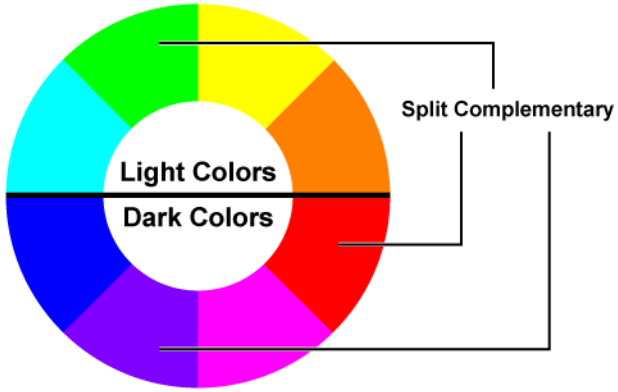
Technical Issues Concerning Color

- Analogous Color Scheme



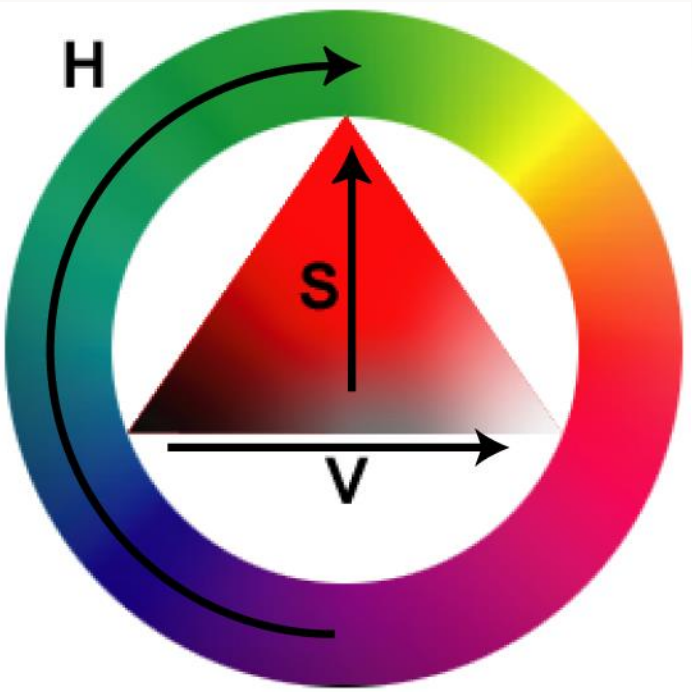
Technical Issues Concerning Color

- Split Complementary Color Scheme



Technical Issues Concerning Color

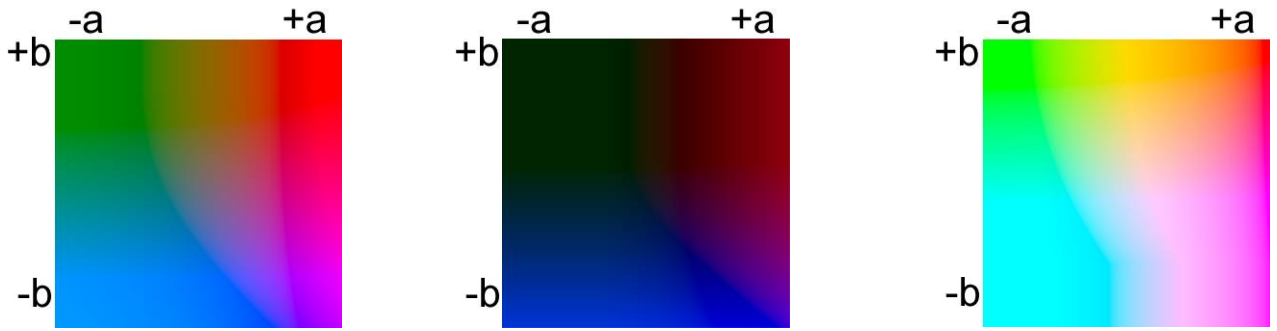
- Color Space



The hue, saturation, and value (HSV) color space

Technical Issues Concerning Color

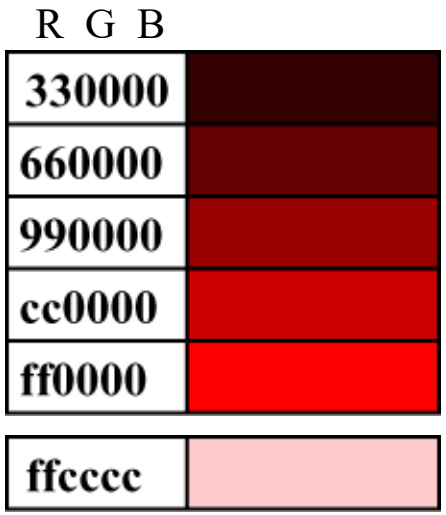
- Color Space



The International Commission on Illumination (CIE) L*a*b* color space

Technical Issues Concerning Color

- Web-Based Color
  - Web pages, uses hexadecimal coding to specify the RGB values of a color



Increasing levels of blue and green

Technical Issues Concerning Color

- Web-Based Color
  - A computer with a monitor set to 8-bit color (256 colors) only allows for 216 colors to be shown in a Web browser because the operating system restricts 40 of the possible 256 colors for its own use
  - Colors are referenced according to their position in the Color Look-up Table (CLUT)

MAXIM

An 8-bit monitor requires a browser-safe palate

Technical Issues Concerning Color

- Web-Based Color
  - If a graphic contains colors that are not in the CLUT, the system will try to create the colors by interpolating between two similar colors

Normal version

Dithered version

Technical Issues Concerning Color

- http://www.moillusions.com/2006/03/eclipse-of-mars-illusion.html