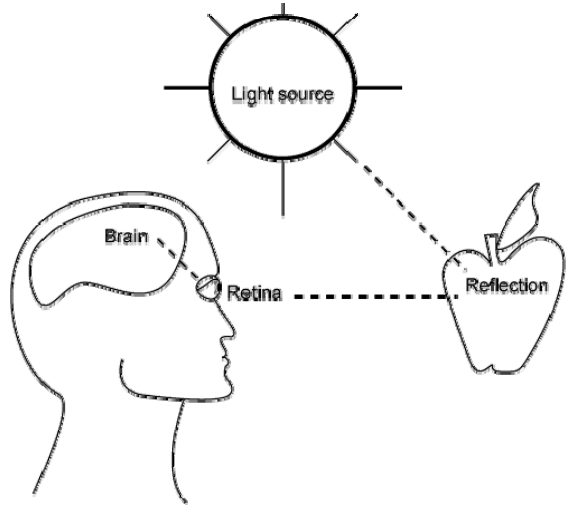
Chapter 9: Colour

- **The Human Perceptual System**
- **Technical Issues Concerning Colour**
- **Using Colour in Interaction Design**
- **Colour Concerns for Interaction Design**

Our Focus: Symbolic colour use

- Our focus is on twodimensional, symbolic colour use:
- Colour perception for naturalistic scenes involves more aspects:
  - Illumination: Opacity, Translucency
  - The colour of an object depends on the light source and the nature of the light it emits (Metamerism)
  - addressed in computer graphics



Sources Addison Wesley , Plimmer, Weber 2009

The Human Perceptual System

- Colour Perception
- Colour Deficiencies
- Using Colour
- Contrast

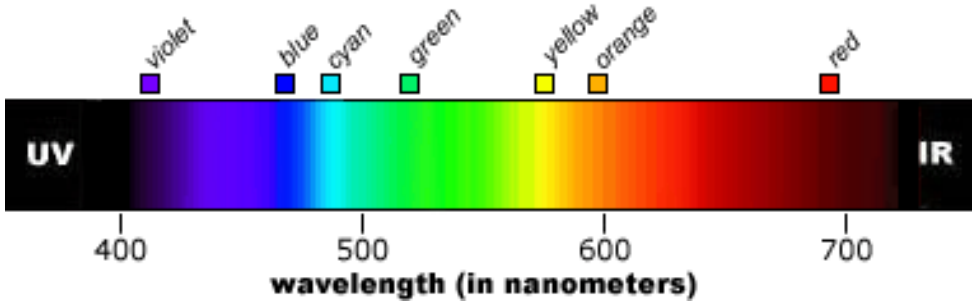
Sources Addison Wesley , Plimmer, Weber 2009

The Human Eye as camera

- The human eye has a high spatial resolution.
- The human eye works like a colour camera with many “pixels”.
- Eyes with high spatial resolution have evolved many times independently in the history of life.

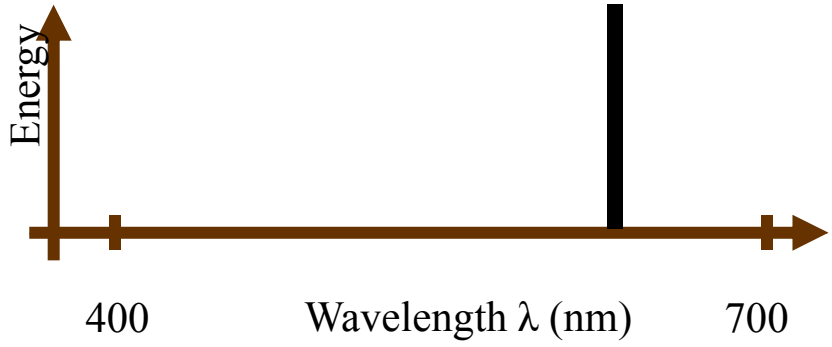
Colour perception

- Visible light is an electromagnetic radiation in a narrow frequency range.
- (Compared with acoustics: less than one octave)
- light hitting the human eye in one pixel is mostly a mixture of frequencies.

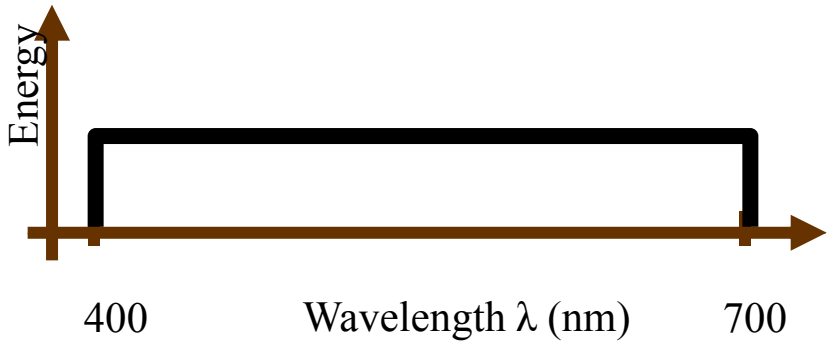


Spectral Density Function (SDF): S(λ)

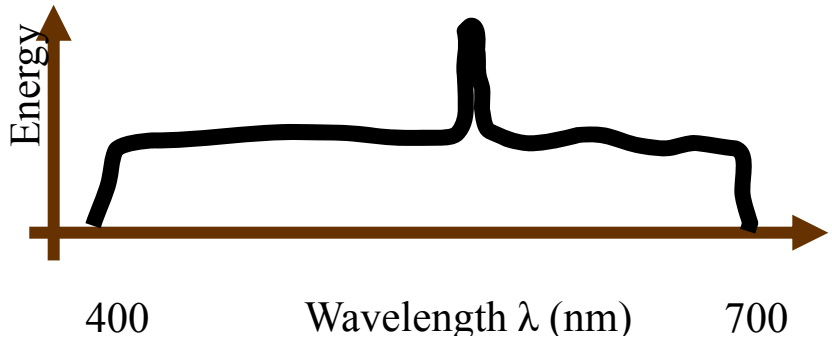
- S(λ) = power / unit wavelength = energy



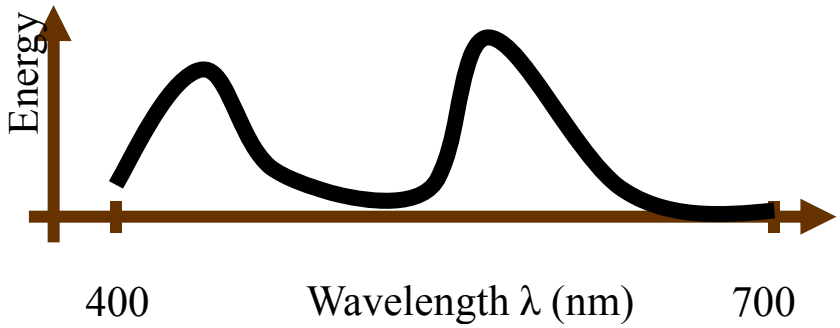
spike or "single" wavelength= "spectral colour", monochromatic light, laser light



uniform white/gray light= daylight



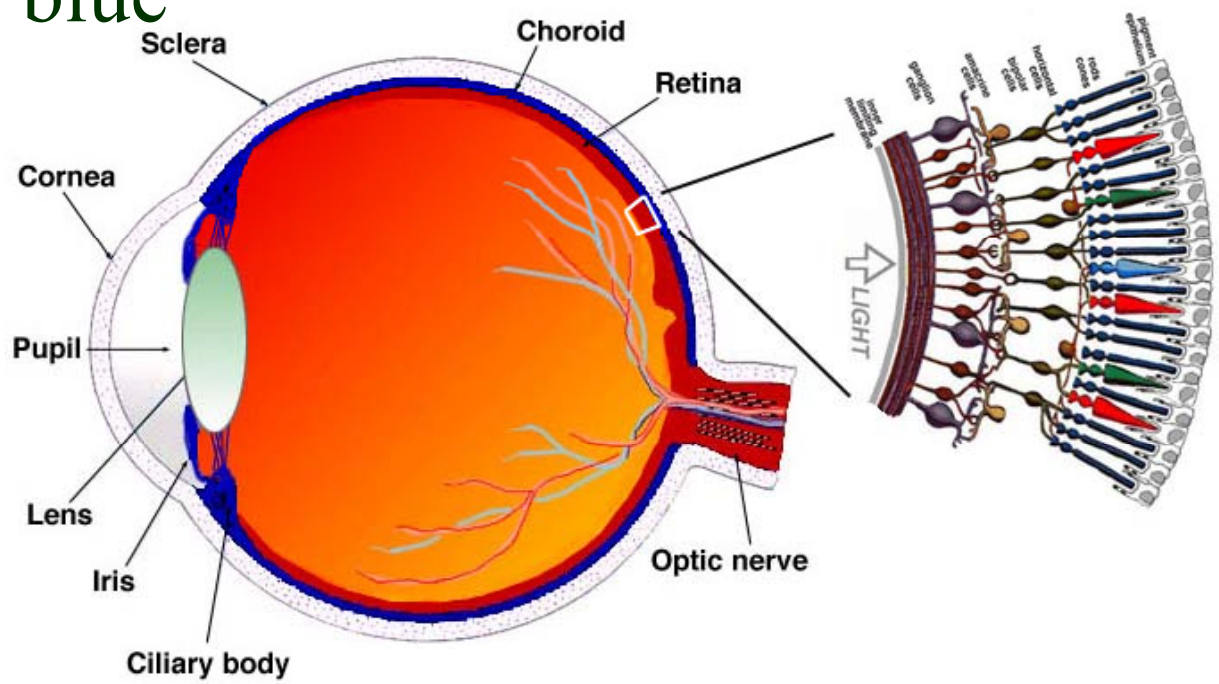
white light plus a dominant wavelength

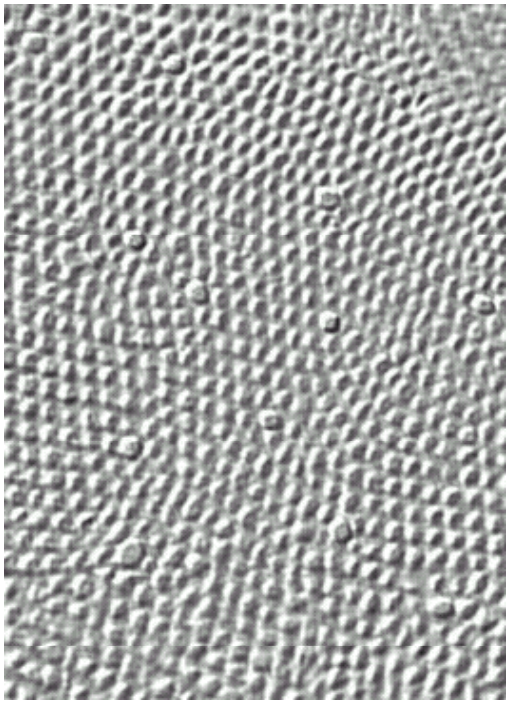


arbitrary SDF: blue plus orange/yellow

Color perception in the human eye

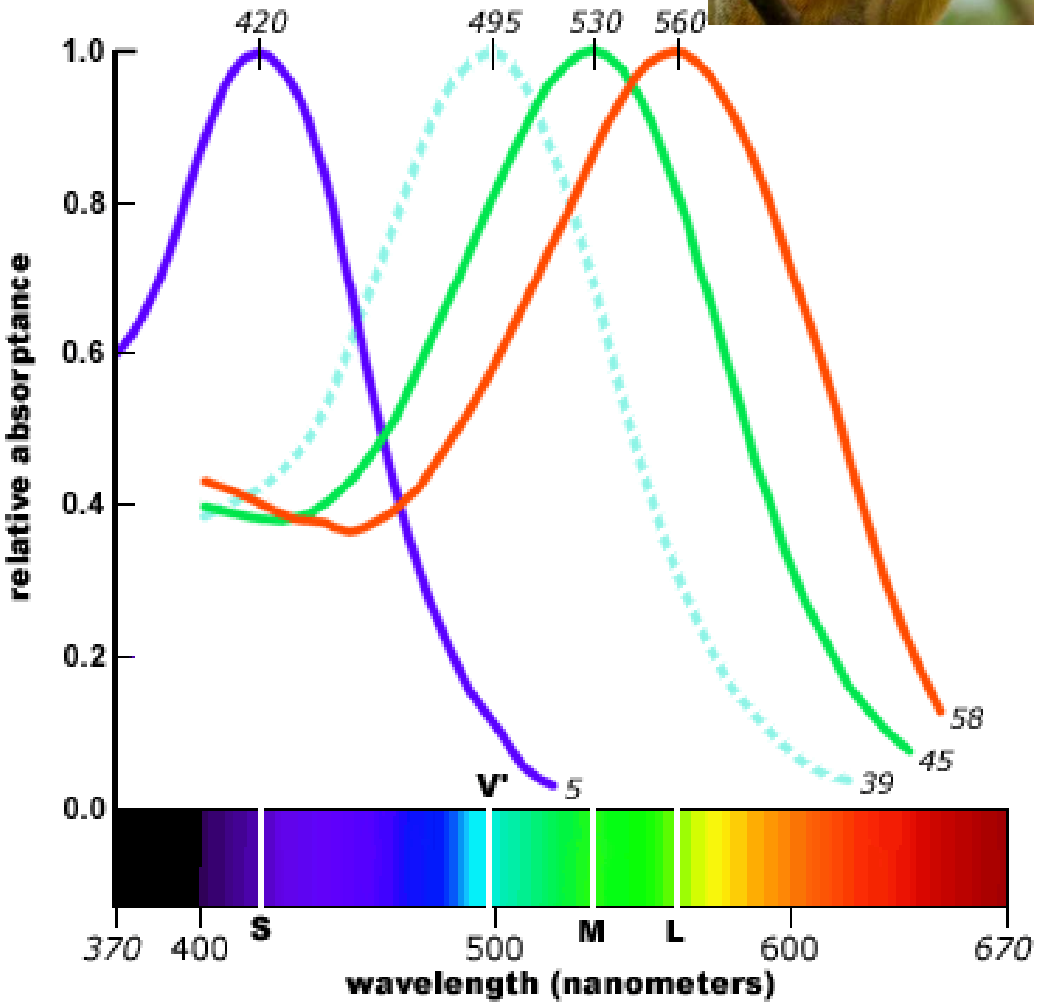
- two types of receptors: rods and cones
- Three variants of cones: sensitive to red, green blue





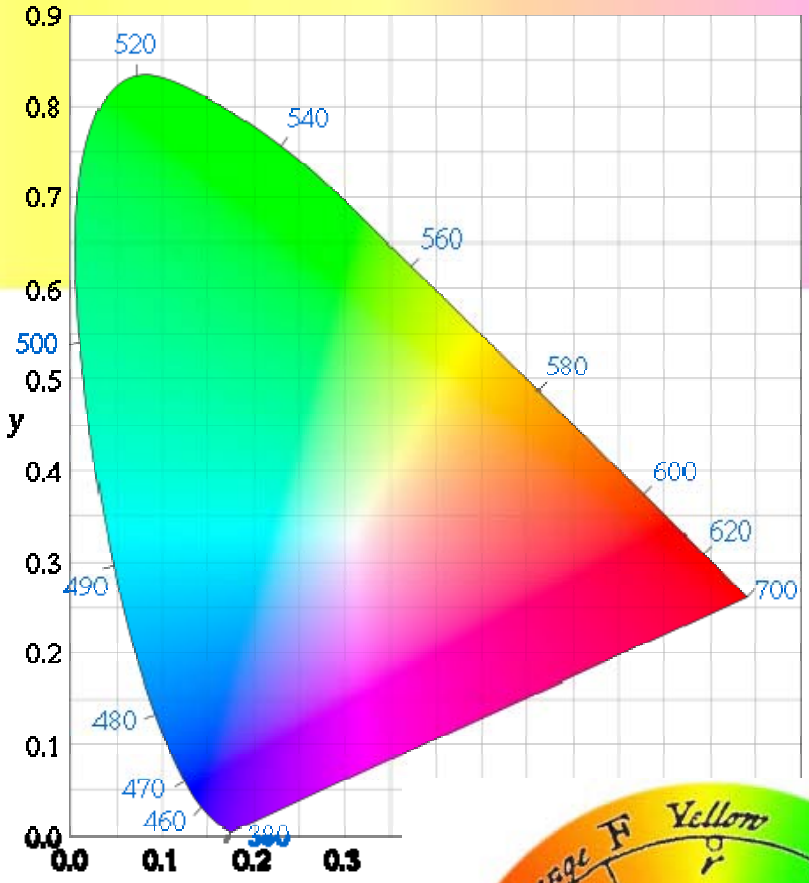
Human cone sensitivity

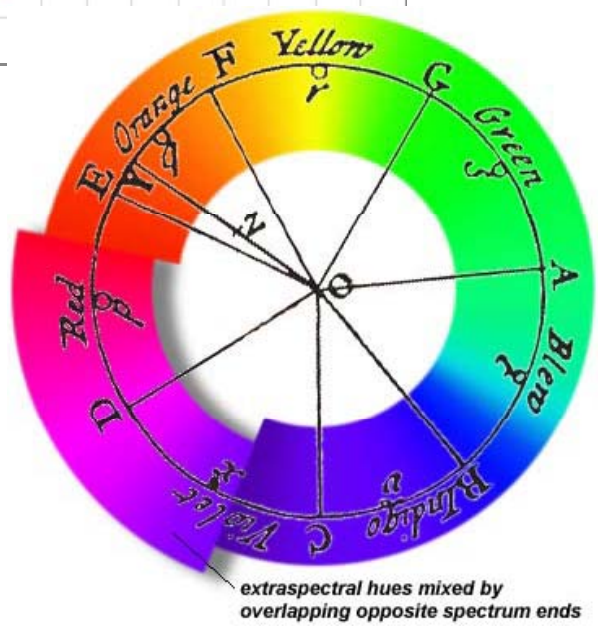
- The sensitivity areas overlap.
- No pure frequency can activate a single cone.
- but monochromatic light has as little overlap as possible.
- is perceived as saturated.



HUE

- CIE chromaticity diagram
- Extreme points give the most saturated color impressions
- can be approximated by color cycle.
  Hue: angle in the color cycle.

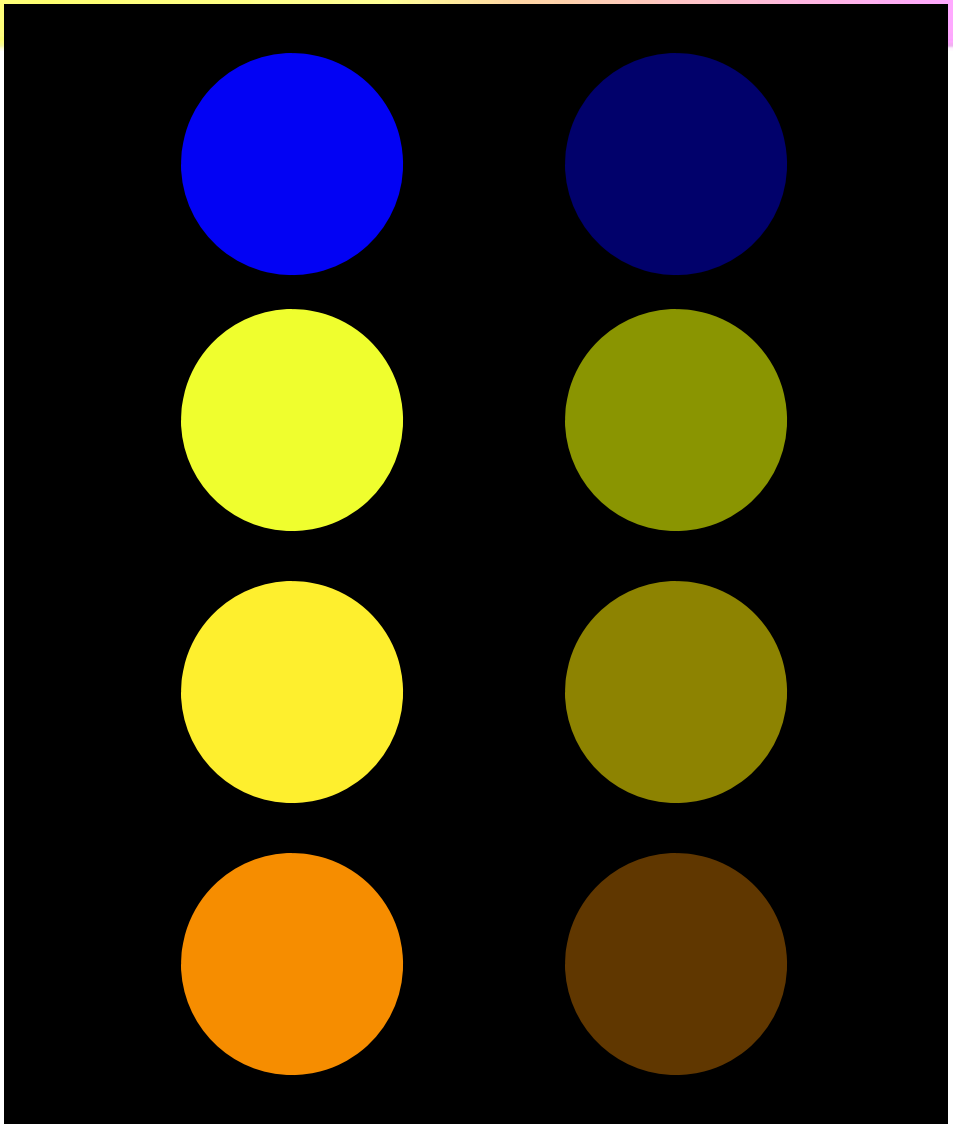




Sources Addison Wesley , Plimmer, Weber 2009

Hue/saturation split is only approximate

- For some particular colors, changing the saturation can change the perceived hue or the color quality.



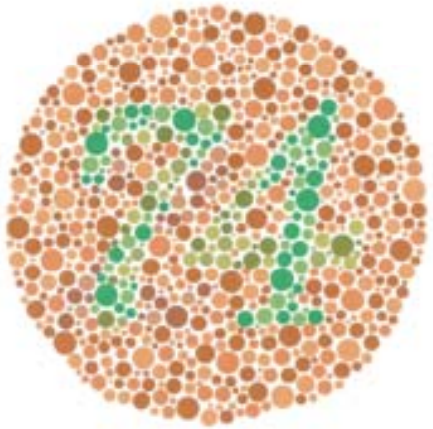
Sources Addison Wesley , Plimmer, Weber 2009

Colour Vision Deficiencies

- Variation in the sensitivity of cones result in colour vision deficiency (colour blindness).
- Many people have a colour vision deficiency
  - 8% of male individuals
  - 0.4% of female individuals
- The most common form is red-green deficiency known as deuteranomaly
  - 5% of male individuals
  - 95% of colour deficiencies in male individuals

Sources Addison Wesley , Plimmer, Weber 2009

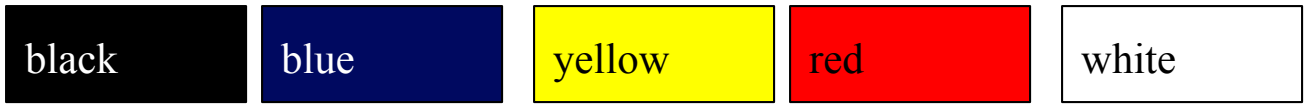
Colour Vision Deficiencies



- Example of an Ishihara color test:
- Persons with a color vision deficiency might not be able to read the number 74.
- Persons with the most common colour deficiencies can distinguish some colours, but not all.

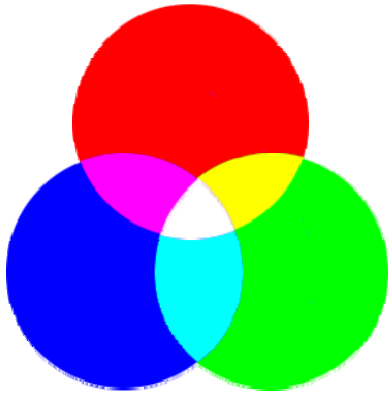
Addressing Colour Vision Deficiencies

- Because colour vision deficiencies are so prevalent, color schemes should be adapted.
- Because the most common color deficiencies allow the viewers still to distinguish certain colors, a set of colors should be chosen that are distinguishable for people with the most common forms of color blindness, e.g.:



Technical Issues Concerning Colour

- Colour Displays
  - Computer screens create colour by mixing red, green, and blue (RGB) light
  - purpose: to activate the three cone types as directly as possible. All hues can be expressed, but not all saturations.
  - Computer screen colour mixing is additive, printer colour mixing is subtractive and uses the complementary colours of the screen colours: yellow cyan, magenta.



Sources Addison Wesley , Plimmer, Weber 2009

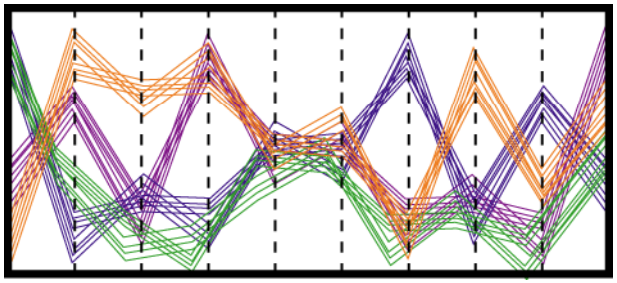
Using colour in Interaction Design

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

Sources Addison Wesley , Plimmer, Weber 2009

Using colour in Interaction Design

- Clarification, Relation, and Differentiation
- Colour can be used to clarify differences and similarities and communicate relationships
- Colour codes can be used to support a logical information structure.



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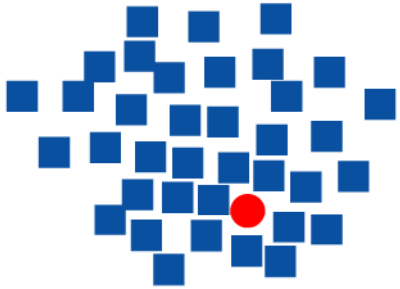
Using Colour in Interaction Design

Colour can be used to catch the attention of the user



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6
7  <ul>
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14 </ul>
15 <p>Of course we can't teach you everything about everything, so we are teaching
16 <p> For Beryl this is digital ink and haptics (but not in cars). The challenges
17 <p> Gerald will cover advanced specification techniques for User Interfaces. Or
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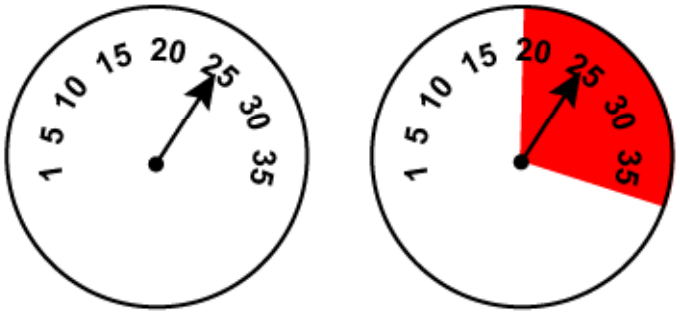


Sources Addison Wesley , Plimmer, Weber 2009

Using Colour in Interaction Design

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

Using Colour in Interaction Design

- Redundant Coding

MAXIM

A clear structure and presentation must already be present before colour 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, colour and shape (Thorell & Smith, 1990)

Sources Addison Wesley , Plimmer, Weber 2009

Colour Concerns for Interaction Design

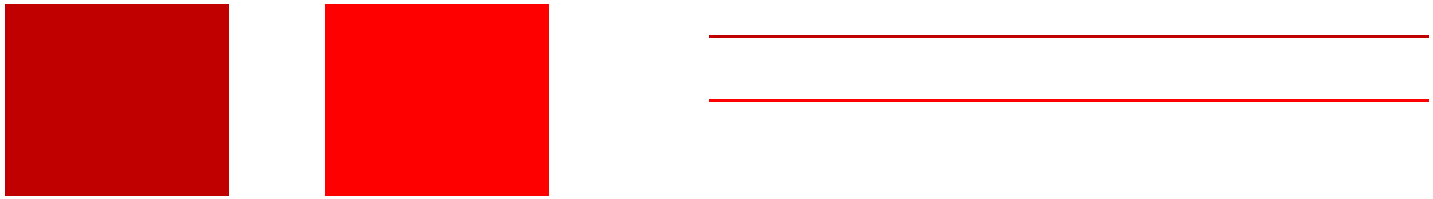
- Indistinguishable Differences
- Optimal colours
- Number of colours
- Incompatible Differences
- colour Backgrounds

Sources Addison Wesley , Plimmer, Weber 2009

Colour Concerns for Interaction Design

- Indistinguishable Differences

Our ability to perceive subtle changes varies with the size of the coloured area. Colour differences of areas are easier to determine than colour differences of lines.



Our sensitivity to changes in hue varies for the different hues.

Sources Addison Wesley , Plimmer, Weber 2009

Colour Concerns for Interaction Design

- Number of colours
  - To remember a colour and then recognize it later, we should use only a few distinct colours
  - To be able to tell the difference between two adjacent colour-coded objects, we can use more colours

MAXIM

Interface colours should never distract the user or compete with content

Sources Addison Wesley , Plimmer, Weber 2009

Colour Concerns for Interaction Design

- To the right are problematic color combinations.
- colours 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)

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

Sources Addison Wesley , Plimmer, Weber 2009

Technical Issues Concerning Colour

- The use of colour in interaction design involves the following four components:
  - Human perception
  - Display technology
  - User tasks
  - Computing environment

Finally

- Colour is part of the aesthetics of a interface

- and
- Aesthetics are very important!!!
  - ‘nice’ interfaces work better.

Sources Addison Wesley , Plimmer, Weber 2009