Colour Perception

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PSYC 579

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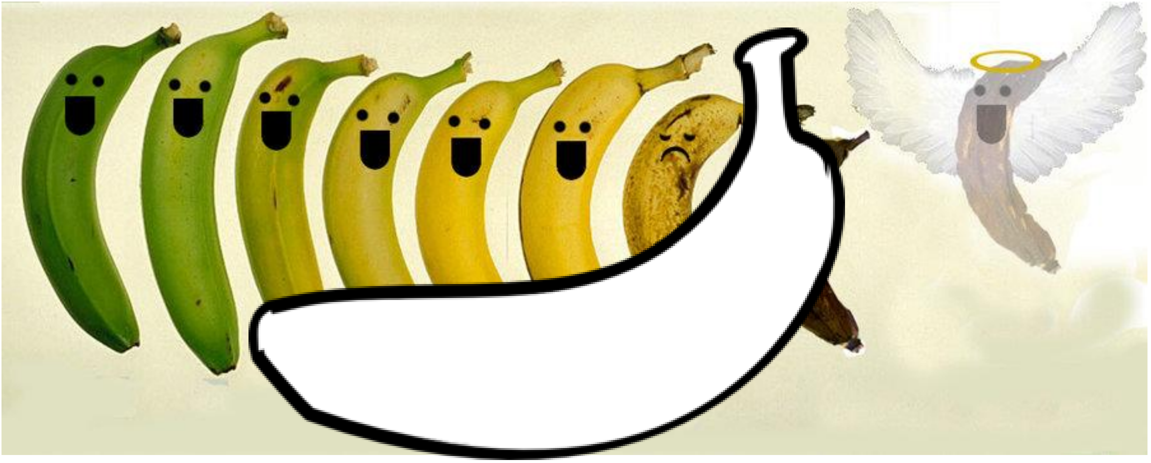
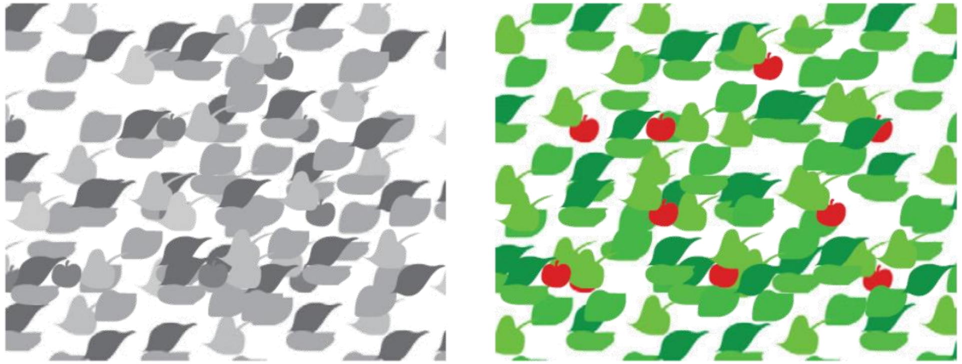
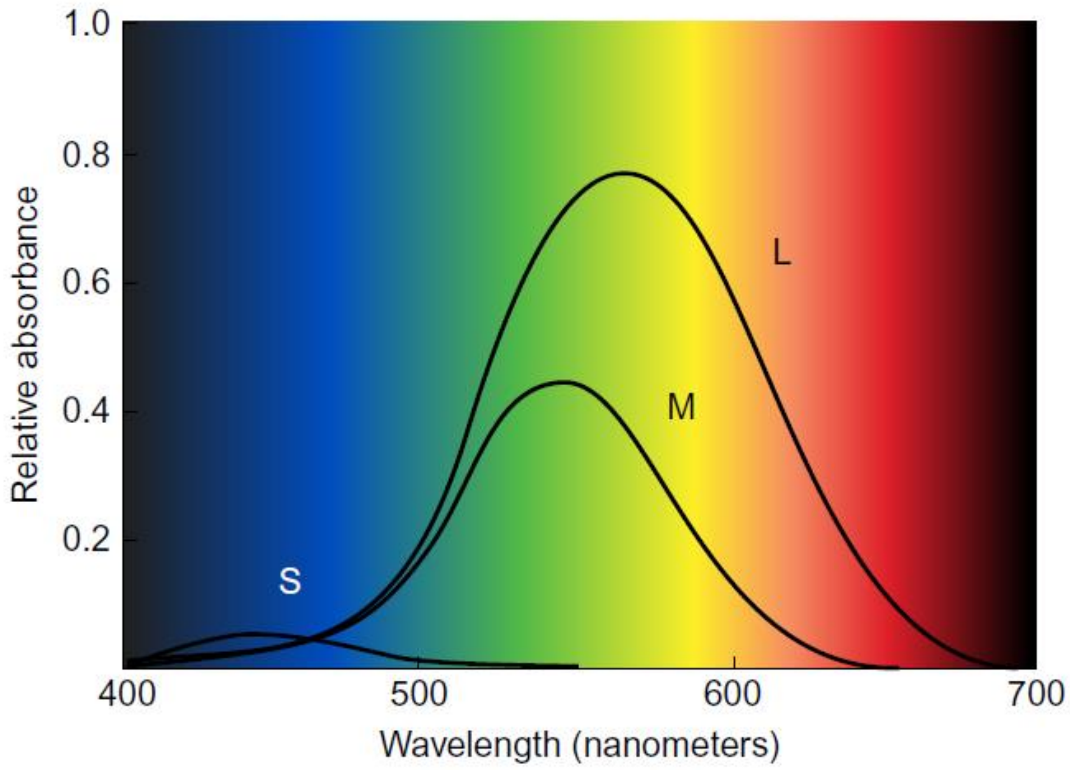
Outline

- Trichromacy theory
- Opponent process theory
- Colour spaces
- Considerations for the use of colour
- Task based colour design





Using colour in daily functioning



Trichromacy Theory

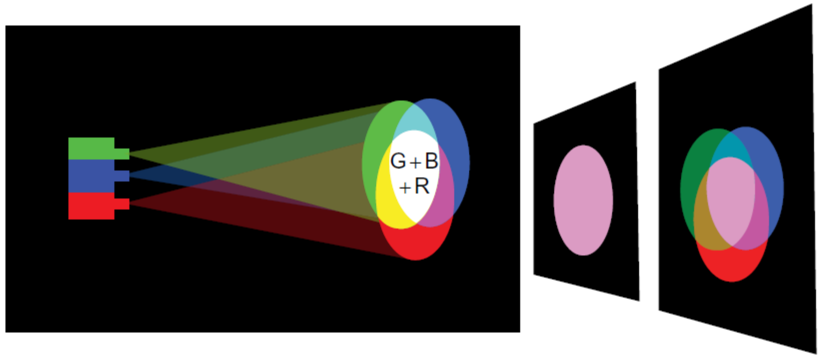
Colour vision

Colour space

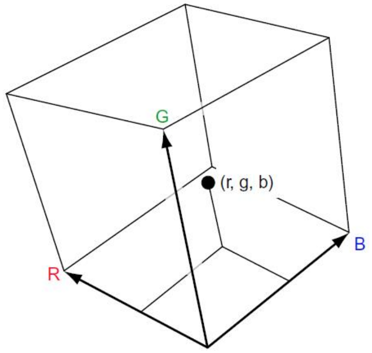
Colour Primaries

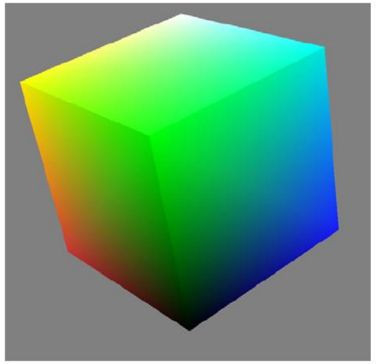
- Only need combination of 3 *primaries* to match any colour
- TV – RGB
- Paints – RYB
- Printers – Cyan, Magenta, Yellow
- Light Calorimetry
  - C ≡ rR+gG+bB
  - ≡ perceptual match

Colour Gamut - based on a chosen primaries

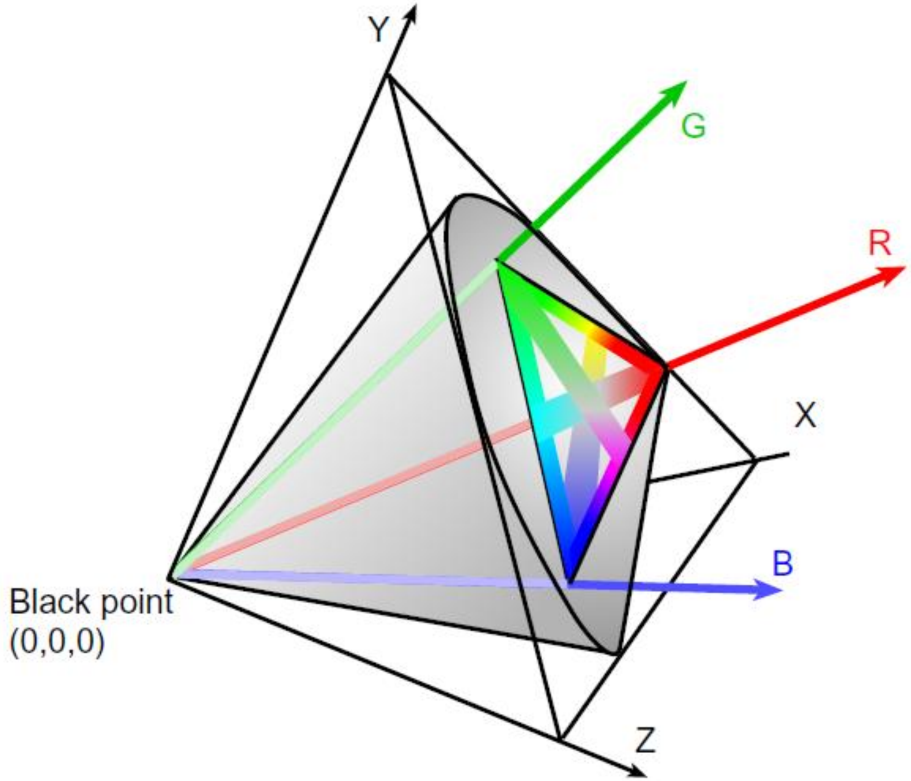


(a) (b)





Colour Standards



- **Goal** – reproduce same colour on any number of output devices
- Based on a standard observer
- *Commission Internationale de L'exclairage* (CIE)
- Use abstract observer sensitivity functions called **tristimulus values** (XYZ) (measure based on mathematically properities)
- Y value same as luminance
- CIE used for precise colour specification

Properties of the chromaticity diagram

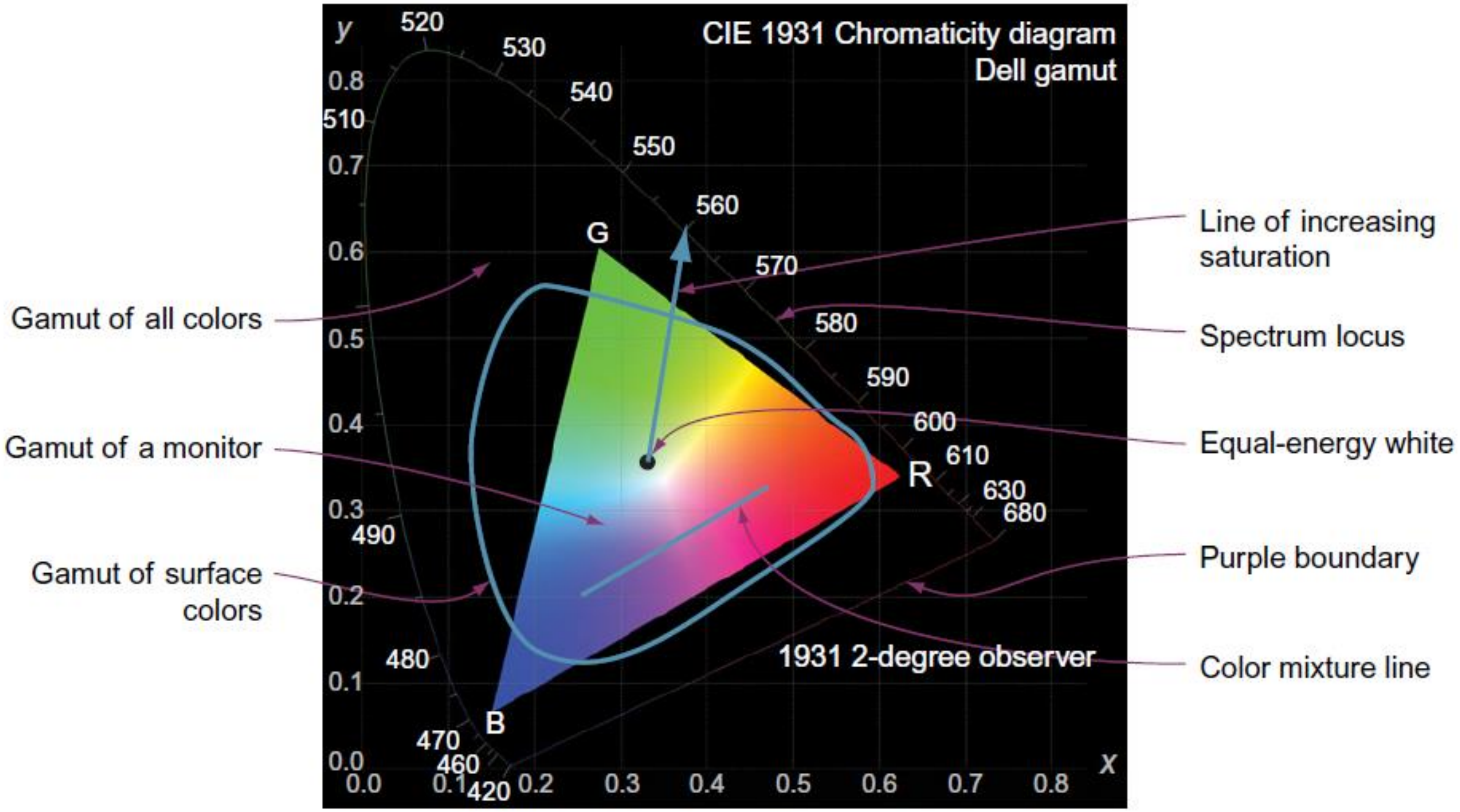


Figure 4.7 CIE chromaticity diagram with various interesting features added. The colored triangle represents the gamut of a computer monitor. Colors as shown are only approximate.

Uniform colour spaces

CIE_{lab}

CIE_{luv}

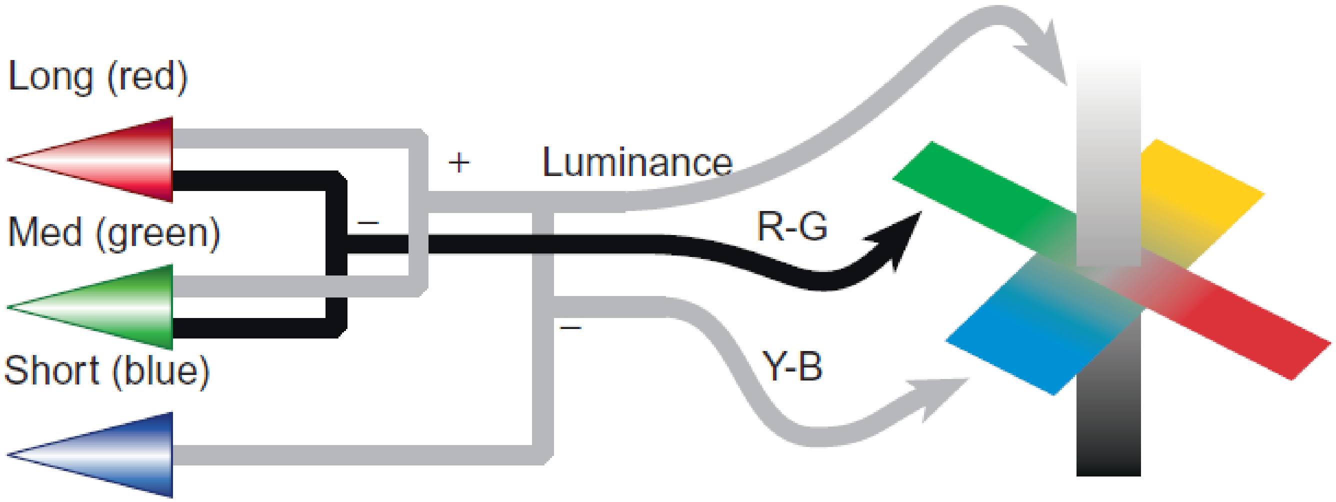
Transform from CIE colour space to a uniform colour space so that the differences between colours used are equal distances perceptually and in colour space

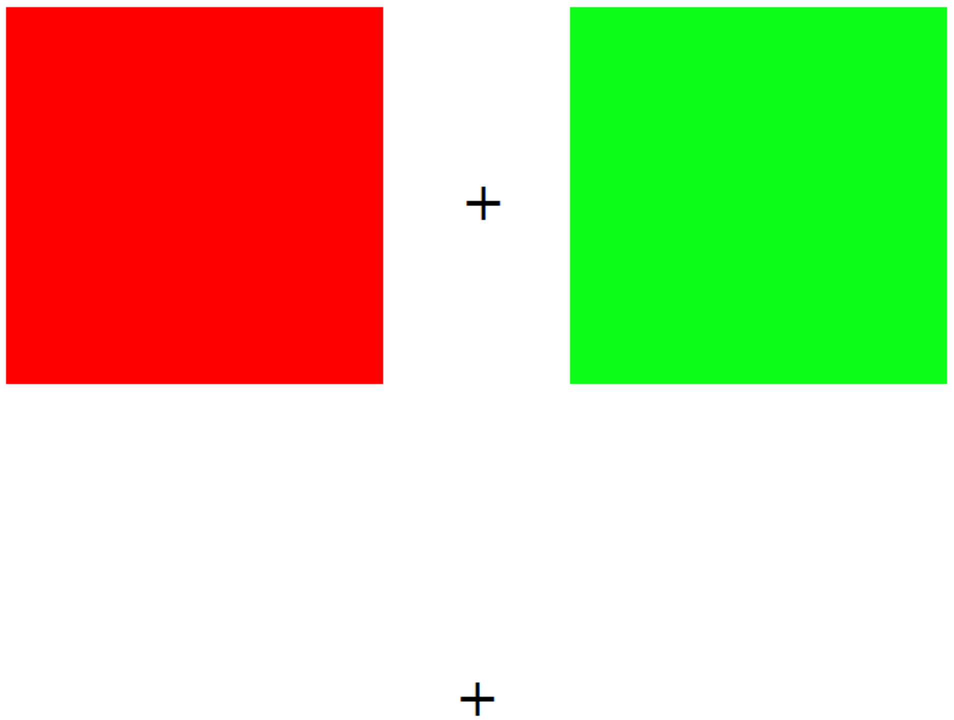
Colour tolerance: based on perceived colour, specified in industry when ordering coloured parts

Colour Codes: using colours to code data such as wires in a cable, should be as far apart as possible in uniform colour space

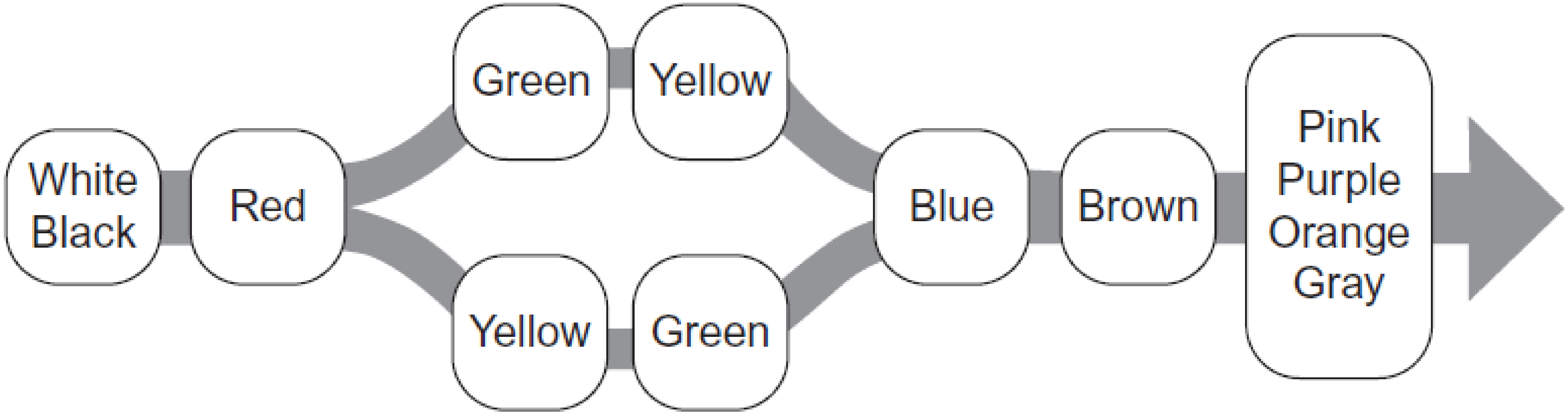
Pseudocolour Space: using colour to represent ordered data values, use to make perceptual equal steps in a sequence of colours

Opponent Process Theory





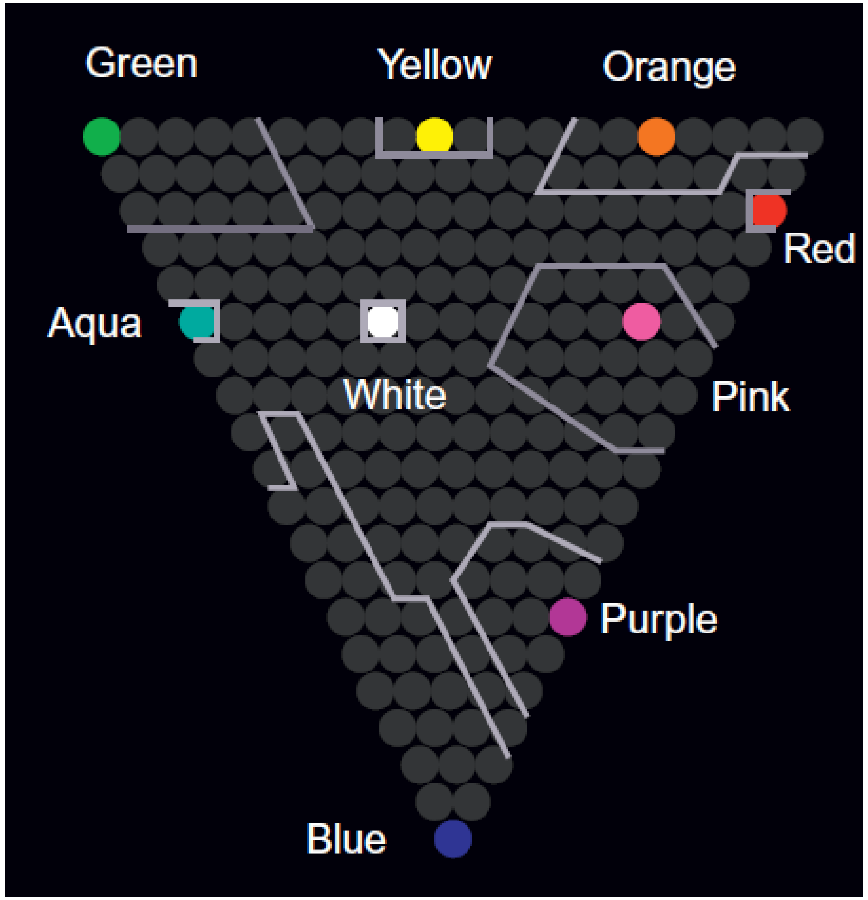
Colour terms across cultures



Categorical Colours

Naming Colours

- 8 effective colour categories
- Contrast effects need to be taken into consideration
- Pure monitor red perceived as orange



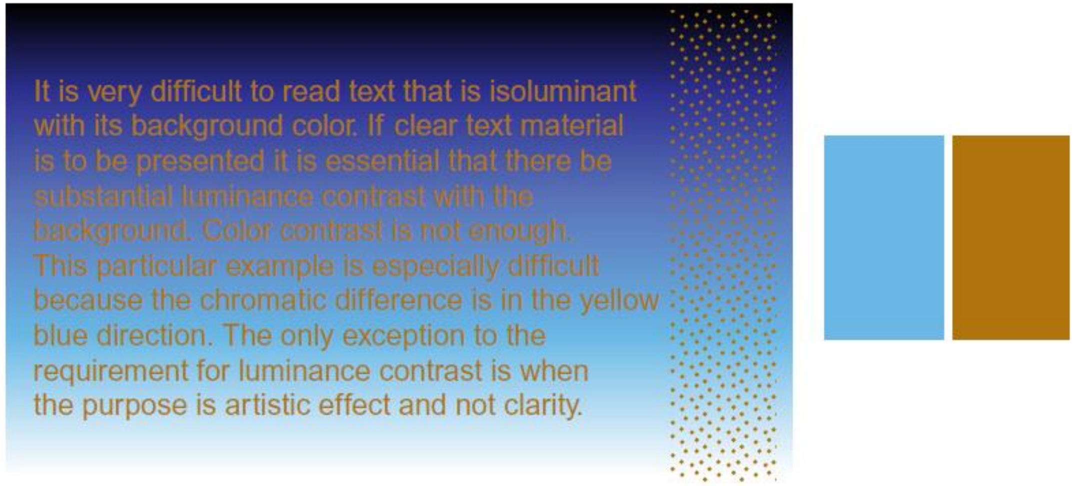
Colour channels

Luminance Channel

- High spatial frequency information
- Depth perception
- Form perception (unless stimulus is large)
- motion

Chromatic Channel

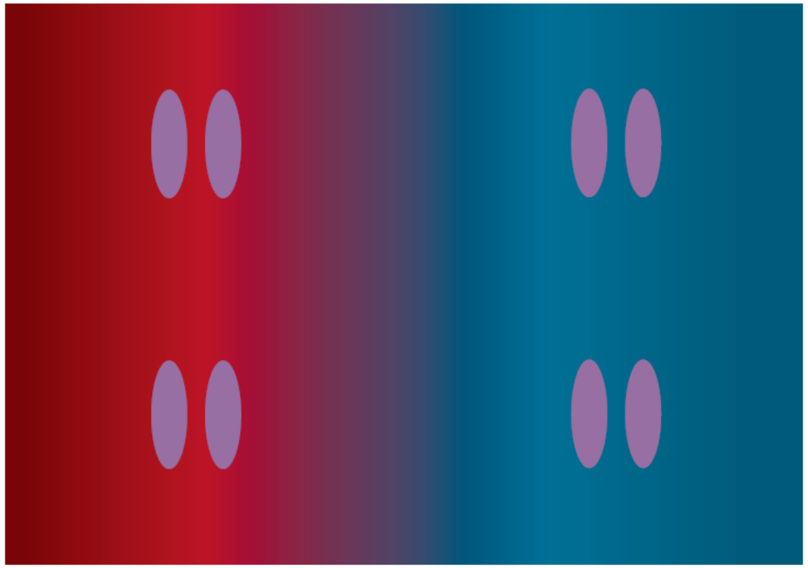
- Isoluminous/equiluminious patterns
- Rienforce form – add border with large luminance difference
- Categorization



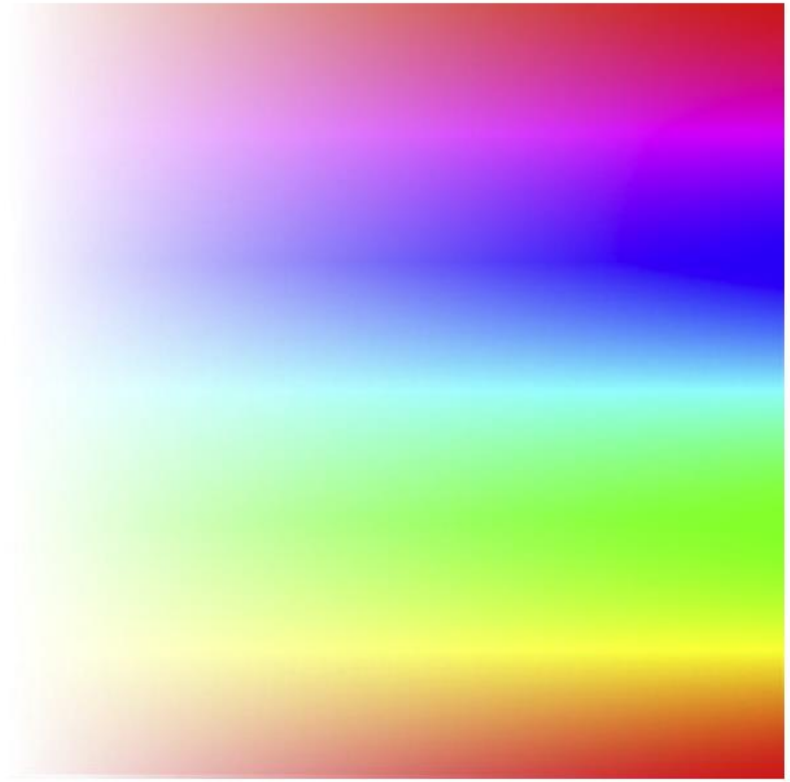
Weaknesses in equiluminous patterns

Colour Constancy

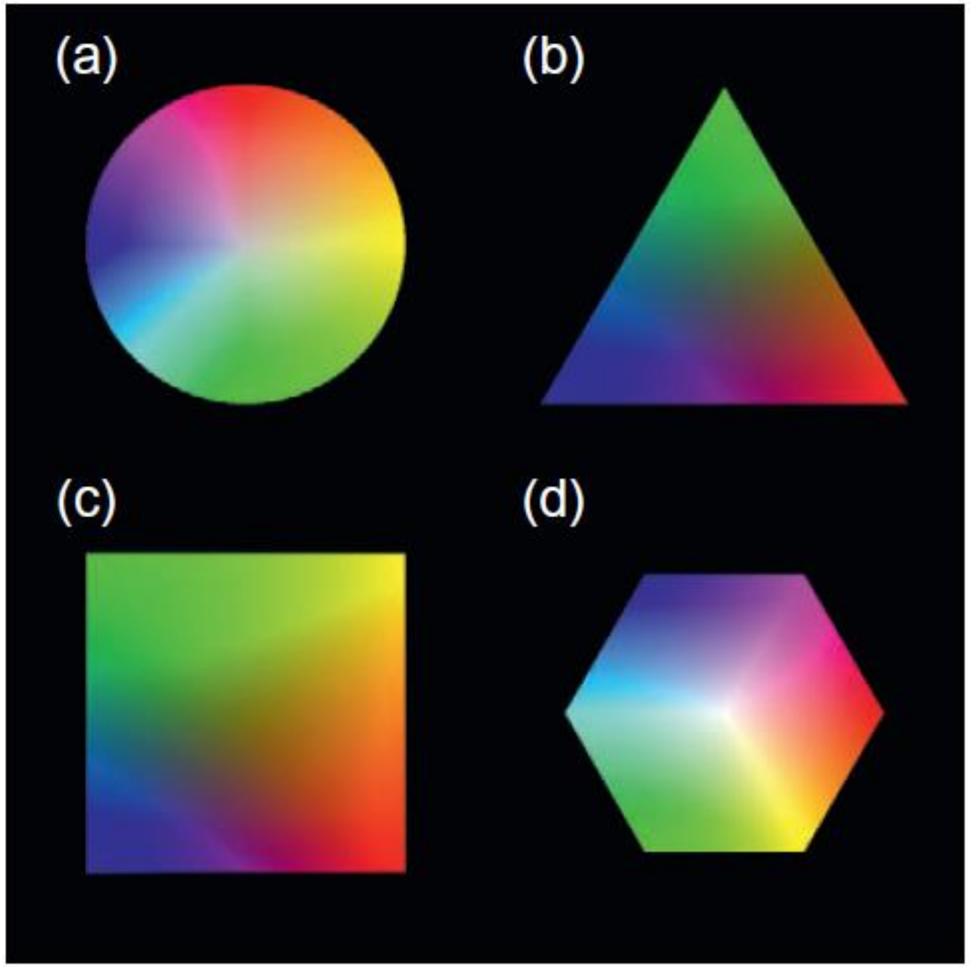
- Chromatic adaptation and chromatic contrast effects
- Not designed for absolute colour perception
- Context is key to colour perception



Saturation



- Perceptual “pureness” of a colour
- High Saturation
  - more vivid
  - stronger activation of R/G, B/Y channels
- For use in Data Visualization
  - Use higher saturation to denote higher numerical values



Applications

Colour specification interfaces

- Colour spaces – RGB
  - Assign value to R, G, and B
  - Not intuitive
- Colour spaces – HSV
  - *Hue* – approximation to the visible spectrum
  - *Saturation* – distance from white-gray-black axis to purest hue value
  - *Value* – black and white axis

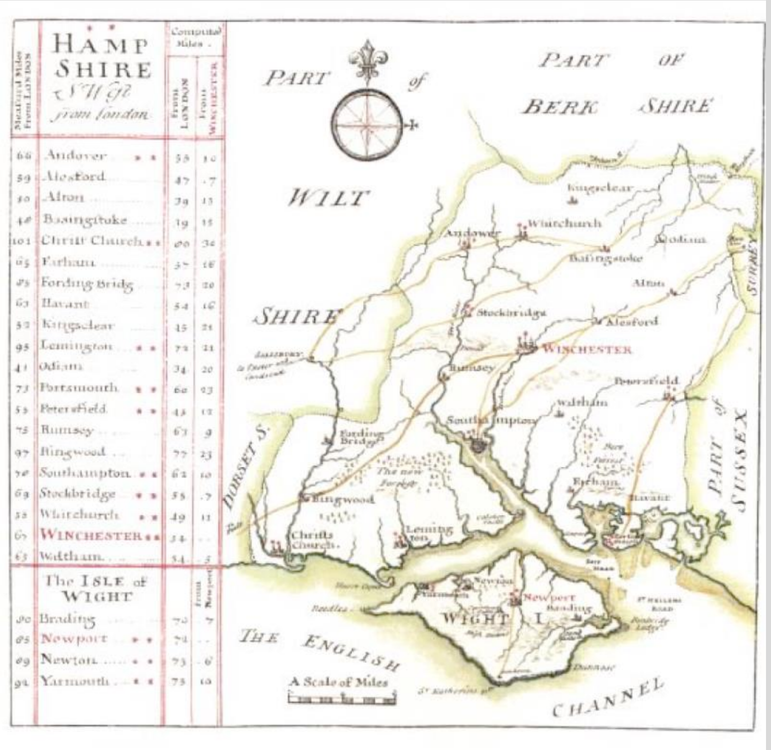
Colour for naming: Nominal codes

- Chromatic categories better than luminance categories

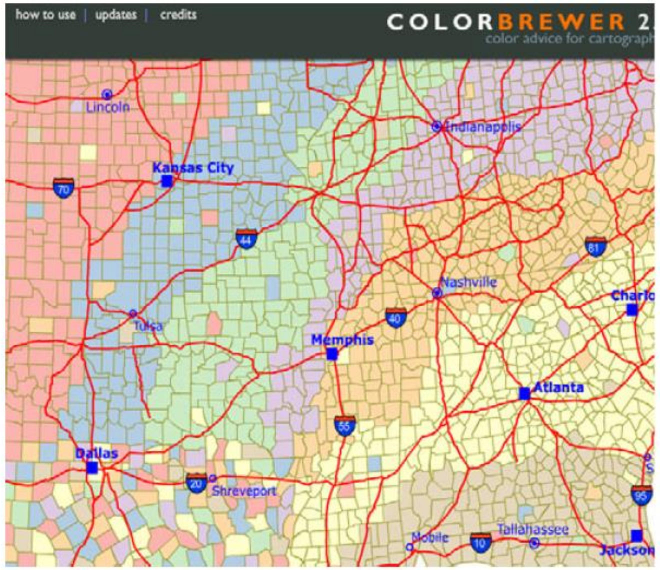
- More options!

Rules

- Distinctiveness
- Unique Hues
- Contrast with background
- Colour blindness
- Number
- Field Size


HAMP SHIRE
from London
Computed Miles
PART of BERK SHIRE
WILT SHIRE
WINCHESTER
DORSET S.
PART of SUSSEX
The ISLE of WIGHT
THE ENGLISH CHANNEL
A Scale of Miles


A Map of HAMPSHIRE
PART OF BERK SHIRE
WILT SHIRE
WINCHESTER
THE ENGLISH CHANNEL
English Miles


how to use | updates | credits
COLORBREWER 2.
color advice for cartograph
Lincoln
Kansas City
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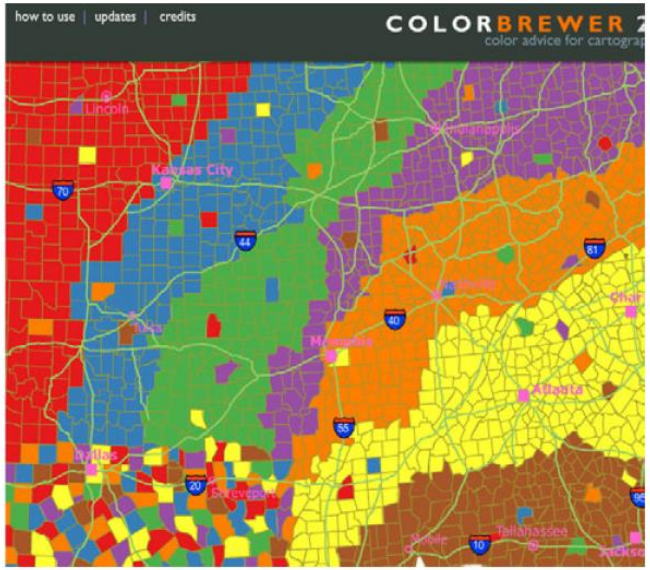
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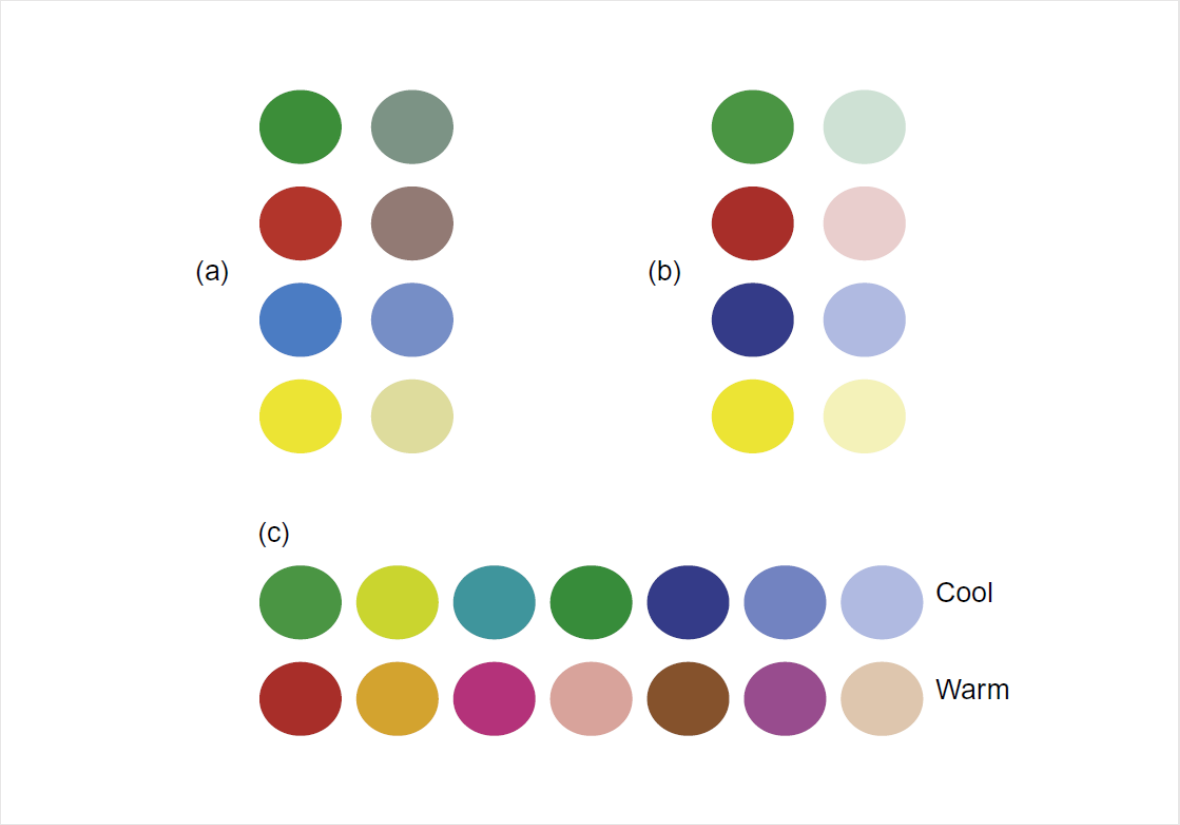
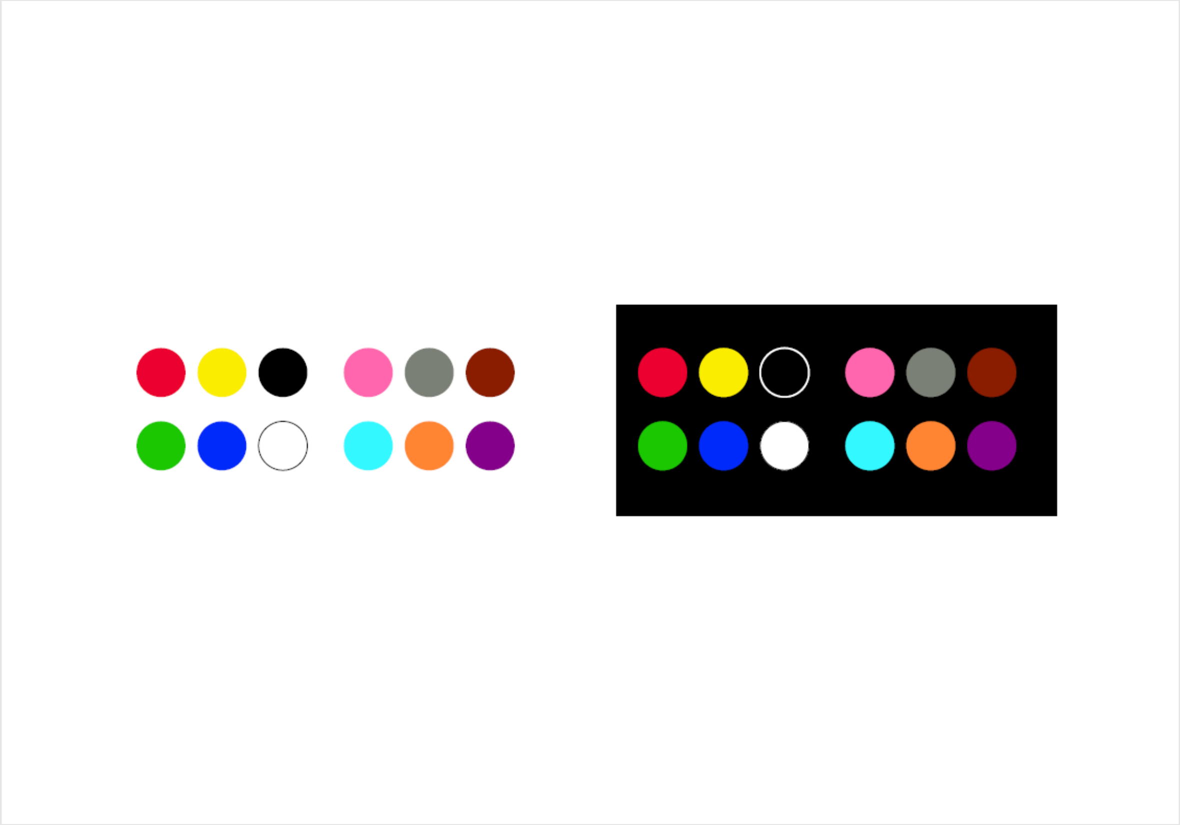




Colour Families and Labeling

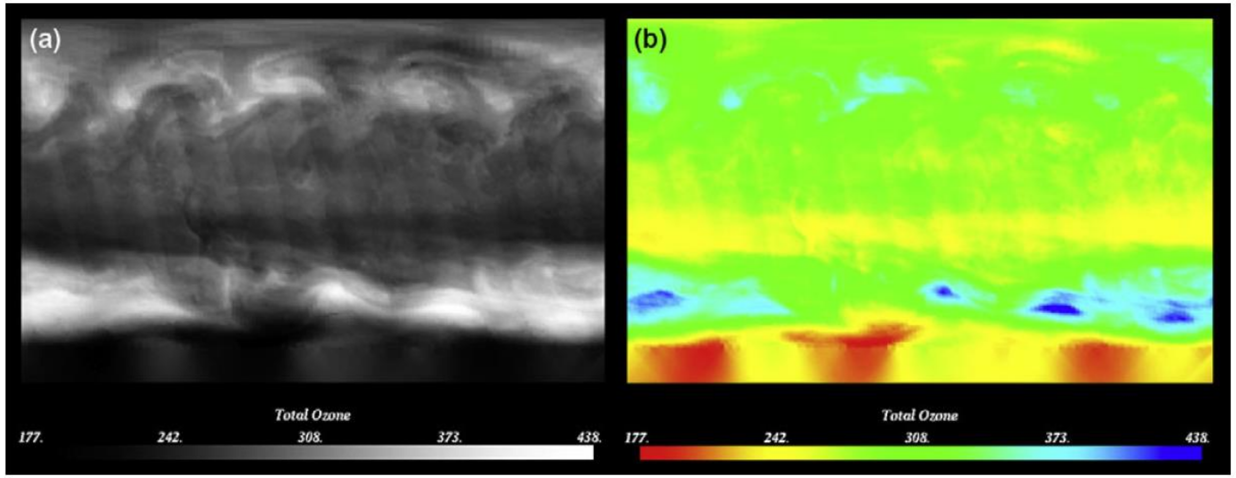


Figure 4.26 The same data showing ozone concentrations in the southern hemisphere is represented using (a) grayscale and (b) spectrum approximation pseudocolor sequences. (*Images courtesy of Penny Rheingans (Rheingans, 1999)*.)

Applications

Colour Sequences for Data Maps

- Pseudocolouring
- Challenges
  - Ordering colours

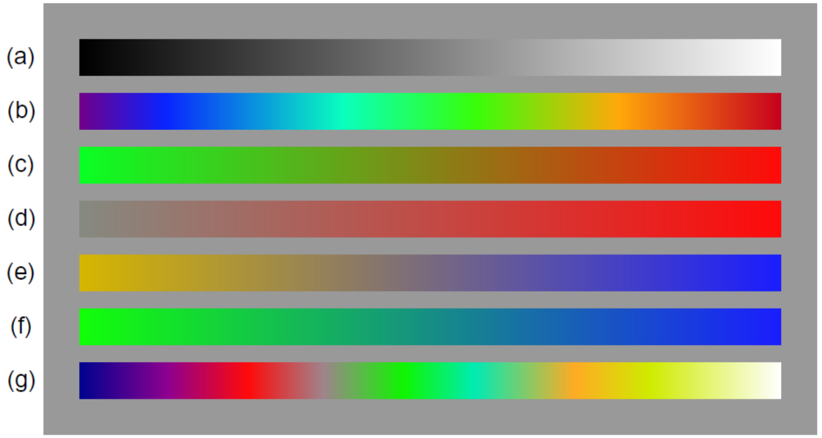


Figure 4.27 Seven different color sequences: (a) Grayscale. (b) Spectrum approximation. (c) Red–green. (d) Saturation. (e, f) Two sequences that will be perceived by people suffering from the most common forms of color blindness. (g) Sequence of colors in which each color is lighter than the previous one.

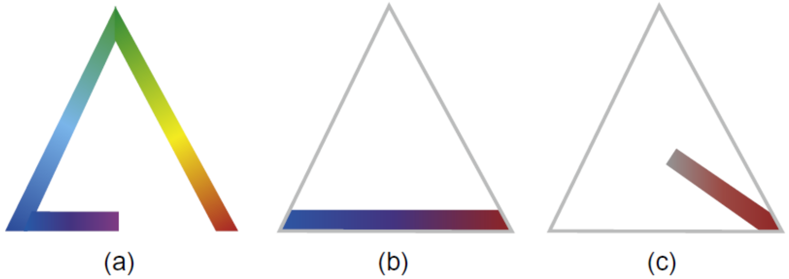
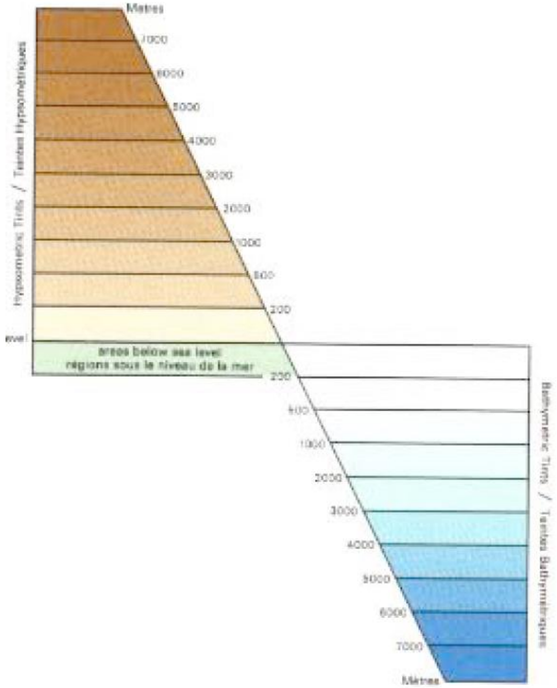
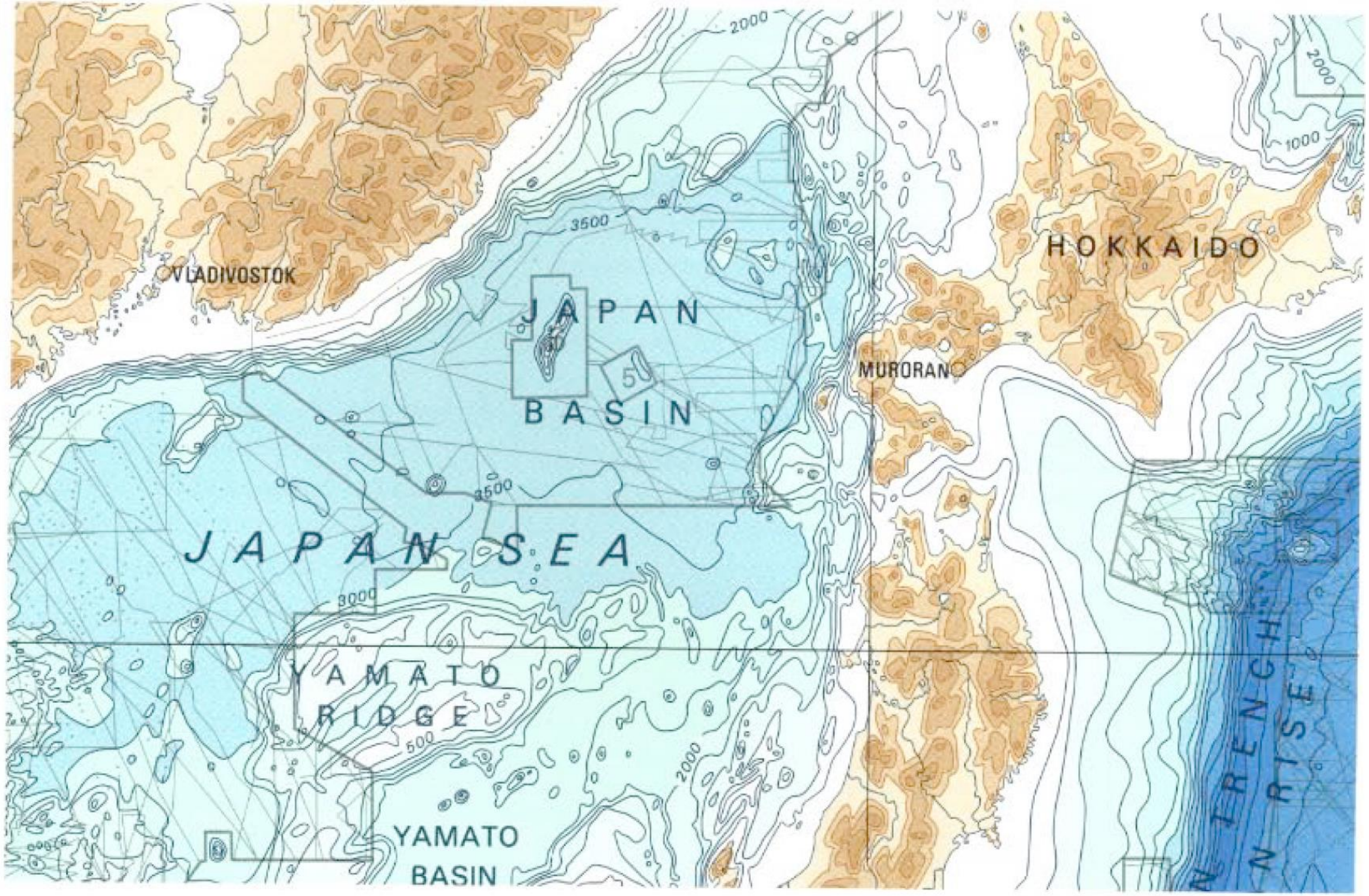


Figure 4.28 Sequences on a chromaticity diagram. (a) Spectrum approximation. (b) Blue–red sequence. (c) Saturation sequence.

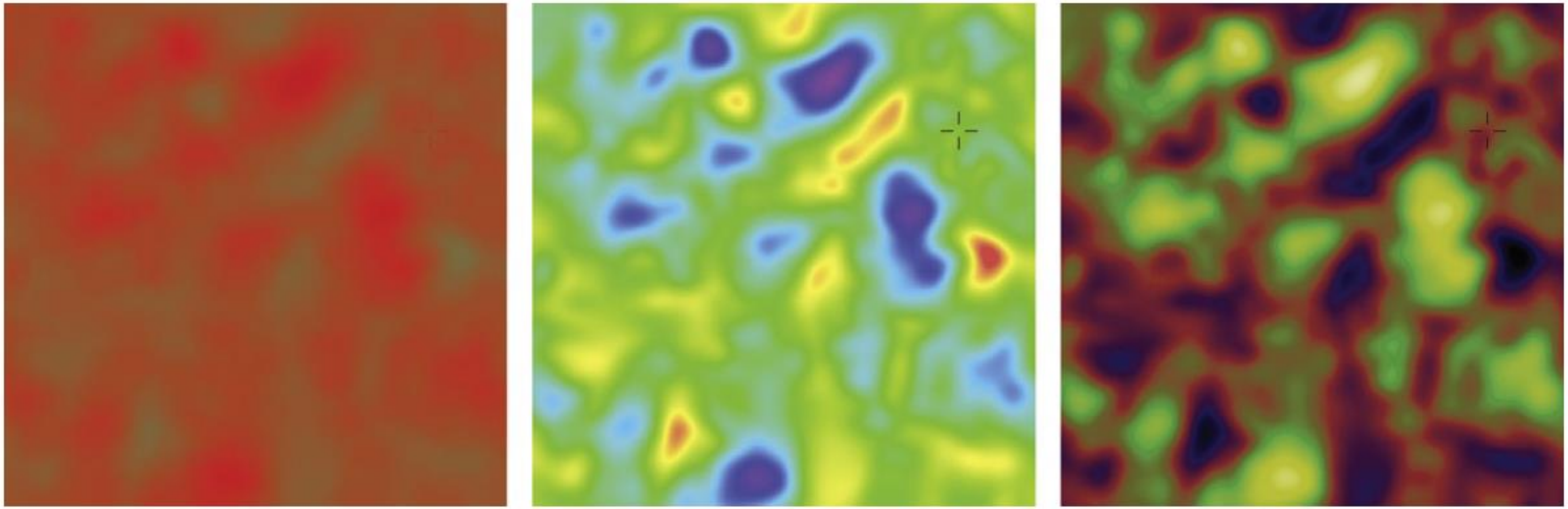
Colour sequences

Effective mapping





Saturation, Spectrum and Spiral colour sequences



Applications: Colour reproduction

Problem: Reproducing colour in different display devices effectively

Monitors can produce more colour than printers, but is that useful?

Solution: Understand how our visual system perceives colour

Colour perception is relative, not absolute, preserve the relationships!

Rules

1. The gray axis of the image should be preserved. What is perceived as white on a monitor should become whatever color is perceived as white on paper.
2. Maximum luminance contrast (black to white) is desirable.
3. Few colors should lie outside the destination gamut.
4. Hue and saturation shifts should be minimized.
5. An overall increase of color saturation is preferable to a decrease.

Important lessons

- 3 dimensional organization of colour in humans
- Two chromatic channels and one luminance channel
- Chromatic channels
  - Low spatial resolution – small objects need high saturated colours
  - Chromatic contrast – only a few colours will be readily identifiable
  - Contrast effects – large areas less strongly colours