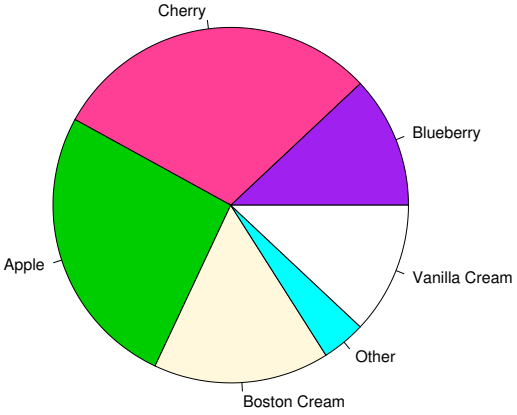
Colour for Presentation Graphics

Ross Ihaka

Department of Statistics
University of Auckland

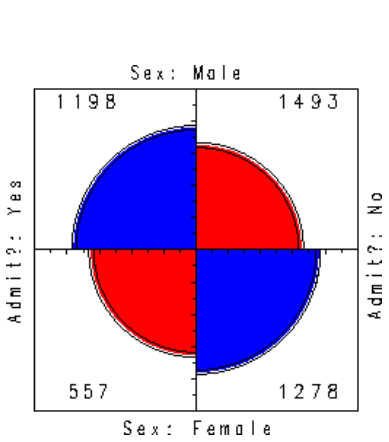
The Problem

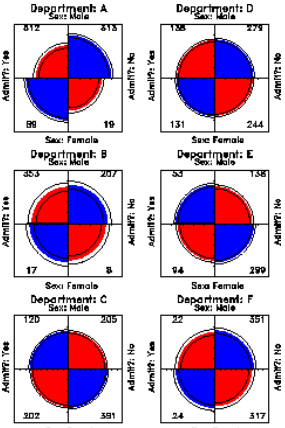
- Many presentation graphics use coloured areas to encode information.
- The colours are used to indicate association with data groups.
- Examples:
  - Bar graphs
  - Pie charts
  - Mosaic plots
- How should the colours be chosen?



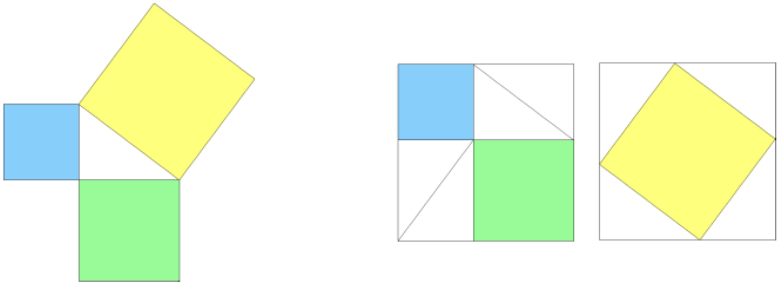
January Pie Sales

Example from The POSTSCRIPT Language Tutorial and Cookbook.
Produced by `demo(graphics)` in R.





Michael Friendly: The Berkeley Admissions Data.
http://www.math.yorku.ca/SCS/Courses/grcat/grc3.html#Fig_4fold2



American Mathematical Society: Visual Explanations in Mathematics.
http://www.ams.org/new-in-math/cover/visual1.html

Approaches to Colour Choice

Approaches to Colour Choice

- Avoid colour.

Approaches to Colour Choice

- Avoid colour.
- Determine colours by experimentation.

Approaches to Colour Choice

- Avoid colour.
- Determine colours by experimentation.
- Use “good taste” or expertise.

Approaches to Colour Choice

- Avoid colour.
- Determine colours by experimentation.
- Use “good taste” or expertise.
- Use fixed palettes designed by an expert.

Approaches to Colour Choice

- Avoid colour.
- Determine colours by experimentation.
- Use “good taste” or expertise.
- Use fixed palettes designed by an expert.
- Look for guiding principles.

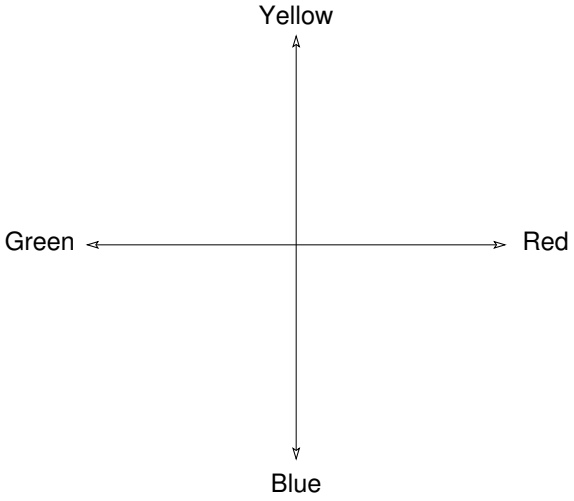
Colour Vision

- The cone cells of the retina provide our normal light (photopic) vision.
- Initially there was a single class of cone cell providing monochrome vision.
- The single class of cone cell differentiated into separate yellow and blue sensitive cells.
- The yellow class of cone cell differentiated into separate red and green sensitive cells.
- We now have three different types of cone cell, with peak sensitivity at different light wavelengths.

Color Axes

- Evolution has given us a perception of colour which is three dimensional.
  - Axis 1: Brightness.
  - Axis 2: Location on a yellow/blue scale.
  - Axis 3: Location on a red/green scale.

- Our natural perception of colour seems to correspond to the use of polar coordinates for axes 2 and 3.
  - Axis 1: Brightness (or Luminance)
  - Axis 2: Colourfulness (or Chroma)
  - Axis 3: Hue


Yellow
Green
Red
Blue

Colour Spaces

- **RGB**

  Colours are represented by the amount of red, green and blue primaries required to produce a given colour sensation.
  Device dependent.

- **HSV, HSL, . . .**

  Transformations of RGB space which match our perception of colour better than RGB.
  Device dependent.

- **CIE-XYZ**

  Colours are described in terms of colour matching to a fixed (but imaginary) set of primary colours.
  Device independent.

Uniform Colour Spaces

- **Munsell**

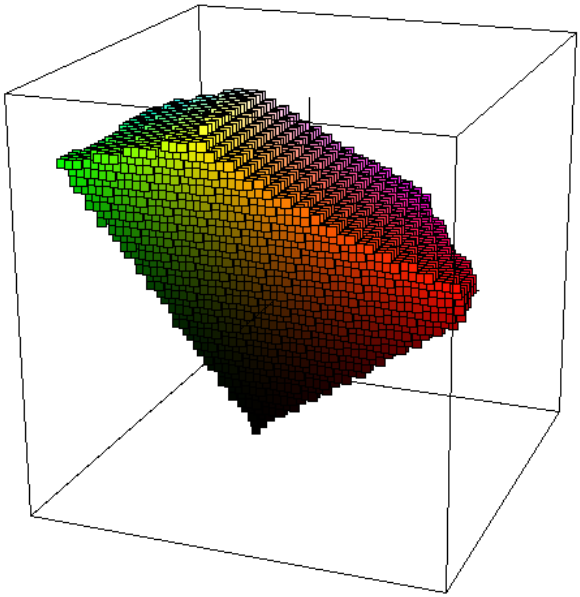
  An empirically calibrated, “perceptually uniform” color space. Defined in terms of hue, brightness and chroma.
  Device independent.

- **CIE-LAB**

  A transformed version of CIE-XYZ which is more perceptually uniform. Designed for reflective applications.
  Device independent.

- **CIE-LUV**

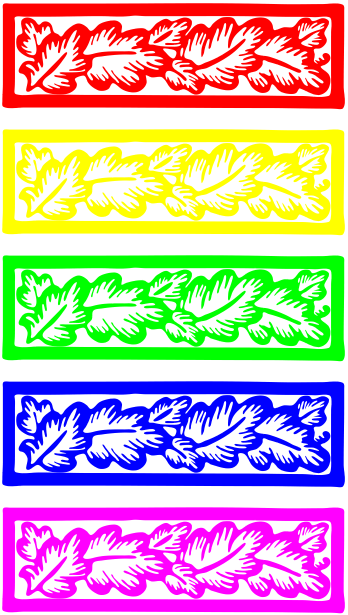
  Another transformed version of CIE-XYZ. Designed for emissive applications.
  Device independent.



CIE-LUV

Colour Harmony or Balance

- Some of the most sensible advice on colour use is to be found in the work of the American colourist Albert Munsell.
- Munsell taught painting in Boston and derived some simple principles for good colour use.
- He provides simple recommendations on how colours can be chosen in a harmonious way.
- Unlike many prescriptions for colour use, Munsell's recommendations are *quantitative*.
- The recommendations are directed at Munsell's empirically derived uniform colour space.



Full Saturation Hues.

These colours vary wildly in brightness and colourfulness.

The circus wheel and poster, although they yell successfully for momentary attention, soon become so painful to the vision that we turn from them.

"Balanced" Colours
After Munsell

These colours have equal
brightness and colourfulness.

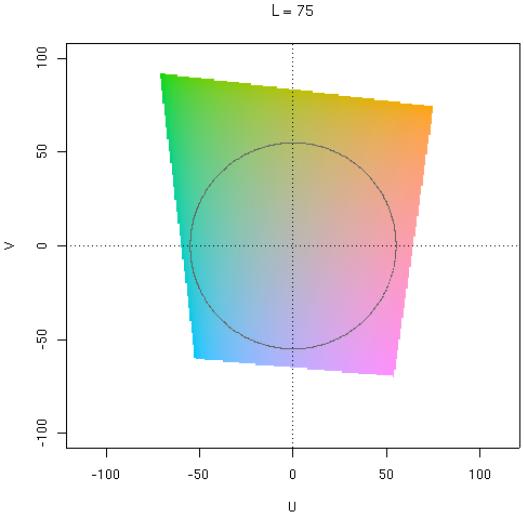
Munsell Rediscovered

- Munsell set down his ideas on colour harmony shortly before the art world rejected prescriptions of balance and order.
- Despite their rejection in fine arts, the ideas have been retained and appreciated in the graphic arts printing industry.
- The ideas appear to now be undergoing a rediscovery by those working in visualisation user interface design.

Choosing Colours for Presentation Graphics

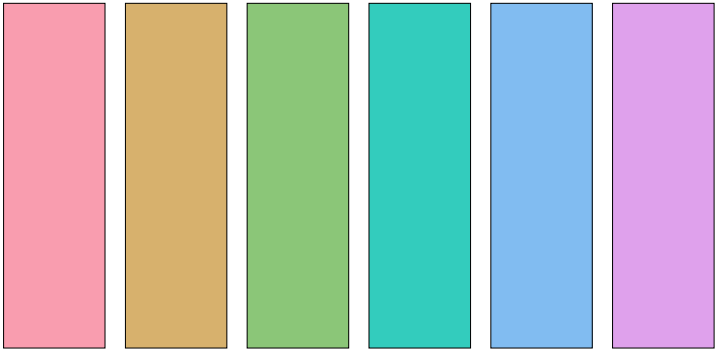
- Work in a perceptually uniform colour space (e.g. LUV).
- To make colours comparable, make them have:
  - Equal luminances (i.e. equally bright)
  - Equal chroma (i.e. be equally colourful).
- Given these (and any other) constraints, space the colours out as much a possible.
- Such colours can be described as having “equal impact,” because they differ only in hue.

A Slice Through LUV Coordinates (L = 75)

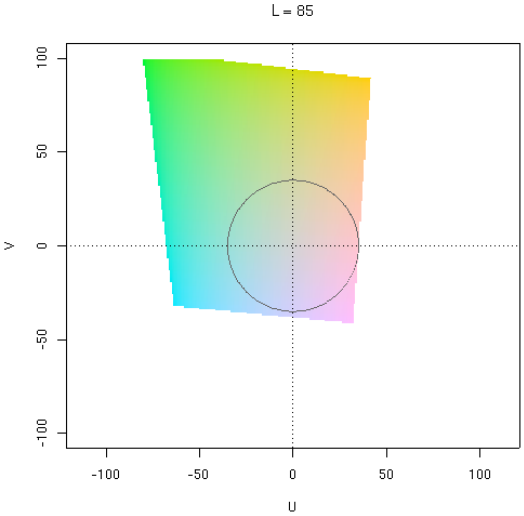


The circle has radius 55.

A Six Colour Palette (L = 75, C = 55)

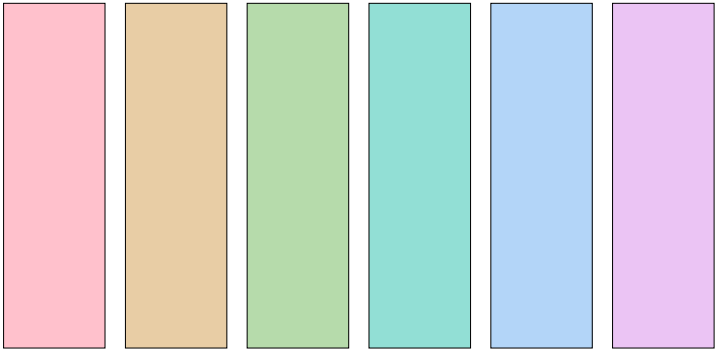


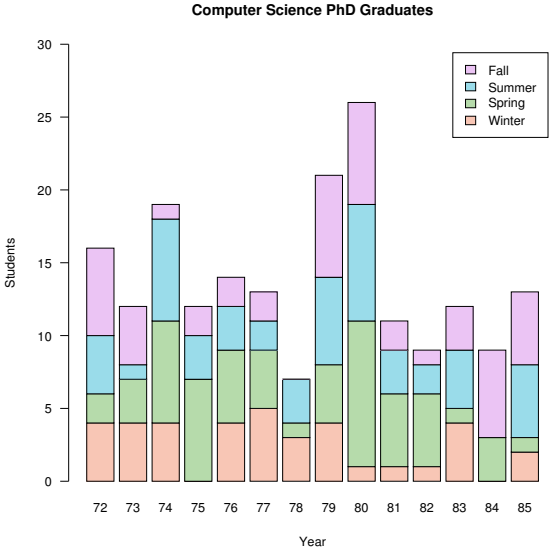
A Slice Through LUV Coordinates (L = 85)



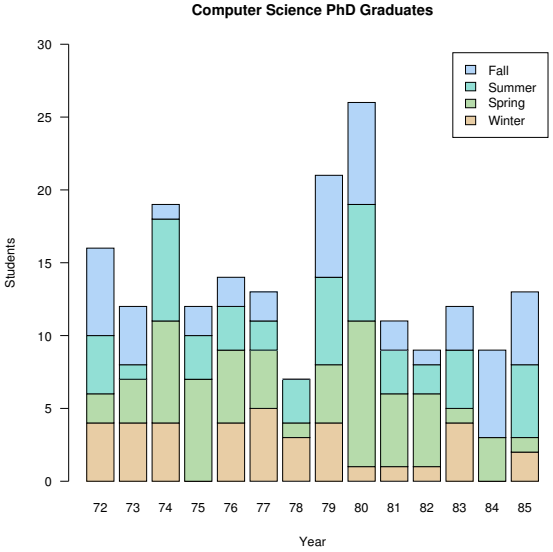
The circle has radius 35.

A Six Colour Palette (L = 85, C = 35)

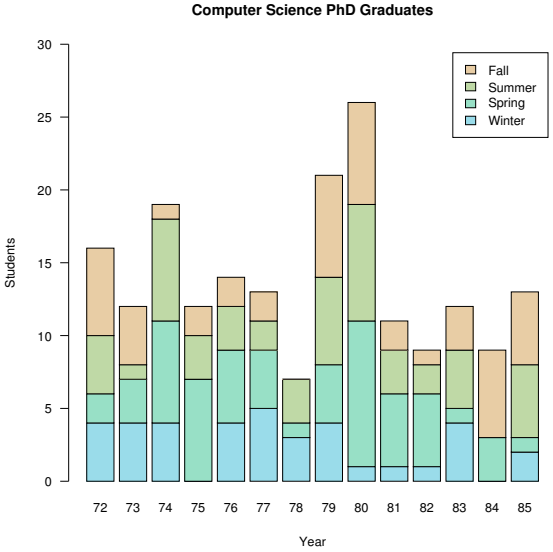




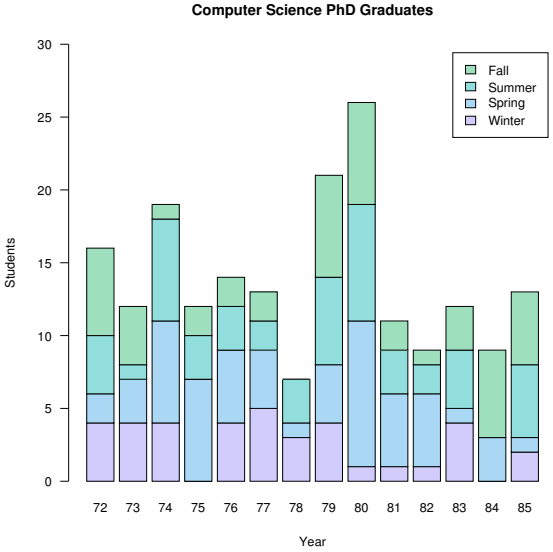
Equispaced colours, full circle (after Foley and Van Dam).



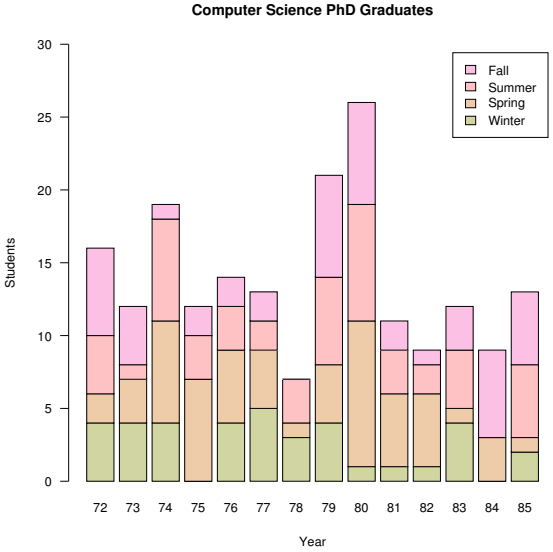
Equispaced colours, half circle (after Foley and Van Dam).



Metaphorical colours (after Foley and Van Dam).



Cool colours (after Foley and Van Dam).



Warm colours (after Foley and Van Dam).

Conclusions and Further Work

- There is a simple recipe which can be used to choose colours for display graphics.
- No special expertise is required to apply the recipe and it generally produces pleasing results.
- The ideas here apply only to the filling of areas in presentation graphics.
- It is likely that there are additional ideas of balance which apply to the drawing of lines and glyphs.
- This is the subject of further study.