Colour

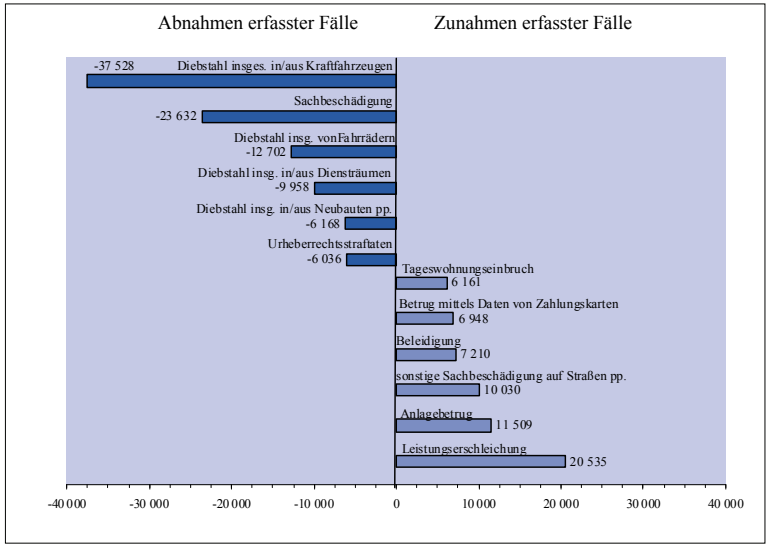
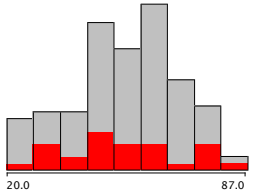
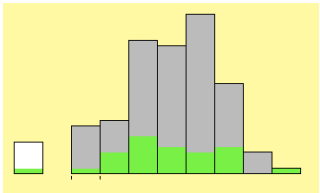


Abb. A3-1: Bevölkerung 1996 und 2008 nach Lebensformen, Ländergruppen und Migrationshintergrund (in %)

Quelle: Statistische Ämter des Bundes und der Länder, Mikrozensus

Mondrian and MANET

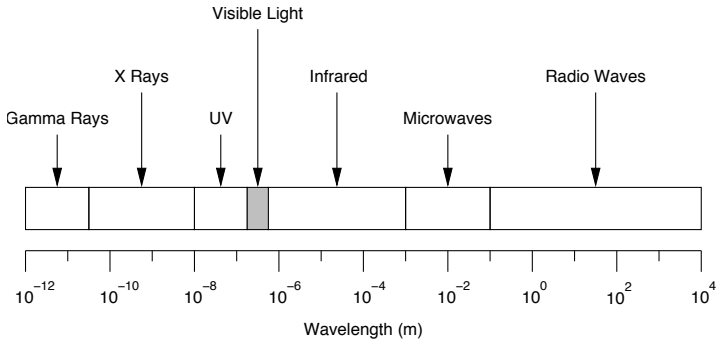




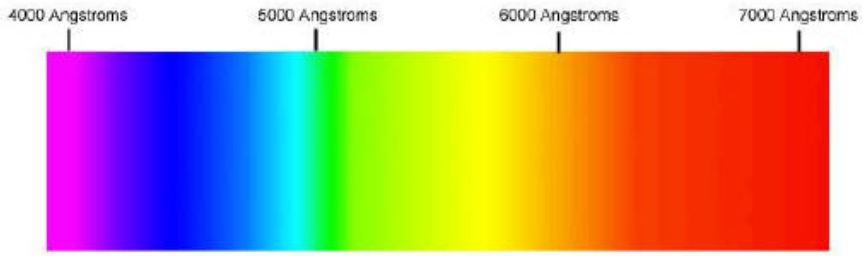
Many Eyes Examples

manyeyes.alphaworks.ibm.com/manyeyes/

Electromagnetic spectrum



Wavelength and colour



Colour blindness

- Deuteranopia (red weakness) 5% of males
- Protanopia (green weakness) 2.5% of males
- Tritanopia (blue weakness) 0.5% of all males

Color Oracle

Wikipedia

Prevalence of color blindness

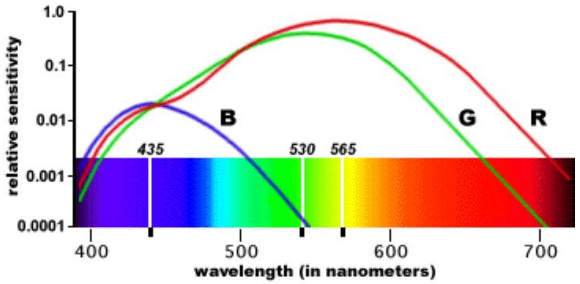
	Males	Females	Total	References
Overall	–	–	–	
Overall (United States)	–	–	–	
Red-green (Overall)	7 to 10%	–	–	[28][29]
Red-green (Caucasians)	8%	–	–	[30]
Red-green (Asians)	5%	–	–	[30]
Red-green (Africans)	4%	–	–	[30]
Monochromacy	–	–	–	
Rod monochromacy (dysfunctional, abnormally shaped or no cones)	0.00001%	0.00001%	–	[31]
Dichromacy	2.4%	0.03%	1.30%	[28][31]
Protanopia (red deficient: L-cone absent)	1% to 1.3%	0.02%	–	[28][31]
Deuteranopia (green deficient: M-cone absent)	1% to 1.2%	0.01%	–	[28][31]
Tritanopia (blue deficient: S-cone absent)	0.001%	0.03%	–	[31]
Anomalous Trichromacy	6.3%	0.37%	–	[31]
Protanomaly (red deficient: L-cone defect)	1.3%	0.02%	–	[31]
Deuteranomaly (green deficient: M-cone defect)	5.0%	0.35%	–	[31]
Tritanomaly (blue deficient: S-cone defect)	0.01%	0.01%	–	[31]

Young-Helmholtz theory

- Red Green Blue colour receptors
- Relative abundance of cones
  - R 40
  - G 20
  - B 1

Colour and cone cells

- There are three different types of cone cell and they have different responses to light:

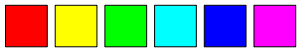


Opponent colour theory

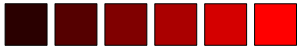
- The colour pairs *red/green* and *yellow/blue* are in opposition.
- A colour can be described by its values on three scales
  - light / dark
  - red / green
  - yellow / blue

Perceptual colour parameters

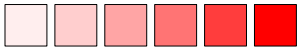
- *Hue* – the property of colour corresponding to wavelength.



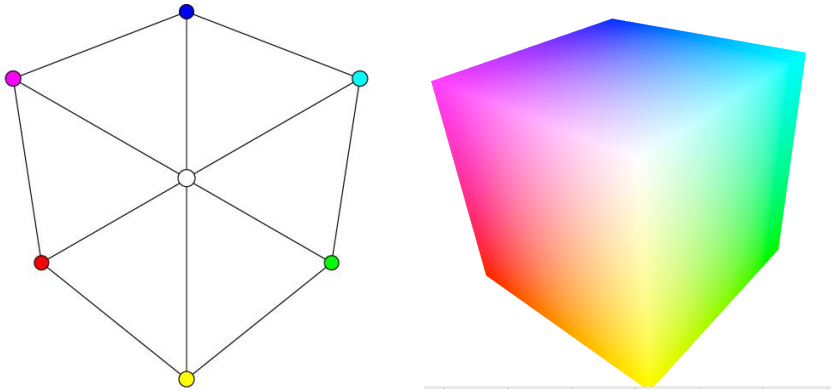
- *Brightness* – the same hue can exist in brighter or dimmer forms.



- *Purity* – colours can be pure (the hues found in the spectrum), or they can be a mixture of hues. So pink is a mix of red and white.

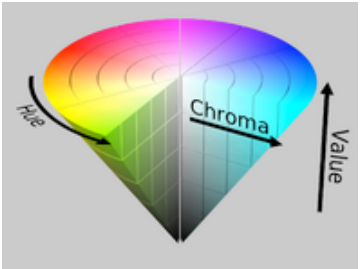


RGB colour cube



HSV colour specification

- *Hue* is the "angle" around the colour hexagon to the colour.
- *Saturation* (Chroma) is distance from the central axis of the hexcone to the colour as a fraction of the horizontal distance from the central axis to the boundary.
- *Value* is the fraction of the distance from the base of the hexcone to the colour.



HSV in R

```
#Colour wheel
dev.new()
pie(rep(1, 36), col = hsv(h=0:35/36))

#Saturation ramp
dev.new(); plot.new()
plot.window(xlim=c(0, 12), ylim=c(0,1), asp=1)
rect(0:11, 0, 1:12, 1, col = hsv(s = 0:11/11))

#Hue ramp
dev.new(); plot.new()
plot.window(xlim=c(0, 12), ylim=c(0,1), asp=1)
rect(0:11, 0, 1:12, 1, col = hsv(h = seq(1/12, 3/12, length=12)))
```

HCL

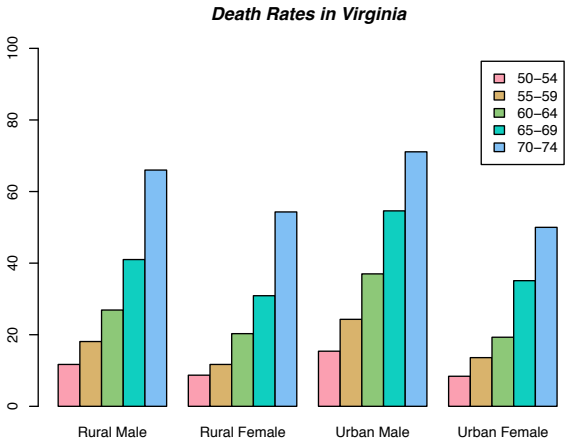
- *Hue* dominant wavelength, colour
- *Chroma* intensity of colour (compared to grey)
- *Luminance* brightness (amount of grey)

Barchart colouring (equal impact)

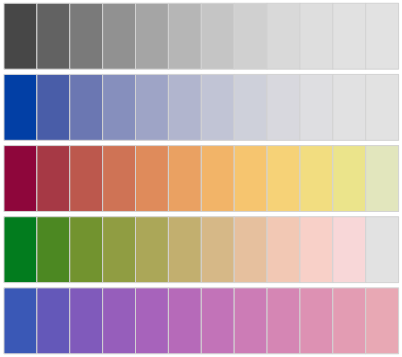
- Each bar should have a different colour with the same impact =>
  - equal chroma
  - equal luminance
  - different, equally spaced, hues
- Qualitative palettes:

Equal impact in practice

As suggested by Ross Ihaka



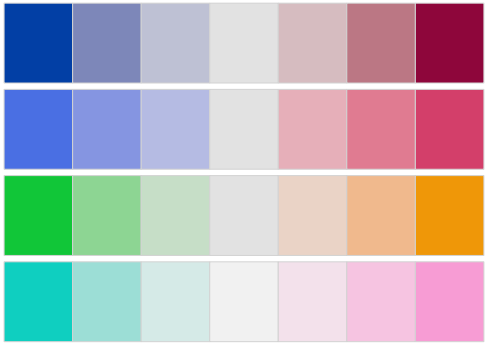
Interval colouring (sequential)



Vary
luminance (1)
chroma & luminance (2)
hue, chroma &
luminance (3) - (5)

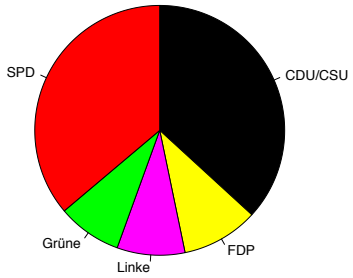
"Low values uninteresting, high values interesting"

Interval colouring (diverging)

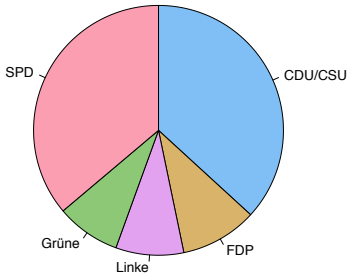


Neutral value in the middle

German election 2005 (1)

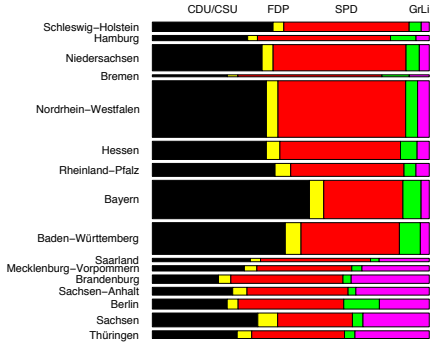


HSV

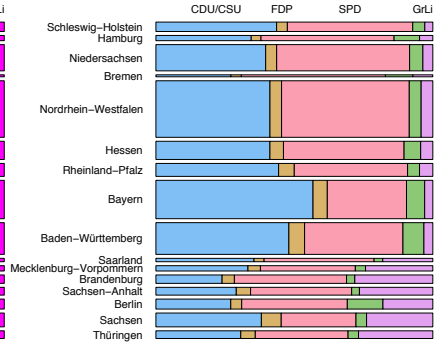


HCL

German election 2005 (2)



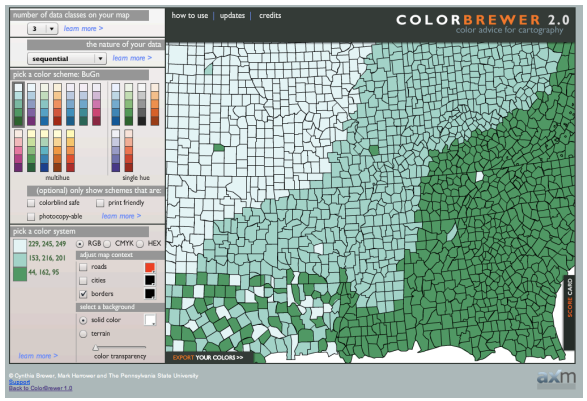
HSV



HCL

Colorbrewer

- Cindy Brewer's "good" colour schemes for maps
- colorbrewer2.org/

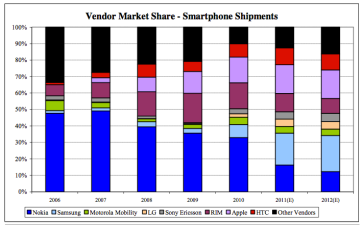


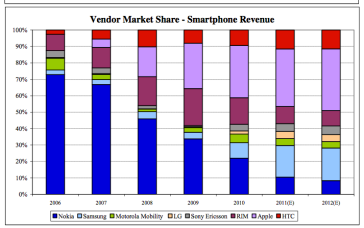
Some conclusions

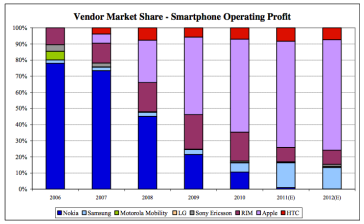
- Colour choice is difficult
- Combinations of colours have to be chosen
- Colour blindness may be an issue
- There are strong associations with individual colours
- Response to colour is to some extent subjective

- Offer alternative colour schemes
- Consider multiple views
- Use interaction!

tech.fortune.cnn.com/2011/11/14/
android-sells-the-smartphones-
apple-makes-the-money/







Source: Oppenheimer & Co. Inc. Estimates