Data Visualisation

Chapter 3: Visual Perception and Colour

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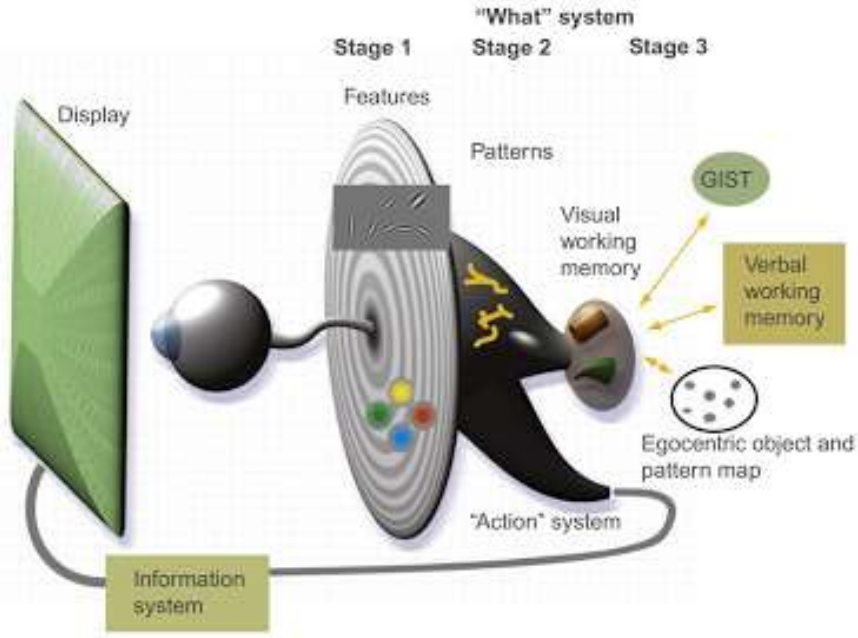
Visual Information Processing System

- By understanding a little about our visual perception system, and it's limitations, we can ensure we design effective data visualisation that do not deceive.



Colin Ware's (2013) three stage model of visual information processing (p. 20)

Reality is a Construct

- Visual illusions remind us of the limitations of our visual perception system and how our brains construct reality.

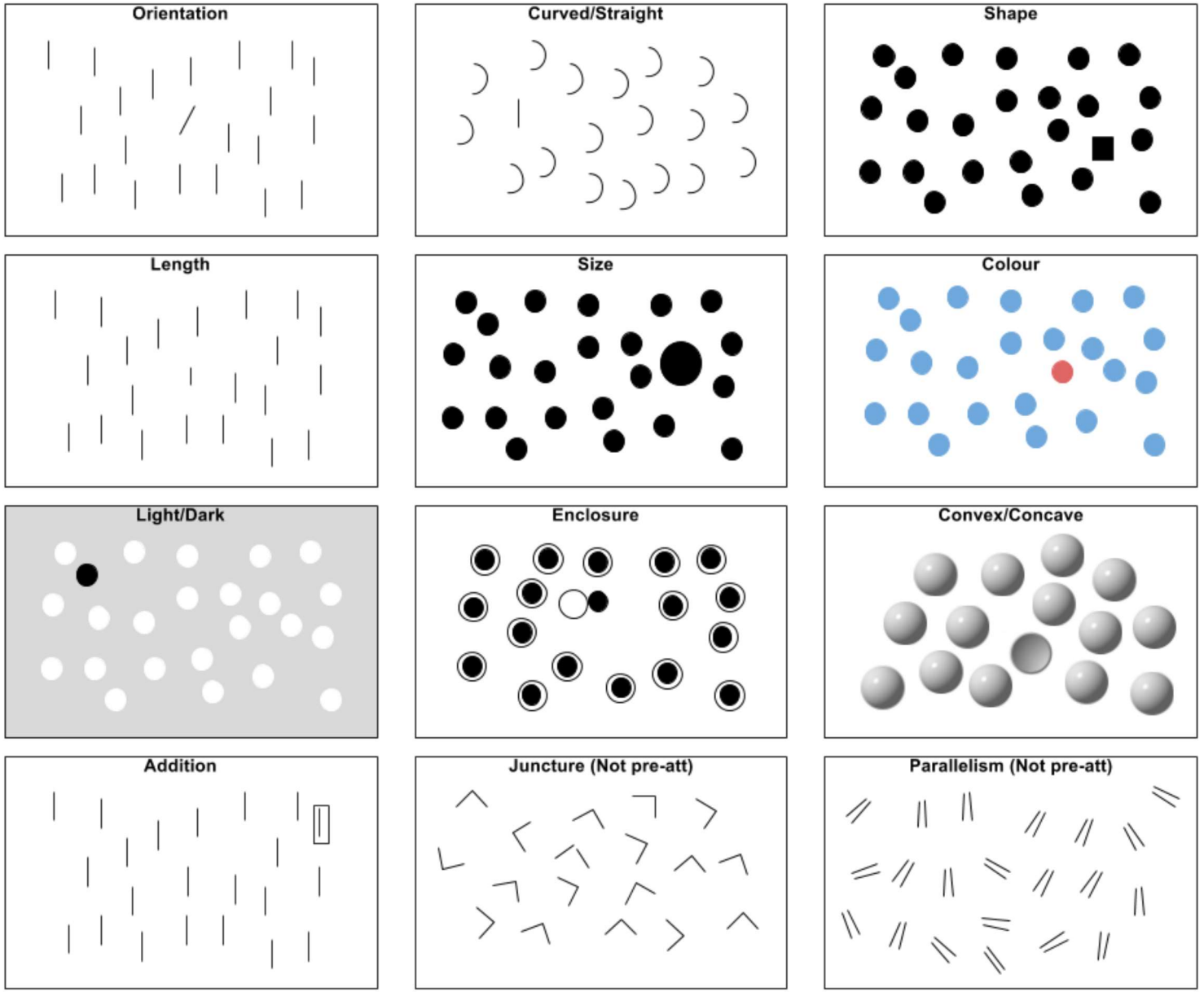
Preattentive Processing

- What draws your attention?

Preattentive Processing Cont. 2

- **Preattentive processing** is the degree to which a visual object is made available for our attention (Ware, 2013)
- Many features are known to be preattentively processed:
  - Orientation
  - Curved/straight
  - Shape
  - Length
  - Size
  - Colour
  - Light/dark
  - Enclosure
  - Convex/Concave
  - Addition

Preattentive Processing Cont. 3

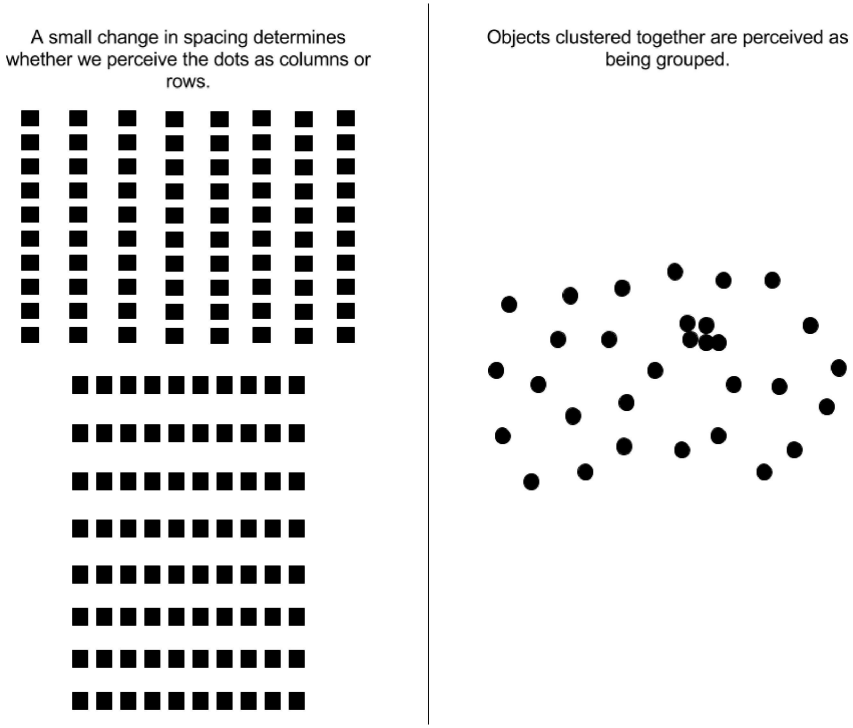


Gestalt Laws

- Gestalt laws attempt to explain the way humans recognise visual patterns. We will look at the following laws and how they relate to data visualisation:
  - Proximity
  - Similarity
  - Connectedness
  - Continuity
  - Symmetry
  - Closure
  - Figure Ground Principle
  - Common fate

Proximity

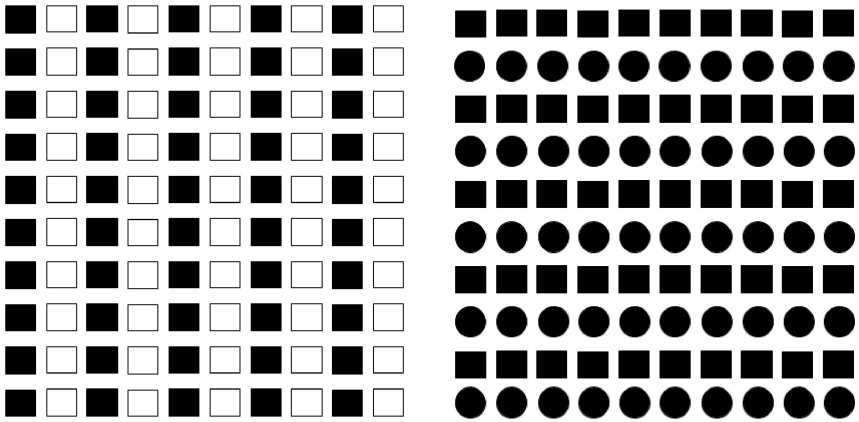
- Objects close or clustering together are perceptually grouped.



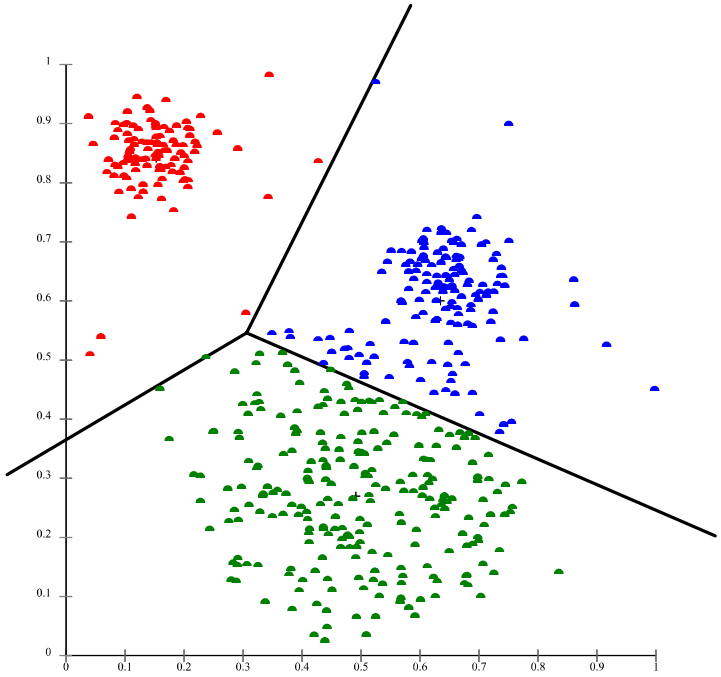
Proximity Example

Similarity

- Objects of similar characteristics (e.g. size, shape, colour) are grouped.

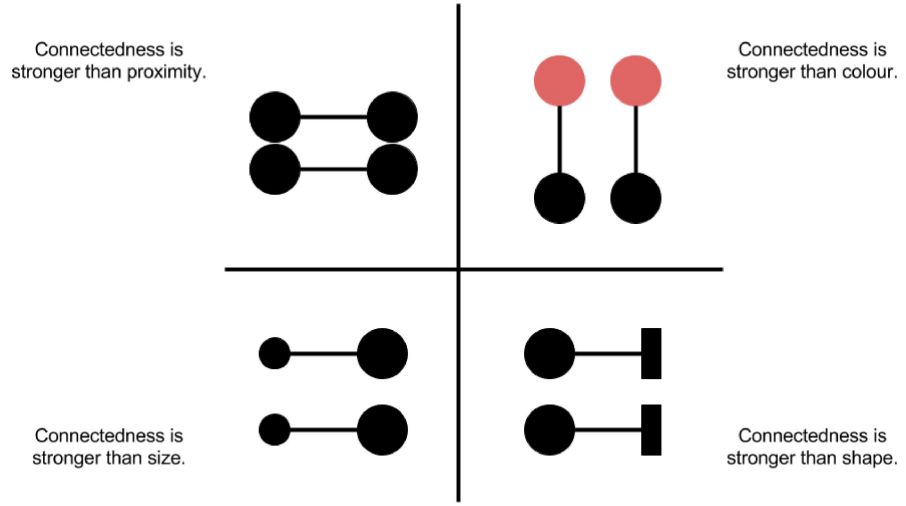


Similarity Example

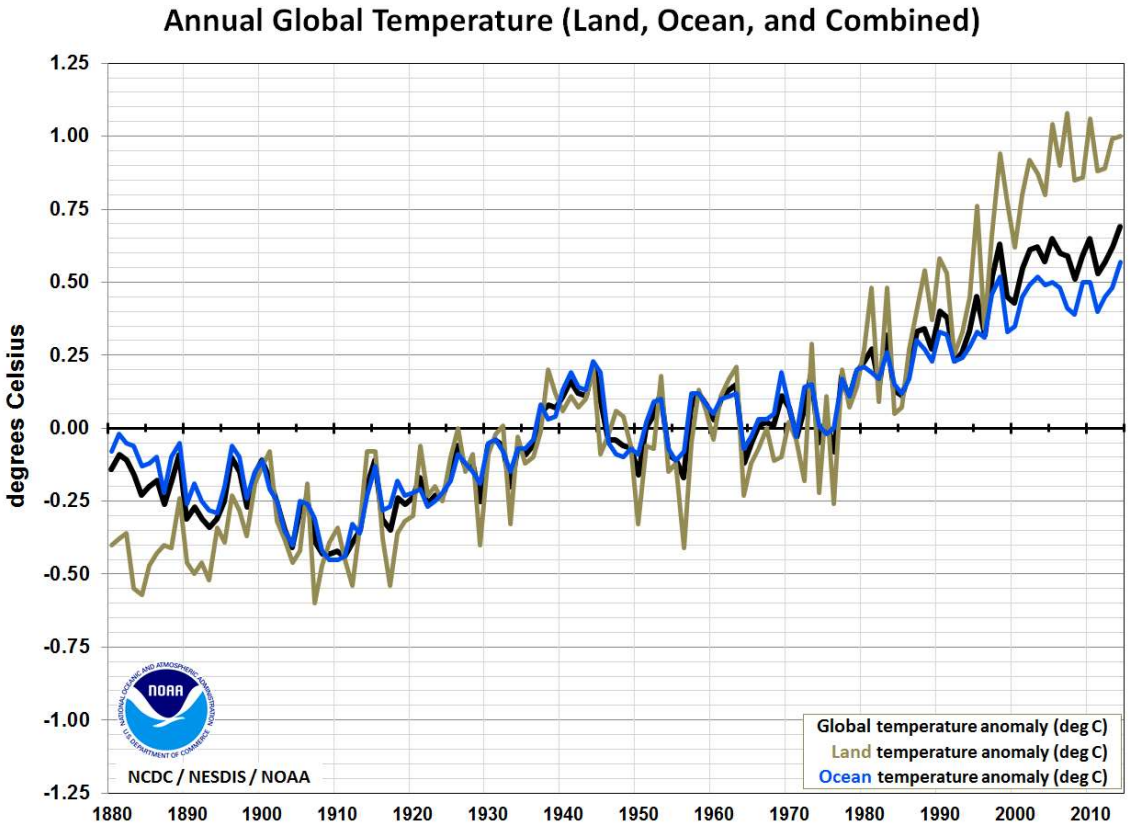


Connectedness

- More powerful than proximity, colour, size or shape. Objects connected by lines demonstrate relationships between objects.



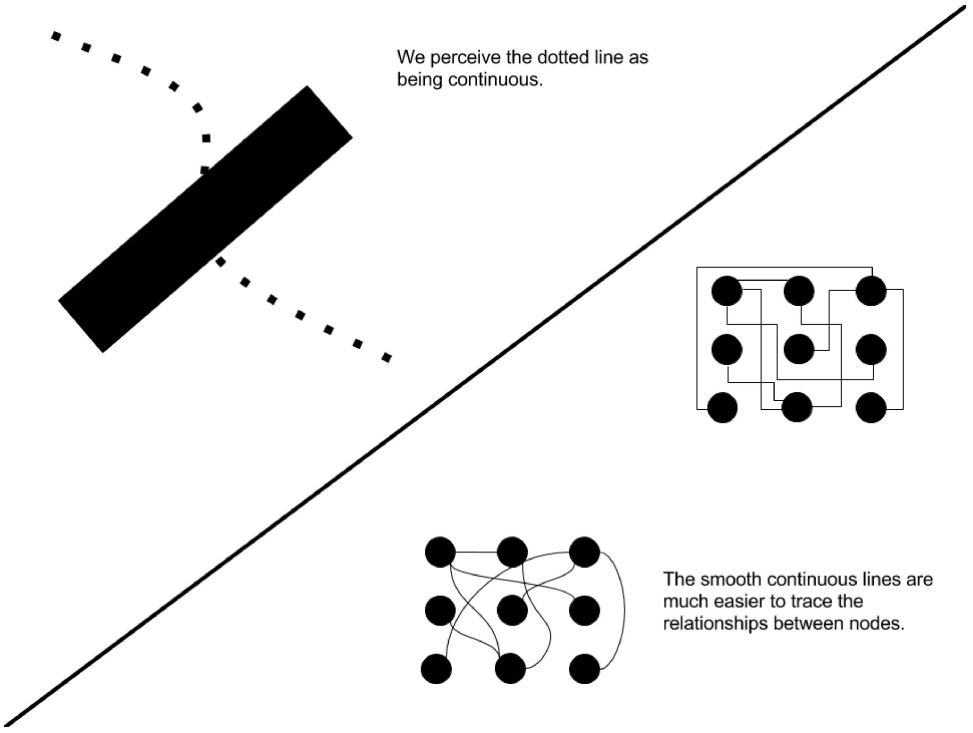
Connectedness Example



NCDC Land, Ocean and Combined Temperature

Continuity

- This law predicts that we are inclined to perceive objects from elements that are smooth and continuous, versus irregular and jagged.



Continuity Example

Energy Visuals

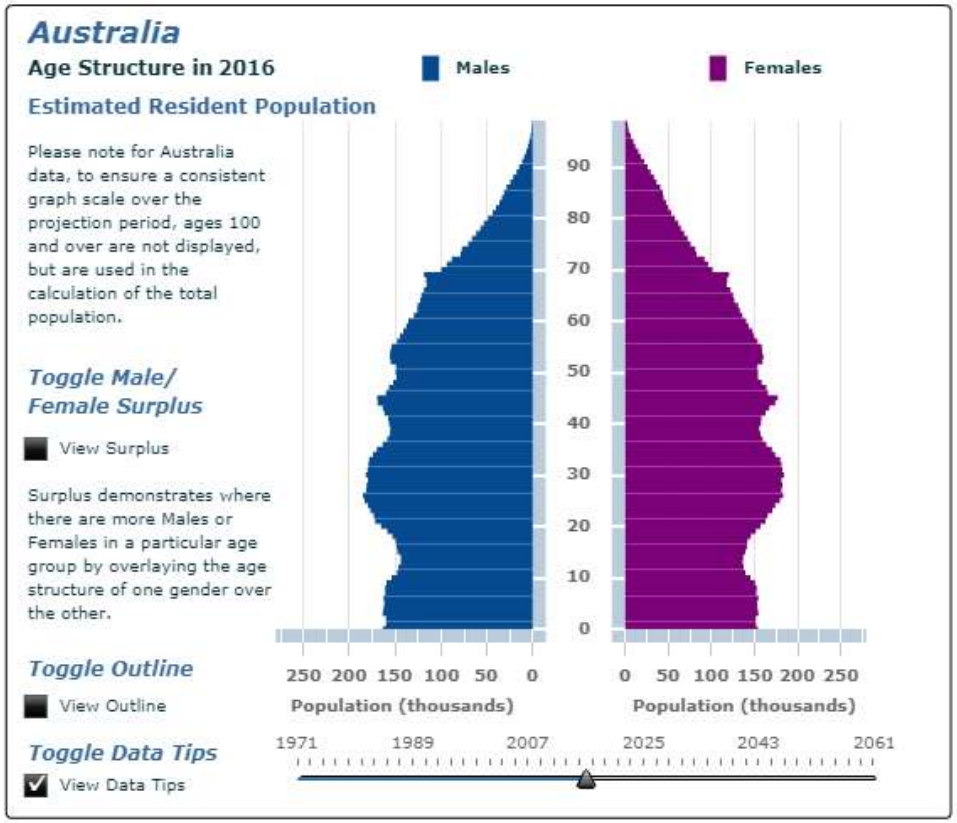
Symmetry

- We tend to group symmetrical objects together.

We tend to see three pairs of different brackets, as opposed to six brackets.

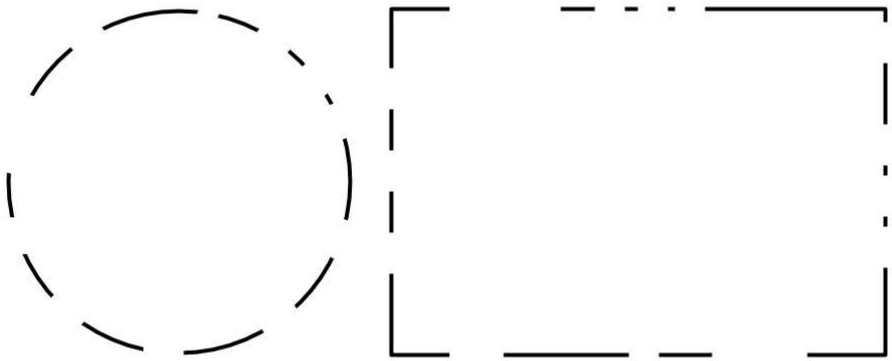
Symmetry Example

- ABS Population Pyramids



Closure

- Closure refers to our tendency to “fill in the gaps” when we see incomplete patterns that resemble familiar shapes and objects.



Closure Example

- Overlapping density plots

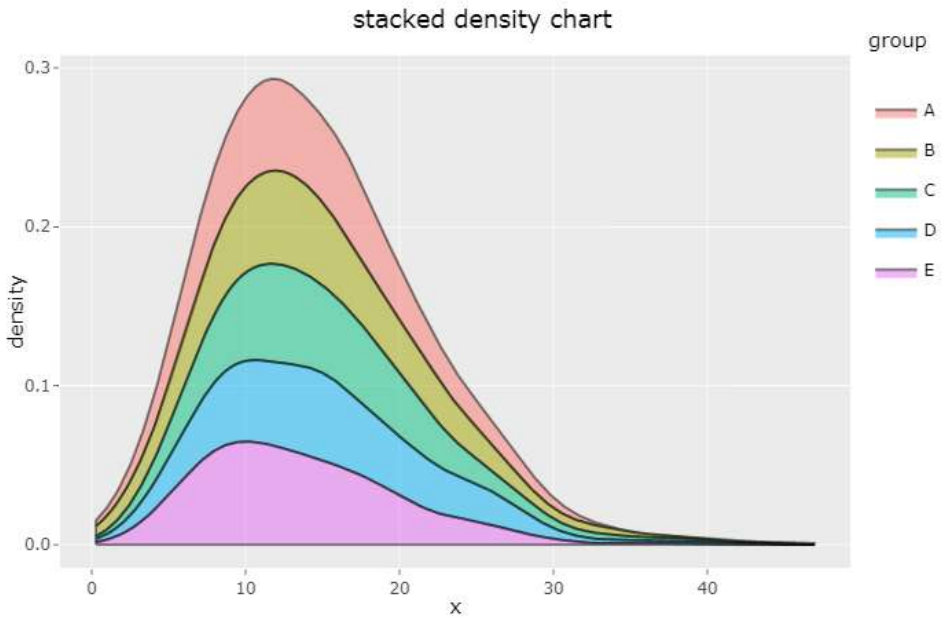
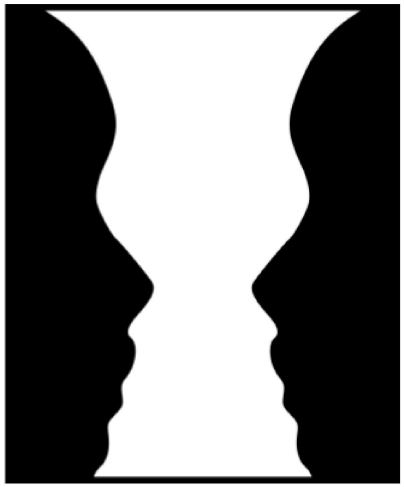


Figure Ground Principle

- The figure ground effect tells us that smaller objects within a figure are interpreted as the foreground, while larger objects make up the ground.

When a figure and background are equal, it creates imbalance. We cannot decide if we see two faces or one vase.



If you make the figure smaller, we are more inclined to see a vase.

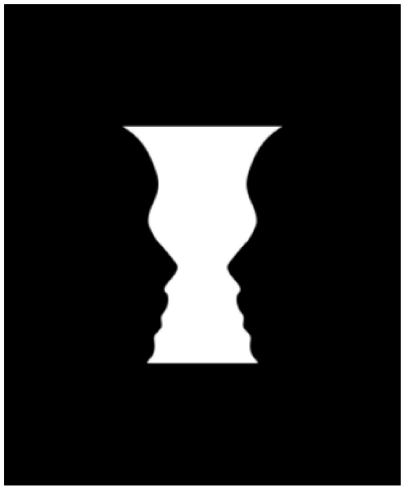
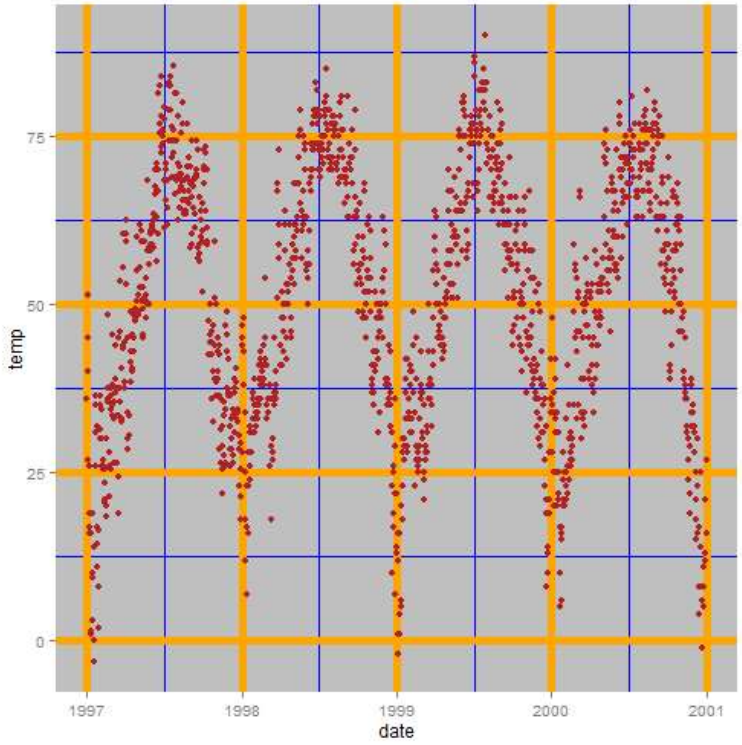


Figure Ground Principle Example

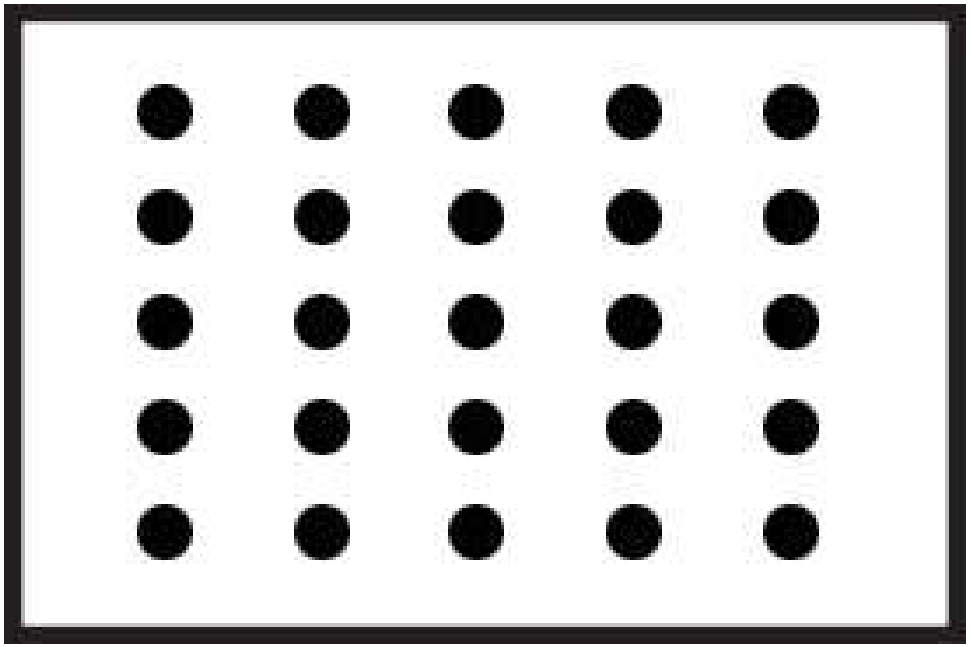
- Beautiful plotting in R?



Beautiful plotting in R: A ggplot2 cheatsheet by ZevRoss

Common Fate

- Objects perceived to be moving in the same direction are grouped together and share a common path.



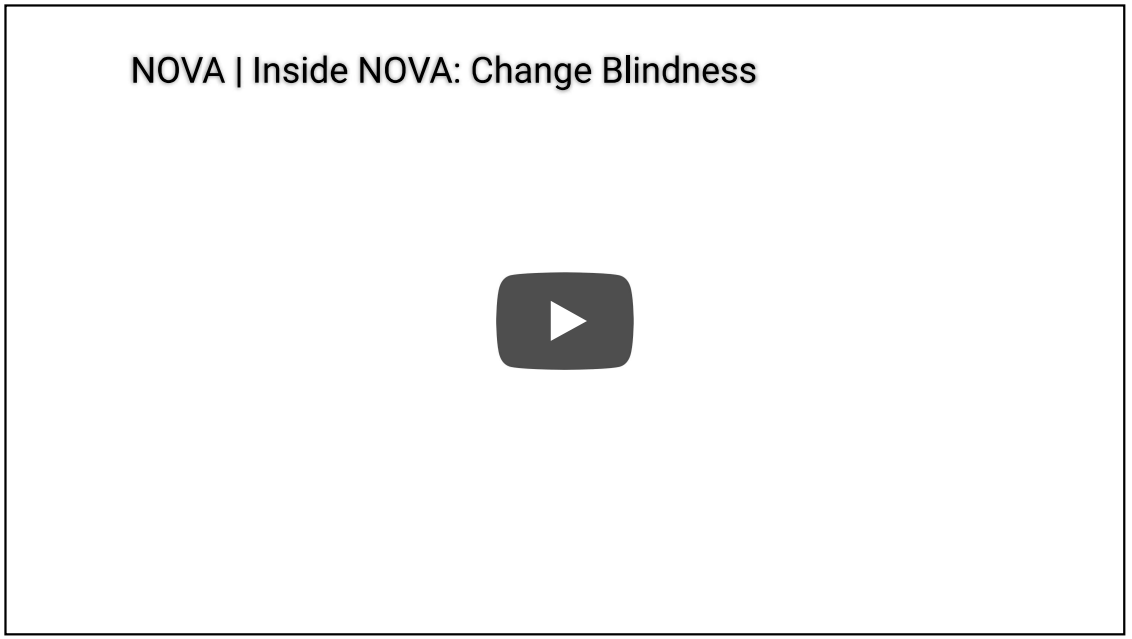
Common fate by Reaktor

Common Fate Eample

- Hans Rosling's Bubble plots

Change Blindness

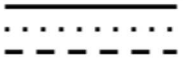
- Breaks in our attention can make us insensitive to changes in our environment.



Inattentional Blindness

- Focusing our attention can cause other things in the environment to go unnoticed.

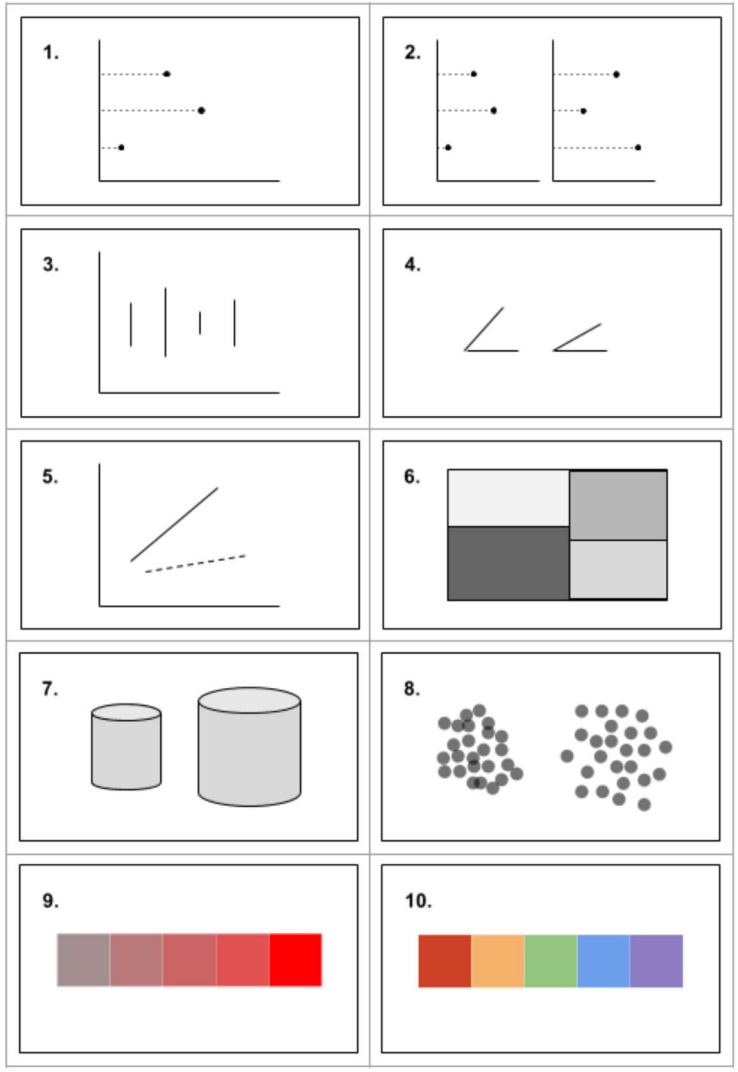
Visual Variables

Feature/Object	Example	Notes	Nominal	Ordinal	Quantitative
Position		Powerful and accurate			✓
Length		Powerful and accurate			✓
Size		Less accurate, but still useful			✓
Angle/Slope		Less accurate, but still useful			✓
Shape		Can only use a few different shapes.	✓		
Colour - Hue		Can only use a few different hues.	✓		
Colour - Sequential		Can only use a few different ordered levels.		✓	
Colour - Diverging		Can only use a few different ordered levels.		✓	
Colour - Continuous		Less accurate than other quantitative encodings			✓
Texture		Bygone feature, but may still have applications.	✓		
Line - Type		Can only use a very limited number of types.	✓		
Line - Weight/Boldness		Not very accurate, but still useful.			✓

Visual Comparison Accuracy

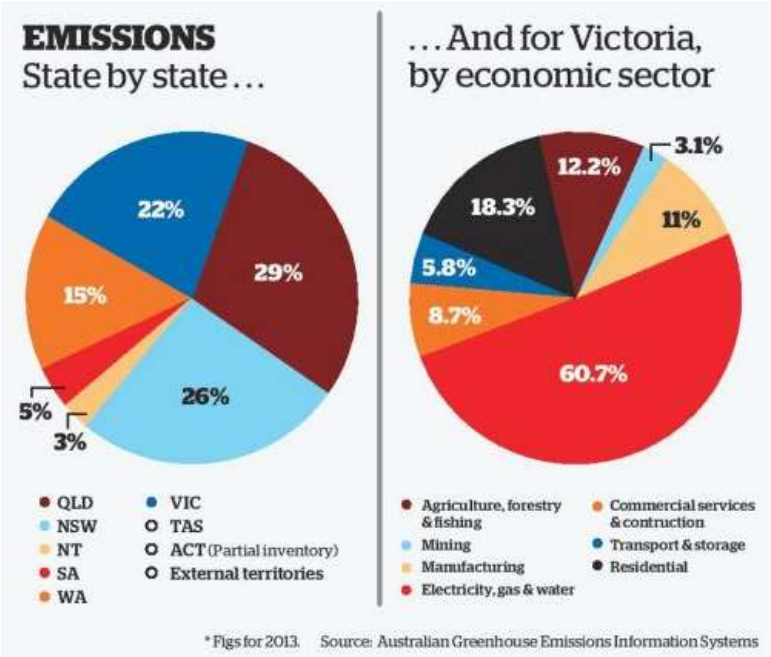
Visual Comparison Accuracy
(Cleveland and McGill, 1985)

Rank (Most - Least)	Feature
1	Position - common scale
2	Position - same scale , but unaligned
3	Length
4	Angle
5	Slope
6	Area
7	Volume
8	Density
9	Colour saturation
10	Colour hue



Activity - Deconstruct

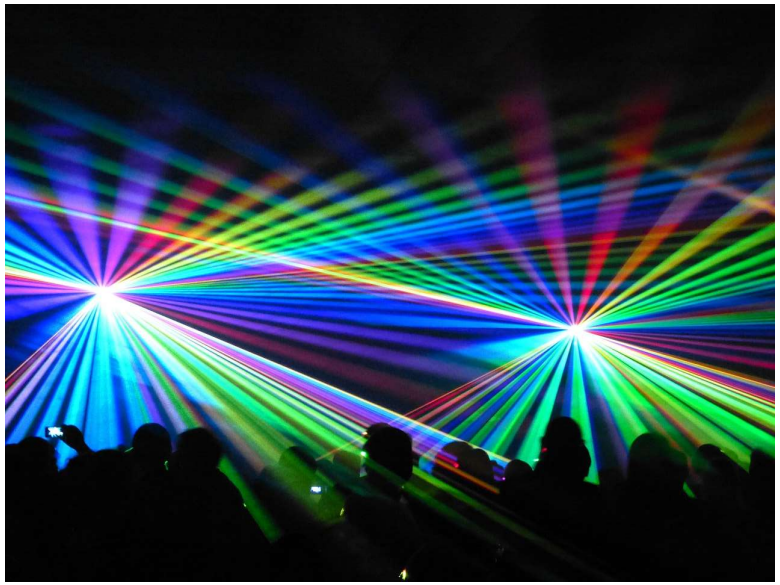
- What are the perceptual issues associated with pie charts?



Old King Coal, a dying dynasty - The Citizen (2016)

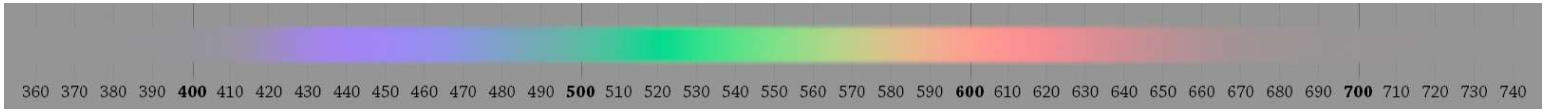
Colour

- Think about the different ways that colour is used in data visualisation.



RGB

- Colour is our visual perception system's response to the visible spectrum of light. Visible light is electromagnetic radiation emitted in wavelengths between 400 - 700 nm.
- Light outside this range is not visible to the human eye and include the infrared range (700 nm to 1 mm) and the ultraviolet range (10 - 400 nm).

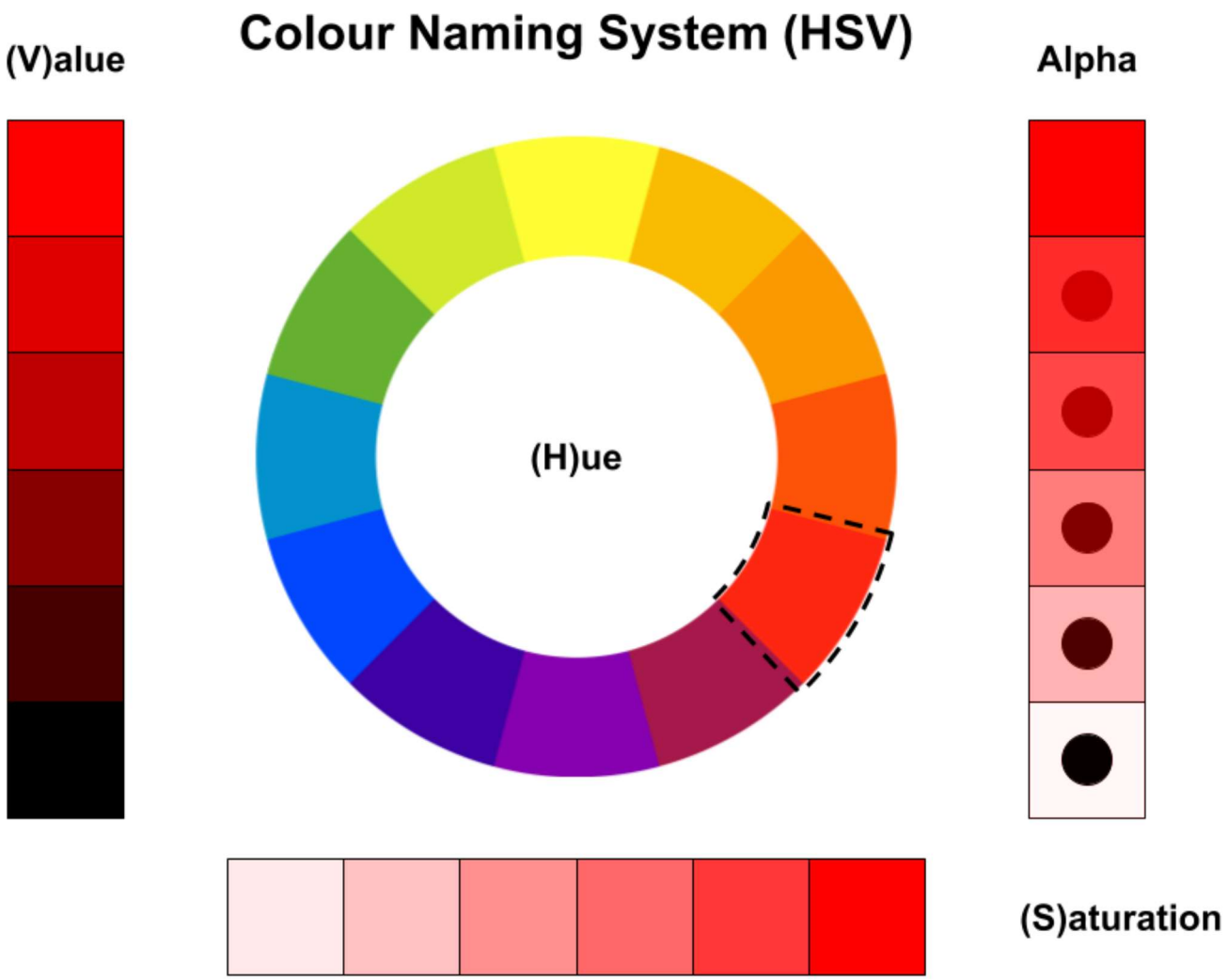


RGB Cont.

- Within the visible light range there are three primary colours that photo receptors (cones) within our eyes' retinas can respond to, hence humans are said to be trichromatic. These colours include blue, green and red.

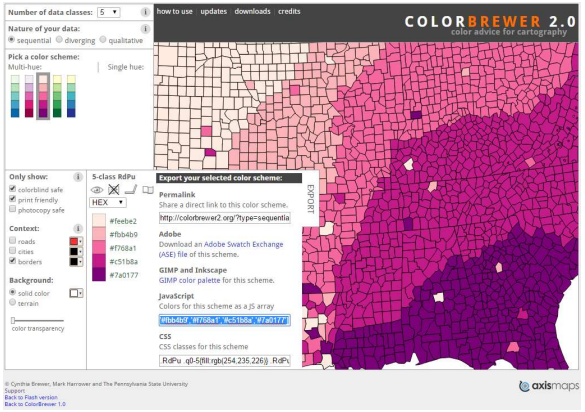
"RGB illumination" by en:User:Bb3cxv under CC BY-SA 3.0 via Commons.

HSV Colour Naming

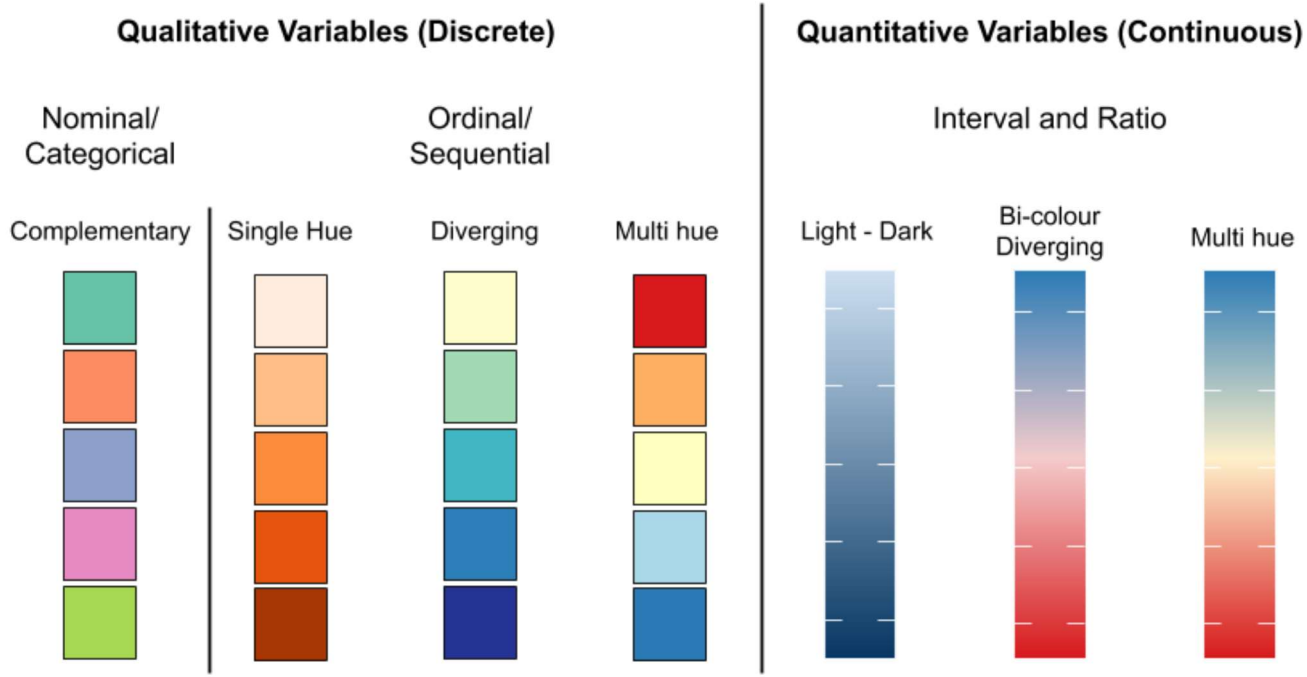


Colour Selection

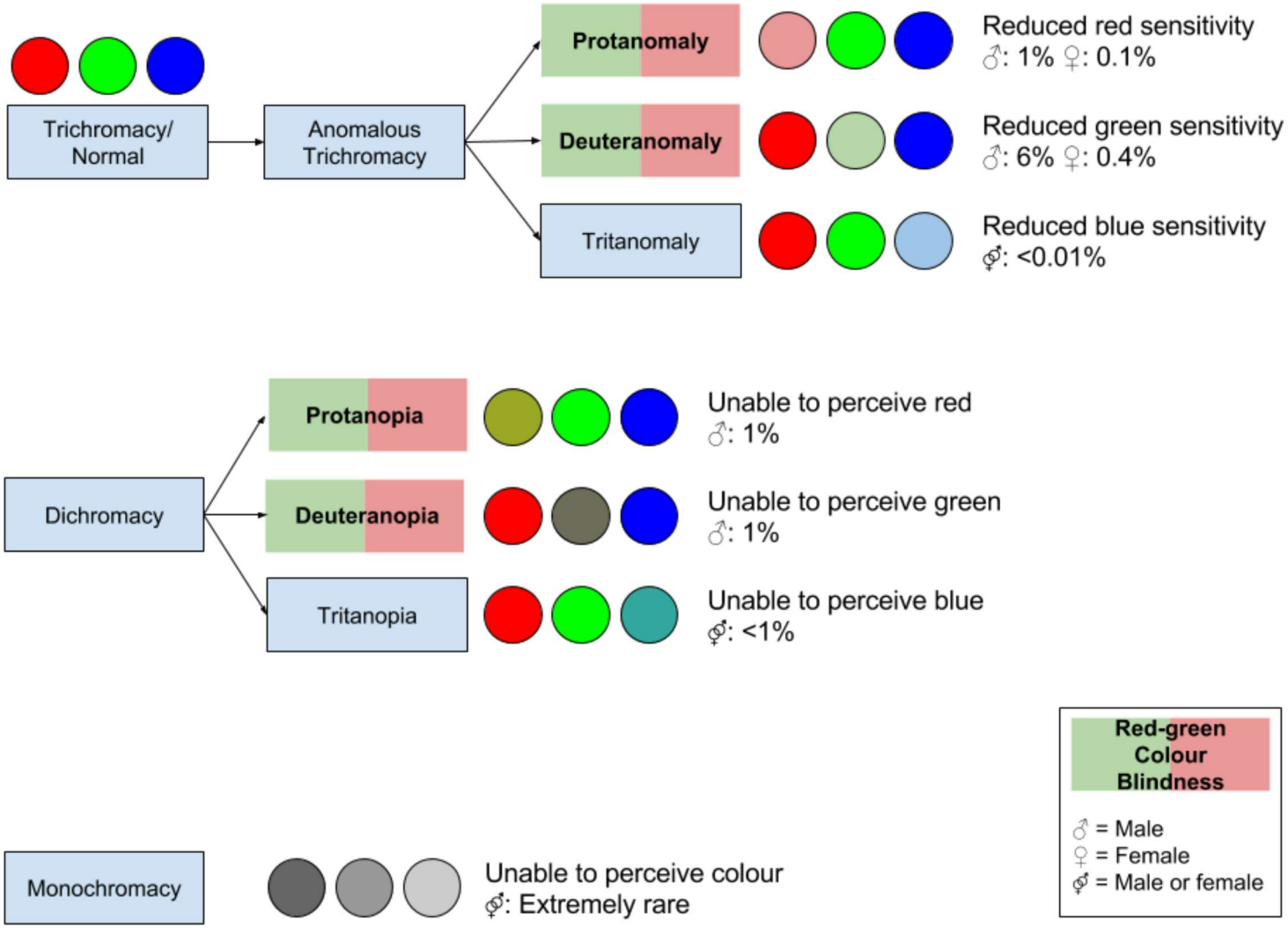
- Cynthia Brewer developed the ColorBrewer palettes to promote best practice in map representation. However, her work applies to all data visualisation.
- Select effective colour palettes based on:
  - Sequential
  - Diverging
  - Qualitative data
  - Single or multi-hue
- Colour-blind and print-safe palettes
- Web tool - http://colorbrewer2.org/



Colour Scales



Colour Blindness



Statistics taken from https://en.wikipedia.org/wiki/Color_blindness

Colour Associations

Colour	Positive	Negative
Red	Passion, strength, energy, heat, love	Blood, war, fire, danger, anger, aggression
Green	Nature, spring, fertility, safety, environment	Inexperience, decay, envy, misfortune
Yellow	Sun, summer, gold, harvest, optimism	Cowardice, treason, hazard, illness, folly
Blue	Sky, sea, stability, peace, unity, depth	Depression, obscenity, conservatism, passivity
White	Snow, purity, peace, cleanliness, innocence	Cold, clinical, surrender, sterility, death, banality
Gray	Intelligence, dignity, restraint, maturity	Shadow, concrete, drabness, boredom
Black	Coal, power, formality, depth, solidarity, style	Fear, void, night, secrecy, evil, anonymity

Responsible Use of Colour

References

Ware, C. 2013. *Information visualization: Perception for design*. 3rd ed. Waltham, MA: Morgan Kaufmann.