Vision and Perception

Eye Movements

- Fixation : A period of time when the eye is focused on a single point.

- Saccade : An eye motion from one fixation point to another.

- Normal vision alternates between saccades and fixations, with each lasting just 100ths of a second.
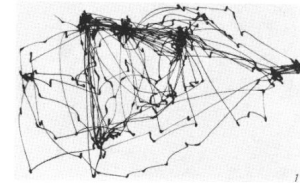
Eye Movement Studies

- An image is presented to a subject.

- The subject may (or may not) be given a specific task to carry out.

- A record is made of where the subjects' eyes are directed as they study the image.

Early eye-tracking study

- Alfred Yarbus

- "Eye movements and vision" Plenum Press 1967

- Seven people studied the same picture and their eye movements were monitored.

- They were all educated and knew the picture.

- One person was asked to look at the picture a number of times with different instructions as to what information to look for each time.
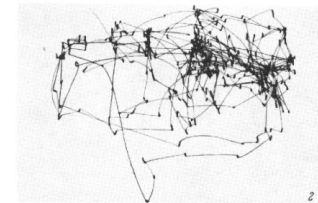
An unexpected visitor (Ilya Repin, 1884)
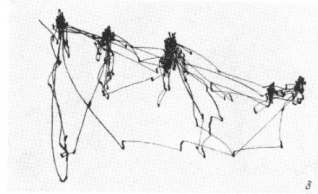

Examine the picture
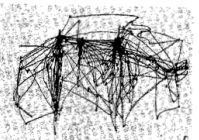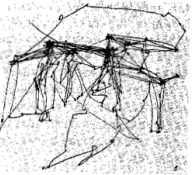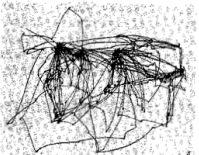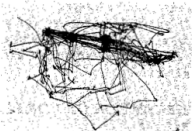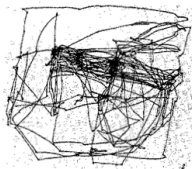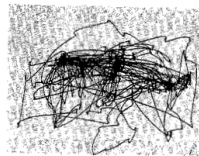
Seven different people's eye movements on examining the picture
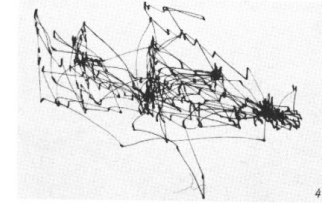

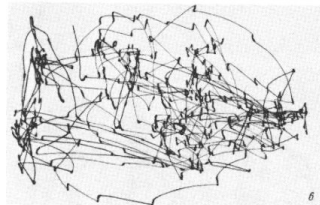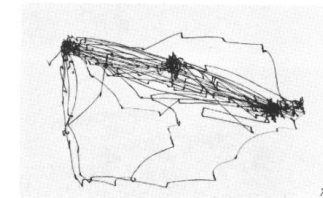How wealthy is the family?

How old are the people in the room?

What were the family doing before the visitor arrived?

Remember the positions of objects and people in the room

How long has the visitor been away?

Graphical illusions

- Help us understand how the human visual system works
- Context affects judgement
  - sizes of surrounding objects
  - colours of adjacent objects
  - depth cues (perspective can be misinterpreted)
- Angles are difficult for us
  - we overestimate acute angles
  - we underestimate obtuse angles

The Café Wall Illusion
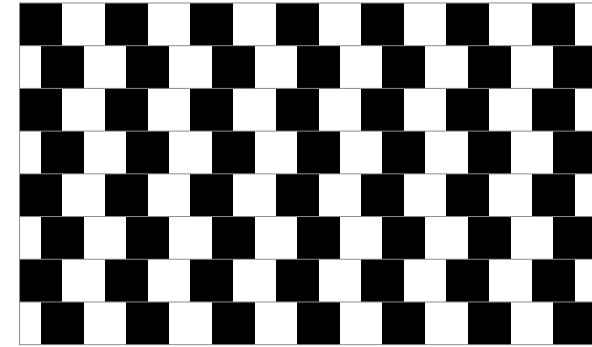
The lines are all horizontal or vertical
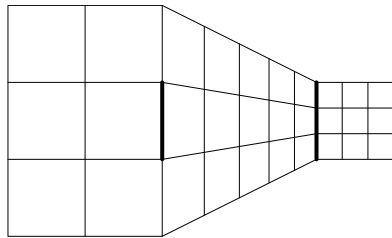
The Ames room
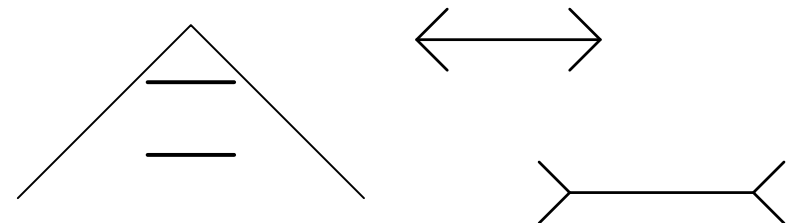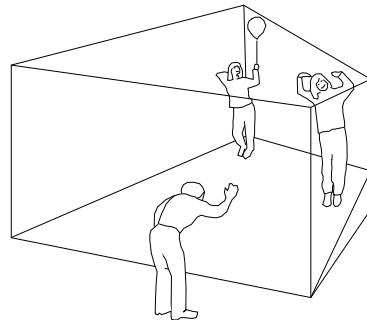
Ponzo illusion   Müller-Lyer illusion

Poggendorf Illusion

Which of the two lower lines
is the extension of the upper line?

Which of the two lower lines
is the extension of the upper line?
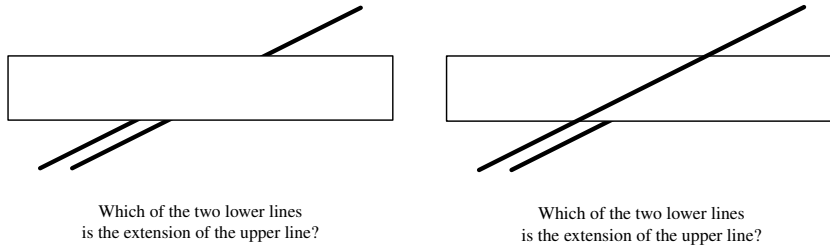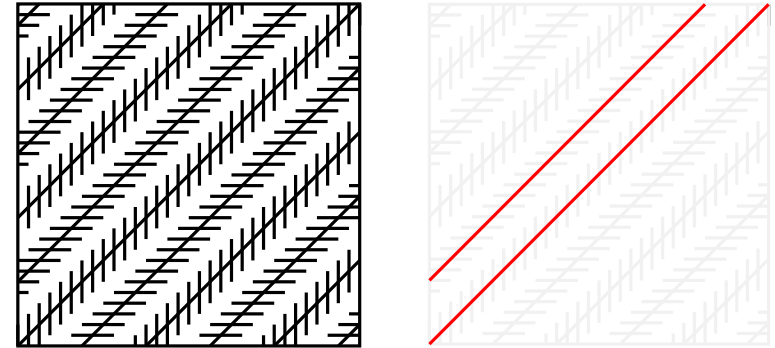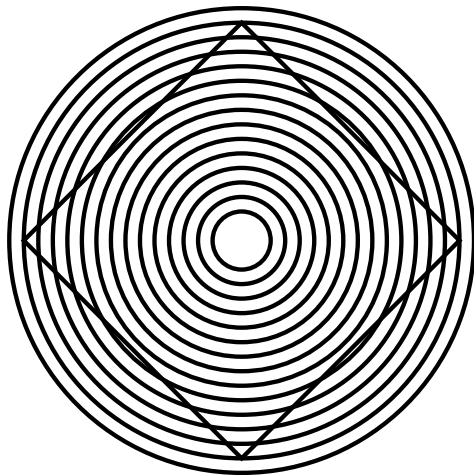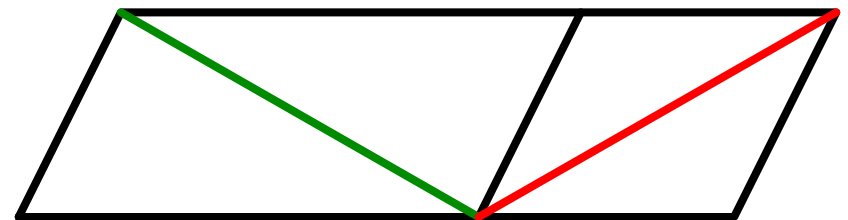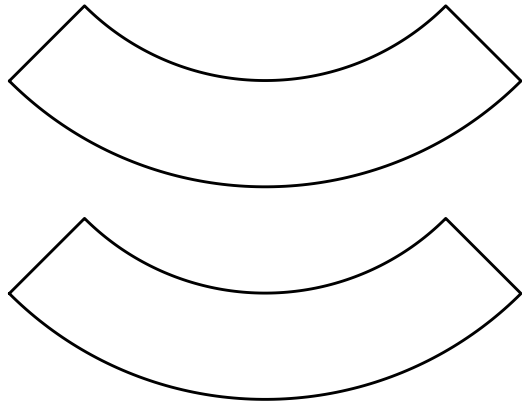
Zöllner Illusion

Ehrenstein Illusion

A Linelength Illusion

Jastrow Illusion

Tichener Illusion
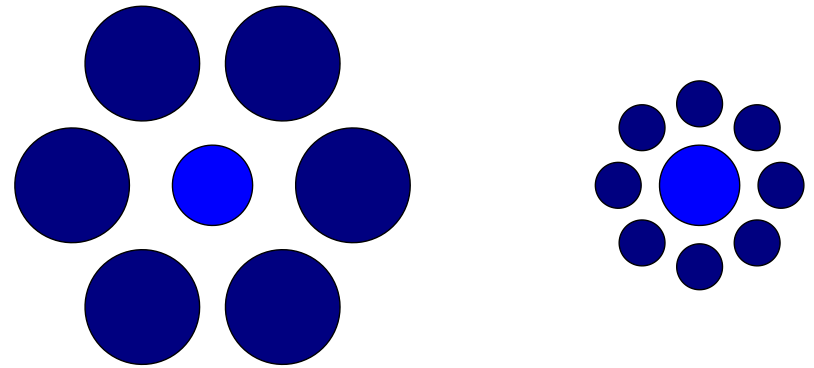
Irradiation Illusion

Mach Banding

Herman Grid
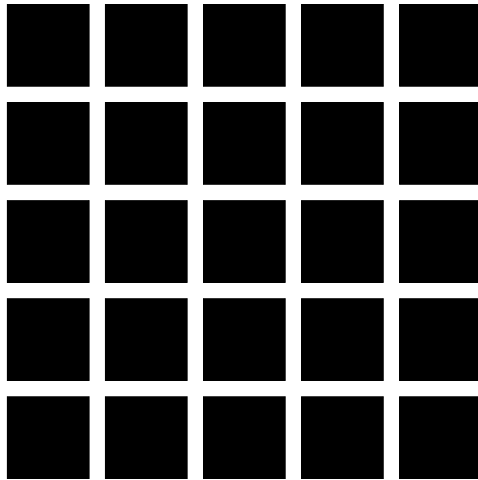
Colour Contrasts

Perception and Cognition

- Graphical perception (*Preattentive vision*)
  - Some visual processing takes place without any conscious effort on our part.

- Graphical cognition
  - Some visual processing requires that we consciously inspect the things that we are looking at.

Laws of Perception (1)

- Weber's Law
  - applies to a variety of perceptual encodings.
  - Consider two lines with lengths x and x + w. Weber's law says that the chance of detecting a difference depends on the value of w/x.
  - Let the difference between x and x + w be detected by a given individual with probability $p_x(w)$. For a fixed p, let the value of w which is detected with this probability be $w_p(x)$. Then Weber's law says $w_p(x) = k_p x$
  - We detect relative differences in values.

Laws of Perception (2)

- Stevens' Law
  - let $p(x)$ be the perceived value of x
  - Stevens' Law says $p(x)=Cx^\beta$
  - C and β depend on the encoding method used and on the observer
  - Typically observed ranges for β
    - length   0.9 - 1.1
    - area   0.6 - 0.9
    - volume 0.5 - 0.8

Laws of Perception (3)

- Stevens' Law examples (area with $\beta = 0.7$)
- Compare areas of size 2 and 1
  - $p(2)/p(1) = 2^{0.7}/1^{0.7} = 1.62$
  - the bigger area is seen as less than twice the size
- Compare areas of size $1/2$ and 1
  - $p(1/2)/p(1) = 0.5^{0.7}/1^{0.7} = 0.62$
  - the smaller area is seen as more than half the size

Graphical inference

- Buja, Cook, Hofmann, Wickham
- Generate random plots based on the null hypothesis and compare the actual plot with the randoms.
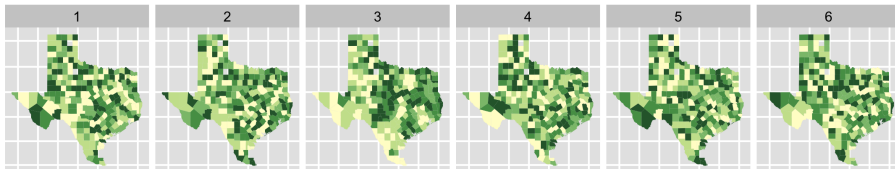

Fig. 1. One of these plots doesn't belong. These six plots show choropleth maps of cancer deaths in Texas, where darker colours = more deaths. Can you spot which of the six plots is made from a real dataset and not simulated under the null hypothesis of spatial independence? If so, you've provided formal statistical evidence that deaths from cancer have spatial dependence. See Section 8 for the answer.
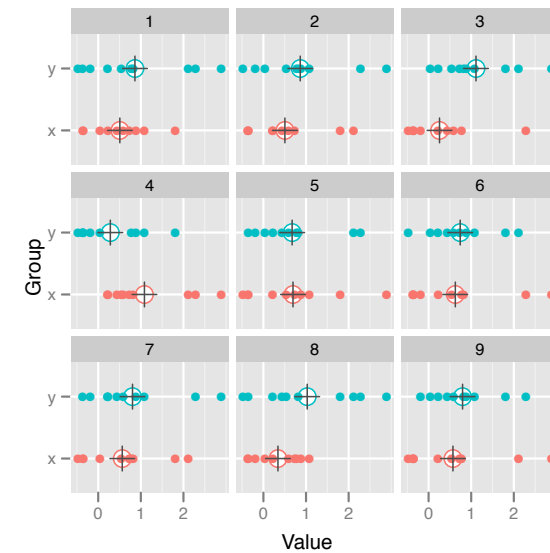

Fig. 3. A visual t-test. For each data set, the observations are shown as points and the group means as crosses. The accused is hidden amongst eight innocents. Can you spot him?
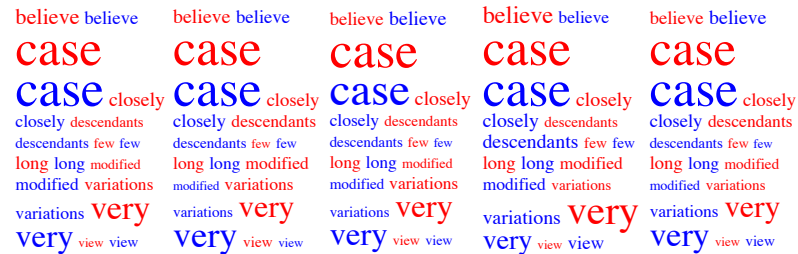
Fig. 5. Five tag clouds of selected words from the 1st (red) and 6th (blue) editions of Darwin's "Origin of Species". Four of the tag clouds were generated under the null hypothesis of no difference between editions, and one is the true data. Can you spot it?
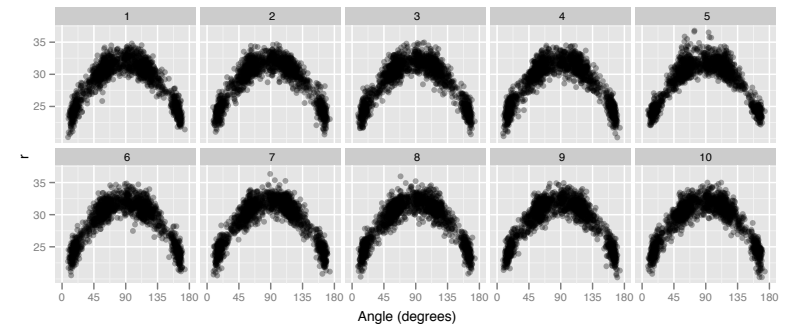

Fig. 6. Scatterplot of distance vs. angle for three pointers by the LA Lakers. True data is concealed in line-up of nine plots generated under the null hypothesis that there is a quadratic relationship between angle and distance.

Perception and graphics?

- Illusions can be a problem with static graphics

    – do they occur often?

- Alternative views of the same information are helpful

- Multiple views of the same information are helpful

- Testing observed effects statistically is helpful

- Interactive graphics are valuable