

# **Module 2. Univariate statistics**

## **Data Science**

**Sabine De Vreese   Lieven Smits   Pieter Van Der Helst   Bert Van Vreckem**  
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# Learning Goals

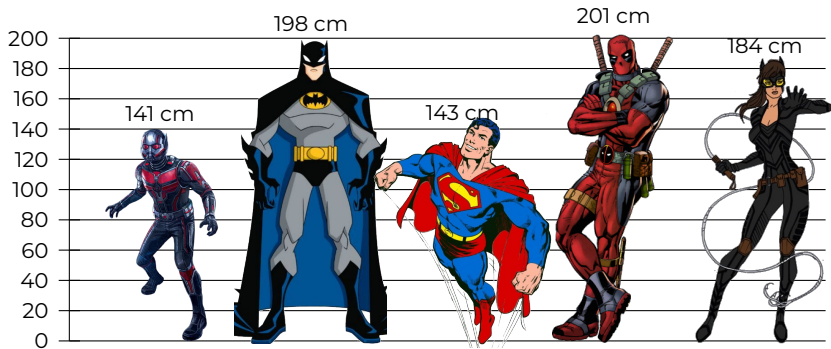
- Descriptive statistics
- Central tendency and dispersion for each measurement level
- Know formulas, being able to calculate
- Suitable visualization techniques for each measurement level

# Central Tendency and Dispersion

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# How tall are my friends?

Remember our superheroes:



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# Measure of Central Tendency

What value is representative of the entire group?

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# Mean or Average

## Arithmetic mean

The **arithmetic mean** (notation:  $\bar{x}$ ) is the sum of all values divided by the number of values

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

$x_1$	$x_2$	$x_3$	$x_4$	$x_5$
141	198	143	201	184



# Mean or Average

- Q1** What happens if Ant-Man shrinks to a size of 10 cm?
- Q2** The arithmetic mean of 15 numbers is 12. What number should be added to get a mean of 13?



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# Median

## Median

To find the **median**, sort all values and pick the middle number

- Odd number of values: no problem
- Even number of values: average of the middle two

$x_1$	$x_2$	$x_3$	$x_4$	$x_5$
141	198	143	201	184



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# Median

- Q1** What happens if Ant-Man shrinks to a size of 10 cm?
- Q2** What is the median of the number of people saved by Batman during the last eight years?

4	7	11	16	20	22	25	26
---	---	----	----	----	----	----	----



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# Mode

## Mode

The **mode** is the value that appears most often in a dataset.

Number of people saved by Superman during the last 15 years:

3	7	5	13	20	23	39	23	40	23	14	12	56	23	29
---	---	---	----	----	----	----	----	----	----	----	----	----	----	----



Number of people saved by Batman during the last 8 years:

4	7	11	16	20	22	25	26
---	---	----	----	----	----	----	----



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# Measures of Dispersion

How large are the differences within the group?

# Range

## Range

The **range** of a dataset is the absolute value of the difference between the highest and the lowest value.

$x_1$	$x_2$	$x_3$	$x_4$	$x_5$
141	198	143	201	184



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# Quartiles

## Quartiles

The **quartiles** of a sorted set of numbers are the three values that divide the set into 4 equally large subsets. Notation:  $Q_1$ ,  $Q_2$ ,  $Q_3$

Number of people saved by Superman during the last 15 years:

3	7	5	13	20	23	39	23	40	23	14	12	56	23	29
---	---	---	----	----	----	----	----	----	----	----	----	----	----	----



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# Calculating Quartiles

- Different software programs have slightly different ways of calculating quartiles.
- The following method is easy to perform by hand. Start by sorting the values.
  - When  $n$  is odd.
    - The median ( $Q_2$ ) is the middle value (as before).
    - Leave out the median.  $Q_1$  is the median of the first half,  $Q_3$  is the median of the second half.
  - When  $n$  is even.
    - The median ( $Q_2$ ) is the average of the two middle values.
    - $Q_1$  is the median of the first half,  $Q_3$  is the median of the second half.

# Interquartile Range (IQR)

## Interquartile Range

The **interquartile range** is the difference between the third and first quartile  $|Q_3 - Q_1|$ .



# Variance and Standard Deviation

## Variance

The **variance** ( $s^2$  or  $\sigma^2$ ) is the mean squared difference between the values of a data set and the arithmetic mean.

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$$

## Standard deviation

The **standard deviation** ( $s$  or  $\sigma$ ) is the square root of the variance

$x_1$	$x_2$	$x_3$	$x_4$	$x_5$
141	198	143	201	184



# Properties of the Standard Deviation

- Can the standard deviation be negative?

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- Can the standard deviation be negative?
- What is the smallest possible value? What does this imply?
- What effect do outliers have on the standard deviation?
- What is the unit of the standard deviation (in relation to the unit of the variable)?
- How do you interpret the standard deviation combined with the average?

# Properties of the Standard Deviation

Why  $n - 1$  in the denominator and not  $n$ ?

You can prove the reason for the change mathematically, but we will investigate it empirically

See Python example code in `demo-analysis-1-var.ipynb`



Het journaal 1 - 21/02/14



Het weer 13.30u



100'' Journaal 15u

HOME

VIDEOZONE

LIVE CENTER

PROGRAMMA'S

NIUWS

WUTERS VS. WAES

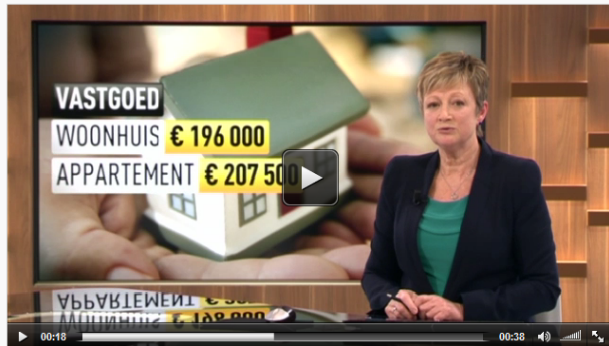
OOK DAT NOG

60 SECONDEN

VK14 OP TV

LIVESTREAM

MEEST BEKEKEN



**Eigen dak boven hoofd wordt steeds duurder**

### Andere afleveringen



Het journaal 1 - 21/02/14



Het journaal L - 20/02/14



Het journaal 1 - 20/02/14



Het journaal L - 19/02/14

This news item reports on high prices for houses and flats. Do the numbers give a good idea of the situation?



# Remember!

**Providing only a center value is never sufficient!**

- What is the dispersion?
- How is the data distributed? Normal distribution?
- Is the group sufficiently homogeneous?

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# Central Tendency and Dispersion: Summary

Measurement Level	Center	Spread Distribution
Qualitative	Mode	—
Quantitative	Average/Mean Median	Variance, Standard Deviation Range, Interquartile Range

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# Summary of Symbols

	Population	Sample
number of elements	$N$	$n$
average or mean	$\mu$	$\bar{x}$
variance	$\sigma^2 = \frac{\sum(x_i - \mu)^2}{N}$	$s^2 = \frac{\sum(x_i - \bar{x})^2}{n-1}$
standard deviation	$\sigma$	$s$

# Data visualisation

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# Chart type overview

Measurement level	Chart type
Qualitative	Bar chart
Quantitative	Boxplot Histogram Density plot

See Python-example code in `demo-analysis-1-var.ipynb`

# Pie Chart

## Attention!

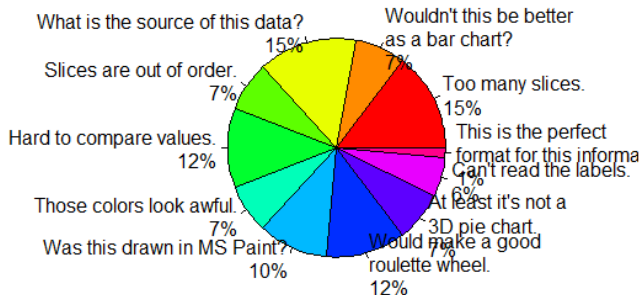
Avoid using a pie chart!

Disadvantages:

- Comparing angles is harder than comparing length
- Unusable for data with many categories

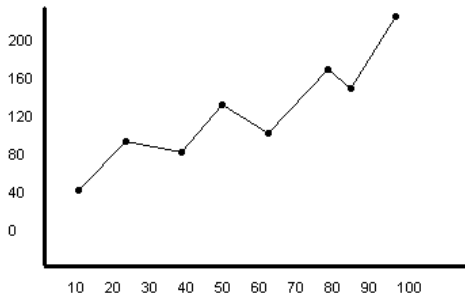
# Pie Chart

## What people are saying about your pie chart



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# Interpretation of Charts



Tips:

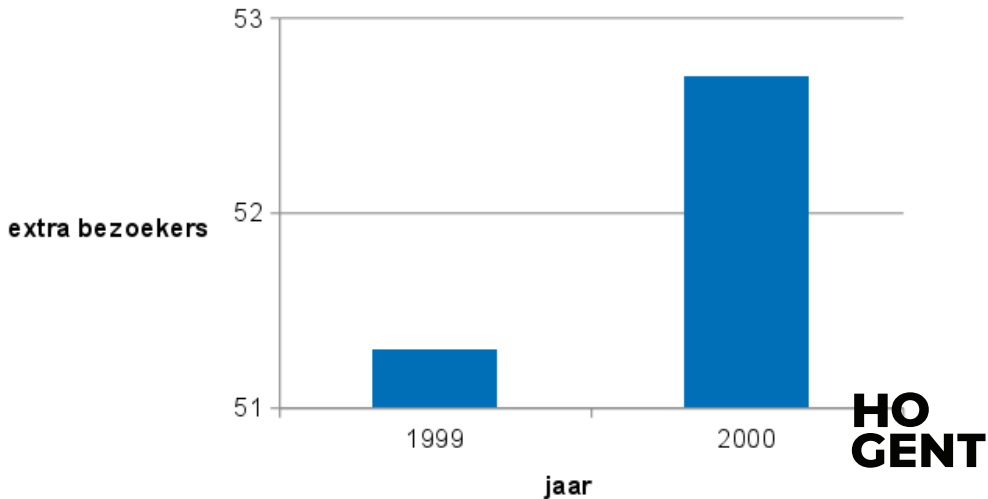
- Label the axes
- Add a clear title
- Name the unit (and, if necessary, order of magnitude)
- Add a label that clarifies the chart

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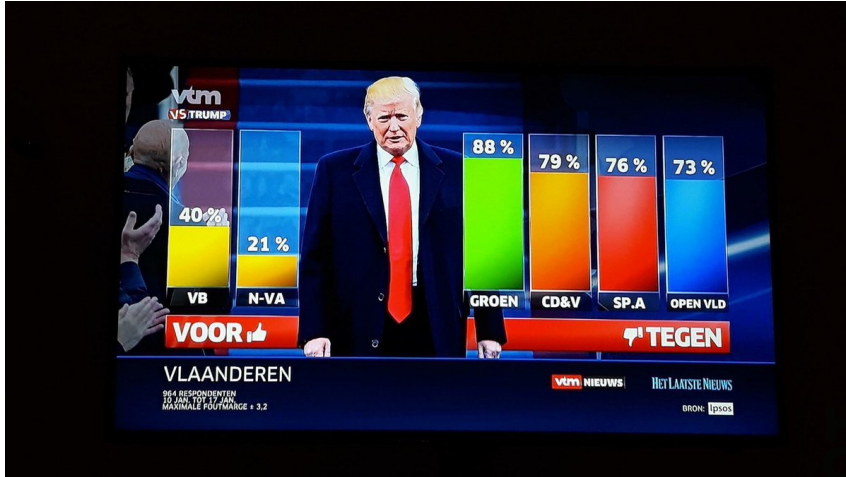


# Data distortion

= misrepresenting data so that invalid conclusions are drawn



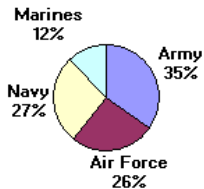
# Data distortion



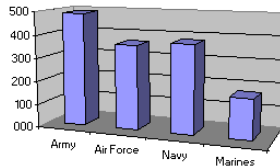
# Data distraction

- Avoid bells and whistles
- Minimize “ink to data” ratio

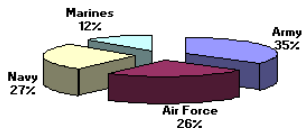
Active Duty Personnel, 1998



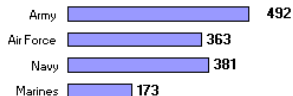
Active Duty Personnel, 1998  
(millions)



Active Duty Personnel, 1998



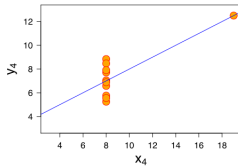
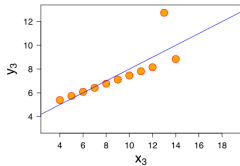
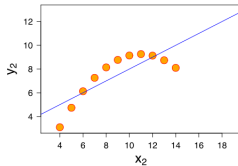
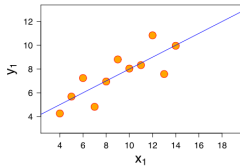
Active Duty Personnel, 1998  
(millions)

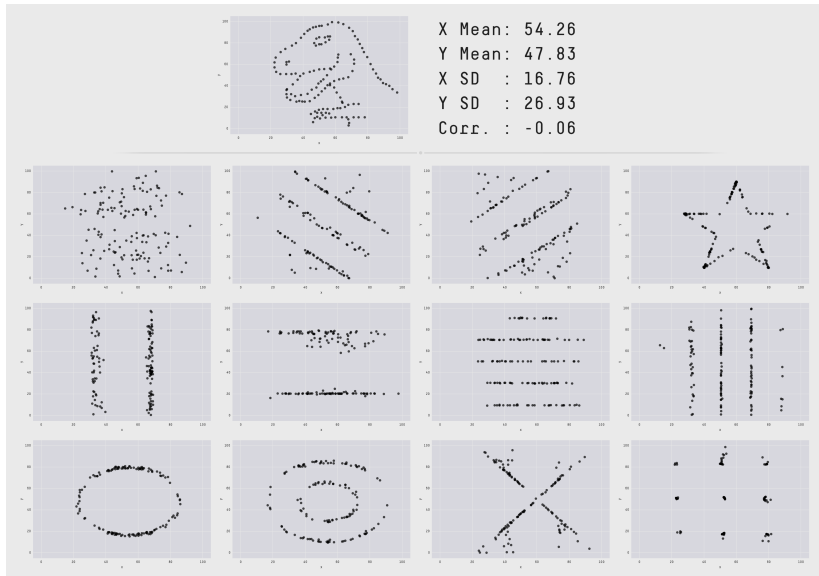


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# The importance of data visualization

**Anscombe's Quartet** are four completely different datasets with the same measurements of central tendency and dispersion.





“The Datasaurus Dozen” (Source:  
<https://www.autodeskresearch.com/publications/samestats>)