Statistical methods for archaeological data analysis I: Basic methods

01 - Introduction

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Synopsis

> "There will be no foolish wand-waving or silly incantations in this class. As such, I don't expect many of you to appreciate the subtle science and exact art that is statistics."

Why statistics at all...

For you:

Statistics are used! If you want to understand them, you have to learn it!

For archaeology/science as discipline

Statistics make everything easier!

- Statements become more understandable and especially replicable
- Statistical statements are right or wrong no matter what reputation the scientist has
- Statements and data become comparable
- Getting the Knowledge of all the material for intuitive understanding of scientific/archaeological relations takes decades, learning statistics only months

Figures don't lie, but liars figure.

Samuel Clemens (alias Mark Twain)

Statistics are only correct if question, approach and method are correct

e.g.: is social stratification observable on metal grave goods? Or on jewellery? What if this depends on the (not observed) sex of the deceased...

Measuring and especially coding of measurements requires subjective decisions all the time:

Reasons for the decisions are often not understandable → subjective influence

Statistics for statistics sake?

A logic (archaeologic) meaning have to be behind an analysis. And the results of analyses have to be logical (archaeological) testable.

Statistic tool R: history (after Theus)

R is the successor of S resp. S-Plus

- S history:
  - 1976-1980: S-Version 1; (development by AT&T Labs) collection of Fortran routines
  - 1980-1984: S-Version 2 Porting to UNIX, definition of the command language
  - 1988-1991: S-Version 3 Porting to C, object-oriented, models
  - 1999-today:

S-Version 4 improved object-orientation (parallel the commercial version S-Plus)

- R history

  - early 90th: Development in New Zealand (R. Ihaka, R. Gentleman) Lisp based, only platform was Mac
  - middle 90th: expansion onto other platforms
  - end 90th: distributed development by the R-Core-Team

- R-Core-Team: 17 developers all over the world

- R-”specialists”: ca. 50 contributer
- developers of R-packages: hundreds, daily more

Why R?

Open Source

- Free accessible source code: transparency of the program
- Free to distribute: you don't have to pay horrific prices or make illegal copies

Reference of the used algorithms

- Scientific citable

Power

- The tool can do everything! Really! Exept making coffee...

Spread

- Runs on all (major) operating systems
- Is widely used in the scientific field

Why R?

Disadvantages

- Command line: unfamiliar (new/old way to work with a computer)
- GUIs look different
- Knowledge of the english language is helpful
- Names of functions and parameters have to be kept in mind: is it col.names, colnames or header?
- Documentation is partly not very intuitiv: you should know what you are searching for

Basic literature

Stephan Shennan, Quantifying Archaeology.

The textbook for this course.

David L. Carlson, Quantitative Methods in Archaeology Using R

A archaeology specific R textbook

Dubravko Dolić, Statistik mit R.

John Verzani, Using R for Introductory Statistics.

R-specific (introductory) statistical books

More literature

- M. Fletcher/G. R. Lock, Digging Numbers: Elementary Statistics for Archaeologists. Oxford Univ. Comm. Arch. Monogr. 332 (Oxford 2005).
- M. J. Baxter, Exploratory Multivariate Analysis in Archaeology (Edinburgh 1994).
- M. Baxter, Statistics in Archaeology (London 2003).
- P. Ihm, Statistik in der Archäologie: Probleme der Anwendung, allgemeine Methoden, Seriation und Klassifikation. Archaeo-Physika 9 (Köln 1978).
- J. Bortz, Statistik für Sozialwissenschaftler4 (Berlin u. a. 1993).

Schedule

date	topic	chapt. Shennan
24.02.2021	Session: Introduction] (01_session/session_1_introduction.html)	1+2
03.03.2021	Session: Introduction into R	-
10.03.2021	Session: Explorative Statistics/Graph. Display	3
17.03.2021	Session: Descriptive Statistics	4
24.03.2021	Session: Nonparametric Tests	5
31.03.2021	Session: Chi-square test	7
14.04.2021	Session: Probability Theory and Distributions	5
21.04.2021	Session: Distributions	6
28.04.2021	Session: Parametric Tests	6
05.05.2021	Session: Regression & Correlation	8
12.05.2021	Session: Cluster Analysis	11
26.05.2021	Session: Correspondence Analysis	13
02.06.2021	Test	-

Sample and Population

Population:

- Amount of all items of relevance for an analysis.

Sample

- Selection of items on basis of certain criteria (e.g. representativity) which
- will be analysed instead of the population

Example opinion poll

- Population: all federal citizens who have a meaning
- Sample: the citizens who are polled by the polling organization

complete record of all the values ↔ sampling

In archaeology only sampling is possible! The population can never be investigated!

Flavours of statistics

Descriptive statistics

- Summary and description of data by using parameters (mean, standard deviation etc.)

(graphical display)

- Summary and description of data by using graphs (bar charts, pie charts etc.)
- Useful for pattern detection and description, therefore intermediate position

Explorative statistics

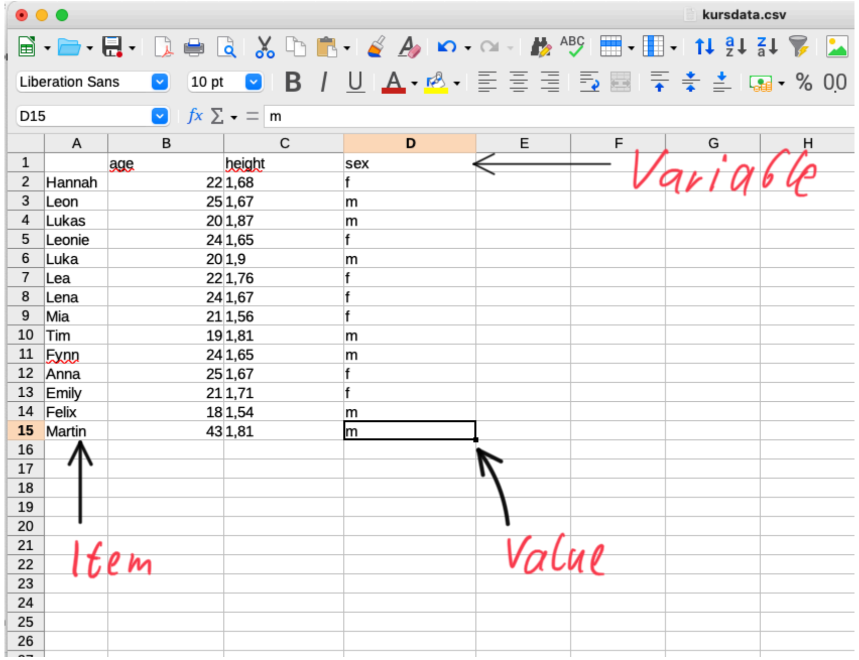
- Summary and description of data for pattern detection (e.g. correspondence analysis)

Statistical inference or statistical induction

- testing of hypothesis on data (e.g. chi-squared test)

Data, variables, values

- variable:
  - What ist measured or analysed.
  - e.g. height
- item:
  - That whichs variable is measure
  - e.g. me as „possessor“ of a height, graves, persons...
- values:
  - The actual measurement.
  - e.g. my height is 1.81 m.



	A	B	C	D
1		age	height	sex
2	Hannah	22	1,68	f
3	Leon	25	1,67	m
4	Lukas	20	1,87	m
5	Leonie	24	1,65	f
6	Luka	20	1,9	m
7	Lea	22	1,76	f
8	Lena	24	1,67	f
9	Mia	21	1,56	f
10	Tim	19	1,81	m
11	Fynn	24	1,65	m
12	Anna	25	1,67	f
13	Emily	21	1,71	f
14	Felix	18	1,54	m
15	Martin	43	1,81	m

Flavours of Statistics 2: Troll math

one: univariate statistics:

- Only on variable is involved
- e.g. weight of bronze axes

two: bivariate statistics:

- Two variables are involved, of interest is their relation
- e.g. relationship of length and width of bronze axes

many: multivariate statistik:

- More than two variables are involved, of interest is their relation
- e.g. place of finding of axes (grave, depot, settlement) in relation to their chemical composition (proportion of copper, tin, arsenic, lead etc.)

More than one variable

Independent Variable:

- The assumed cause of a relationship

Dependent variable:

- The assumed effect of the independent variable in a relationship

example:

- Number of pearls in a grave (Dependent) vs.
- sex of the deceased (independent)
- Hypothesis: The number of pearls in a grave depends on the sex of the deceased

Can (have to be) not always to be defined

- e.g.: volume and height of a vessel...

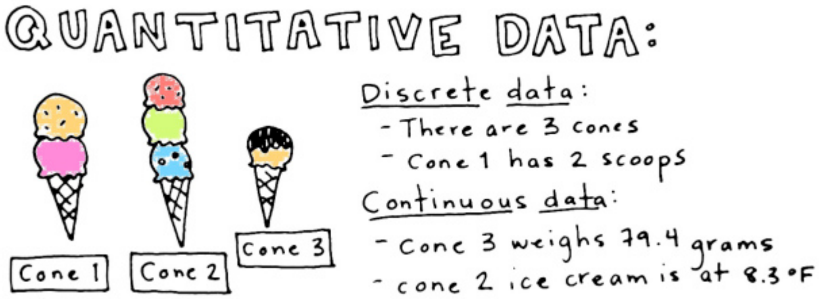
continuous vs. discrete

discrete variable:

- Variable which can take only certain values without intermediate values
- e.g. income, counts of ceramic objects, sex (?)
- 'counted'

continuous variables:

- Variable which can take all value and intermediate value
- e.g. height, temperature, proportion value
- 'measured'



QUANTITATIVE DATA:

Discrete data:
- There are 3 cones
- Cone 1 has 2 scoops

Continuous data:
- Cone 3 weighs 79.4 grams
- cone 2 ice cream is at 8.3°F

Source: https://statsthewayilikeit.com

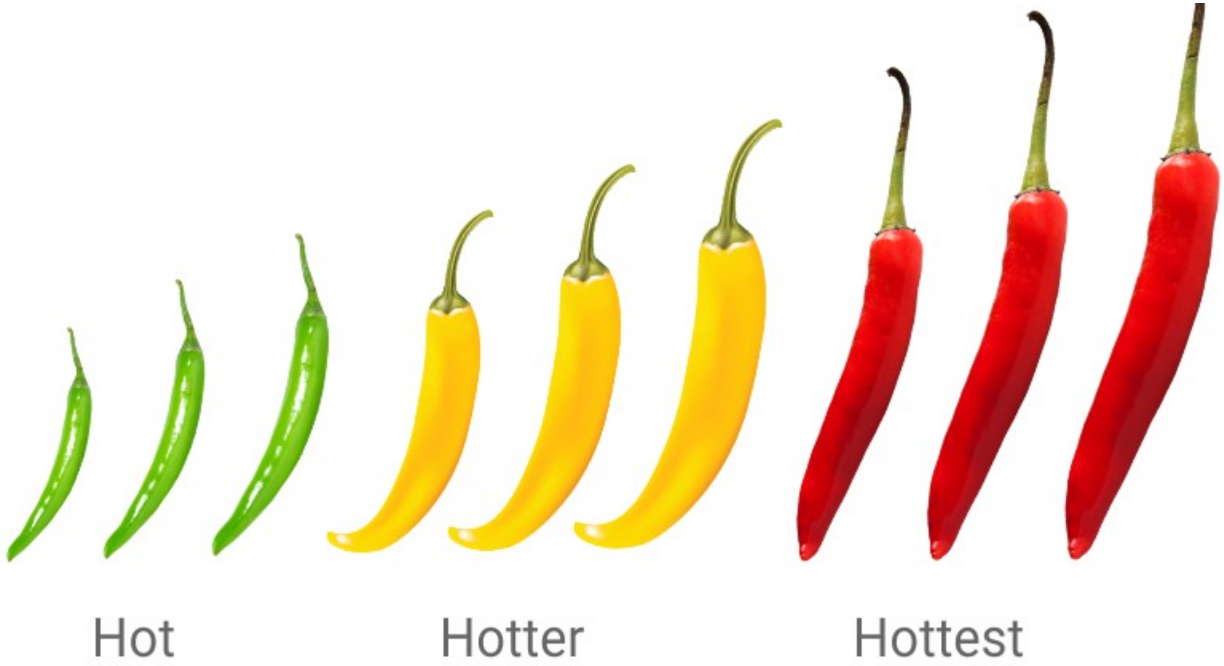
Levels of measurement

I am a bird.
I am yellow.
I am awesome.
I am a seahorse.
I am orange.
I am super awesome.
I am a T-rex.
I am green.
I am extinct.

nominal or categorical:

- You can only decide if something belongs to a category
- Categories which do not have a defined relationship among each other, only counting is possible (e.g. sex)

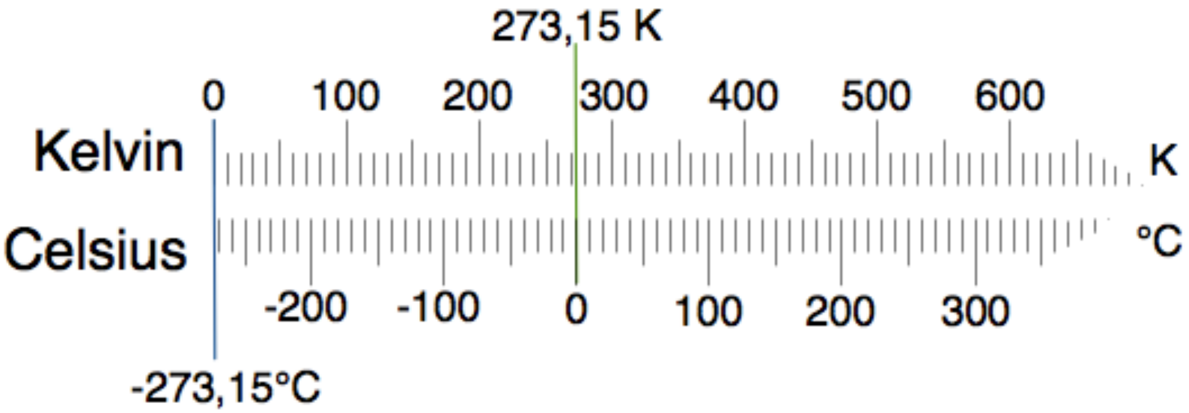
Levels of measurement



ordinal:

- Categories which are comparable and differ from each other in their characteristic [size/power/intensity]
- their rank is determinable (e.g. preservation conditions – bad < medium < good)

Levels of measurement



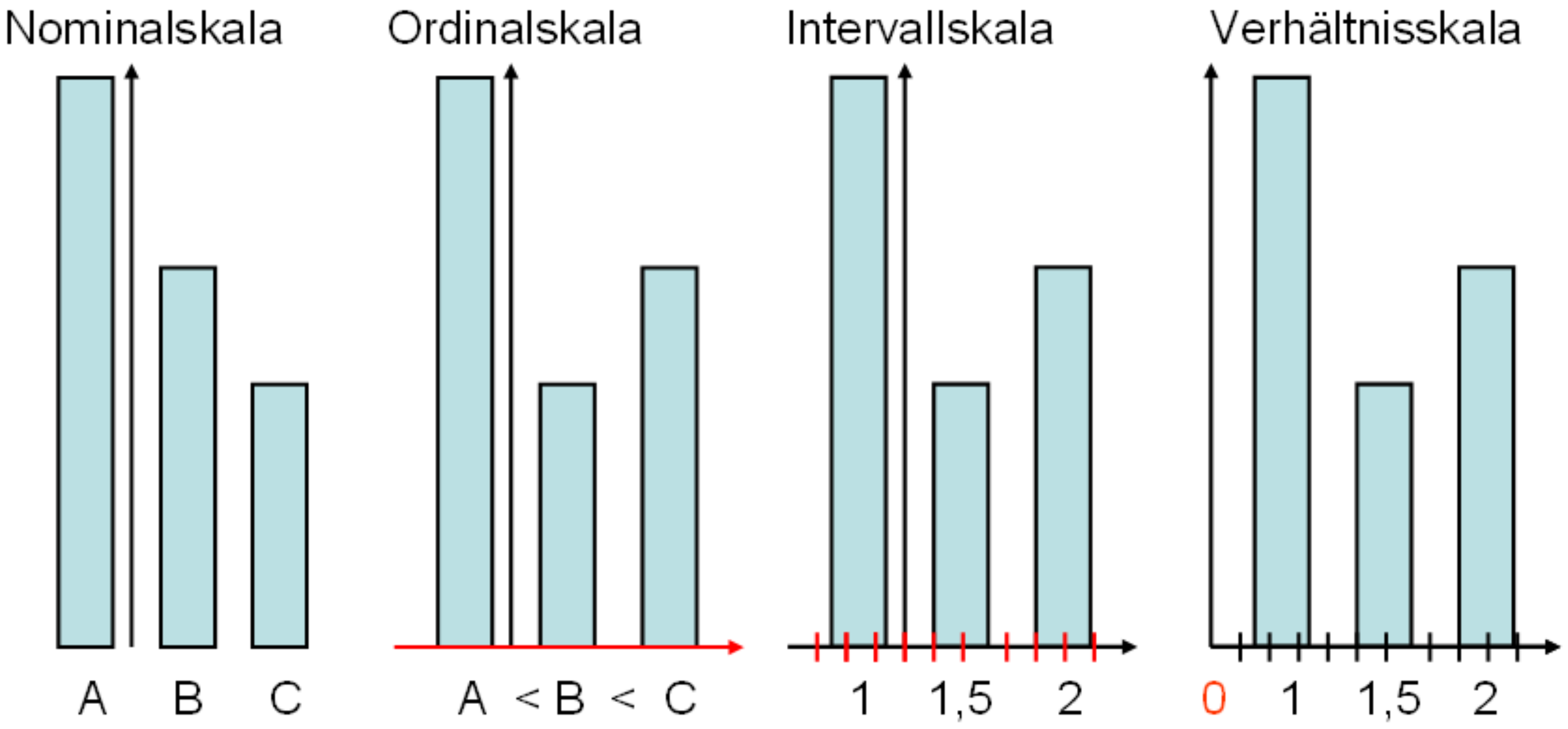
metric:

- Variable has a defined system of measurement, all calculations are possible. To distinguish are

1. interval: The variable has an arbitrary choosen neutral point (°C)
2. ratio: The variable has an absolute neutral point (°K)

- Sometimes also used: absolut scale
  - counts (number of inhabitans)

Levels of measurement



Levels of measurement

scale	Meaningful statements	Examples
nominal	equality, inequality	Telephon numbers, illnesses, ceramic types
ordinal	bigger-smaller-relationship	Wind forces, academic ranks, classes of wealth, stratigraphic relations
interval	Equality of differences	Temperature in °C, calender age
ratio	Equality of ratios	Measurement of lengths, weight, height of a vessel

after Bortz 2005

Levels of measurement

Change of the level

downscaling:

- Always possible.
- e.g. classification of measurements (small-medium-big)
- But: leads to loss of information

upscaling:

- Sometimes possible
- e.g.: instead of classification of ceramics in coarse-fine ware measurement of grain size
- But: leads to larger data volume and higher complexity of measurement

Conclusion:

- For analysis should the best fitting level of measurement be choosen.
- Because there can always occure a change in the requirements, rule of thumb: take one level finer than you think you will need in the end (as said, just a rule of thumb...)

Data collection: list

Simple list of the data

example:

```
##  [1] 154 167 187 165 190 176 167 156 154 165 167 171 154
```

data preparation: matrix of data

Table of multiple values each item

example:

name	height	sex
Hannah	154	2(female)
Leon	167	1(male)
Lukas	187	1
Leonie	165	2
Luka	190	1
Lea	176	2
Lena	167	2
Mia	156	2
Tim	154	1
Fynn	165	1
Anna	167	2
Emily	171	2
Felix	154	1

data preparation: “tally sheet” / frequency table

Table of multiple items each value example:

name	Tally marks	counts
154	|||	3
156	|	1
167	|||	3
165	||	2
171	|	1
176	|	1
187	|	1
190	|	1

data preparation: classification

Table of multiple items each class of value

example:

name	Tally marks	counts
<150		0
150-159	||||	4
160-169	|||||	5
170-179	||	2
180-189	|	1
>190	|	1

Class width here 10 cm

Rule of thumb: ca. 8 – 12 classes or

Number of classes $k \approx \sqrt{n}$, here therefore $k \approx \sqrt{13} = 3.6055513 \approx 4$

Equations & symbols

meaning	symbol
ca.	$a \approx b$
count	n
sum	$\sum_{i=1}^{n} x_i$
This means	$x_1 = 0, x_2 = 4, x_3 = 5, x_4 = 2, x_5 = 1, x_6 = 1; n = 6$
	$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 = \sum_{i=1}^{n} x_i$
Product the same way	$\prod_{i=1}^{n} x_i = x_1 * x_2 * x_3 * x_4 * x_5 * x_6 = 0$

Example arithm. mean

Equations are recipes

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

observations : x_i ={154, 167, 187, 165, 190, 176, 167, 156, 154, 165, 167, 171, 154}

number of observations : n=13

$$\bar{x} = \frac{154 + 167 + 187 + 165 + 190 + 176 + 167 + 156 + 154 + 165 + 167 + 171 + 154}{13}$$

$$\bar{x} = \frac{2173}{13}$$

$$\bar{x} = 167.1538462$$

@charlesetoroma - unsplash

Homework: description of the participants

Choose one of the following five groups and collect the data about the participants accordingly

Data to collect for the groups

- A) Email, number of the computer in front of you
- B) Sex, Age
- C) laptop yes/no, foot size
- D) actual cash in your purse, height
- E) homecountry, operation system used at home

Collect the data matrix, determine the level of measurement of each variable and send me your data collection via email until weekend.

Make it a group work! organise yourself! No one is an island!