Utrecht University

CENTRE FOR DIGITAL HUMANITIES

13 Oct 2022

Basics of Statistics Session One

training for researchers and teachers in the Humanities

materials available at https://edu.nl/6uuj4

Hugo Quené **Kirsten Schutter**

h.quene@uu.nl k.schutter@uu.nl

Centre for Digital Humanities & Utrecht inst of Linguistics OTS
Utrecht University

1

Introduction

Hugo Quené www.hugoquene.nl

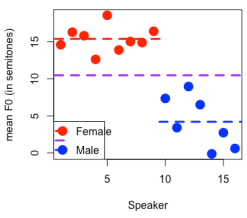
- background in **speech** research
- speech is highly variable, hence **statistics**

Kirsten Schutter

- background in methodology & statistics esp. for language and speech research

today's tutorial

- quantitative (vs. qualitative)
- parametric (vs. nonparametric)
- frequentist (vs. Bayesian)



2

who are you? what do you want to learn?

- introduce yourself
- on your laptop or mobile phone, go to

  https://app.wooclap.com/GLHBZL

3

Schedule

9:30 Session One (*lecture, 1:00h*)
variation, variables, descriptive stats
10:30 coffee break
10:45 Session Two (*hands on, 1:30*)
12:15 lunch
13:15 Session Three (*lecture, 1:00*)
modeling, inference & testing, regression
14:15 coffee break
14:30 Session Four (*hands on, 1:30*)
16:00 Q&A and wrap-up (*0:30*)
16:30 end

4

Principle 1
Data are sampled

- observed data are only a **sample** of larger population
  - population may be infinite and unknown
    (trees, humans, texts, sentences, responses)
- sample is ideally **random**, but may be **biased**:
  - e.g. selection bias, response bias …
- we try to find pattern in imperfectly sampled data,
  allowing for **uncertainty** from sampling

5

Principle 2
Observed data vary, randomly and systematically

variable: sth capable of varying

- **systematically** ("signal")
  observed effect, or pattern, often obscured
- **randomly** ("noise")
  due to sample variability, and measurement error,
  and unknown sources of variation
- pooled effects of random variation typically result
  in "normal" or "gaussian" distribution of random error
- errors tend to **cancel out** each other (on average)
  large sample: errors "disappear", patterns aggregate!

6

Why statistical analysis?

aims to discover **pattern** in data,
to discern meaningful **signal** from noise,
to **learn** from data,
to **make sense** of data

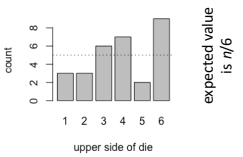
(e.g. Peck & Devore, 2012; Spiegelhalter, 2020)

7

Example 1: fair die

```
> table(x)
x
1 2 3 4 5 6
3 3 6 7 2 9
```

- die is cube, six sides, each with probability of 1/6
- outcome is **discrete** or **categorical** variable
- outcomes of n=30 throws:
  3 3 4 2 4 1 6 2 6 6 6 6 4 5 6 4 6 6 4 3 3 1 6 4 3 1 5 3 2 4
- left: frequencies (counts) in table form
- right: frequencies (counts) in "bar chart" figure form
  - **categorical**: spaces between discrete bars
- sampling variability: expected vs observed pattern



21 July 2021 8

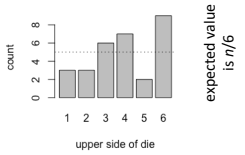
8

Example 1: fair die (continued)

```
> table(x)
x
1 2 3 4 5 6
3 3 6 7 2 9
```

- categorical variable
- center:
  median (50% percentile) 4
    - between 15th and 16th ranked observation

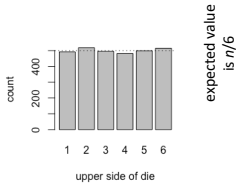
  mode (most frequent value) 6
- dispersion:
  median absolute deviation (mad) 2.2



9

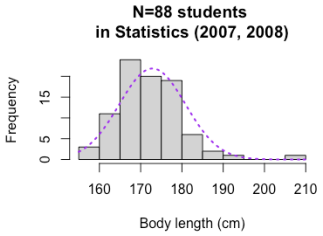
Example 1: fair die (continued)

- as sample size *n* increases:
  clearer pattern, less noise
- **because independent sampling errors tend to cancel out each other**



10

Example 2: students' body length



- from N=88 students from two cohorts
- right: frequencies (counts) in histogram bins
  - continuous: no spaces between bars
- sampling variability: expected vs observed pattern

- centre: mean 173 median 172
- dispersion: std.dev. 8.0 mad 7.4

between 44th and 45th ranked observation

21 July 2021 11

11

Know your variables

- independent grouping, factor, predictor
- dependent outcome (depends on sample)

- categorical e.g. die, gender
- continuous e.g. body length, shoe size

- examples… last vote (party), boosted, self-test outcome, T-shirt size, age…

predictor, or outcome ?
categorical, or continuous ?

12

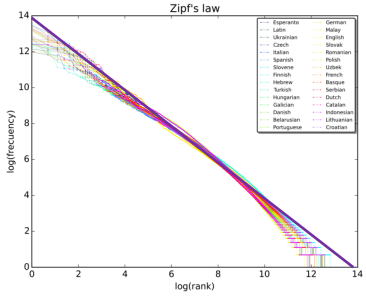
Know your "levels of measurement"

	name	properties	operations	example
continuous	ratio	equal intervals, with zero	multiply, divide	body length
	interval	equal intervals, no zero	add, subtract	temp'ture celsius
categorical	ordinal	with natural order, no distances	count, order	education level, die
	nominal	no natural order	count	ice cream flavour

13

Statistical model

model: Zipf's Law (straight purple line)
error: deviations from predicted values



https://upload.wikimedia.org/wikipedia/commons/a/ac/Zipf_30wiki_en_labels.png

- simplified version of reality
  (or rather: of data taken from reality)
- data = model + error
- simplest model: the **mean** (average)
  simplest error: **standard deviation**
- assuming interval or ratio level,
  assuming approximately normal distribution,
  assuming independent observations, …

14

variance and standard deviation

$$s = \sqrt{s^2} = \sqrt{\frac{\sum(x_i - \overline{x})^2}{n-1}}$$

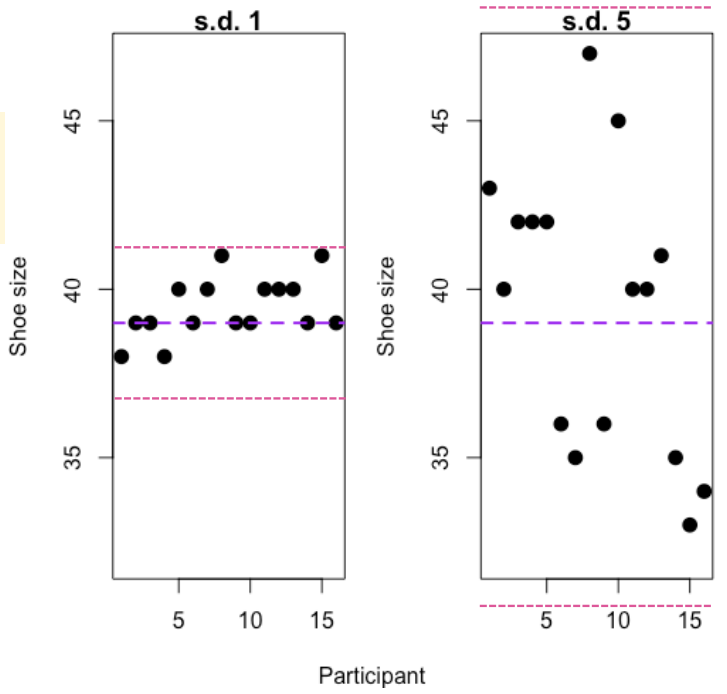
- s^2 variance (in squared units)
  s standard deviation (sd, in orig units)

x: { 1, 2, 3 }
n=3, n−1=2
mean: (1+2+3)/n = 2
deviations: { -1, 0, +1 }
$(dev)^2$: { 1, 0, 1 }
SS dev: 1+0+1 = 2
variance = 2/2 = 1
std.dev. = 1

https://hugoquene.github.io/QMS-EN/ch-centre-and-dispersion.html

15

most shoe sizes between mean ± (2 × 1)



most shoe sizes between mean ± (2 × 5)

16

Questions ?

17