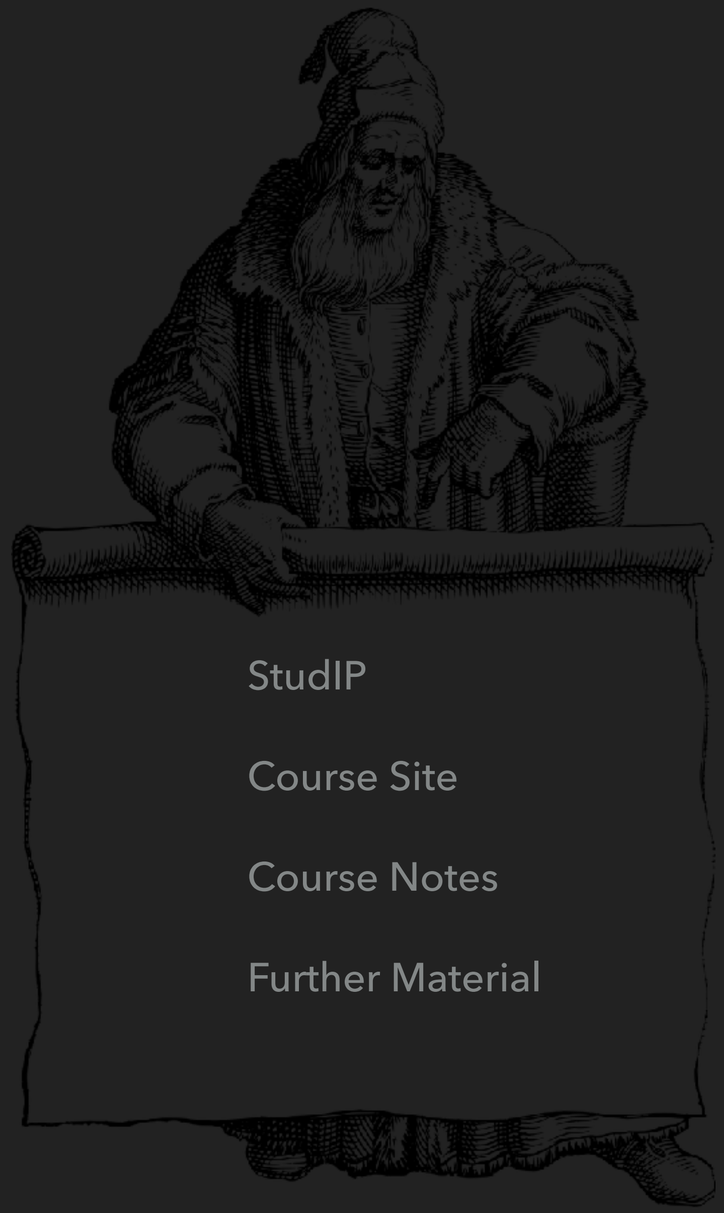
INTRODUCTION TO

DATA ANALYSIS

MAIN COURSE MATERIAL

- course website (link also on StudIP)
  - https://michael-franke.github.io/IDA-2019/
  - slides, homework etc. will appear here
- course notes as web-book (link also on StudIP)
  - https://michael-franke.github.io/intro-data-analysis/
  - main reading



LECTURES

- make sure to catch both lectures each week
  - Wednesday, 10:15-11:45 (66/E33)
  - Friday, 12:15-13:45 (32/102)
- prepare reading in advance (see schedule on website)
- reread chapter after lecture

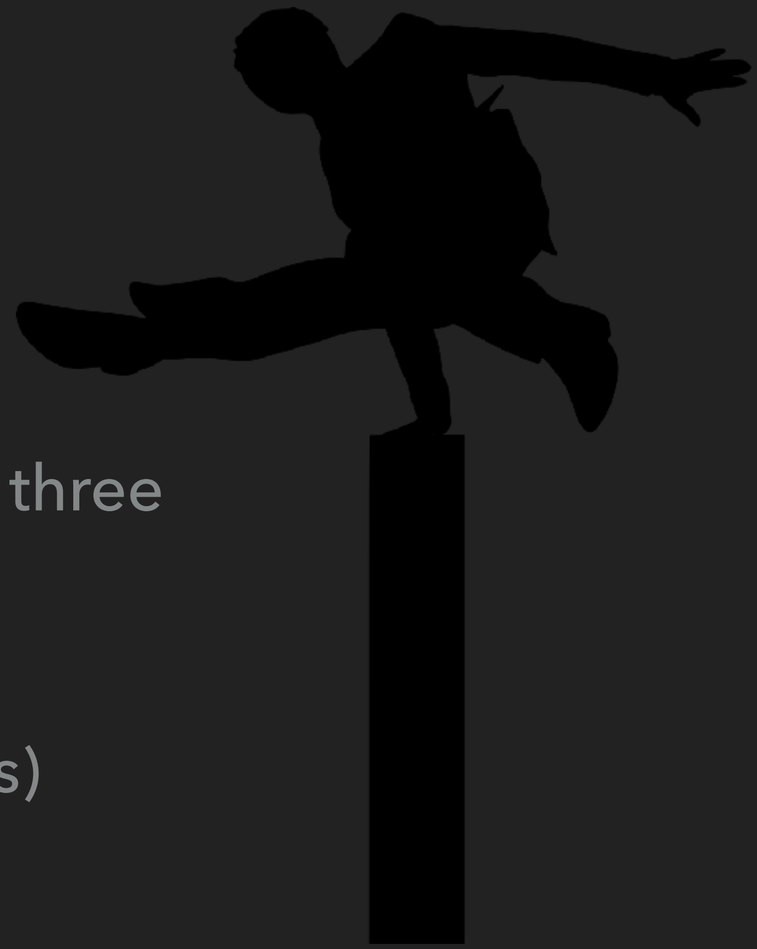
TUTORIALS

- tutorials give extra background and practical exercises (tutors vary w/o notice)
- everybody should catch at least one tutorial per week
- tutorial times and locations (also on StudIP)
  - Monday, 10:15-11:45 (66/E34)
  - Tuesday, 8:15-9:45 (66/E33)
    [this tutorial will not take place on Nov 5]
  - Tuesday, 12:15-13:45 (32/107)

IDA-2019 TEAM

- tutors
  - Tallulah Jansen, Nina Mainusch, Maria Pershina, Jona Carmon, Taher Habib, Marc Viladrich
- web-book
  - Florence Bockting, Tobias Anton
- additional support
  - Noa Kallioinen, Ann-Christin Meisener

COURSE REQUIREMENTS



- required for passing:
  1. passing grade on homework assignments
     - weekly assignments to be submitted in groups of three
  2. passing grade on final exam
     - 4h written, “open-book” (bring hand-written notes)
- see course website for more information
  https://michael-franke.github.io/IDA-2019/grading/

HOMEWORK

- HW issued on Friday evening (after lecture)
- HW due Friday next week at noon (before lecture)
- submit electronically via StudIP
  - upload to your group's folder
  - as Rmd or PDF (LaTeX, hand-written scan)
- no detailed comments as corrections but sample solution

LEARNING GOALS

- ability to explore data sets in hypothesis-driven manner
- manipulate & visualize data
- understand logic of statistical inference (frequentist vs Bayesian statistics)
- ability & confidence to critically assess DAs in research papers
- ability & confidence to tackle your own DA for an experimental BSc thesis

TECHNICAL SKILLS YOU WILL ACQUIRE IN THIS COURSE

- basics of R & `tidyverse`
  - write your own DA scripts
    (manipulation, visualization, statistical analyses)
- reproducible writing in Rmarkdown
- glimpse at probabilistic programming languages
  (WebPPL, greta)
- first contact with generalized linear models

WHAT YOU SHOULD NOT EXPECT OF THIS COURSE

- details of common algorithm for statistical computation (MCMC, optimization, …)
- emphasis on history and/or philosophy of statistics
- reactive practical competence in statistics
  - “Our aim is understanding.”
  - “We do not teach tricks!”
    “We do not share recipes!”

COMPARISON OF RELATED COURSES

- statistics @ Psych
  - focus on frequentist methods
  - SPSS instead of R
- probability theory @ Math
  - focus on theory not applications
  - math not computer science
  - foundational issues
- neuroinformatics @ CogSci
  - more focus on theory & math
  - applications in neuroscience / ML
- intro data analysis @ CogSci
  - focus on computation
  - applications in behavioral psych
  - frequentist & Bayes

SCHEDULE (PRELIMINARY)

week	Content of tutorials	Wednesday lecture	Friday lecture	HW issued
44			**Course overview** Chapter 1	
45	installing R & packages (Stan, tensorflow)	**Intro to R** Chapter 2	**Data & data handling** Chapter 3	HW1
46	using R, data handling / wrangling	**Data wrangling** Chapter 4	**Summary statistics** Chapter 5	HW2
47	more R, wrangling, summary stats	**NO LECTURE**	**Data plotting** Chapter 6	HW3
48	plotting, more R exercises	**Probability basics** Chapter 7	**Frequentism vs Bayes** Chapter 8	HW4
49	probability calculus, Bayes rule	**Statistical models** Chapter 9	**Parameter Inference 1** Chapter 10	HW5
50	simulations on error control, calculations with Bayes rule	**NO LECTURE**	**Parameter Inference 2** Chapter 10	HW6
51	sampling-based approaches using R, WebPPL, greta	**Classical testing 1** Chapter 11	**Classical testing 2** Chapter 11	HW7

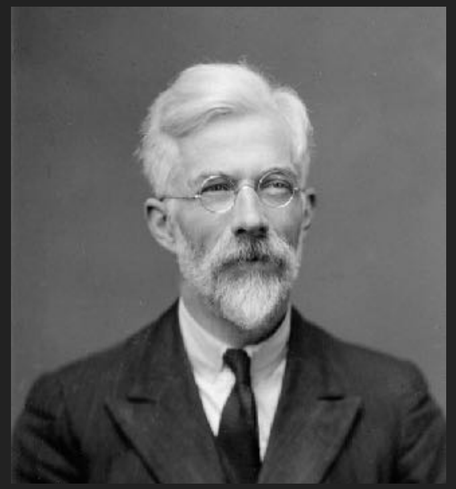
week	Content of tutorials	Wednesday lecture	Friday lecture	HW issued
2	binomial test, t-test, (maybe ANOVA), ...	**Classical testing 3** Chapter 11	**Model comparison** Chapter 12	HW8
3	model comparison, Bayes factors, LR test, AIC	**Bayesian hypothesis testing** Chapter 13	**Model criticism** Chapter 14	HW9
4		**Simple linear regression**	**Generalized regression**	HW10
5		**Generalized regression**	**Hierarchical regression**	HW11
6		**Q&A**	**Final exam**	
7		**Cognitive models in data analysis**	**TBA**	

check course website for updated schedule

FLAVORS OF MODERN STATISTICAL ANALYSIS

FREQUENTISM

objective probability :: tests :: *p*-values :: error control



BAYESIANISM

subjective probability :: beliefs :: updates

STATISTICS AS POTTERY

STATISTICAL INFERENCE

adresses

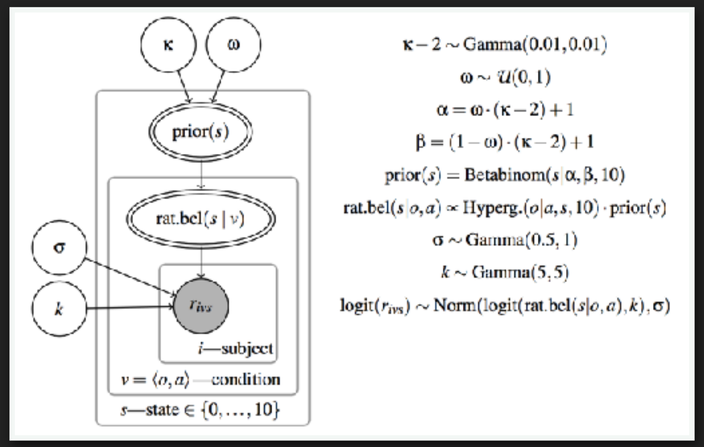
```
Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)         6.056821   0.004718 1283.74   <2e-16 ***
blockreaction      -0.337831   0.005790  -58.35   <2e-16 ***
blockdiscrimination 0.130195   0.005813   22.39   <2e-16 ***
```

RESEARCH QUESTION

?

yields

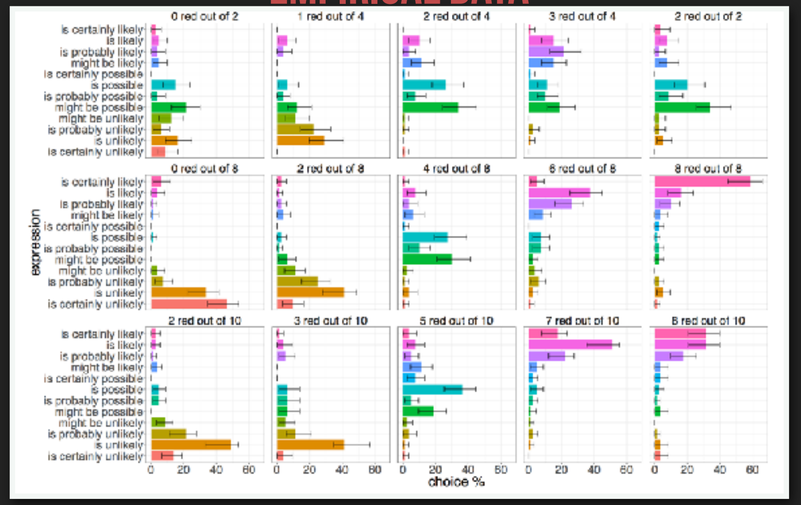
STATISTICAL MODEL



$$\kappa - 2 \sim \text{Gamma}(0.01, 0.01)$$
$$\omega \sim \mathcal{U}(0, 1)$$
$$\alpha = \omega \cdot (\kappa - 2) + 1$$
$$\beta = (1 - \omega) \cdot (\kappa - 2) + 1$$
$$\text{prior}(s) = \text{Betabinom}(s \mid \alpha, \beta, 10)$$
$$\text{rat.bel}(s \mid o, a) \propto \text{Hyperg.}(o \mid a, s, 10) \cdot \text{prior}(s)$$
$$\sigma \sim \text{Gamma}(0.5, 1)$$
$$k \sim \text{Gamma}(5, 5)$$
$$\text{logit}(r_{ivs}) \sim \text{Norm}(\text{logit}(\text{rat.bel}(s|o, a), k), \sigma)$$

motivates

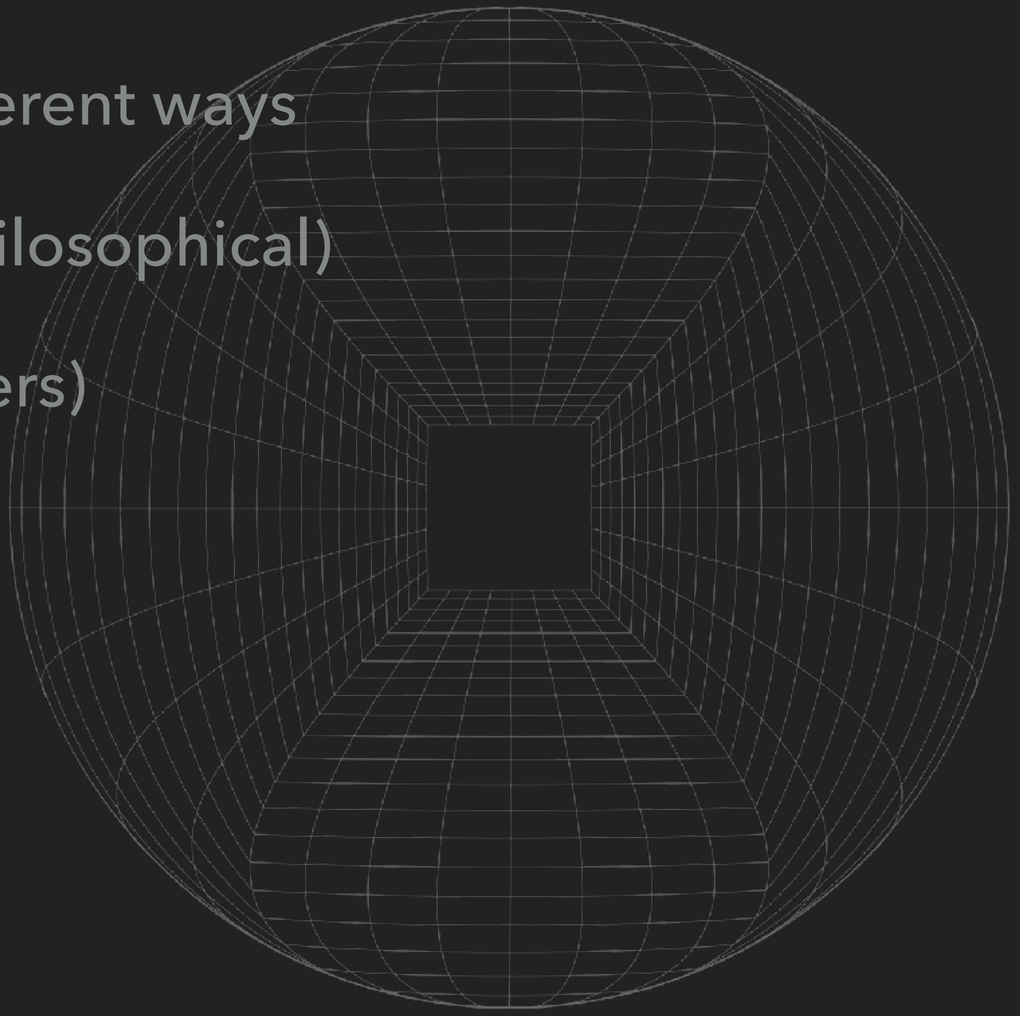
EMPIRICAL DATA



fuels

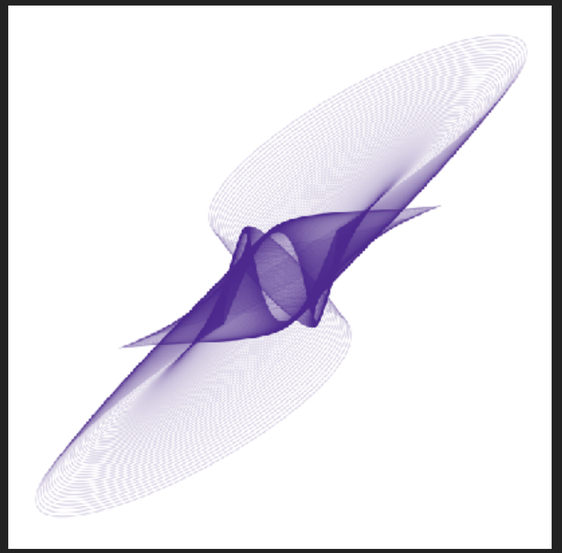
UNDERSTANDING THROUGH COMPUTATION

- statistical concepts can be understood in different ways
  - in terms of their motivation (practical or philosophical)
  - as a mathematical concept (elegance matters)
  - through implementation as algorithms
  - by exploring computational simulations



SELF-ANALYSIS

- aspiring analysts should undergo analysis themselves
- running examples based on online experiments
  - whoever wants can participate
  - collected data will be used in exercises and HW



FURTHER STUDY MATERIAL

- appendix chapter A of course material
- top pick on stats books:
  - Ben Lambert (2018) “A Student’s Guide to Bayesian Statistics”
  - Bodo Winter (2019) “Statistics for Linguists: An introduction using R”

CONTACT

please direct all communication to

Tallulah Jansen <taljansen@uni-osnabrueck.de>

HOMEWORK FOR NEXT CLASS

- read Chapter 1 of course notes
- install all necessary software as described in Chapter 1.5
- visit a tutorial next week to get help with installation
  - no tutorial on Tue at 8:15-9:45 on Nov 5
- prepare Chapter 2