Empirical research in management and economics

The replication crisis and open science

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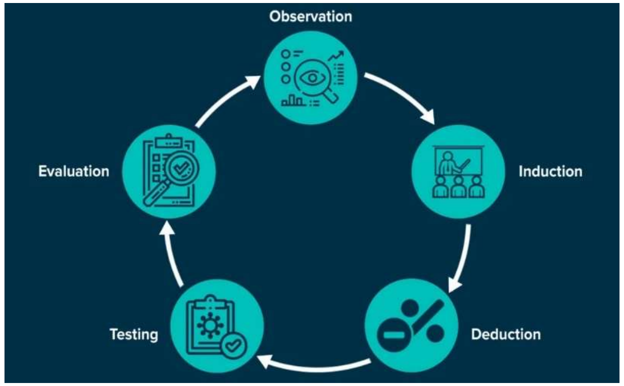


Evaluation is now open

Please take part in the evaluation of the module!

Your feedback is highly appreciated.

Evaluation period: 10–23 January

If you have questions on topics that we covered and that you would like to be clarified in the final lecture …

Submit your question(s) via the following link by 22 January

https://forms.gle/jpcwqhXa6cQPPTwb8

Recap from last week

- What is the goal of a conjoint analysis?
- What are important criteria when designing attribute profiles for a conjoint analysis?
- How does a fractional orthogonal design differ from a full factorial design? What does it mean if a fractional design is orthogonal?
- Give different approaches to collect preference data
- What is the structure of a conjoint analysis model?
- How does effect coding differ from dummy coding?
- Describe the calculation of partworth utilities
- Describe the calculation of attribute importances

Agenda for the semester

Session	Date	Topic
1	13 October	Introduction
2	20 October	Descriptive data analysis
3	27 October	Hypothesis development and measurement
4	3 November	Inferential data analysis I
5	10 November	Inferential data analysis II
6	17 November	Simple regression
7	24 November	Multiple regression
8	1 December	Logistic regression
9	8 December	Factor analysis
10	15 December	Cluster analysis
11	12 January	Conjoint analysis
12	**19 January**	**The replication crisis and open science**
13	26 January	Summary and questions
	11 February	Exam

Goals for this week

- You are familiar with the replication crisis in the behavioral sciences
- You know what *questionable research practices* are (e.g., p-hacking, HARKing)
- You can describe why questionable research practices are problematic and can lead to nonreplicable findings
- You know the principles of open science, including the steps of conducting a preregistration
- You are familiar with principles underlying the Bayesian approach to data analysis

How replicable is research in the behavioral sciences?

→ Psychology

- Sampling scheme
  - 100 articles from three leading psychology journals (published in 2008)
  - Always last experiment reported in the article
  - 97 of the 100 sampled experiments had significant results
- Replication teams from different labs: 270 authors in total

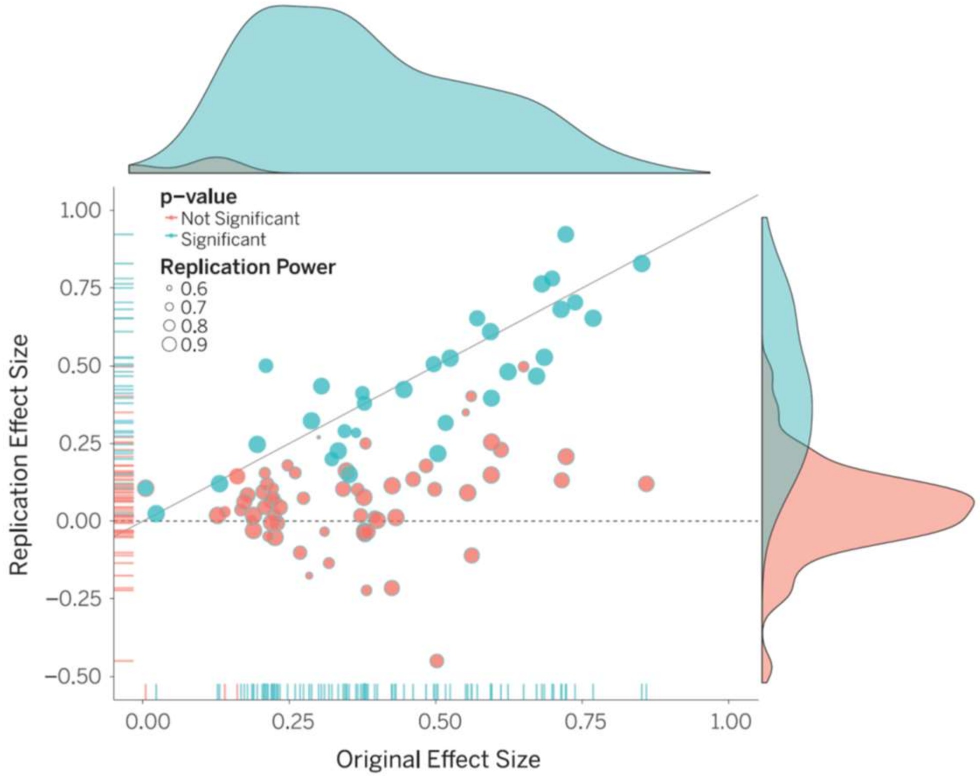
Brian Nosek

Open Science Collaboration (2015)

Replicability of research in psychology

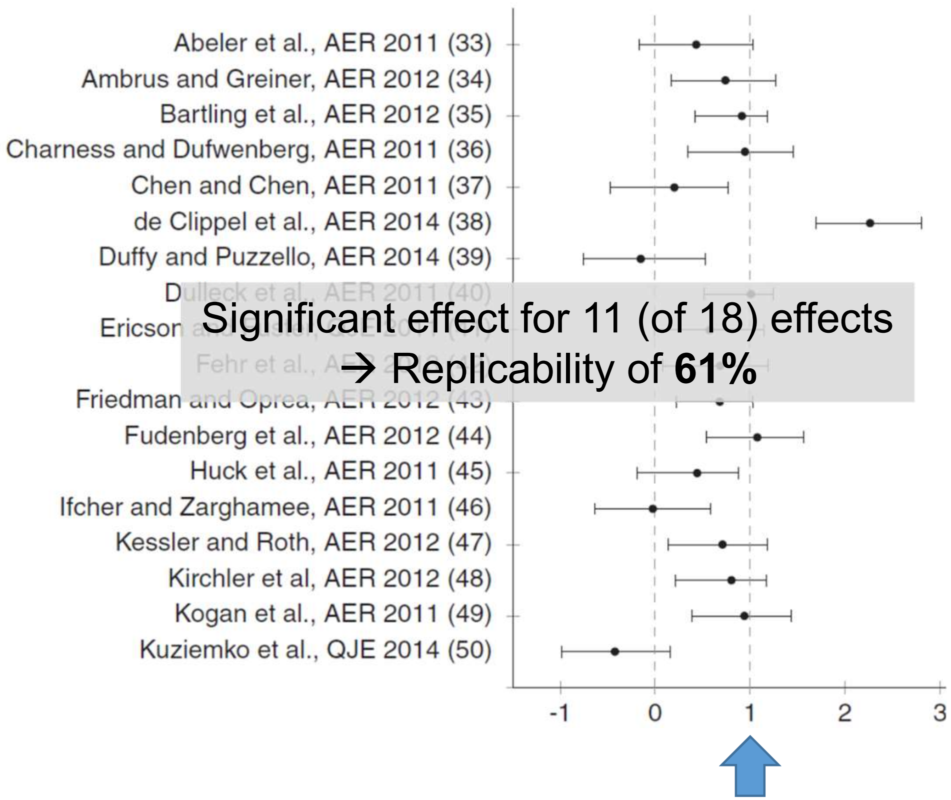
	Replications $P < 0.05$ in original direction	Percent	Mean (SD) original effect size	Mean (SD) replication effect size
Overall	35/97	36	0.403 (0.188)	0.197 (0.257)
JPSP, social	7/31	23	0.29 (0.10)	0.07 (0.11)
JEP:LMC, cognitive	13/27	48	0.47 (0.18)	0.27 (0.24)
PSCI, social	7/24	29	0.39 (0.20)	0.21 (0.30)
PSCI, cognitive	8/15	53	0.53 (0.2)	0.29 (0.35)

Significant effect for 35 (of 97) effects
→ Replicability of **36%**



Open Science Collaboration (2015)

Replicability of research in experimental economics



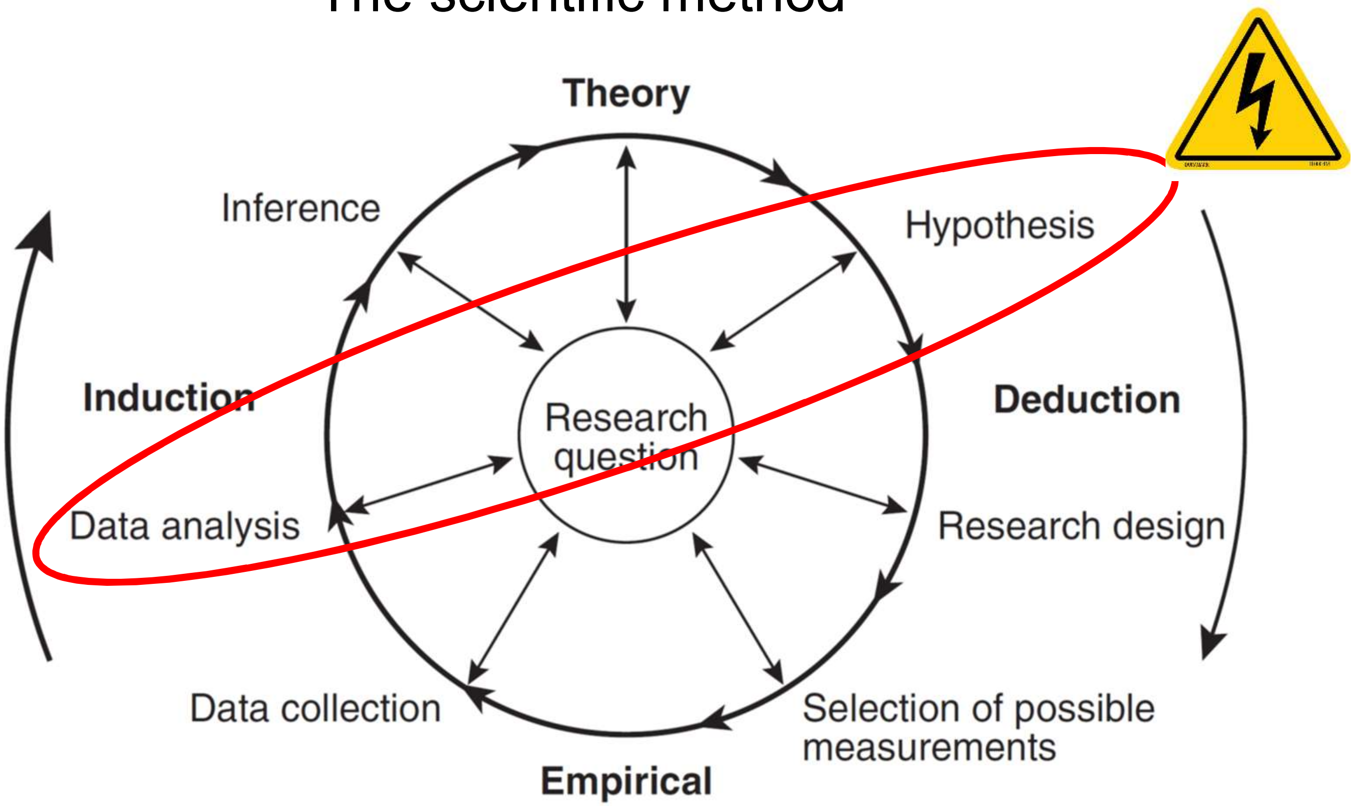
Significant effect for 11 (of 18) effects
→ Replicability of **61%**

1 = original effect size

Camerer et al. (2010)

Hypothetico-deductive model

"The scientific method"

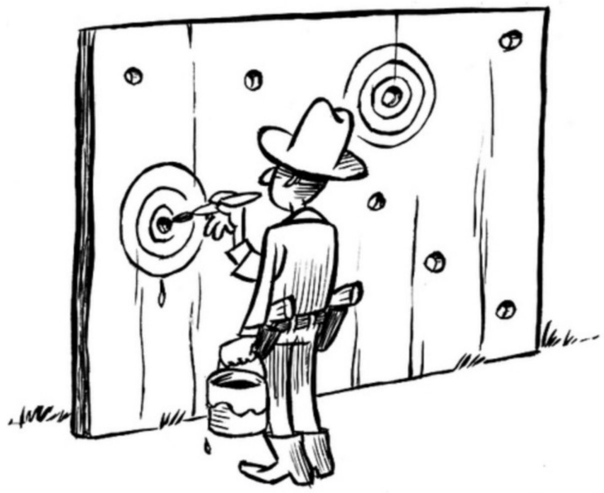


HARKing

Hypothesizing **A**fter the **R**esults are **K**nown (Kerr, 1998)

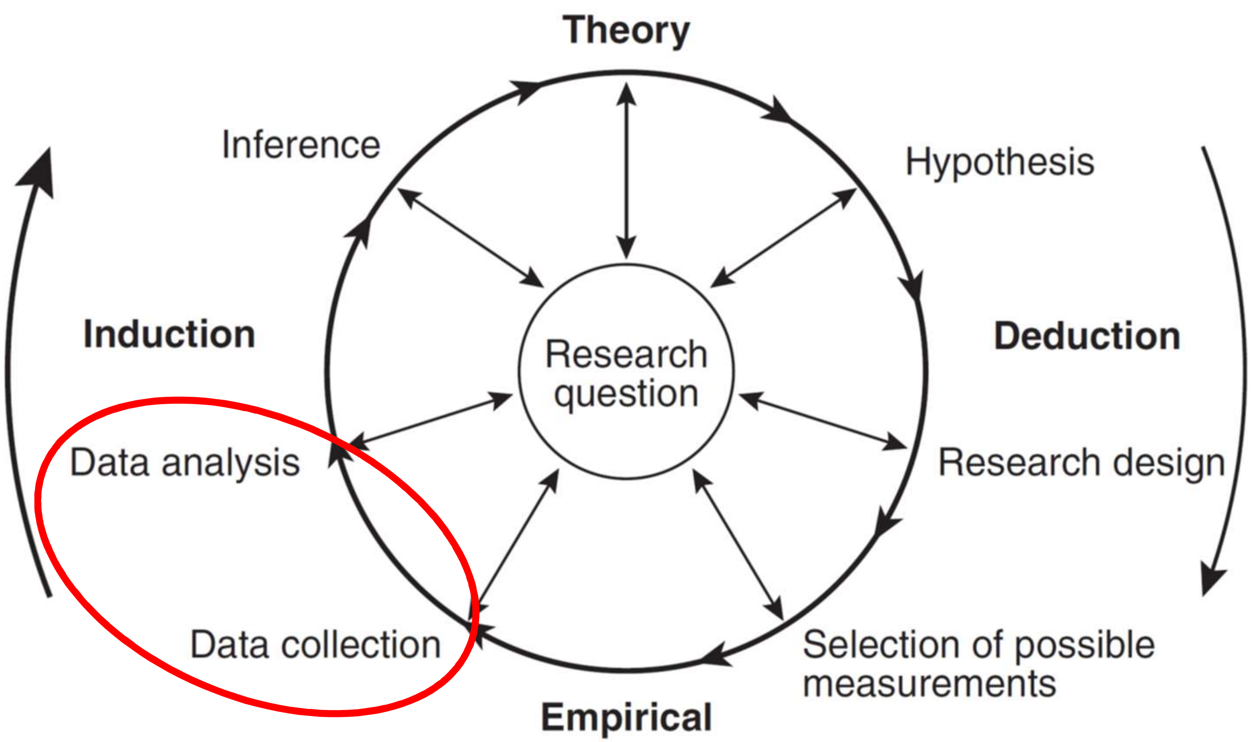
Presenting a post-hoc hypothesis that is informed by a result of the data analysis as if the hypothesis was, in fact, developed prior to data analysis.

Example: Performing unplanned subgroup analyses, finding an effect in one subgroup and writing the introduction with a "hypothesis" that matches these results.



Hypothetico-deductive model

"The scientific method"



Considerable degrees of freedom

Degrees of freedom during data collection and data analysis

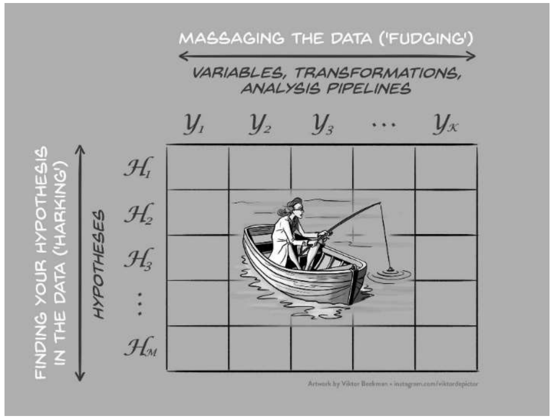
Decisions that have to be made

- When to stop recruiting sampling participants?
- How to define outliers in the data (that are then excluded)?
- Which covariates or moderators should be used?
- On which measures (operationalizations) are the key conclusions based? Which measures are reported?
- (How) Are data transformed (e.g., log-transformation)?
- Which statistical test(s) to run (e.g., regression vs. ANOVA; Pearson vs. Spearman correlation)?
- …

p-hacking

Making relevant decisions contingent on the outcome of the data analysis (i.e., whether it yields a significant result) rather than making them beforehand.

Example: Performing multiple types of analyses and reporting only those that are significant (i.e., $p < 0.05$), selectively removing data until $p < 0.05$ or selecting variables for use in analyses based on whether they yield significant results.

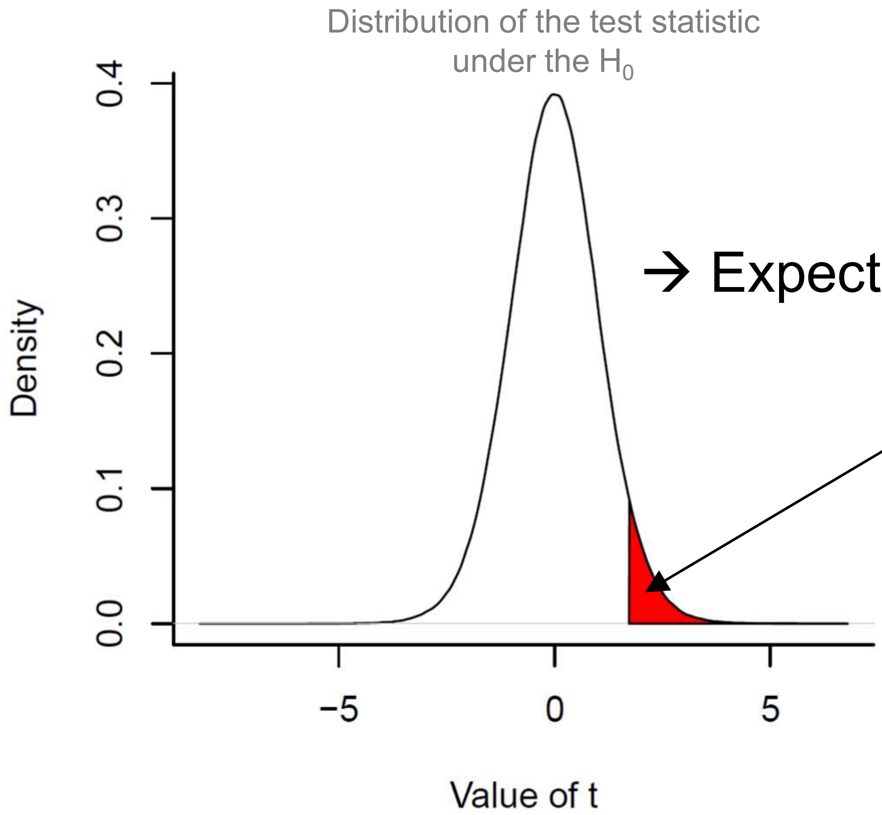


Questionable research practices

- HARKing: Reporting an unexpected finding as having been predicted from the start
- p-hacking
  - Selective reporting of (dependent) variables, experimental conditions, and statistical tests
  - Deciding whether to collect more data after looking to see whether the results are significant
  - Reporting selectively studies that worked
  - Rounding off a p-value just above .05 (e.g., .054) and claim that the results are significant

Why are questionable research practice problematic and can lead to low replicability?

Expected false-positivity rate in standard null hypothesis statistical testing



$\alpha = 5\%$

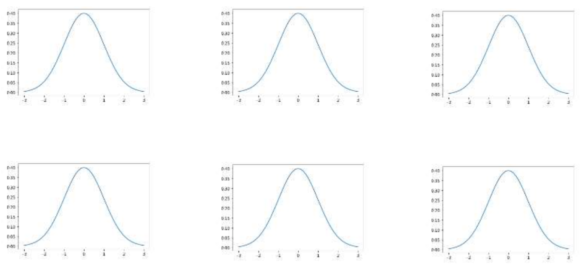
→ Expected false positive rate is 5%

Result-contingent decisions can inflate the false-positive rate

Condition 1	Condition 2	Condition 3
N=20	*N*=20	*N*=20

DV1

DV2

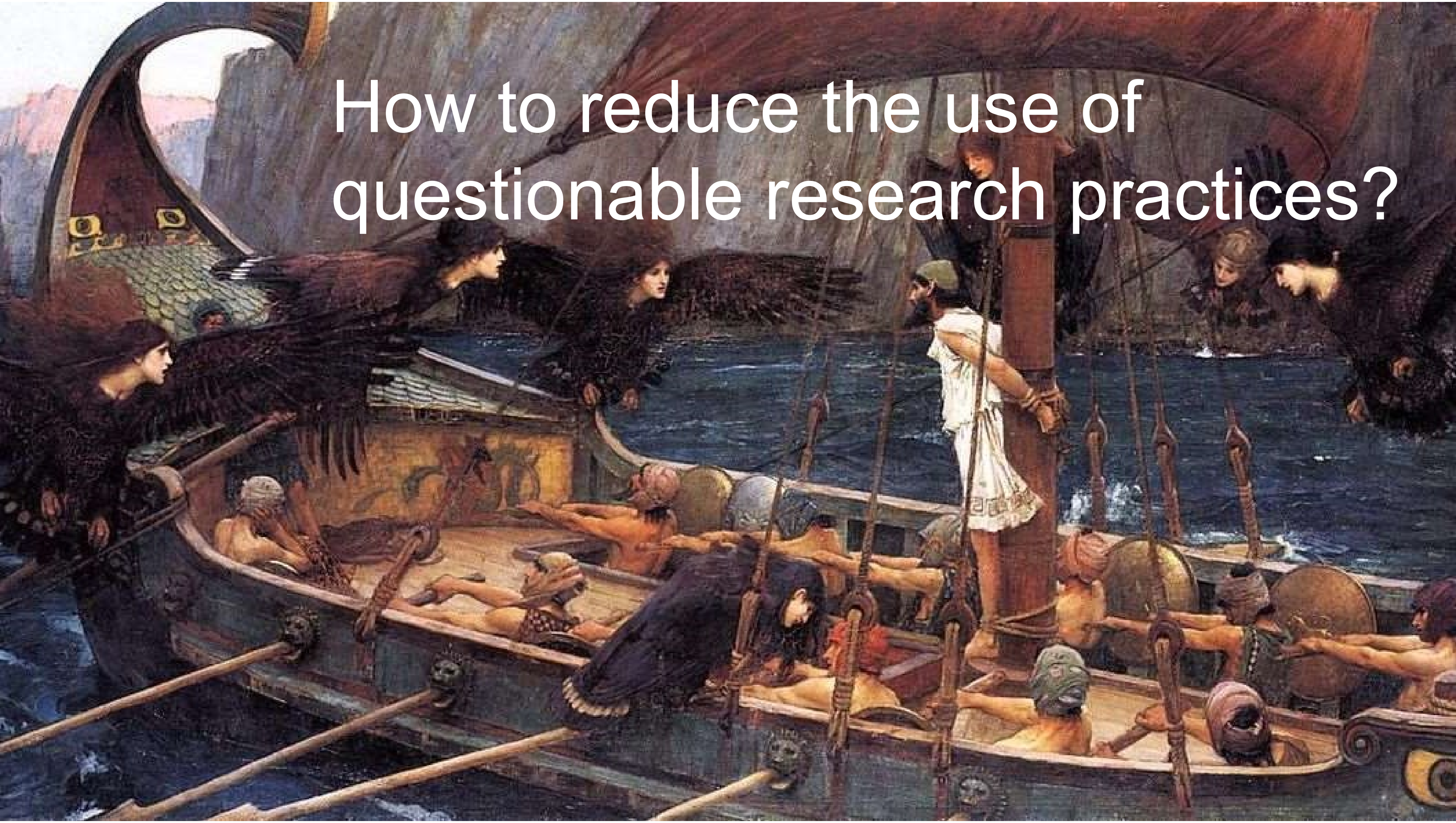


Probability of obtaining a false-positive result (p < .05)

Researcher degree of freedom	
Situation A: Having two dependent variables	9.5%
Situation B: Adding 10 more observations per condition (if with original sample size difference is non-significant)	7.7%
Situation C: Controlling for a third (binary) variable (e.g., gender)	11.7%
Situation D: Having an additional condition and dropping one if it yields nonsignificant results	12.6%
Combine A and B	14.4%
Combine A, B, and C	30.9%
Combine A, B, C, and D	60.7%

Simmons, Nelson, & Simonsohn (2011)

How to reduce the use of questionable research practices?



Preregistration

Specification and public documentation of key methodological decisions prior to data collection

- Research question(s)
- Hypotheses
- Variables (dependent, independent) and how they are connected to the research question(s) or hypotheses
- Study design
- Data collection plan (how participants are recruitment)
- Sample size (e.g., based on a power analysis)
- Statistical models for addressing research question(s)/hypotheses (incl. data transformations)
- Exclusion and inclusion criteria

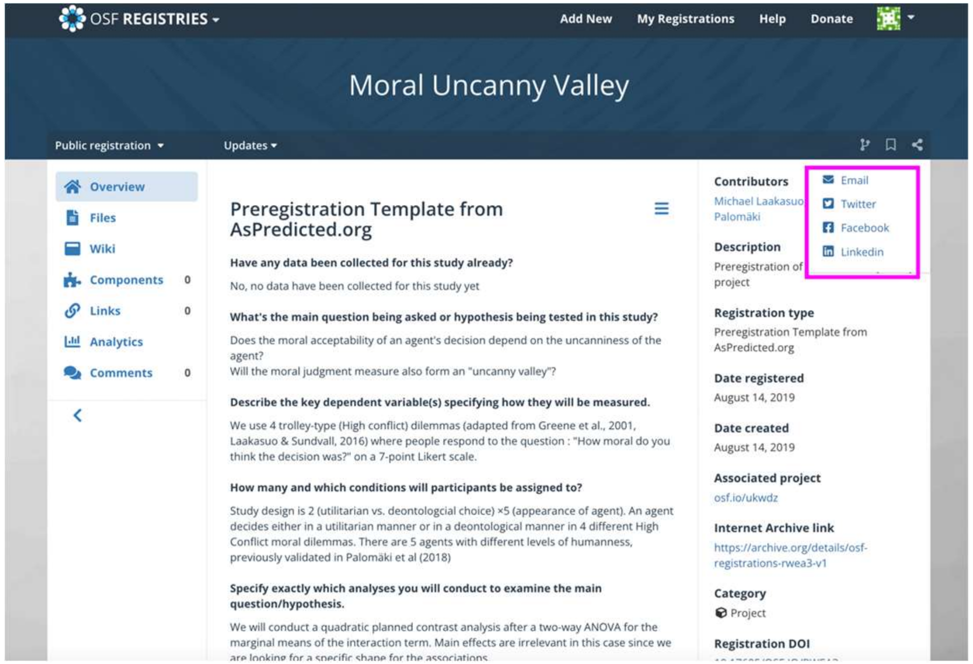
→ Once submitted, the research plan is time-stamped and can no longer be modified

Preregistration

Repositories for submitting a preregistration

ASPREDICTED

OSF template



Reporting a preregistered study

- Report the results of all preregistered analyses, regardless of the outcome
- Deviations from the preregistration are possible
  - Running different analyses
    → Report the change transparently and provide a justification
  - Running additional (i.e., unpreregistered) analyses, conducting unplanned data transformation (if data turn out to show a skewed distribution)
    → Transparently label them as “unregistered” or “exploratory”

Homework for Exercise this week

Watch this brief tutorial (< 9 min) on preparing a preregistration on ASPREDICTED

https://www.youtube.com/watch?v=7ic_BgpmakI

Open data

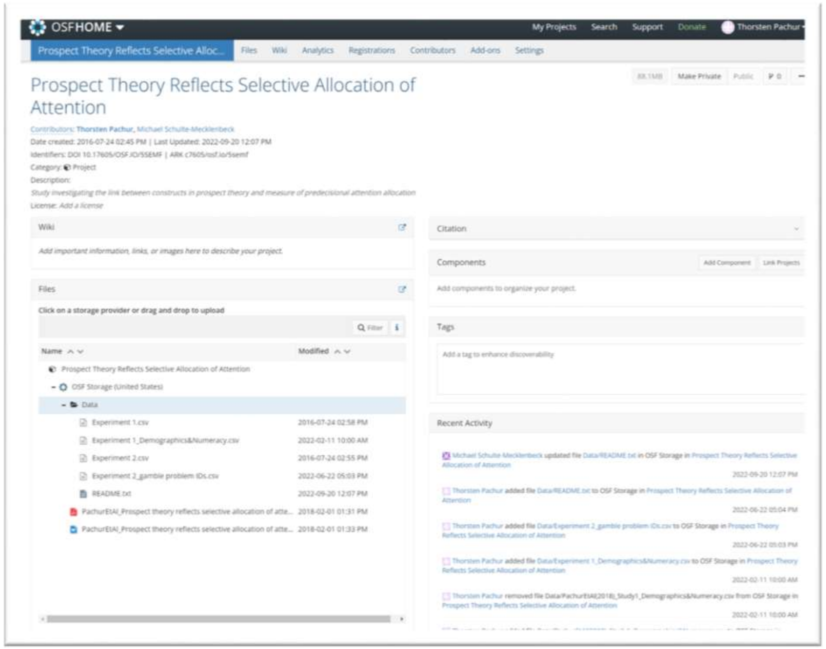
Open Science Framework (OSF)

https://osf.io/

→ Center for Open Science

CENTER FOR OPEN SCIENCE

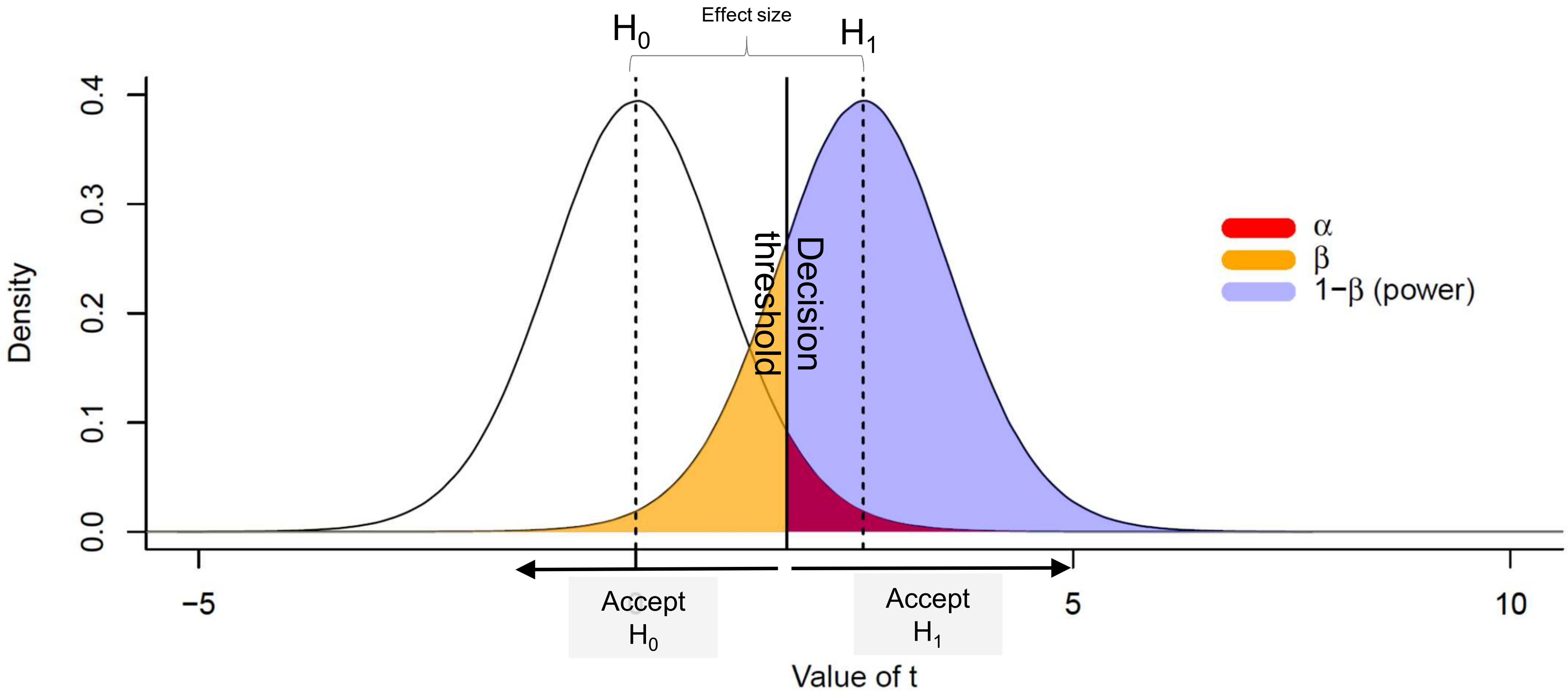
- Storage of
  - Materials
  - Preregistration file
  - Data, analysis code



Brian Nosek

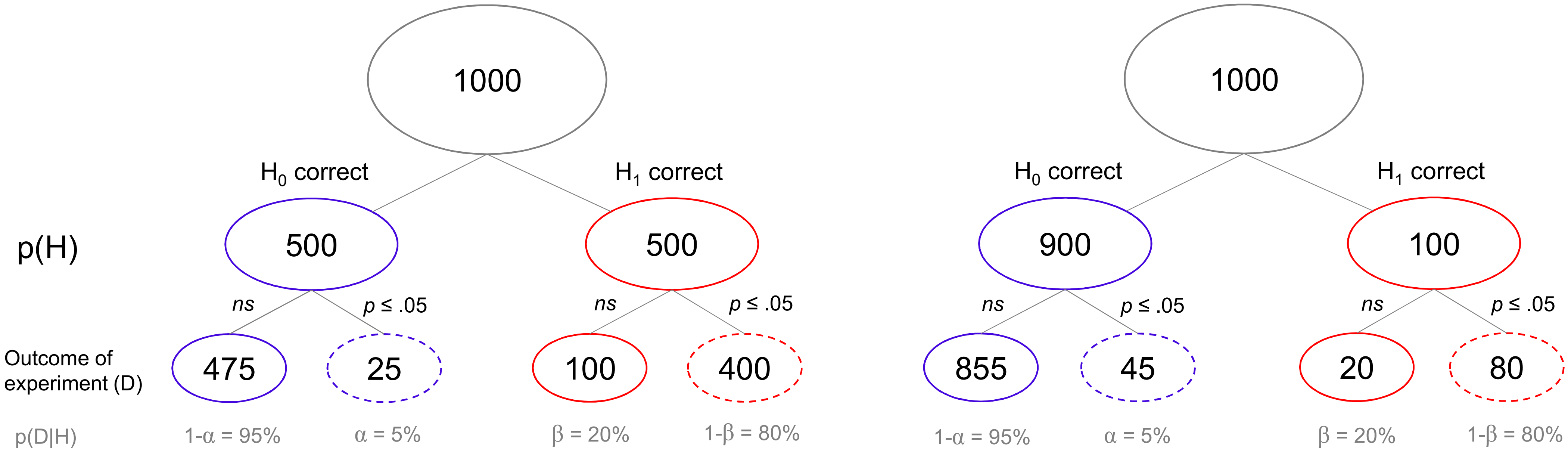
Toward better data analysis

Statistical inference



H_0 and H_1 are ***equally likely*** a priori

H_0 is ***less likely*** than H_1 a priori



How often ist H_1 correct when $p \leq .05$?
→ $p(H_1|D)$

$$\frac{400}{25 + 400} = .94$$

$$\frac{80}{45 + 80} = .64$$

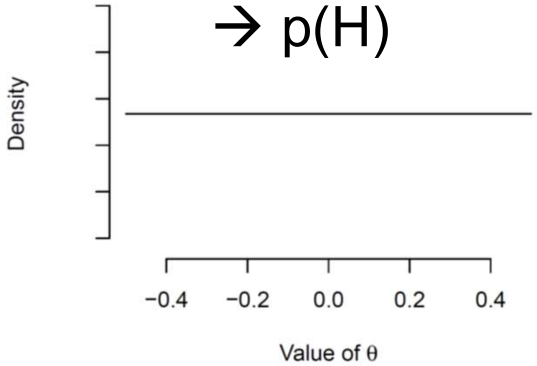
→ How strongly we can trust our results depends on the priors of the hypotheses!

Bayesian data analysis

→ How probable is a given **hypothesis**?

Prior distribution

→ p(H)



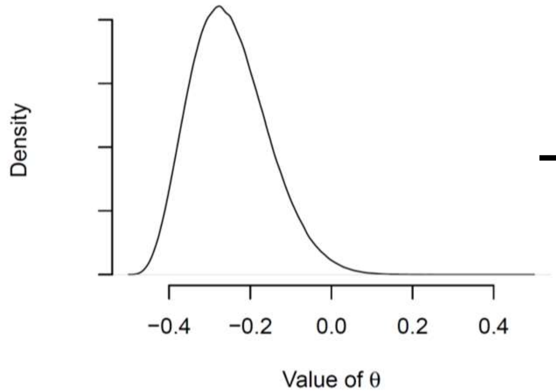
updating

Data

$$p(\theta|D) = \frac{p(D|\theta) \times p(\theta)}{p(D)}$$

Bayes' rule

Posterior distribution



→ p(H|D)

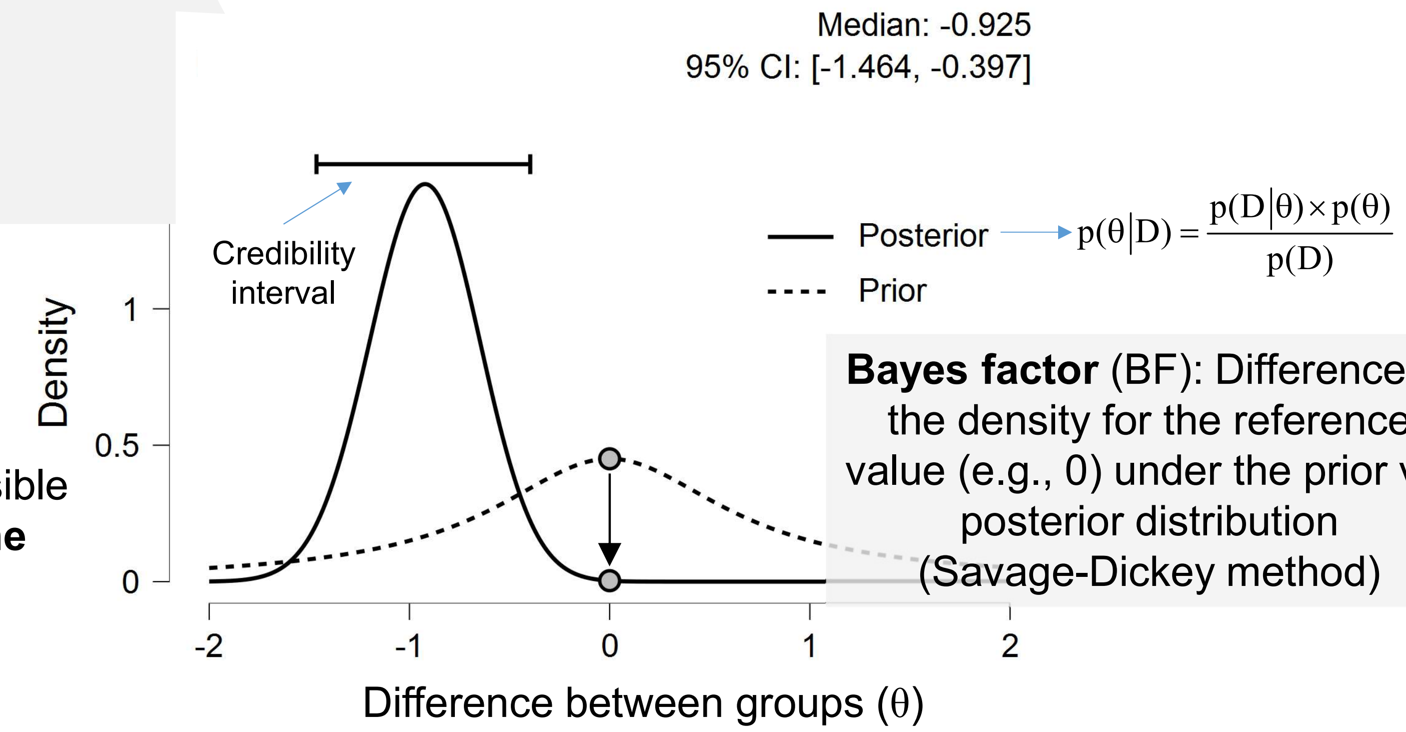
Hypothesis = value of θ

Comparing two means: Bayesian t-test

BF_{10}: Evidence for H_1 relative to evidence for H_0
BF_{01}: Evidence for H_0 relative to evidence for H_1

$$BF_{01} = \frac{1}{BF_{10}}$$

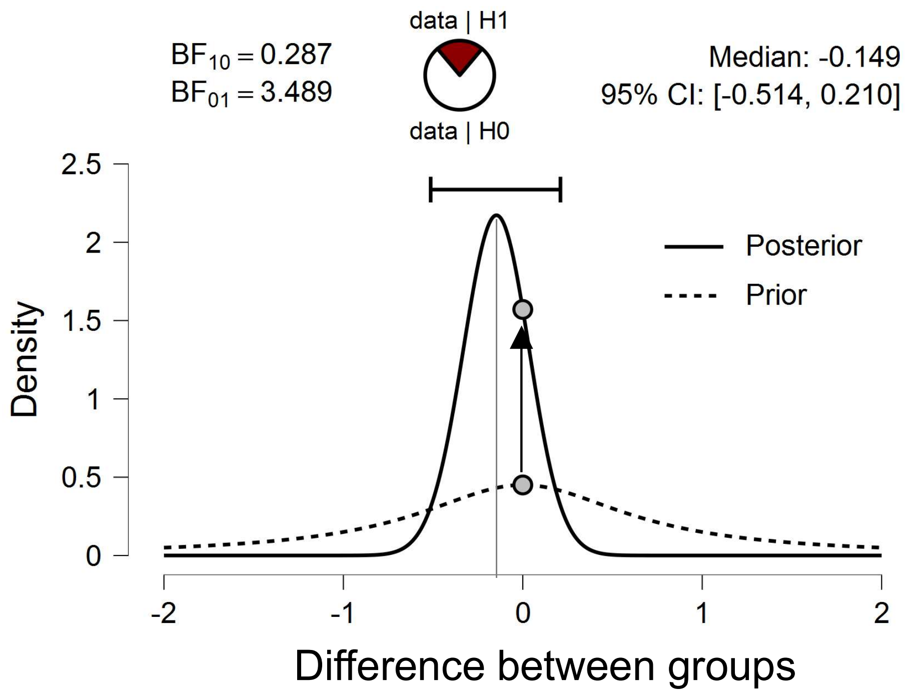
$$\frac{p(H_1|D)}{p(H_0|D)} = \underbrace{\frac{p(D|H_1)}{p(D|H_0)}}_{BF_{10}} \times \frac{p(H_1)}{p(H_0)}$$



Bayes factor (BF): Difference of the density for the reference value (e.g., 0) under the prior vs. posterior distribution (Savage-Dickey method)

With the Bayes factor it is possible to quantify the **evidence for the null hypothesis**!

Comparing two means: Bayesian t-test



How to interpret a Bayes factor?

Bayes factor (BF_{10})	Interpretation
>100	Decisive evidence for H_1
30–100	Very strong evidence for H_1
10–30	Strong evidence for H_1
3–10	Substantial evidence for H_1
1–3	Anecdotal evidence for H_1
1	No evidence
1/3–1	Anecdotal evidence for H_0
1/10–1/3	Substantial evidence for H_0
1/30–1/10	Strong evidence for H_0
1/100–1/30	Very strong evidence for H_0
<1/100	Decisive evidence for H_0

Data in favor of alternative hypothesis

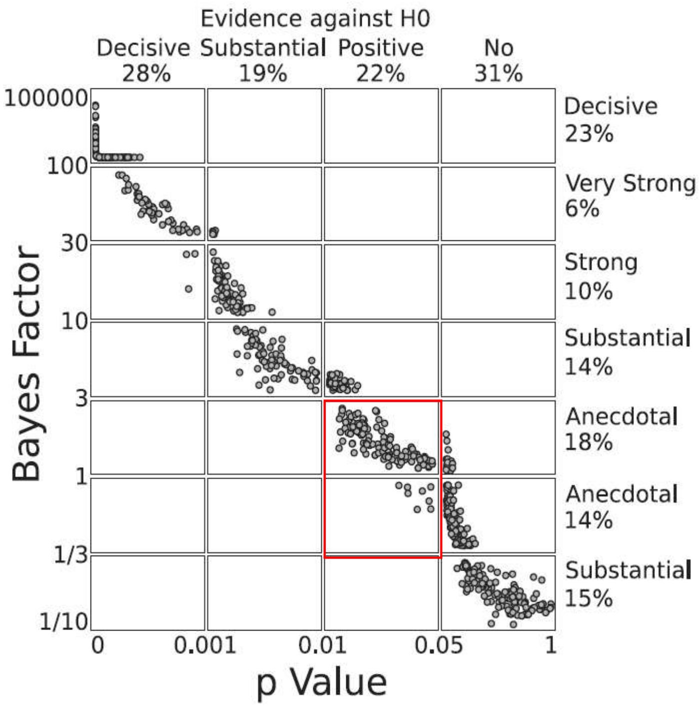
No inference on either hypothesis possible (→ collect more data!)

Data in favor of null hypothesis

Jeffreys (1961)

Do not trust p-values

Example: 855 *t* tests in experimental psychology



70% chance of only anecdotal evidence

Wetzels et al. (2011)

Self-quiz questions

- What is meant by the replication crisis?
- What is meant by HARKing—and why is it problematic?
- Describe research practices that represent p-hacking
- Why might p-hacking have contributed to the replication crisis?
- Which aspects of a research project are specified in a preregistration?
- What is the logic of Bayesian data analysis?
- What does a Bayes factor represent? Give an advantage of Bayes factors over p-values in statistical inference.

If you wanto to learn more about the topics…

Coming up in SS 2027

- Module "*Open Science: Best Practices in Empirical Research*" (Thorsten Pachur)
- Module "*Introduction to Bayesian Data Analysis*" (Linus Hof)