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Open Science – Introduction

Open Science Workshop

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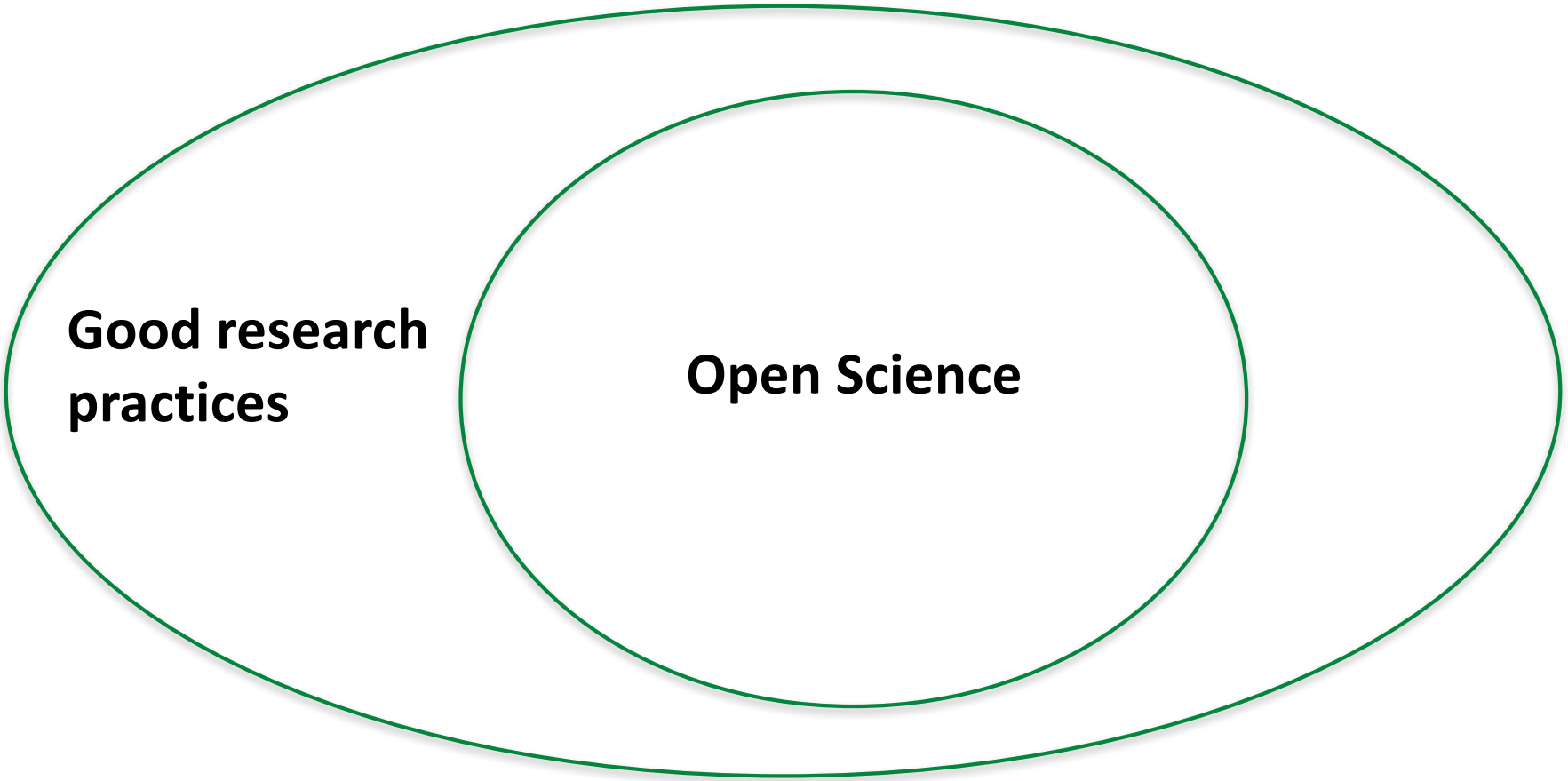
Open Science ∈ Good Science



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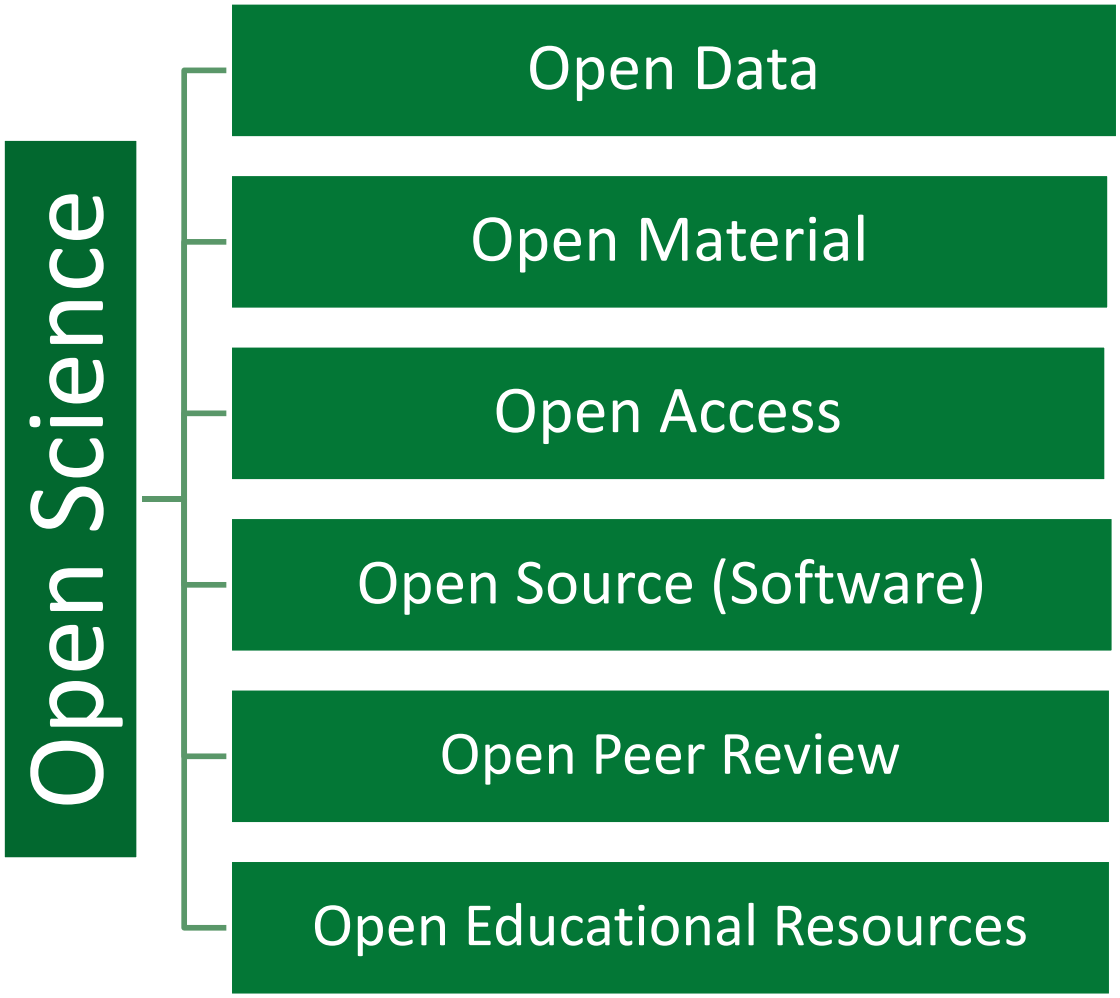
Pillars of Open Science



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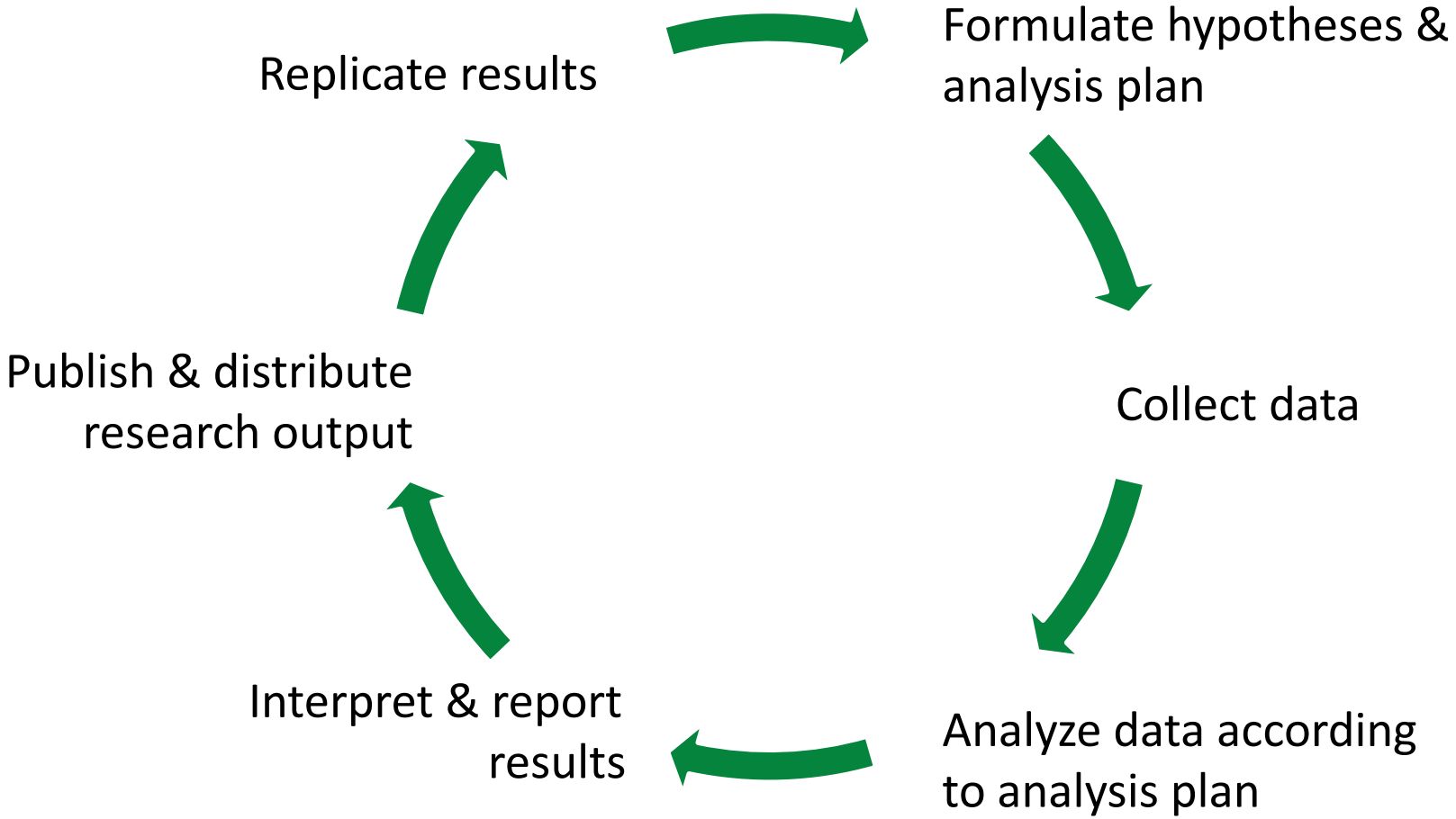
Why transparency?

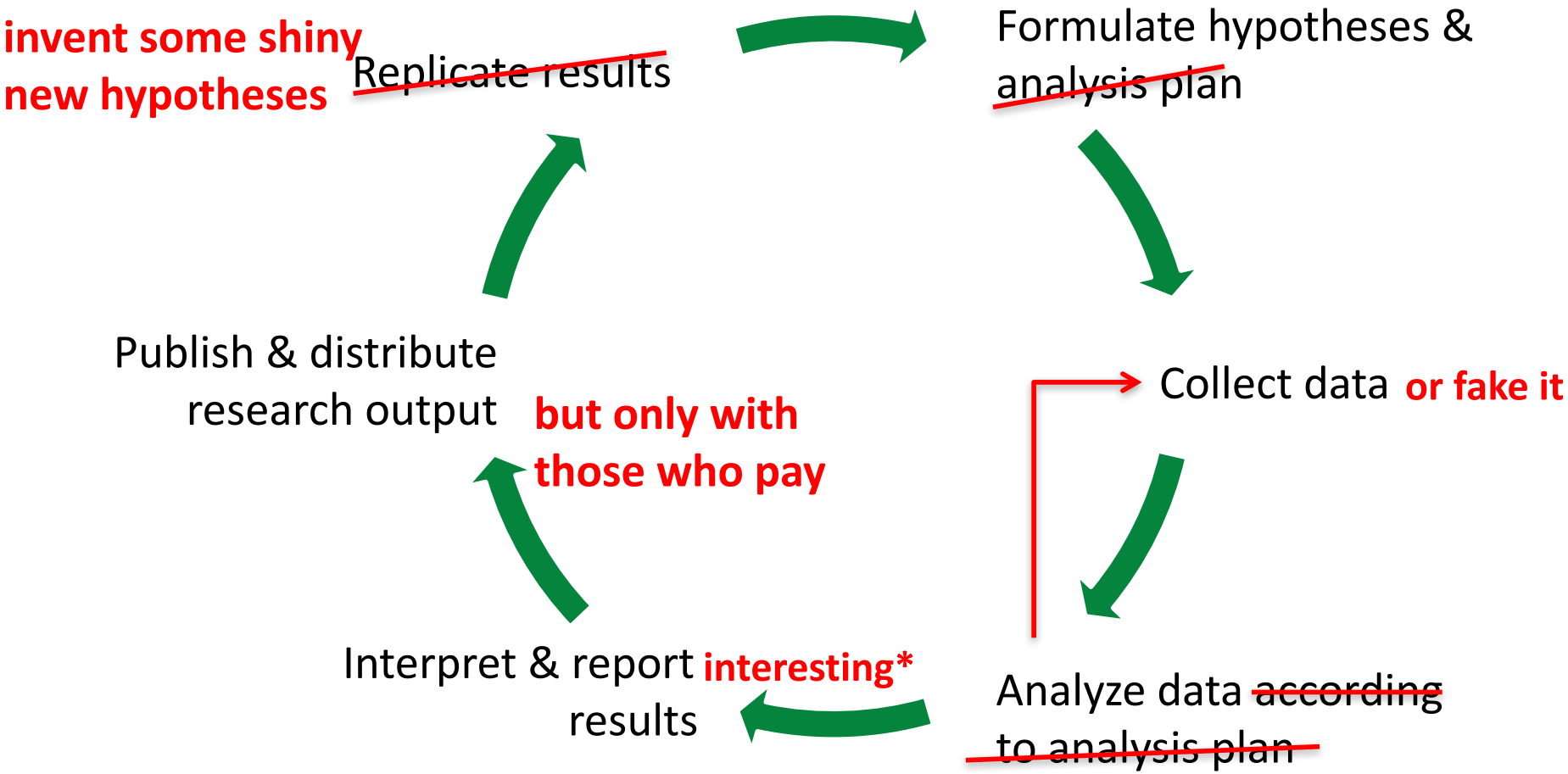
The Confirmatory Research Process



Wagenmakers et al. (2012)

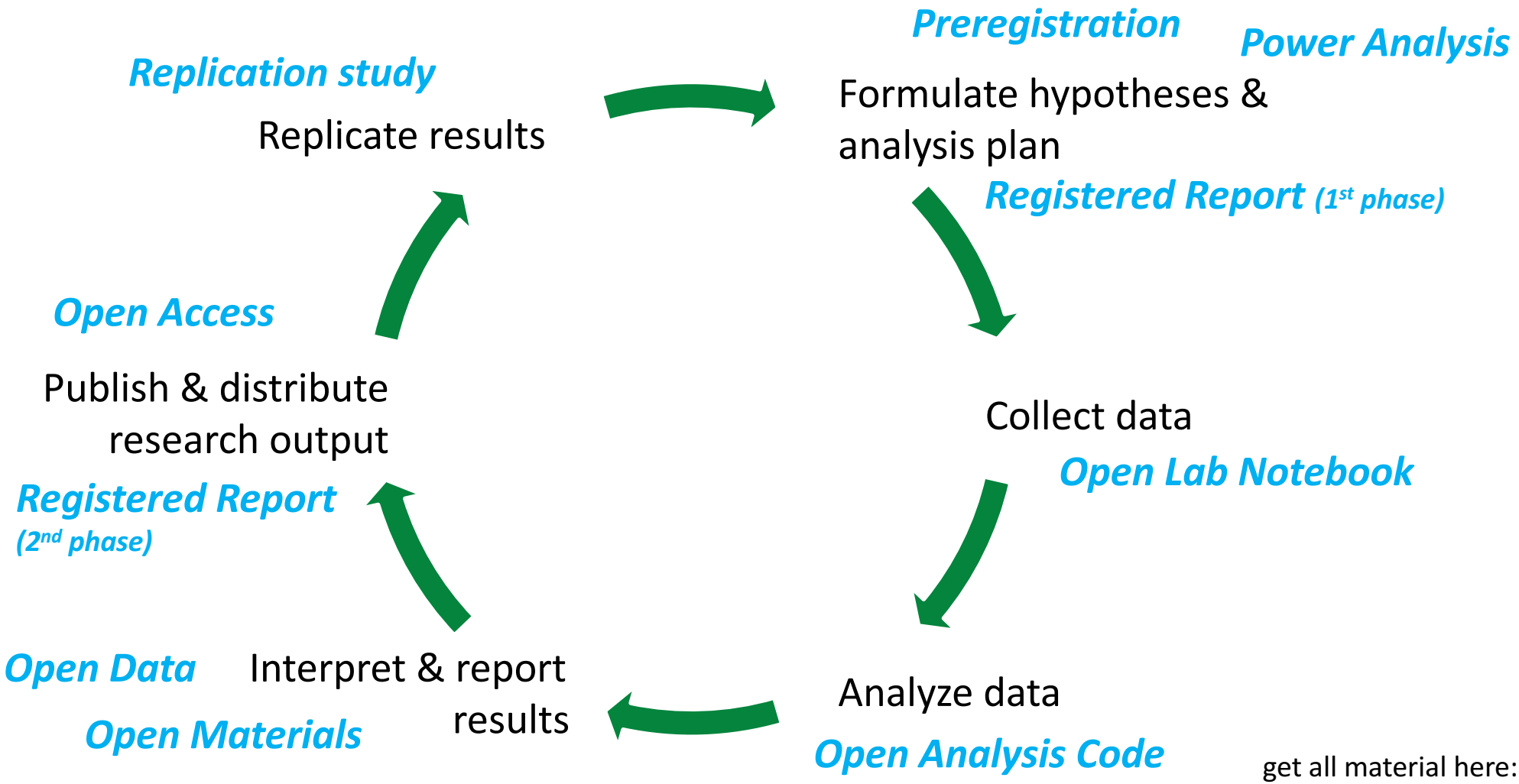
Why transparency?

How can you know that it does not look like this?



*** p < .05; that fit a theory; that are surprising / publishable…**

Open Science in the research process



get all material here:
https://osf.io/zjrhu/

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Why transparency?

Increase trust in science, don't waste public resources

Get constructive feedback

Be international and inclusive

Increase the speed of discovery

Pictures from freepik.com by @brgfx, @makyzz; flaticon.com by Icon Pond, Dimitry Miroliubov

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However…

The present situation is not so bright…

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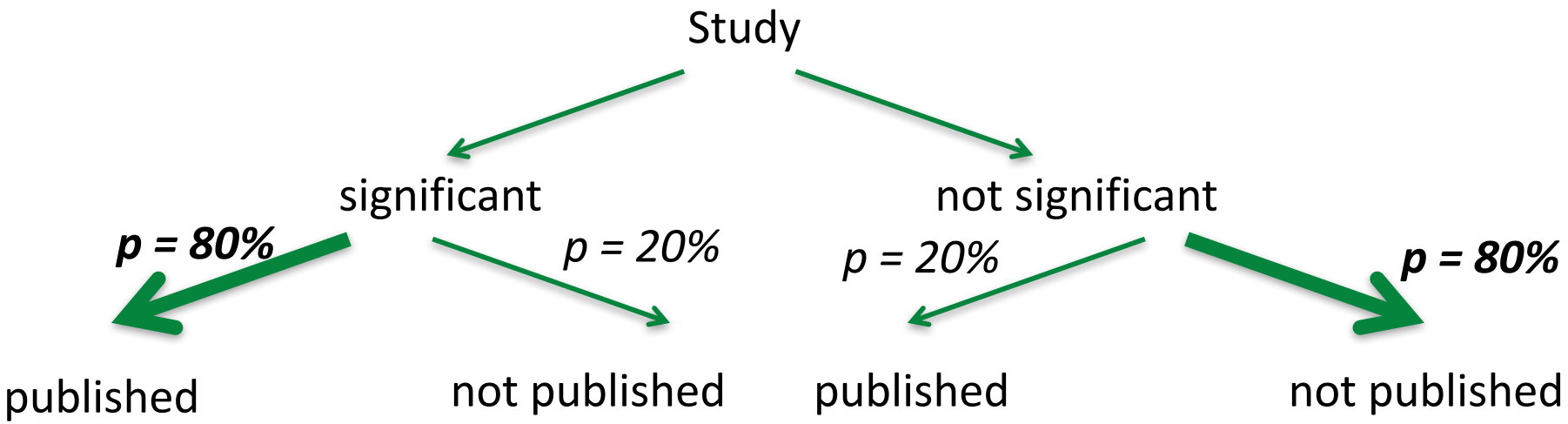
Publication Bias

Definition:

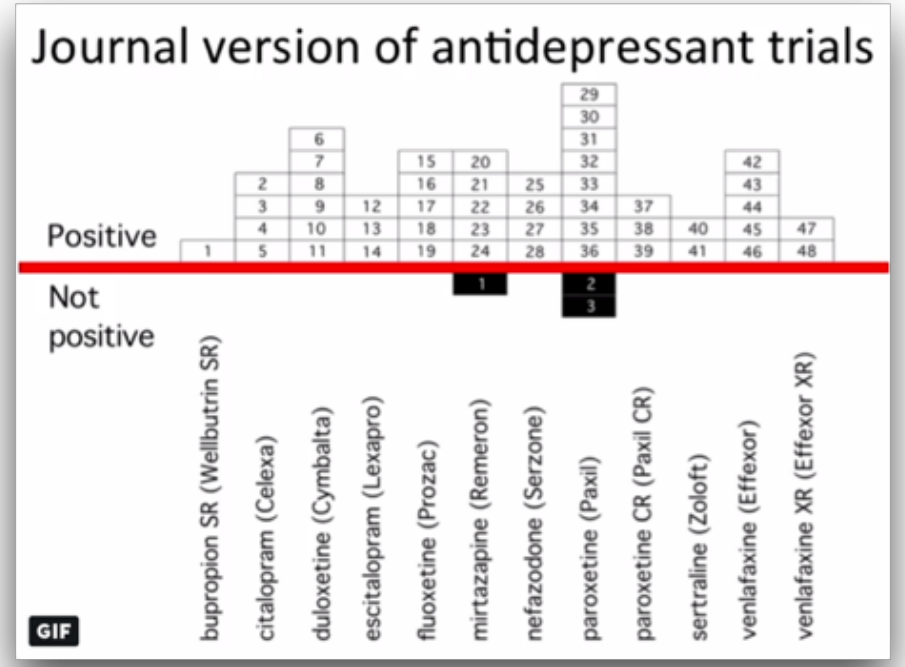
"The phenomenon in which studies with positive results are more likely to be published than studies with negative results."



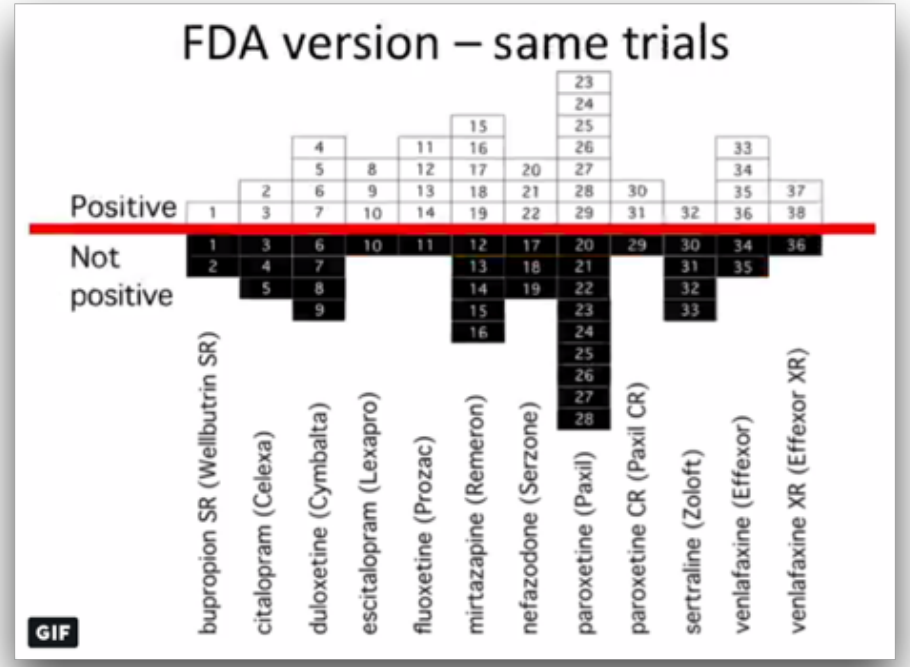
Begg & Berlin (1988)

Publication Bias: Efficacy of anti-depressants (Turner et al. 2008; Meta-Analysis with *k* = 74)

Trials published in journals:
48 positive, 3 negative



Trials registered at FDA:
38 positive, 36 negative



https://twitter.com/eturnermd1/status/737436322344927232 Turner, E. H., Matthews, A. M., Linardatos, E., Tell, R. A., & Rosenthal, R. (2008). Selective Publication of Antidepressant Trials and Its Influence on Apparent Efficacy. New England Journal of Medicine, 358, 252–260. doi:10.1056/NEJMsa065779

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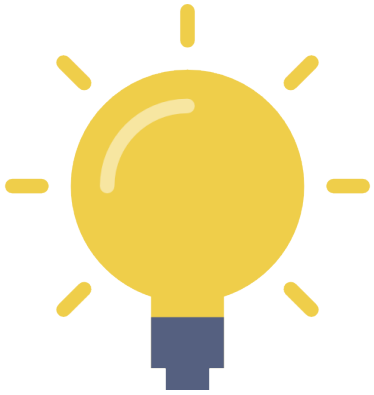
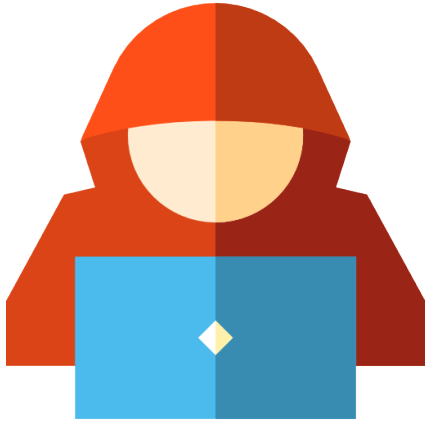
Questionable Research Practices

Scientific Misconduct



Fabrication
(Making up data)

Falsification
(Distorting data)



Questionable Research Practices
(p-hacking, HARKing, selective reporting...)

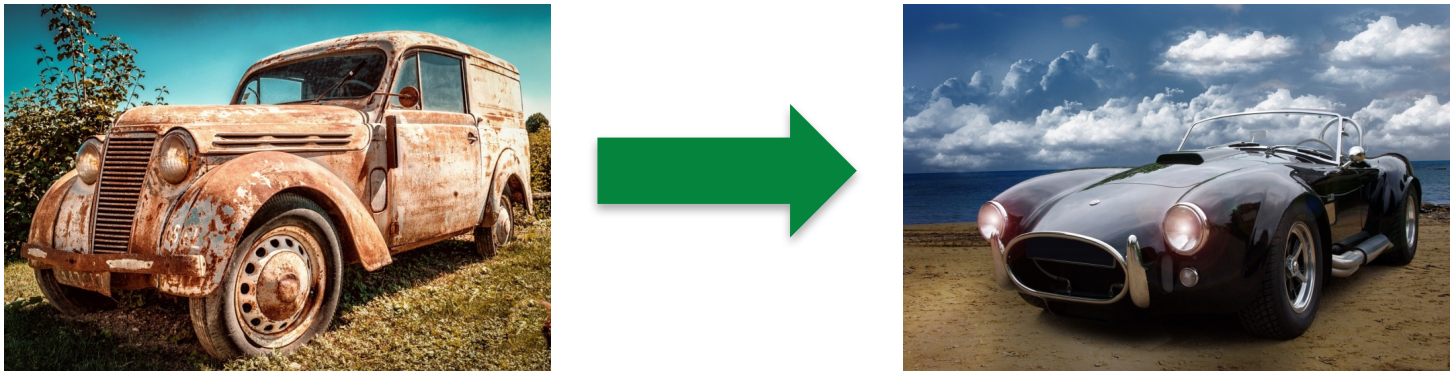
Icon from flaticon.com by Smashicons

Hunter College (2016), John et al. (2012)

Questionable Research Practices

***p*-hacking** (*n.*). Tune your data analysis in a way that you achieve a significant *p*-value in situations where it would have been non-significant.

Questionable research practices (QRPs) (*n.*). Practices of data collection and data analysis that are not outright fraud, but also not really kosher.



Pictures from pxhere.com/de/photo/494938, pxhere.com/de/photo/634757

Simonsohn et al., 2014; John et al. (2012)

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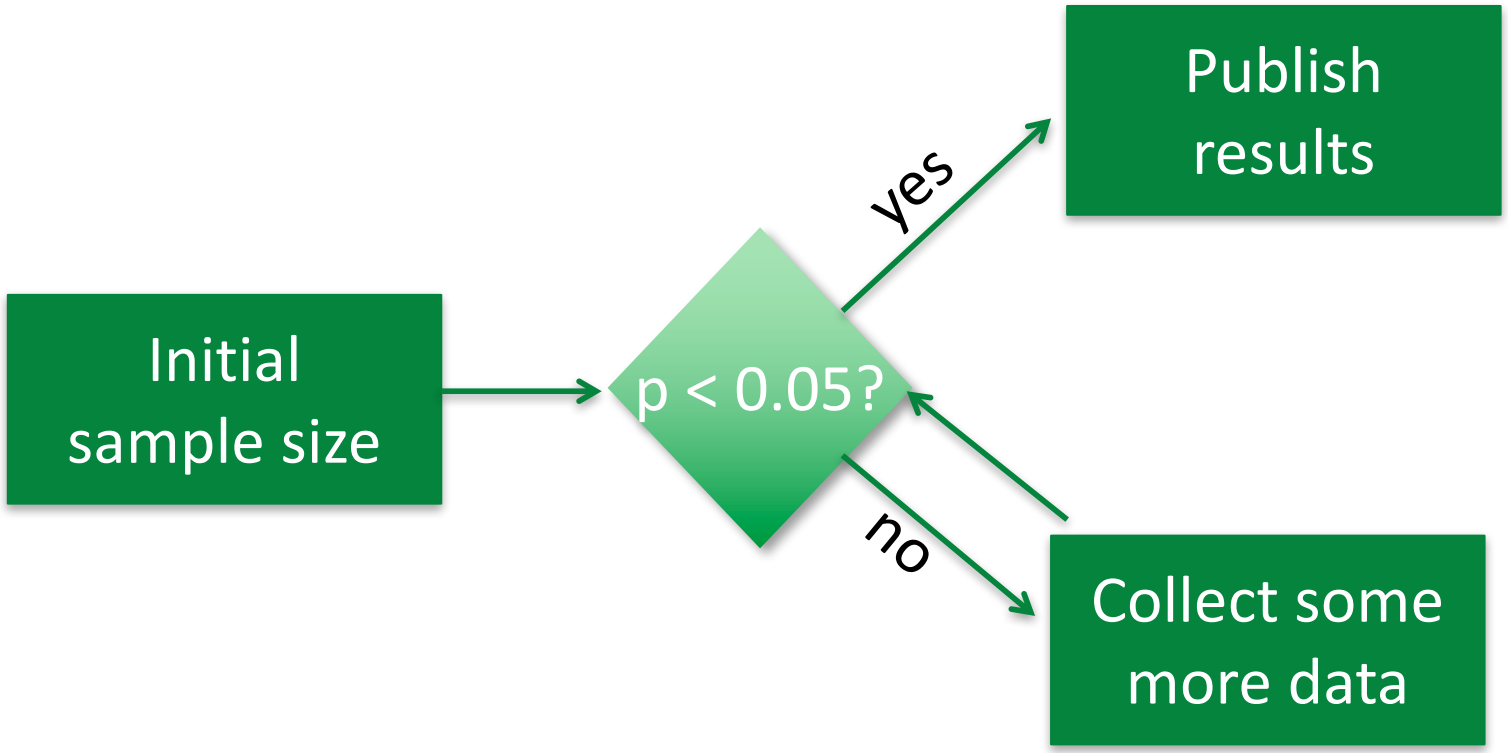
Tools for *p*-Hacking

Optional Stopping



John, Loewenstein, & Prelec (2012)

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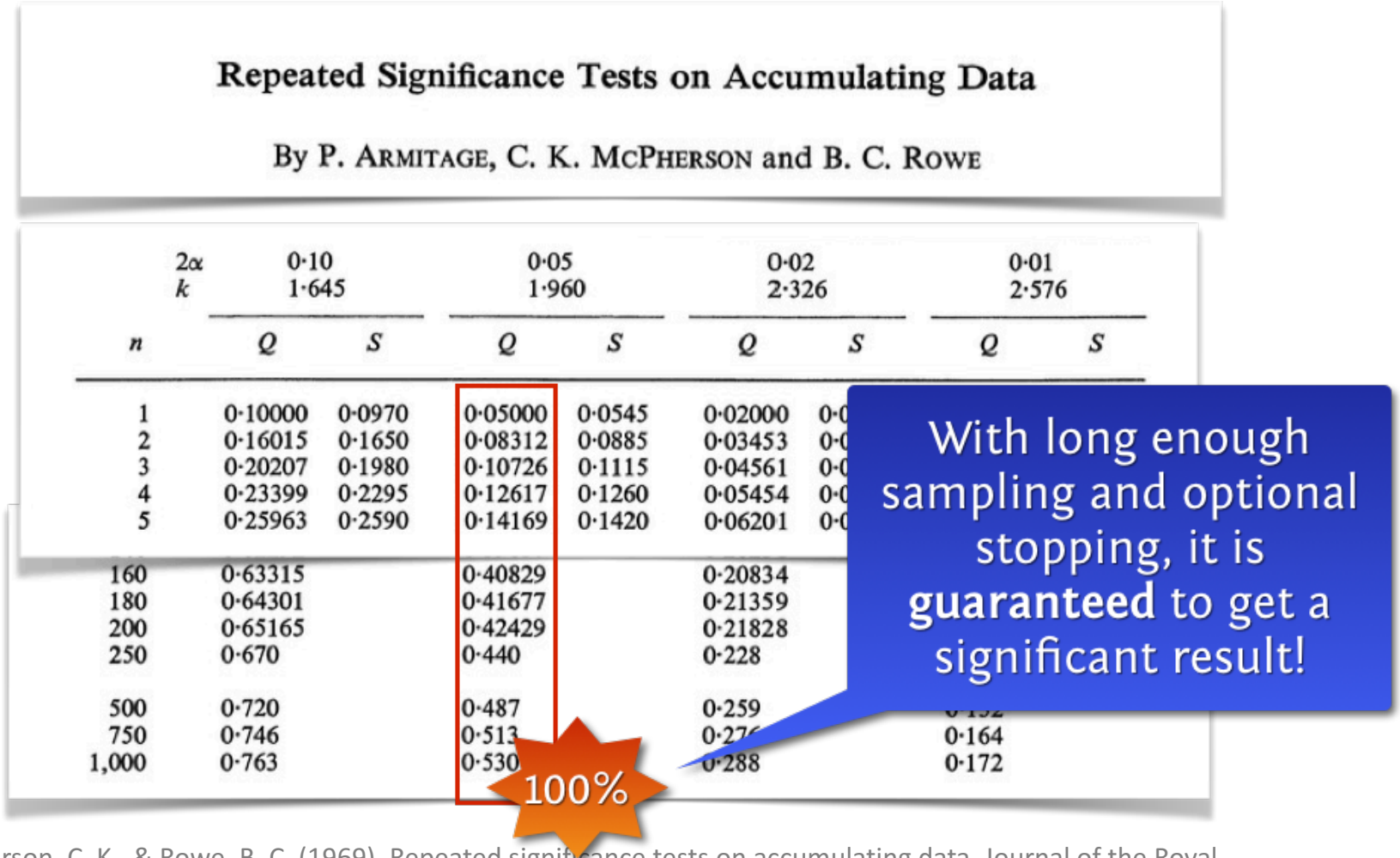
Tools for *p*-Hacking

Optional Stopping



Repeated Significance Tests on Accumulating Data

By P. ARMITAGE, C. K. MCPHERSON and B. C. ROWE

	2α	0·10		0·05		0·02		0·01	
	k	1·645		1·960		2·326		2·576	
n		Q	S	Q	S	Q	S	Q	S
1		0·10000	0·0970	0·05000	0·0545	0·02000	0·		
2		0·16015	0·1650	0·08312	0·0885	0·03453	0·		
3		0·20207	0·1980	0·10726	0·1115	0·04561	0·		
4		0·23399	0·2295	0·12617	0·1260	0·05454	0·		
5		0·25963	0·2590	0·14169	0·1420	0·06201	0·		
160		0·63315		0·40829		0·20834			
180		0·64301		0·41677		0·21359			
200		0·65165		0·42429		0·21828			
250		0·670		0·440		0·228			
500		0·720		0·487		0·259			
750		0·746		0·513		0·27		0·164	
1,000		0·763		0·530		0·288		0·172	

With long enough sampling and optional stopping, it is **guaranteed** to get a significant result!

100%

Armitage, P., McPherson, C. K., & Rowe, B. C. (1969). Repeated significance tests on accumulating data. Journal of the Royal Statistical Society. Series A (General), 132, 235–244.

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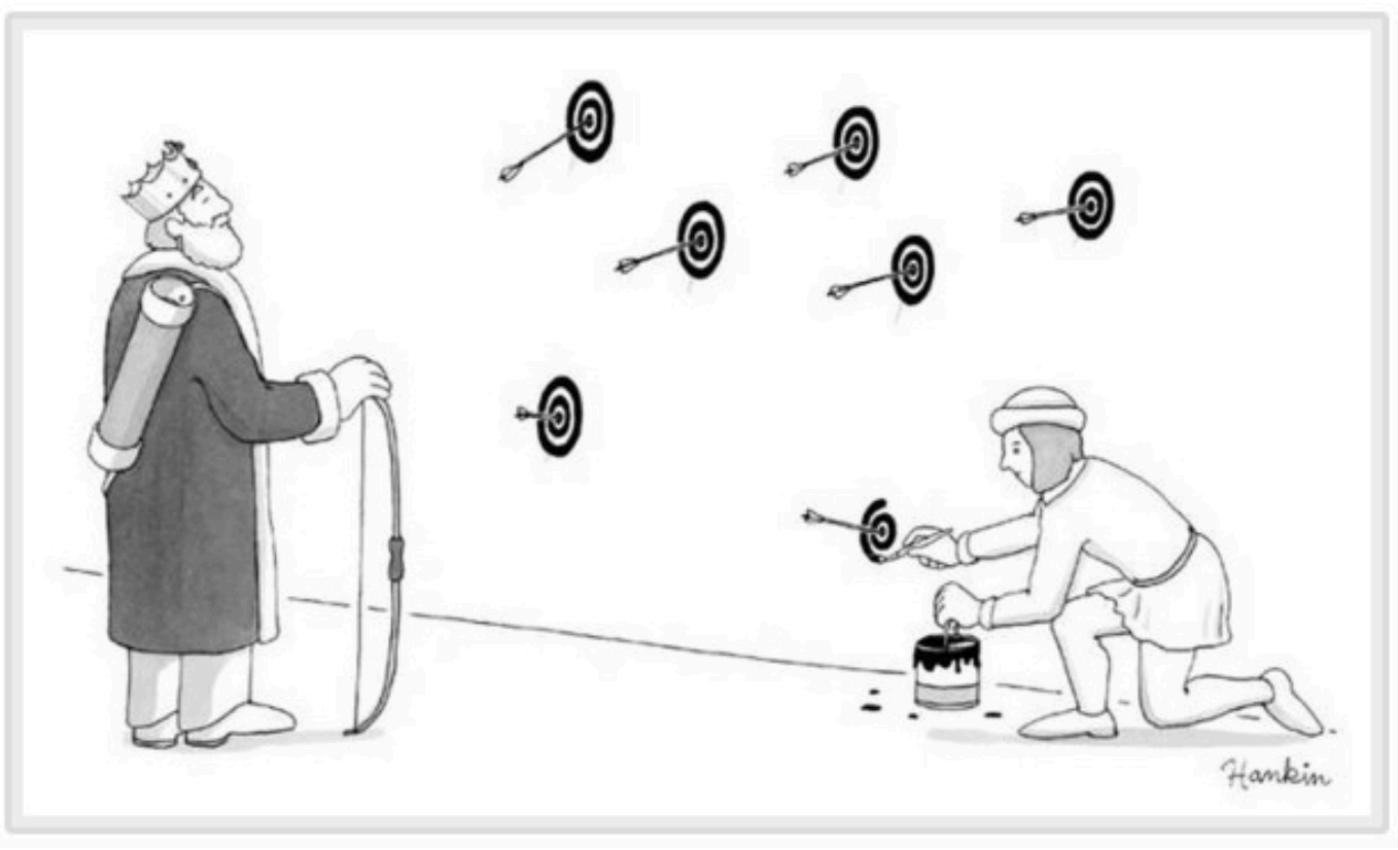
Tools for *p*-Hacking

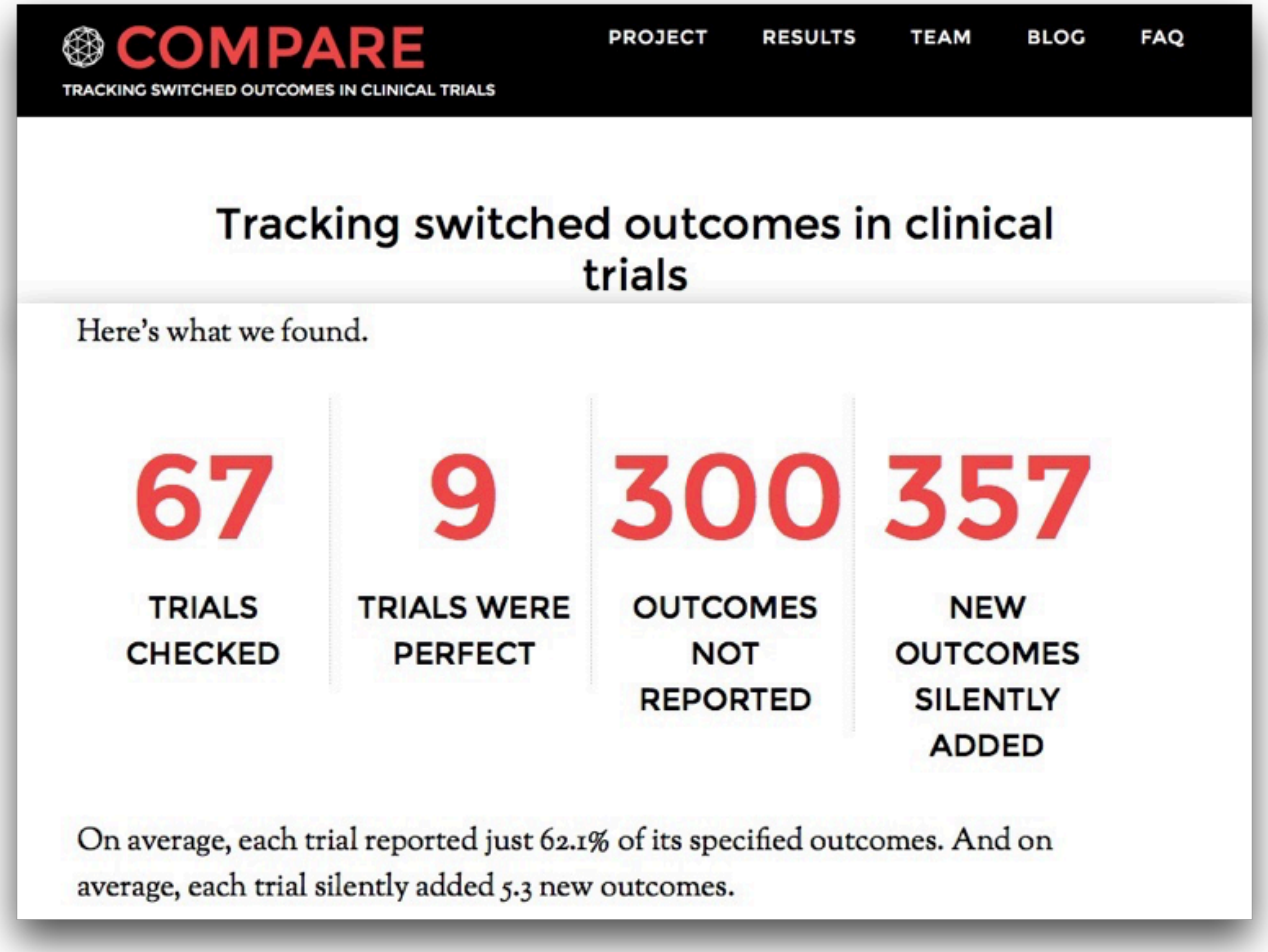
HARKing: Hypothesizing after the results are known



Wagenmakers (2018); Kerr (1998)

Tools for *p*-Hacking

Outcome switching



- 2 outcome variables:
  false positive rate
  5% → 9.5%
- 5 outcome variables with one-sided testing:
  false positive rate
  5% → 41%

http://compare-trials.org/ http://blogs.discovermagazine.com/neuroskeptic/2015/07/23/social-priming-money-for-nothing/#.VuKRSRi5KJM

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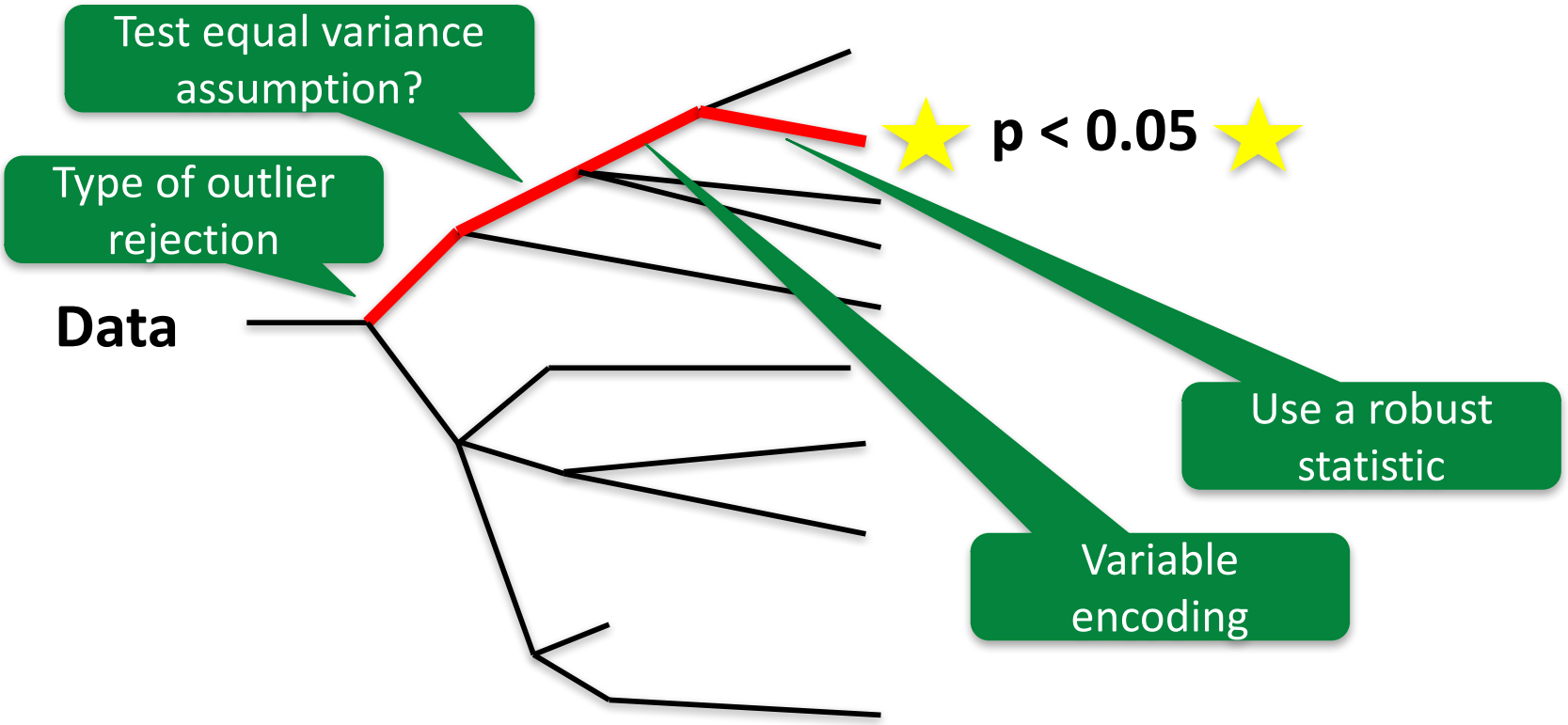
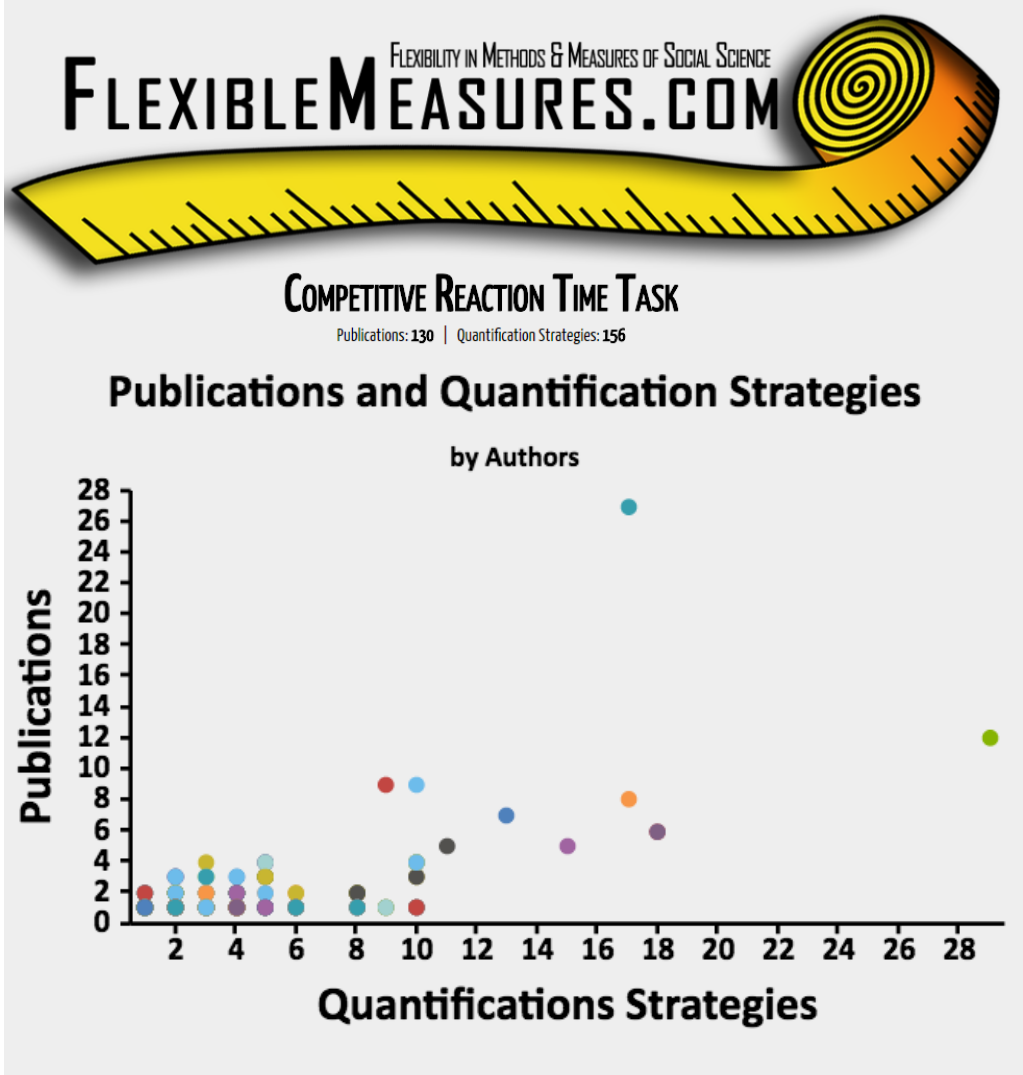
Tools for *p*-Hacking

The garden of forking paths / Analytical degrees of freedom



John, Loewenstein, & Prelec (2012), Gelman & Loken (2013)

Tools for *p*-Hacking



There are currently 130 publications in which results are based on the Competitive Reaction Time Task, and they reported 156 different quantification strategies in total!

Elson (2016): http://www.flexiblemeasures.com

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P-Hacking

Intentional?

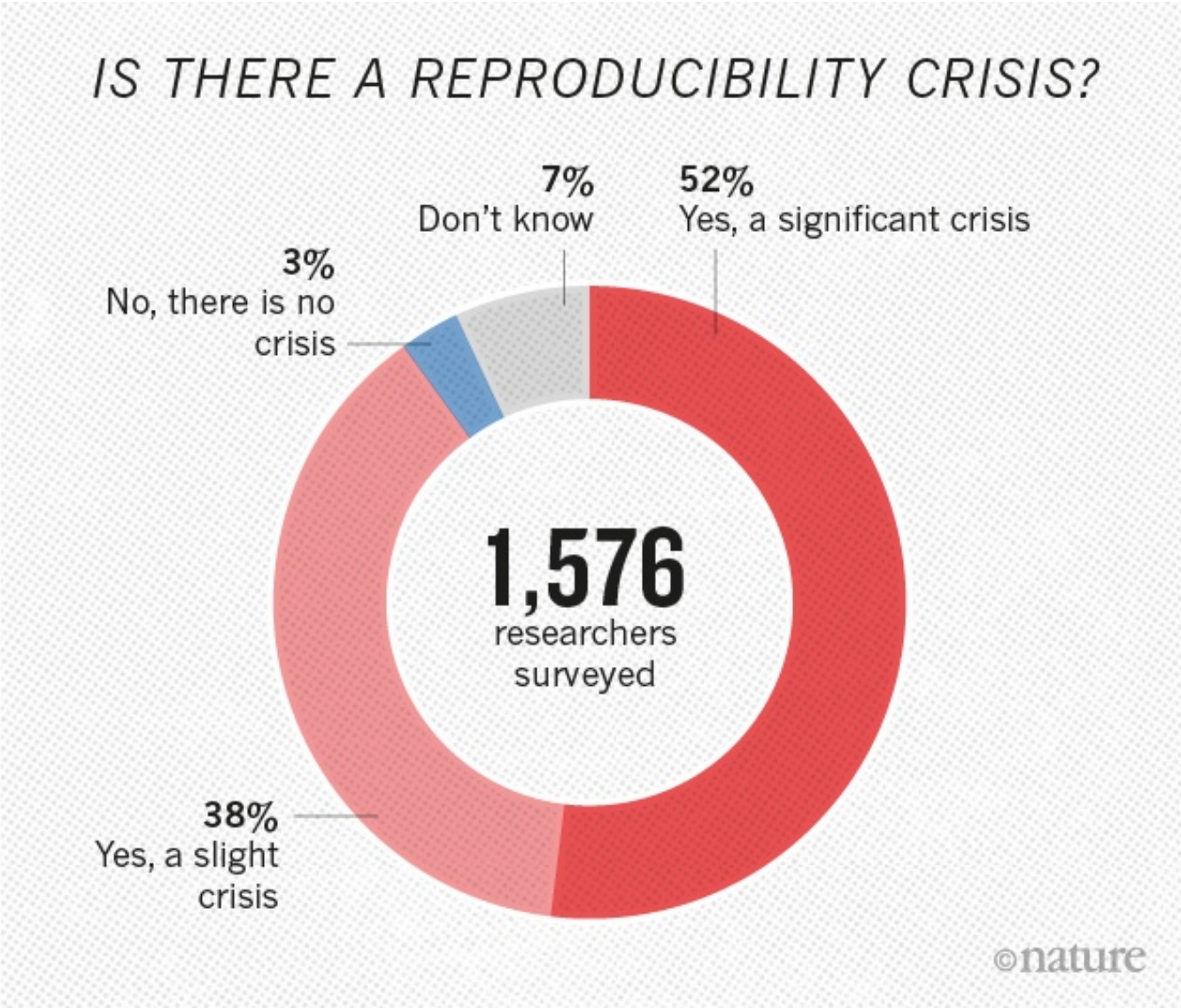
- Evil researcher who only cares about his/her career and not at all about truth-seeking?

Unintentional?

- Wrong education?
- Wrong/uncritical standards of the field?
- Pushed by supervisors, reviewers, or editors?

- → Distorting effects on the published record are probably comparable, but the ethical evaluations differs strongly.

We might have a reproducibility crisis



90% YES

(there is a crisis)

Baker (2016)

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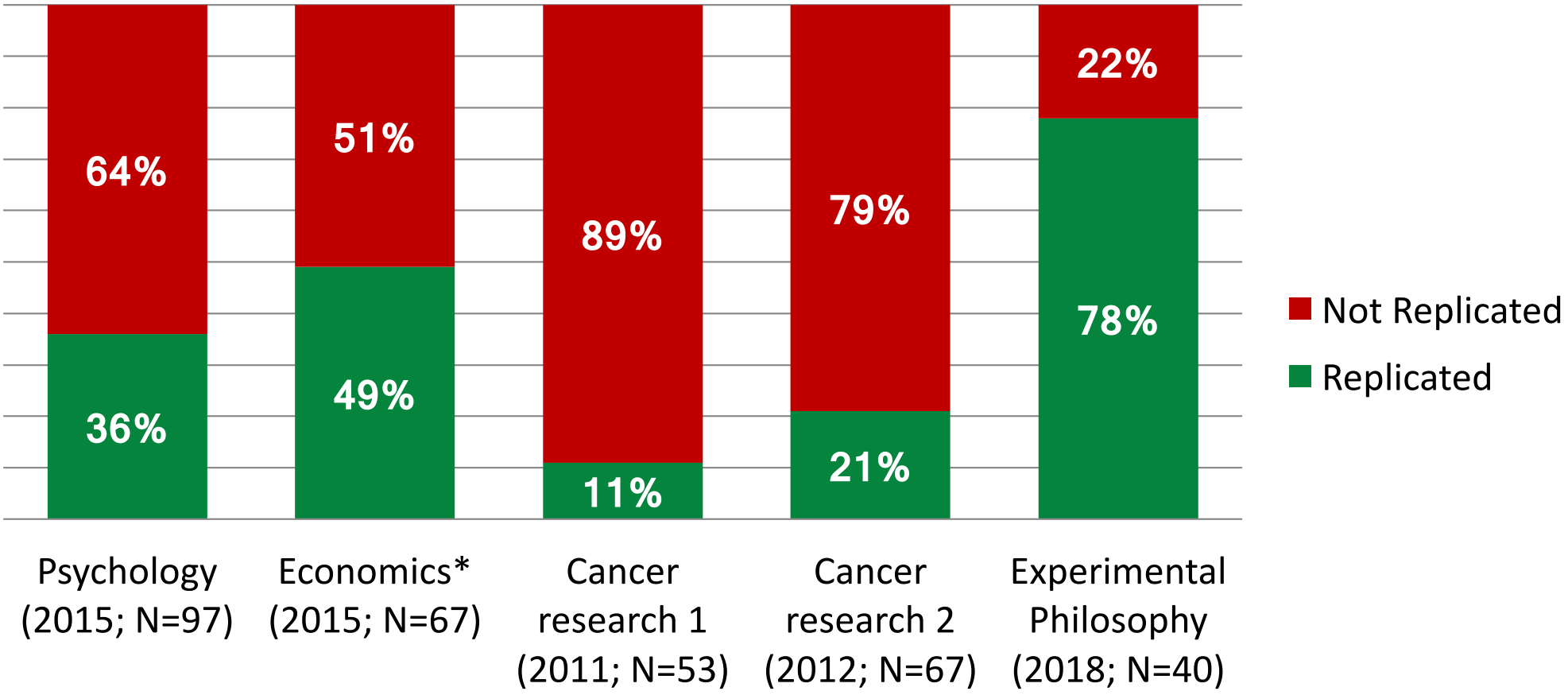
We might have a replication crisis



* The data on economics is about *reproducibility*; i.e. the attempt to get the same results if you apply the original data analysis on the original data set.

Open Science Collaboration (2015); Chang & Li (2015); Begley & Ellis (2012); Prinz et al. (2011); Cova et al. (2018)

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What can you do?

Publication bias
QRPs / p-hacking →

- Scientific progress is slowed down
- Published results cannot be trusted
- Resources are wasted

(1) Identify Questionable Research Practices
(2) Practice Open Science: Make your own research trustworthy
(3) Help to change incentive structures

Icon from flaticon.com by Baianat, en.wikipedia.org/wiki/File:We_Can_Do_It!.jpg

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The Open Research Process

Study Design	Data Collection	Publication & Distribution	Replication

Preregistration

"The specification of a research design, hypotheses, and analysis plan prior to observing the outcomes of a study"

Nosek & Lindsay (2018)

Why?

- Prevent HARKing
- Reduce analytical flexibility
- Make selective reporting visible
- Get early feedback
- Take credit for your ideas
- Regulatory agencies require it

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The Open Research Process

Study Design	Data Collection	Publication & Distribution	Replication

Apply for Registered Report

"Registered Reports are a form of empirical journal article in which methods and proposed analyses are pre-registered and peer-reviewed prior to research being conducted. High-quality protocols are then provisionally accepted for publication before data collection commences."

COS(2018): www.cos.io/rr/

Why?

- Advantages of preregistration
- Guaranteed publication independent of results
- Peer review for your design

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The Open Research Process

Study Design	Data Collection	Publication & Distribution	Replication

Open Lab Notebook

"Researchers use a lab notebook to document their hypotheses, experiments, and initial analysis or interpretation of these experiments. The lab notebook serves as an organizational tool, a memory aid, and can have a role in protecting intellectual property that comes from the research."

Goyal, Malviya, & Kapoor (2012)

Why?

- Gain & share procedural knowledge
- Increase authenticity
- Protect your intellectual property

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The Open Research Process

Study Design	Data Collection	Publication & Distribution	Replication

Open Data

"Open data should be available to everyone to access, use, and share."

GO FAIR (2018)

Why?

- Make your analyses reproducible
- Enable re-use of data for answering other research questions
- Never lose valuable data in a file drawer
- Funding agencies require it

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The Open Research Process

Study Design	Data Collection	Publication & Distribution	Replication

Open Materials

"Making components of the research methodology needed to reproduce the reported procedure and analysis publicly available."

OSF (2016)

Why?

- Make your study reproducible
- Enable re-use of materials for other experiments

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The Open Research Process

Study Design	Data Collection	Publication & Distribution	Replication

Open Access

Literature which is “digital, online, free of charge, and free of most copyright and licensing restrictions”.

Suber (2015)

Why?

- Enable faster progress in research by opening the access to knowledge
- Give back value to the community that funded you and not only to publishers

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The Open Research Process

Study Design | Data Collection | Publication & Distribution | Replication

Open Analysis Code

"Clean, repeatable, script-based workflow […] that links raw data through to clean data and to final analysis outputs."

British Ecological Society (2017)

Why?

- Enable others to reproduce your analyses
- Understand your own code (after some time)
- Recreate your results with one click

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The Open Research Process

Study Design	Data Collection	Publication & Distribution	Replication

Replication

"replication is a scientific method to verify research findings and […] refers to a repetition of a research procedure to check the accuracy or truth of the findings reported."

Schmidt (2009)

Why?

- Enhance credibility of your research
- Gain confidence in your findings & solidify the basis of your research

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Let’s not rest on our laurels: Current challenges.

1. Blind spots
2. High openness, low quality
3. Empirical evidence for effectiveness of reforms
4. Incentive structures

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Let's not rest on our laurels: Current challenges.

1. **Blind spots**
2. High openness, low quality
3. Empirical evidence for effectiveness of reforms
4. Incentive structures

Leave your bubble!

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- Blind spots within psychology?
- Project: Analyse conference programs of the subsections of the DGPs („Fachgruppen“) for keywords such as *replication*, *reproducibility*, *open science*.
- Leave your bubble and spread the word to your community.

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Let’s not rest on our laurels: Current challenges.

1. Blind spots
2. **High openness, low quality**
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4. Incentive structures

Paper does not match preregistration

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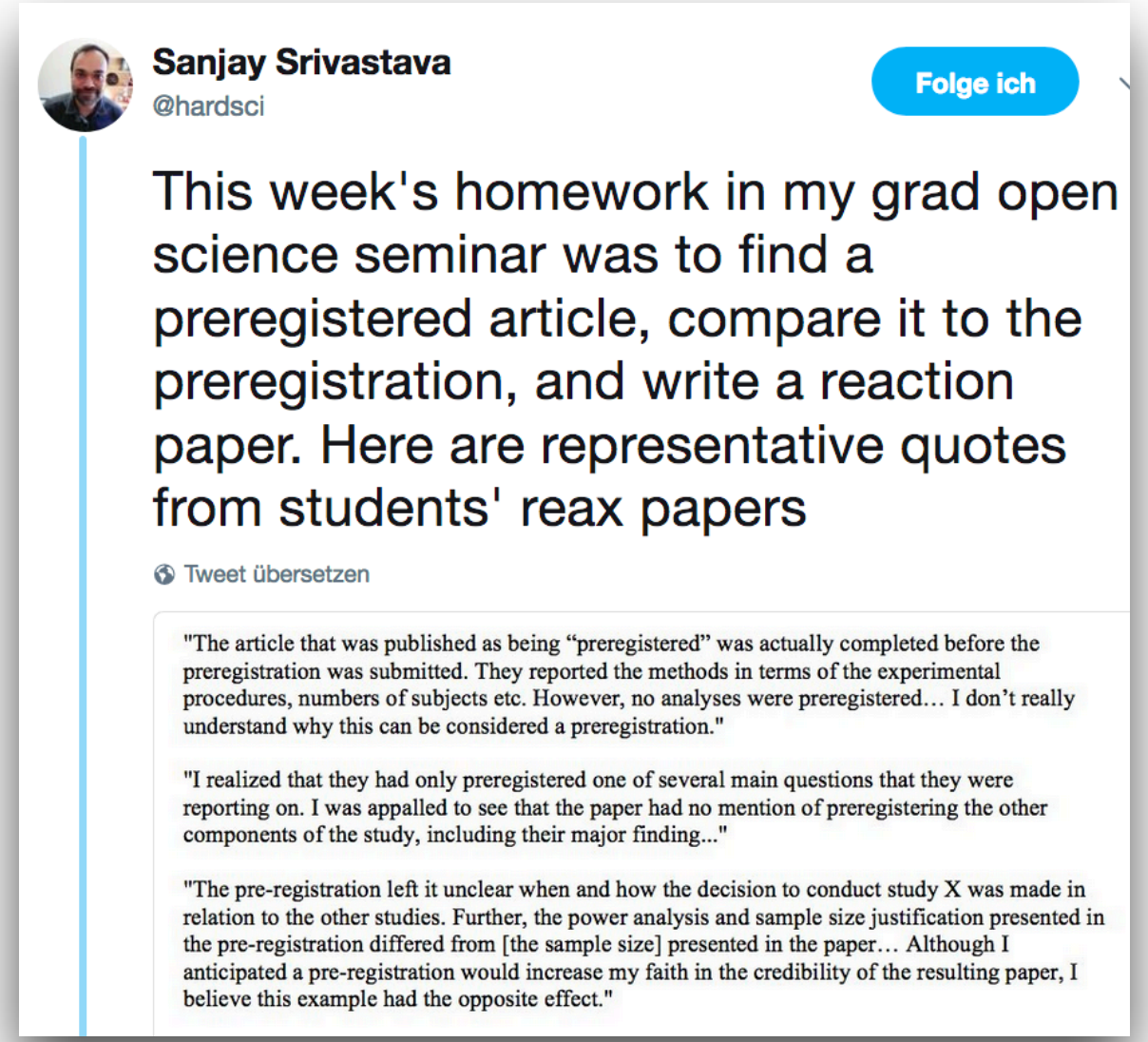

Sanjay Srivastava
@hardsci

Folge ich

This week's homework in my grad open science seminar was to find a preregistered article, compare it to the preregistration, and write a reaction paper. Here are representative quotes from students' reax papers

Tweet übersetzen

"The article that was published as being "preregistered" was actually completed before the preregistration was submitted. They reported the methods in terms of the experimental procedures, numbers of subjects etc. However, no analyses were preregistered… I don't really understand why this can be considered a preregistration."

"I realized that they had only preregistered one of several main questions that they were reporting on. I was appalled to see that the paper had no mention of preregistering the other components of the study, including their major finding..."

"The pre-registration left it unclear when and how the decision to conduct study X was made in relation to the other studies. Further, the power analysis and sample size justification presented in the pre-registration differed from [the sample size] presented in the paper… Although I anticipated a pre-registration would increase my faith in the credibility of the resulting paper, I believe this example had the opposite effect."

Open-washing

„However, the analysis plan was posted to OSF but unfortunately not actually registered“

„Also, the Study 3 design was part of the registration, but it did not include an analysis plan.“

→ half-way preregistration?

„One of the five studies (Study 3) was preregistered“

→ Preregister one trivial research question, get the badge for the whole paper?

https://twitter.com/BrianNosek/status/1003989856643674113

Open-washing

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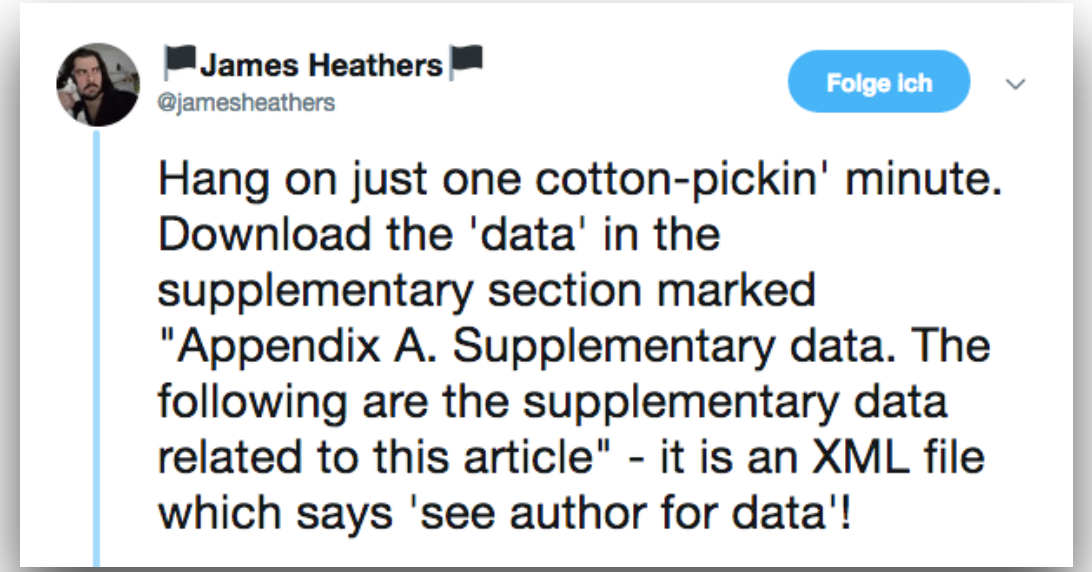


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<?xml version="1.0" encoding="UTF-8" standalone="no"?>
  <data:data>
    <datasets>
      <author>moldham@liverpool.ac.uk</author>
      <type>0</type>
      <dataset>
        <value>1</value>
        <reason>Data will be made available on request
        </reason>
        <comments/>
      </dataset>
```

https://twitter.com/jamesheathers/status/1004330301626208256
https://www.sciencedirect.com/science/article/pii/S0195666317313041

Who is responsible for checking/enforcing the badges?

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- **„Self-disclosure model“**:
  Authors sign the statement „I have a preregistration and my paper matches the prereg“, but verification is left to community (in post-publication peer review)
  ➞ badge means: „This is verifiable *in principle*“
  (but somebody still has to do it)
- **„verification model“**:
  Reviewers and or editors do the verification
  ➞ badge means: „This has been verified and can be trusted“
  (but extra burden for reviewers and editors)
- Registered Reports as a much better model? Preregistration *is* the paper, no mismatch possible. Reviewers check it during stage 1 review.

FAIR data

- **F**indable: Metadata and data should be easy to find for both humans and computers.
- **A**ccessible: Once the user finds the required data, she/he needs to know how can they be accessed, possibly including authentication and authorisation.
- **I**nteroperable: The data usually need to be integrated with other data. In addition, the data need to interoperate with applications or workflows for analysis, storage, and processing.
- **R**eusable: Metadata and data should be well-described so that they can be replicated and/or combined in different settings.

https://www.go-fair.org/fair-principles/

Open Data vs. FAIR data

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- FAIR data can be *not* open
  - e.g., if a data set is findable, reuseable, etc., but only accessible within a closed research group
- Open Data can be *not* FAIR
  - e.g., an undocumented data dump in an uncurated repository, such as OSF, which is neither findable, nor reuseable, nor interoperable
- FAIR dimensions are quality criteria that can be applied to data sets. Ideally, a data set is open *and* FAIR.

https://ask-open-science.org/1116/what-the-difference-between-fair-data-and-open-data-there-any

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Open-Washing =
Hey, let's game the new system!

Endorse open science on Twitter and your CV,
try to get badges with minimum effort,
pretend openness but do not deliver.

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Let’s not rest on our laurels: Current challenges.

1. Blind spots
2. High openness, low quality
3. **Empirical evidence for effectiveness of reforms**
4. Incentive structures

Meta-Science: Gather empirical evidence

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- Hypothesis: Open science practices increase the credibility, the veridicality*, and the replicability of research.
- A critic could say:
  Where is the empirical evidence? You rush implementing all these interventions and reforms without having any evidence that they actually have the desired effect.

* the degree to which a theory or interpretation accurately represents reality

Meta-Science: Gather empirical evidence

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Rowhani-Farid *et al. Research Integrity and Peer Review* (2017) 2:4
DOI 10.1186/s41073-017-0028-9

Research Integrity and Peer Review

REVIEW Open Access

What incentives increase data sharing in health and medical research? A systematic review

Anisa Rowhani-Farid*, Michelle Allen and Adrian G. Barnett

Results: Only one incentive (using open data badges) has been tested in health and medical research that examined data sharing rates. The number of opinion pieces ($n = 85$) out-weighed the number of article-testing strategies ($n = 76$), and the number of observational studies exceeded them both ($n = 106$).

Conclusions: Given that data is the foundation of evidence-based health and medical research, it is paradoxical that there is only one evidence-based incentive to promote data sharing. More well-designed studies are needed in order to increase the currently low rates of data sharing.

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Let’s not rest on our laurels: Current challenges.

1. Blind spots
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3. Empirical evidence for effectiveness of reforms
4. **Incentive structures**

Richard Horton,
Editor von *The Lancet*

Much of the scientific literature, perhaps half, may simply be untrue.

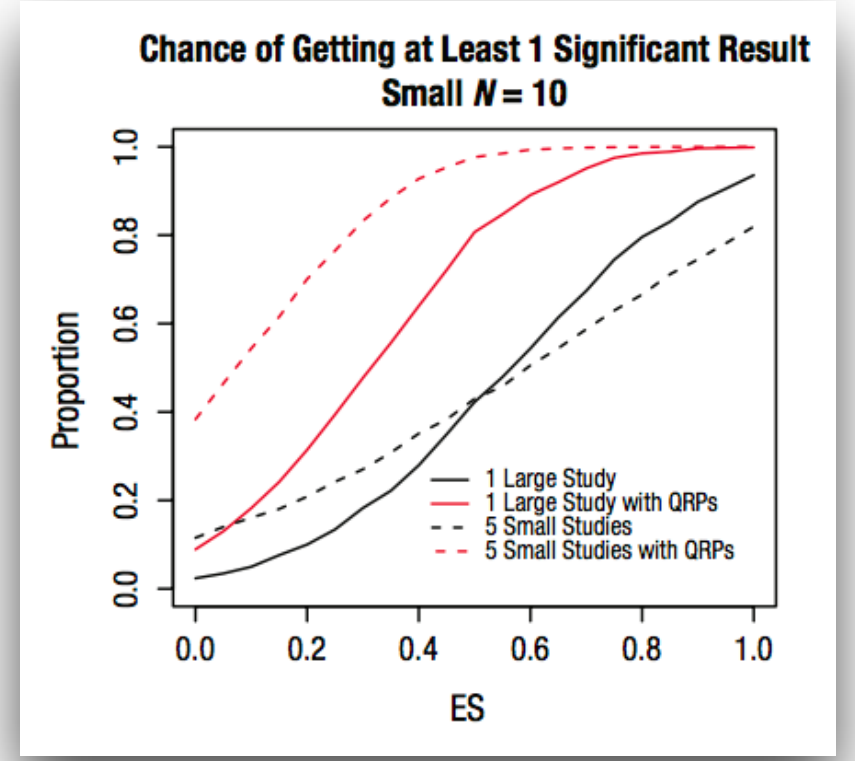
Part of the problem is that no one is incentivised to be **right**.

Quantity, not quality

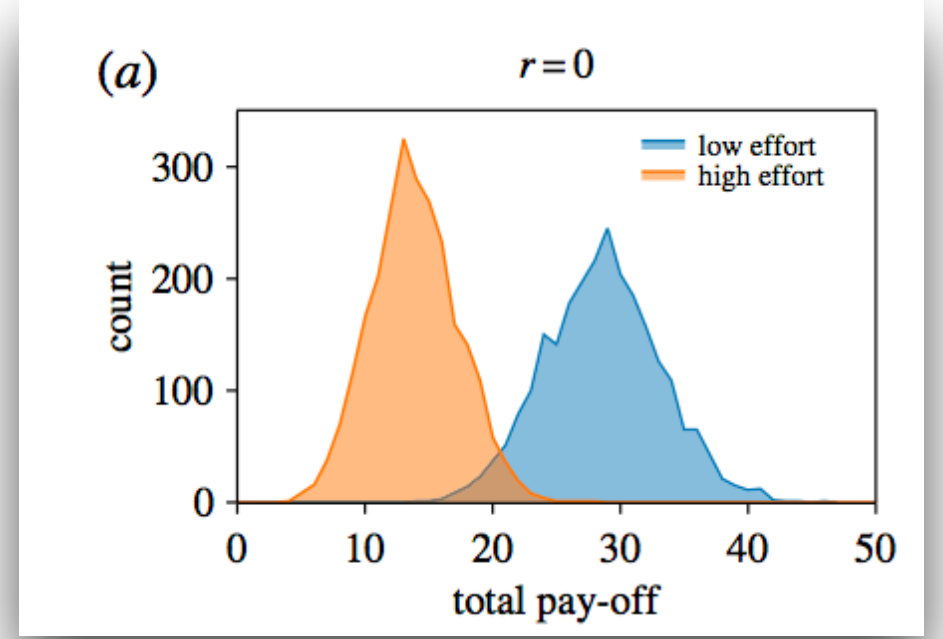
Actual (not desired) relevance at professorship hiring committees:	Rank
Number of peer-reviewed publications	1
Fit of research profile to the advertising institution	2
Quality of research talk	3
Number of publications	4
Volume of acquired third-party funding	5
Number of first authorships	6
…	…

Abele-Brehm, A. E., & Bühner, M. (2016). Wer soll die Professur bekommen? Psychologische Rundschau, 67(4), 250–261. http://doi.org/10.1026/0033-3042/a0003

„The rules of the game“



„Evolution of bad science“



Ideal strategy for a high quantity of publications:
small *n* + many studies + questionable research practices (QRPs), such as *p*-hacking

Bakker, M., van Dijk, A., & Wicherts, J. M. (2012). The Rules of the Game Called Psychological Science. Perspectives on Psychological Science, 7(6), 543–554. http://doi.org/10.1177/1745691612459060
Smaldino, P. E., & McElreath, R. (2016). The natural selection of bad science. *Royal Society Open Science*, *3*(9), 160384–17. http://doi.org/10.1098/rsos.160384

Quantity, not quality

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Actual (not desired) relevance at professorship hiring committees:	Rank
Number of peer-reviewed publications	1
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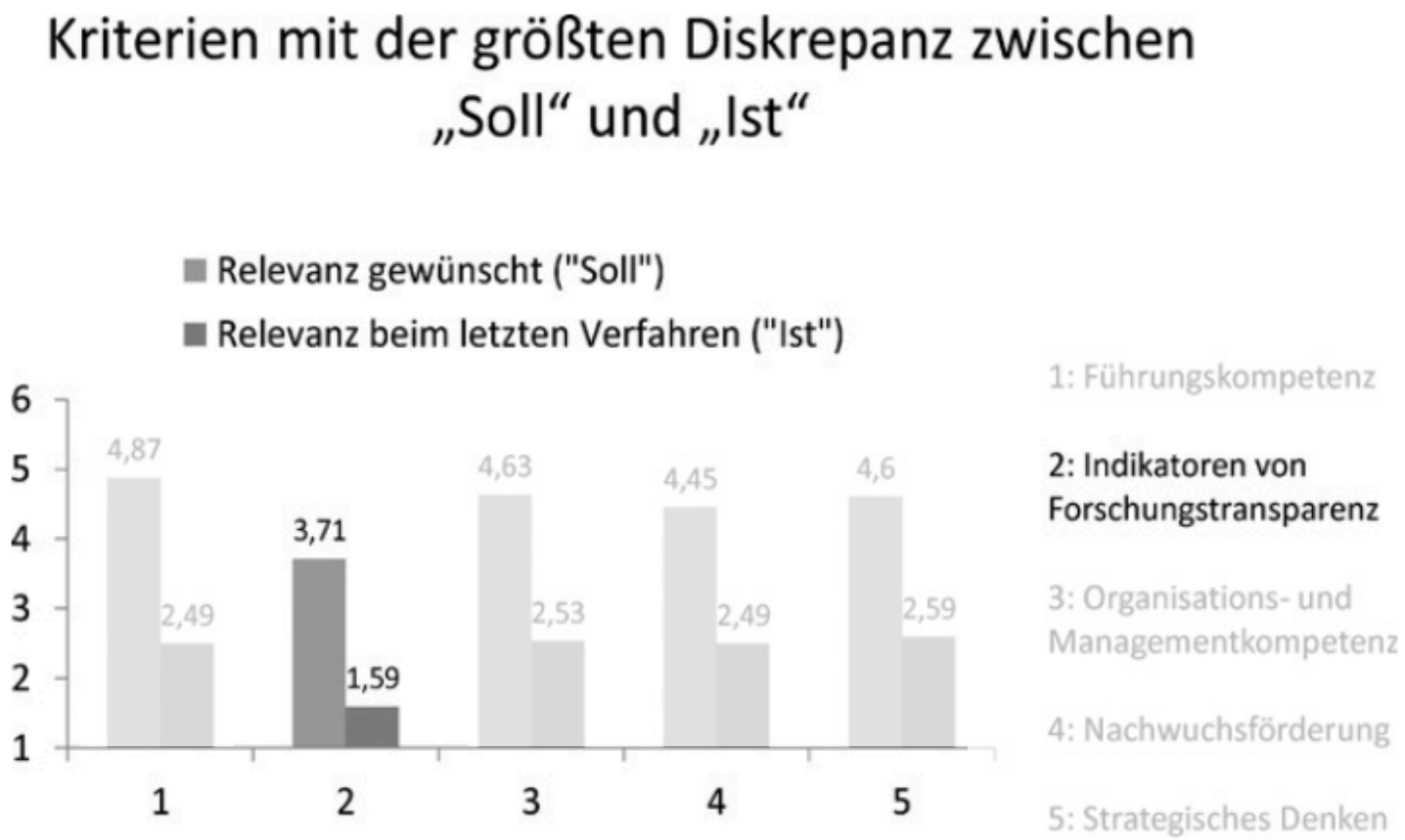
Number of publications	4
Volume of acquired third-party funding	5
Number of first authorships	6
…	…
Quality assessment of the best three publications	17
…	…
Indicators of research transparency	**41 (of 41)**

Abele-Brehm, A. E., & Bühner, M. (2016). Wer soll die Professur bekommen? Psychologische Rundschau, 67(4), 250–261. http://doi.org/10.1026/0033-3042/a0003

Quality, not quantity

Job committees



Abele-Brehm, A. E., & Bühner, M. (2016). Wer soll die Professur bekommen? Psychologische Rundschau, 67(4), 250–261. http://doi.org/10.1026/0033-3042/a000

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Roadmap

Fast adoption vs. High (FAIR) quality?

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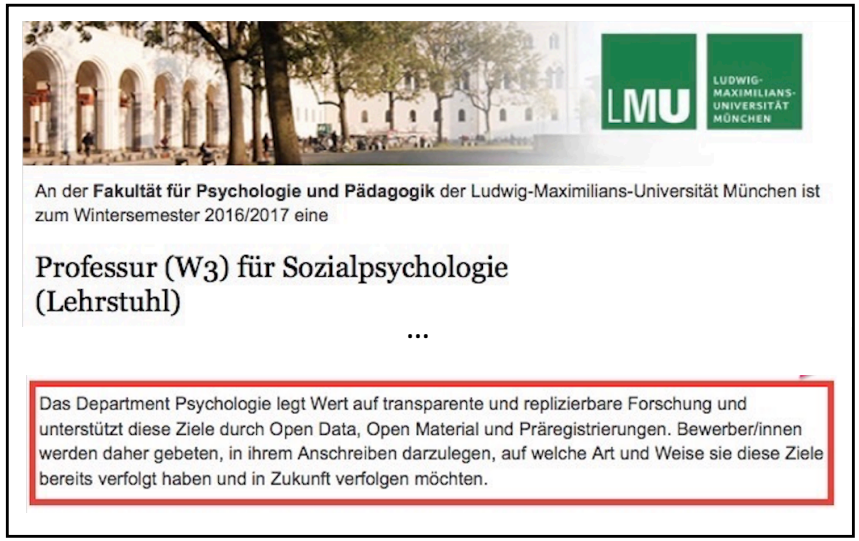
- Low hurdles, one small step at a time
- Reward small steps
  Sharing something - even badly documented data - is better than sharing nothing.
- Learning by doing
  With increasing practice, hopefully the quality gets better, too.
- But: (Initially) Low quality
  Barely reusable data sets; trying to reproduce a result is a pain in the ass or impossible; data reuse very limited.
- Risk of „open-washing“
  Pretending openness without actual value.

- High hurdles
  Mainly enthusiasts/computer scientists will able and motivated use it
- Reward big steps
  Curated repositories with input quality control.
- Instant high quality
  The data sets which are open are instantly FAIR.

Hiring committees: Make „open science“ a desirable or essential job characteristic



An der **Fakultät für Psychologie und Pädagogik** der Ludwig-Maximilians-Universität München ist zum Wintersemester 2016/2017 eine

Professur (W3) für Sozialpsychologie (Lehrstuhl)

...

Das Department Psychologie legt Wert auf transparente und replizierbare Forschung und unterstützt diese Ziele durch Open Data, Open Material und Präregistrierungen. Bewerber/innen werden daher gebeten, in ihrem Anschreiben darzulegen, auf welche Art und Weise sie diese Ziele bereits verfolgt haben und in Zukunft verfolgen möchten.

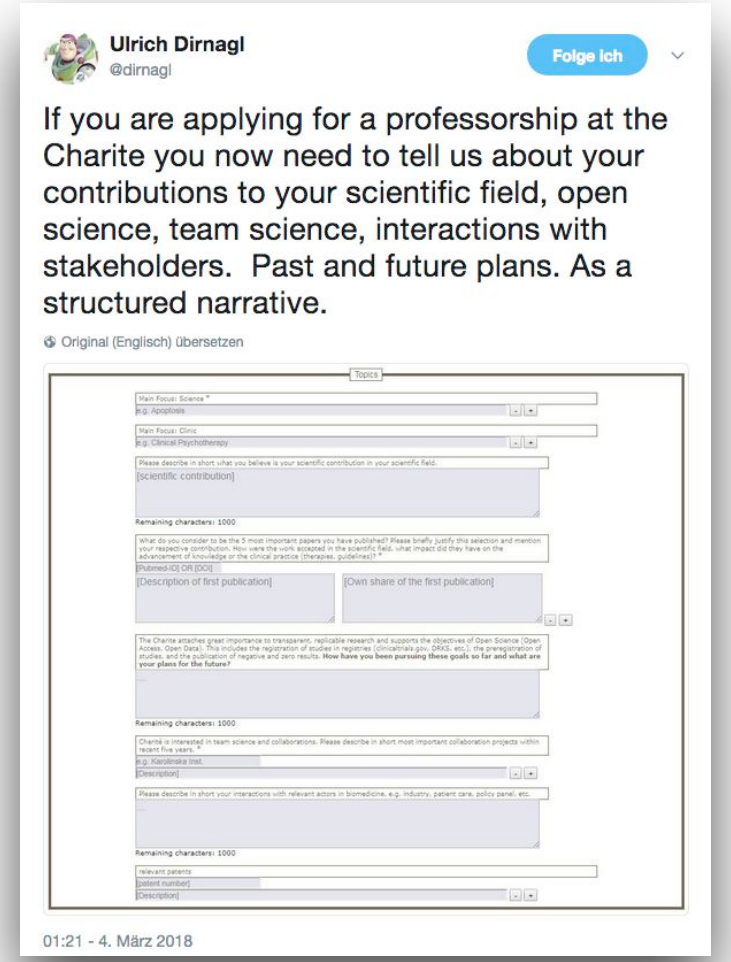
Since 2015: All professorship job descriptions use this requirement

Full Professor (W3)
of Social Psychology

to be filled as soon as possible.

...

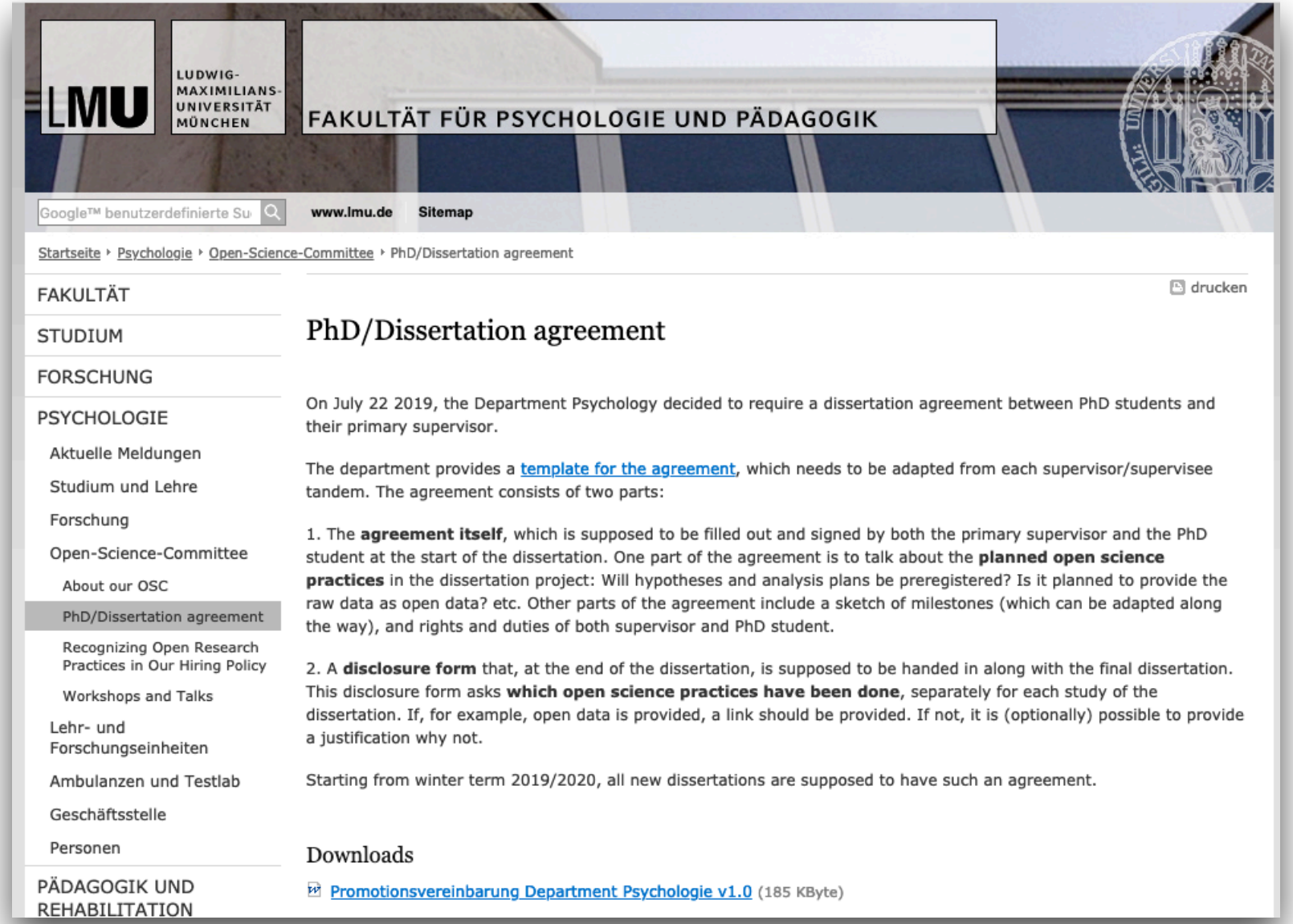
The Department of Psychology aims for transparent and reproducible research (including Open Data, Open Materials, and Preregistrations). Applicants are asked to illustrate how they have pursued these goals in the past and/or how they plan to do so in the future.



See more such prof job ads at: https://osf.io/7jbnt/

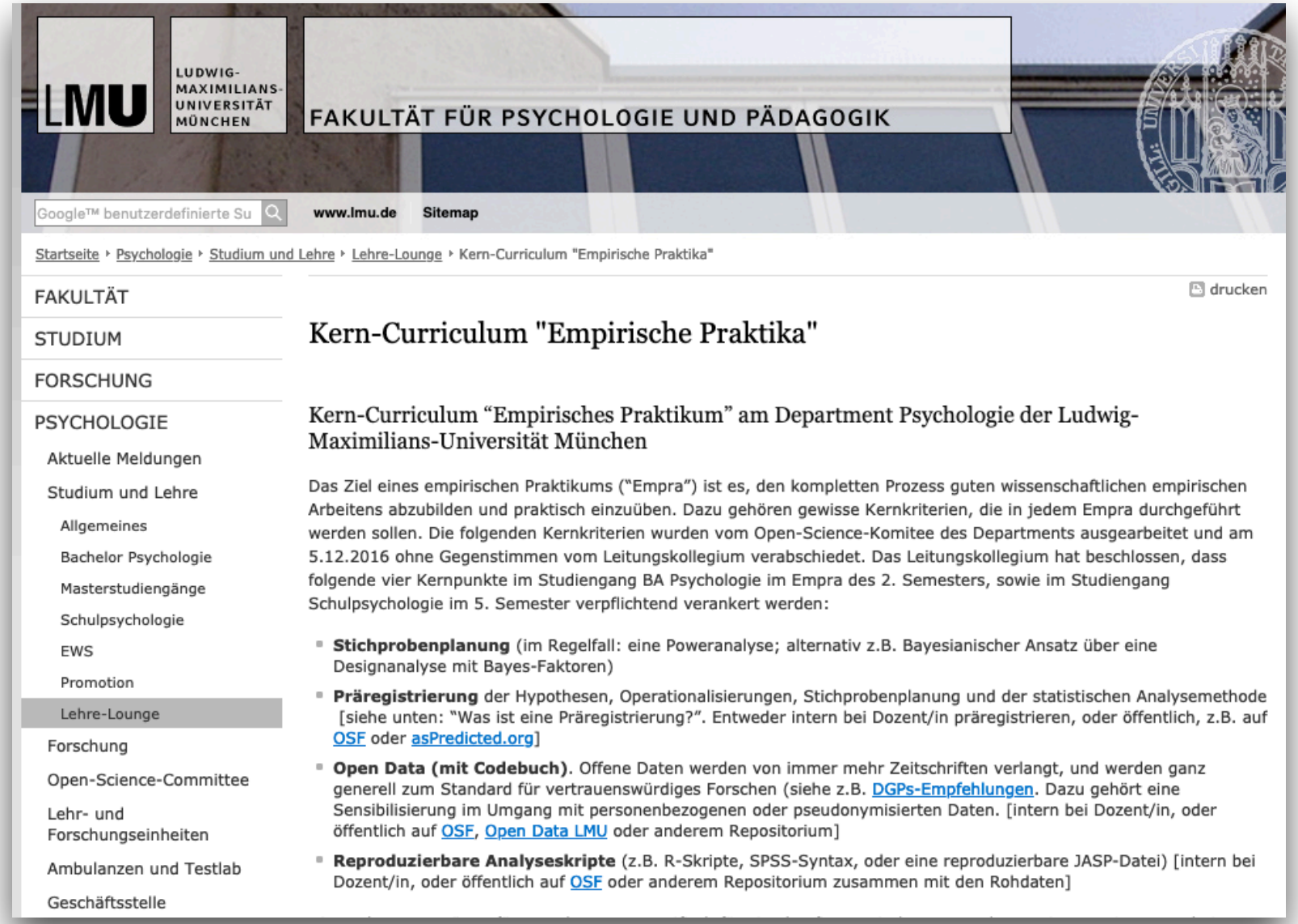
https://docs.google.com/document/d/1ty43Syw0Flkh8ncjW8MZArIkvYe8hLwvhLIlwbtSk_Y/edit?usp=drive_web&ouid=108982640291853577145

Dissertation agreement



http://www.fak11.lmu.de/dep_psychologie/osc/dissertation_agreement/index.html

Open science in curricula



http://www.fak11.lmu.de/dep_psychologie/studium/lehrelounge/kerncurriculum_empra/index.html

Hiring committees: Require an annotated CV with limited items (e.g., <= 10)

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No journal; JIF is irrelevant or misleading

Paper-level citation metrics

Basic information for judging evidential value

Open science indicators: Judging reproducibility

Data: own collection or reuse?

Authors & title	Year	Cit-ations	Sample size per study	*p*-value per study	Open Science indicators	Data set	Applicants contribution
Doe, John & Smith, Peter	2001	47	$n_1 = 21$ $n_2 = 30$ $n_3 = 19$	$p_1 = .048$ $p_2 = .050$ $p_3 = .023$	☐Open Data ☐Open Material ☐Preregistered	☑Own data collection → URL *NA* ☐Archival data	• Analyzed data • Wrote manuscript
Doe, John	2016	26	$n_1 = 180$ $n_2 = 158$	$p_1 = .012$ $p_2 = .001$	☑ Open Data ☑Open Material ☑Preregistered	☑ Own data collection → URL osf.io/as1cd ☐ Archival data	• Designed study • Wrote manuscript

Dougherty, M. R., Slevc, L. R., & Grand, J. (2018, February 2). Retrieved from psyarxiv.com/48qux

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Open Science: Who to ask?

- Ask Open Science Initiative (University of Bielefeld) https://ask-open-science.org/
- Your local Open Science Initiative https://osf.io/tbkzh/wiki/home
- Reddit Open Science https://www.reddit.com/r/Open_Science/

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Open Science: 3 Easy Steps

How you can improve your OS record (almost) without effort

1. When reviewing a paper: Keep an eye on QRPs and ask for open data and open material (https://opennessinitiative.org/)
2. Which parts of your research process can you make open? Start out with the least work-intensive part and give it a try!
3. Get a Twitter account and join the discussion

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Open Science: What you learned

- Open Science as part of good research practice
- The science hamster wheel: Incentive structures in research
- The replication crisis: Non-replicability in research and its problems
- Identify scientific misconduct: Fabrication, Falsification, Questionable Research Practices
- Methods of p-hacking: Optional stopping, HARKing, selective reporting, analytical flexibility
- The open research process: Preregistration, Registered Reports, Open Lab Notebooks, Open Data, Open Materials, Open Access Publishing, Replication Studies
- How to make a change: Open Science networks and initiatives

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Further Resources

- Arslan, R. (2018). *Open science vs. bad science: The replication crisis and possible reforms.* Presentation slides available on osf.io/65mqz/
- Gelman, A., & Loken, E. (2013). The garden of forking paths: Why multiple comparisons can be a problem, even when there is no “fishing expedition” or “p-hacking” and the research hypothesis was posited ahead of time. *Department of Statistics, Columbia University*. stat.columbia.edu/~gelman/research/unpublished/p_hacking.pdf
- John, L. K., Loewenstein, G., & Prelec, D. (2012). Measuring the prevalence of questionable research practices with incentives for truth telling. *Psychological Science 23*(5), p. 524-532. doi: 10.1177/0956797611430953
- Schmidt, S. (2009). Shall we really do it again? The powerful concept of replication is neglected in the social sciences. *Review of General Psychology 13*(2), p. 90-100. doi: 10.1037/a0015108
- Schönbrodt, F. D. (2017). *P-hacking: What it is, how to prevent it.* Presentation at GESIS, slides available on gesis.org/fileadmin/upload/events/Vortragsreihe/Schoenbrodt_GESIS_p-hacking.pdf
- Simmons, J., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science 22*(11), p. 1359-1366. doi: 10.1177/0956797611417632
- Wagenmakers , E.-J.(2018). *The case for radical transparency in statistical reporting.* Presentation slides available on bayesianspectacles.org/wp-content/uploads/2018/01/RadicalTransparency.pdf

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References

- Arslan, R. (2018). *Open science vs. bad science: The replication crisis and possible reforms.* Presentation slides available on osf.io/65mqz/
- Baker, M. (2016). 1.500 scientists lift the lid on reproducibility. *Nature 533*(7604), p. 452-454. doi: 10.1038/533452a
- British Ecological Society (2017). *A guide to reproducible code in ecology and evolution.* Report available on www.britishecologicalsociety.org/wp-content/uploads/2017/12/guide-to-reproducible-code.pdf
- COS (2018). *Registered Reports: Peer review before results are known to align scientific values and practices.* Available on cos.io/rr/
- Cova, F., Strickland, B., Abatista, A., Allard, A., Andow, J., Attie, M., ... & Cushman, F. (2018). Estimating the reproducibility of experimental philosophy. *Review of Philosophy and Psychology*, 1-36. psyarxiv.com/sxdah/
- * Begg, C., & Berlin, J. (1988). Publication Bias: A Problem in Interpreting Medical Data. *Journal of the Royal Statistical Society. Series A (Statistics in Society), 151*(3), p. 419-463. doi:10.2307/2982993
- Begley, C. G., & Ellis, L. M. (2012). Drug development: Raise standards for preclinical cancer research. *Nature*, *483*(7391), 531. www.gulfcoastconsortia.org/wp-content/uploads/2017/01/Begley-Ellis-Nature-Comment-2012.pdf
- Chang, A. & Li, P. (2015). Chang, A. C., & Li, P. (2015). *Is economics research replicable? Sixty published papers from thirteen journals say'usually not'.* papers.ssrn.com/sol3/papers.cfm?abstract_id=2669564
- Gelman, A., & Loken, E. (2013). The garden of forking paths: Why multiple comparisons can be a problem, even when there is no “fishing expedition” or “p-hacking” and the research hypothesis was posited ahead of time. *Department of Statistics, Columbia University*. stat.columbia.edu/~gelman/research/unpublished/p_hacking.pdf
- GO FAIR (2018). *What is the difference between ‘FAIR data’ and ‘Open data’ if there are any?* Available on go-fair.org/faq/ask-question-difference-fair-data-open-data/
- Goyal, R., Malviya, S., & Kapoor, D. N. (2012). Lab notebook: An indispensable resource for researchers. *DHR International Journal Of Pharmaceutical Sciences 2*(1). Available on doublehelixresearch.com/DHRIJPS
- Hunter College (2016). *Psych250-07: Extra credit 3: Data fabrication.* Available on hunterdolkerpsych250.wordpress.com/2016/12/06/extra-credit-3-data-fabrication/
- John, L. K., Loewenstein, G., & Prelec, D. (2012). Measuring the prevalence of questionable research practices with incentives for truth telling. *Psychological Science 23*(5), p. 524-532. citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.727.5139&rep=rep1&type=pdf
- Mullard, A. (2011). Reliability of 'new drug target' claims called into question. *Nature Reviews Drug Discovery 10*, p. 643-644. doi: 10.1038/nrd3545
- Nosek, B. A. & Lindsay, S. (2018). Preregistration becoming the norm in psychological science. *APS Observer, 31*(3). Available on psychologicalscience.org/observer/preregistration-becoming-the-norm-in-psychological-science
- Open Science Collaboration (2015). Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science*, *349*(6251), aac4716. osf.io/447b3/
- OSF (2016). *Badges to acknowledge open practices.* Available on osf.io/tvyxz/wiki/1.%20View%20the%20Badges/
- Prinz, F., Schlange, T., & Asadullah, K. (2011). Believe it or not: how much can we rely on published data on potential drug targets?. *Nature reviews Drug discovery*, *10*(9), 712. hopecenter.wustl.edu/wp-content/uploads/2012/01/Nat-Rev-Drug-Disc-reproducibility-article.pdf
- Schmidt, S. (2009). Shall we really do it again? The powerful concept of replication is neglected in the social sciences. *Review of General Psychology 13*(2), p. 90-100. doi: https://goo.gl/3wEfdz
- Schönbrodt, F. D. (2017). *P-hacking: What it is, how to prevent it.* Presentation at GESIS, slides available on gesis.org/fileadmin/upload/events/Vortragsreihe/Schoenbrodt_GESIS_p-hacking.pdf
- Schönbrodt, F. D. (2016). *Introducing the p-hacker app: Train your expert p-hacking skills.* Blogpost available on nicebread.de/introducing-p-hacker/
- Simmons, J., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science 22*(11), p. 1359-1366. doi: 10.1177/0956797611417632
- Simonsohn, U., Nelson, L. D., & Simmons, J. P. (2014). P-curve and effect size: Correcting for publication bias using only significant results. *Perspectives on Psychological Science*, *9*(6), 666-681. doi: 10.1177/1745691614553988
- Suber, P. (2015). *Open Access Overview.*Available on bit.ly/oa-overview
- Wagenmakers, E. J., Wetzels, R., Borsboom, D., van der Maas, H. L., & Kievit, R. A. (2012). An agenda for purely confirmatory research. *Perspectives on Psychological Science*, *7*(6), 632-638.
- Wagenmakers , E.-J.(2018). *The case for radical transparency in statistical reporting.* Presentation slides available on bayesianspectacles.org/wp-content/uploads/2018/01/RadicalTransparency.pdf

* Unfortunately, there is no Open Access version of this article available

Credentials

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