



Open Science: Transparent and Reproducible

Eva Furrer, Center for Reproducible Science, University of Zurich



The Center for Reproducible Science

→ Mission



→ Research



→ Training



→ People



→ Expertise



→ Network



Web: www.crs.uzh.ch



CRS@UZH

@crsuzh

Improving the reproducibility of empirical research at UZH and promoting research in replication studies and methodology related to reproducibility.

Zurich, Switzerland crs.uzh.ch Joined July 2018

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Goals of the CRS

1. **Teaching and training** to improve the overall reproducibility and quality of empirical research



- Good Research Practice (GRP) courses
- ReproducibiliTea journal club, see <https://www.crs.uzh.ch/en/training/talks/ReproducibiliTea.html>

2. Promote, support and conduct **original research** in reproducibility and methodology



- Methodology for analysis and design of replication studies
- Meta-research (e.g., publication bias, assessment of replicability)

The Swiss Reproducibility Network



Peer-led consortium that aims to promote and ensure **rigorous research practices** in Switzerland by

- establishing appropriate training activities
- designing and evaluating research improvement efforts
- disseminating best practice
- working with stakeholders to coordinate efforts across the sector

SwissRN aims for broad disciplinary representation and an intensive interdisciplinary dialogue. See www.swissrn.org for more information.

Open Science and Reproducibility

Promoting Open Science helps researchers

1. to more easily and reliably build on previous work through Open Access publications and openly available data
2. to accelerate discovery through less repetition of inaccessible work and of data already produced for other projects
3. to increase and maintain the trustworthiness of scientific results which can be verified and replicated

Promoting Reproducibility helps researchers

1. to efficiently benefit from openly available data
2. to accelerate discovery even more through “easily” reproducible projects with shared software and scientific workflows
3. to verify and replicate scientific results

Open science made easy

OPEN SCIENCE MADE EASY

7 steps towards transparent and reproducible research

- 1. Create your own OSF account**

Open Science Framework: (one possible) online platform to document and present your research process transparently

 - Go to <https://osf.io/>
 - Register: name, email, password
 - Create new project: 'My Projects' → 'Create project' → Insert title → 'Create'
 - The URL of the project will not be changed → can be referenced in your paper
 - The account can be used for all the following aspects of Open Science (OS)
 - When you are ready: Change project status from *private* to *public*
- 2. Pre-register your own studies**

Describe your hypotheses, methods and analyses before running the study in your pre-registration

 - In OSF: 'Project overview' – 'registrations' – 'New registration'
 - Choose and complete a template
 - Make it public immediately or use the embargo (up to 4 years) to postpone public access.
 - Pre-registrations can ...
 - be brief or very detailed
 - be made before/during/after data collection
 - include confirmatory, but also exploratory and open research questions
- 3. Open Materials**

Make methods and materials transparent and available

 - Upload documents describing all processes, methods and variables to your OSF project
 - Add the OSF link in your paper
 - Basic lists as well as detailed code books are feasible
 - If possible upload the original questionnaires (be cautious with copyrighted materials!)
- 4. Open Data**

Make your research data publicly available

 - Notify your participants in the informed consent form
 - Make all primary data available that is necessary to reproduce your results
 - Guarantee anonymity (if necessary delete variables, collapse, ...)
 - Prepare your code book
 - Upload your data files and code book to the OSF project, add the link in your paper
 - Make your data citable (doi)
 - Cf. the DGPs recommendation for open data sharing: http://bit.ly/dgpsdata_en
- 5. Reproducible Code**

Make your analyses transparent and your results reproducible

 - Prepare your final, well-commented analyses scripts (for example R code, SPSS syntax)
 - Upload your scripts into your OSF-project and add the link to your paper
 - Make sure your script, if run on your data, produces the exact result outputs that you describe in your paper
 - Your analytic code is helpful even if you cannot make your data publicly available
- 6. Open Access**

Make Pre/Postprints available

 - What am I allowed to make publicly open? Check the journal guidelines at <http://www.sherpa.ac.uk/romeo/>
 - Before the review process starts
 - Compile a preprint document (i.e., your manuscript before peer review)
 - For example, upload at <https://osf.io/preprints/psyarxiv>
 - Ask the community for feedback
 - The preprint can be linked to an OSF-project (for example for supplementary material)
 - As soon as your paper is in press
 - Compile a postprint document (i.e., final version of your manuscript after review)
 - Update the preprint at PsyArXiv by replacing it with the postprint. Indicate the final reference and doi of the PDF version of your article provided by the journal
 - Papers that are made available as a preprint are cited more frequently!
- 7. Do open research and talk about it ...**

Open science can promote your research career and foster research collaborations

 - Refer to your OSF-account on your homepage
 - Emphasize your OS activities in your CV and job applications
 - Refer to your materials, data, scripts in your further work and ask colleagues to do the same if they used your materials
 - Encourage your supervisor, colleagues and your students to practice open science
 - Make your commitment to open science public, e.g. <http://www.researchtransparency.org/>
 - Use the chances of sharing data to establish research collaboration
 - Establish your own local Open-Science-Initiative at your institution, see <https://osf.io/tbkzh/>

Supported by:   

Resources: <http://www.bitss.org> | <https://osf.io/preprints/psyarxiv/> | <https://cos.io/> | <https://cos.io/our-services/open-science-badges-details/>

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 - Compile a postprint document (i.e., final version of your manuscript after review)
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Open science can promote your research career and foster research collaborations

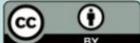
 - Refer to your OSF-account on your homepage
 - Emphasize your OS activities in your CV and job applications
 - Refer to your materials, data, scripts in your further work and ask colleagues to do the same if they used your materials
 - Encourage your supervisor, colleagues and your students to practice open science
 - Make your commitment to open science public, e.g. <http://www.researchtransparency.org/>
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Supported by:   

Resources: <http://www.bitss.org> | <https://osf.io/preprints/psyarxiv/> | <https://cos.io/> | <https://cos.io/our-services/open-science-badges-details/>

Additional information and helpful links:
https://osf.io/x3s5c/wiki/Open_Science_Infos/

© August 2017:
Mitja Back, Friederike Hendriks,
Felix Schönbrodt and the Network for
Open Science Initiatives (NOSI).
Send your questions, suggestions,
comments to
felix@nicebread.de



[Link to Open science made easy document: https://osf.io/hktmf/](https://osf.io/hktmf/)

What do we mean by Reproducibility vs Replicability?

Reproducibility refers to the ability of a researcher to duplicate the results of a prior study using the same materials as were used by the original investigator.

This requires, at minimum, the sharing of data sets, relevant metadata, analytical code, and related software.

Replicability refers to the ability of a researcher to duplicate the results of a prior study if the same procedures are followed but new data are collected.

[Goodman et al., 2016,](#)
[Sci Transl Med](#)

Issues with reproducibility/replicability affects many fields

Biomedicine

Believe it or not: how much can we rely on published data on potential drug targets?

Florian Prinz, Thomas Schlange and Khusru Asadullah

- Drug target validation in oncology, women's health, and cardiovascular diseases
- Only 22 of 67 papers were fully or partially confirmed

[Prinz et al., 2011, Nat Rev Drug Discov](#)

Psychology

Estimating the reproducibility of psychological science

Open Science Collaboration*†

- Only 39 of 100 replication studies were significant
- Mean effect size 50% as in original studies

[Open Science Collaboration, 2015, Science](#)

Issues with reproducibility/replicability affects many fields

Economics

Evaluating replicability of laboratory experiments in economics

Colin F. Camerer,^{1*}† Anna Dreber,²† Eskil Forsell,²† Teck-Hua Ho,^{3,4}† Jürgen Huber,⁵† Magnus Johannesson,²† Michael Kirchler,^{5,6}† Johan Almenberg,⁷ Adam Altmejd,² Taizan Chan,⁸ Emma Heikensten,² Felix Holzmeister,⁵ Taisuke Imai,¹ Siri Isaksson,² Gideon Nave,¹ Thomas Pfeiffer,^{9,10} Michael Razen,⁵ Hang Wu⁴

- Significant effect in 11 of 18 studies
- Mean effect size 66% as in original studies

[Camerer et al., 2016, Science](#)

Social Sciences

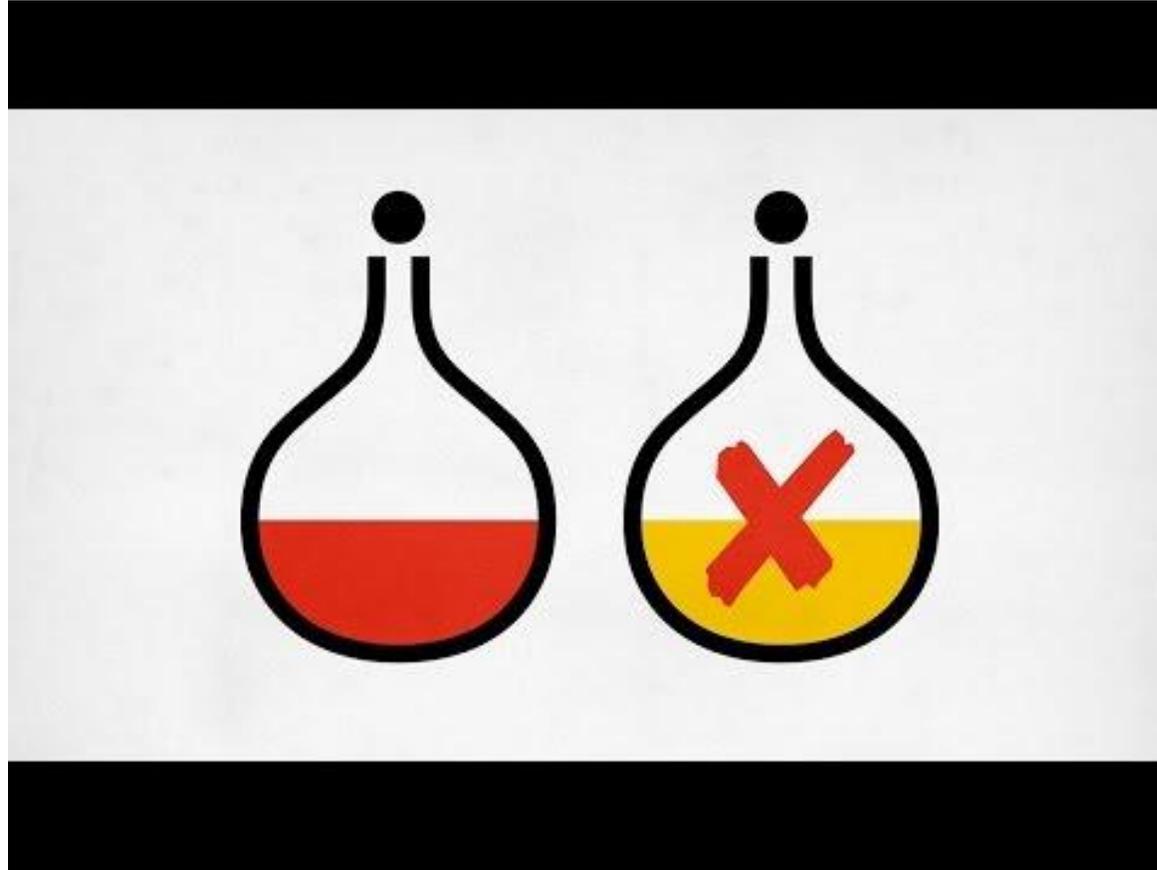


Evaluating the replicability of social science experiments in *Nature* and *Science* between 2010 and 2015

- Significant effect in 13 of 21 studies
- Mean effect size 50% as in original studies

[Camerer et al., 2018, Nat Hum Behav](#)

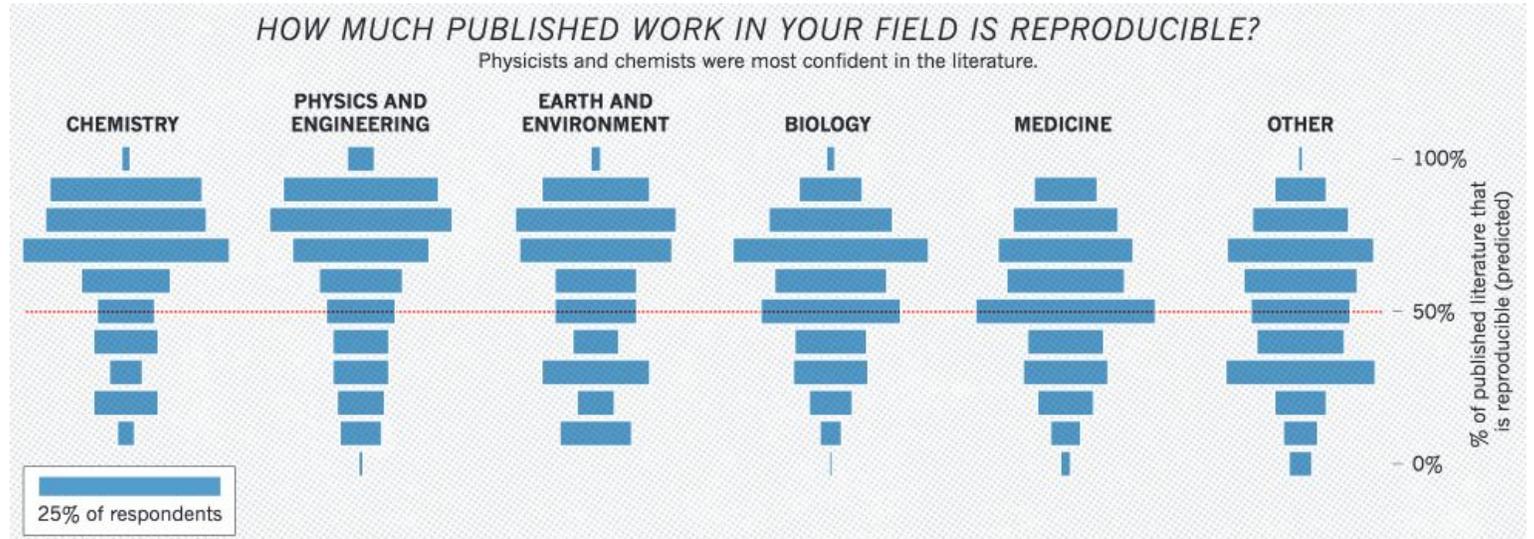
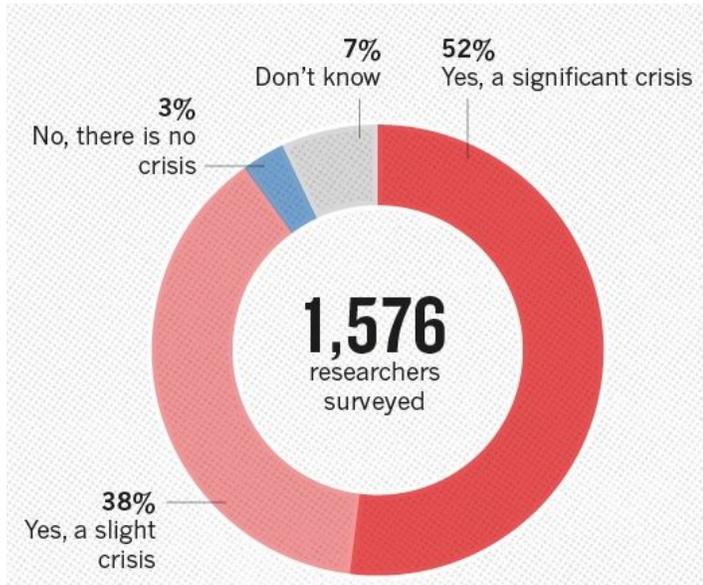
Is there a reproducibility crisis?



Video on Youtube, see https://youtu.be/j7K3s_vi_1Y

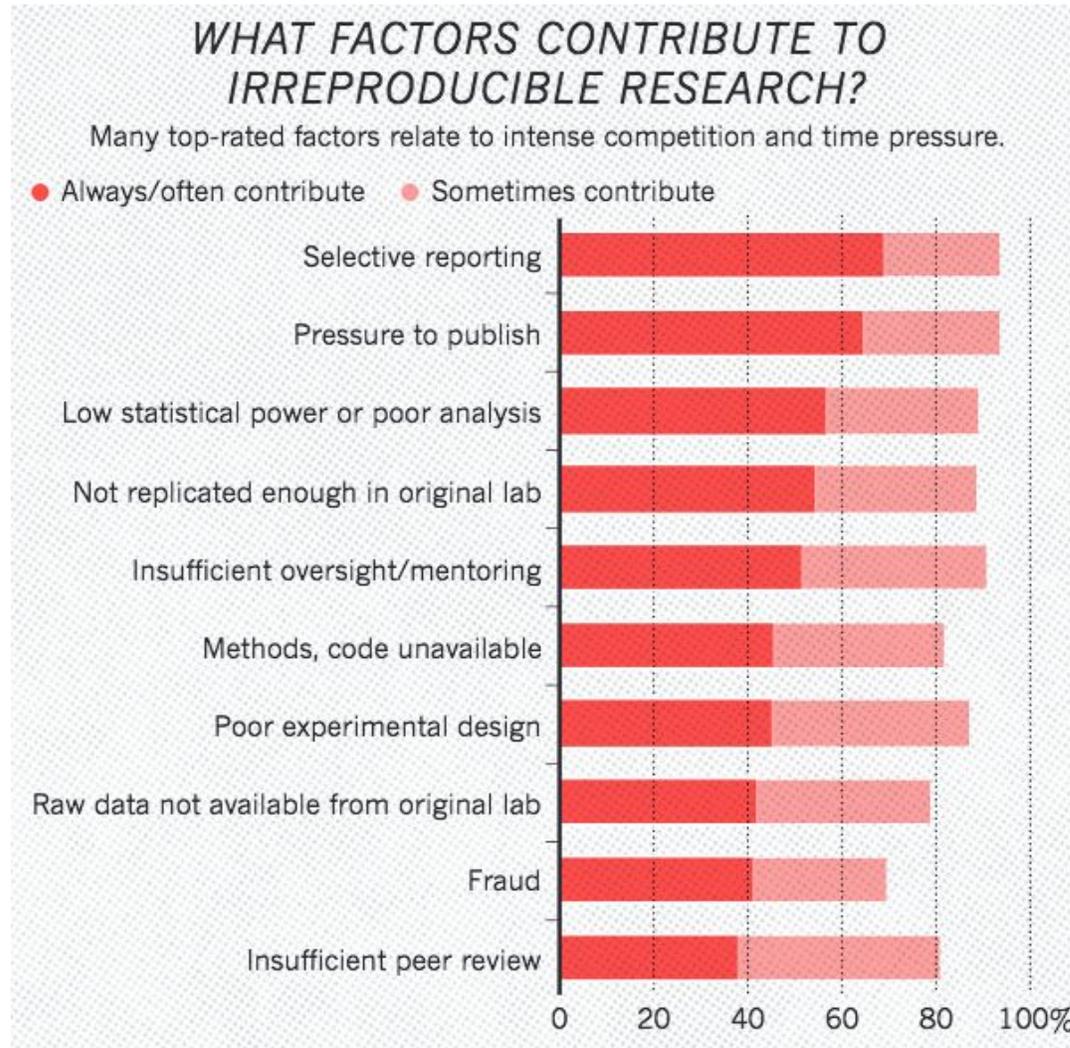
[Baker, 2016, *Nature*](#)

Is there a reproducibility crisis?



Baker, 2016, Nature

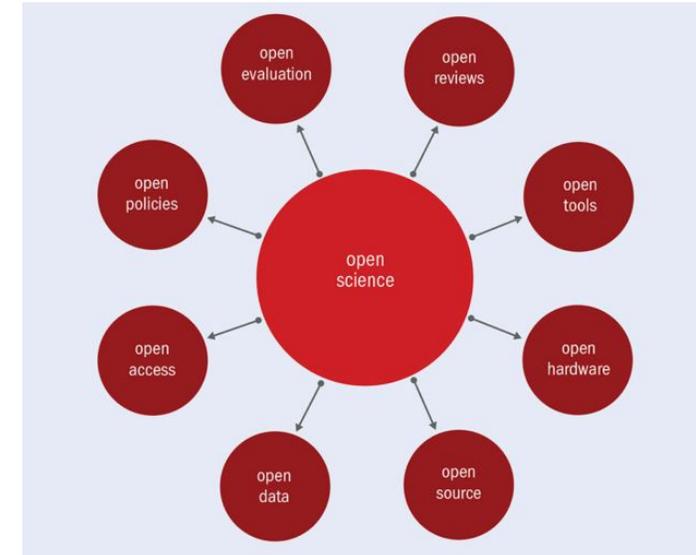
Factors contributing to irreproducible research



Baker, 2016, *Nature*

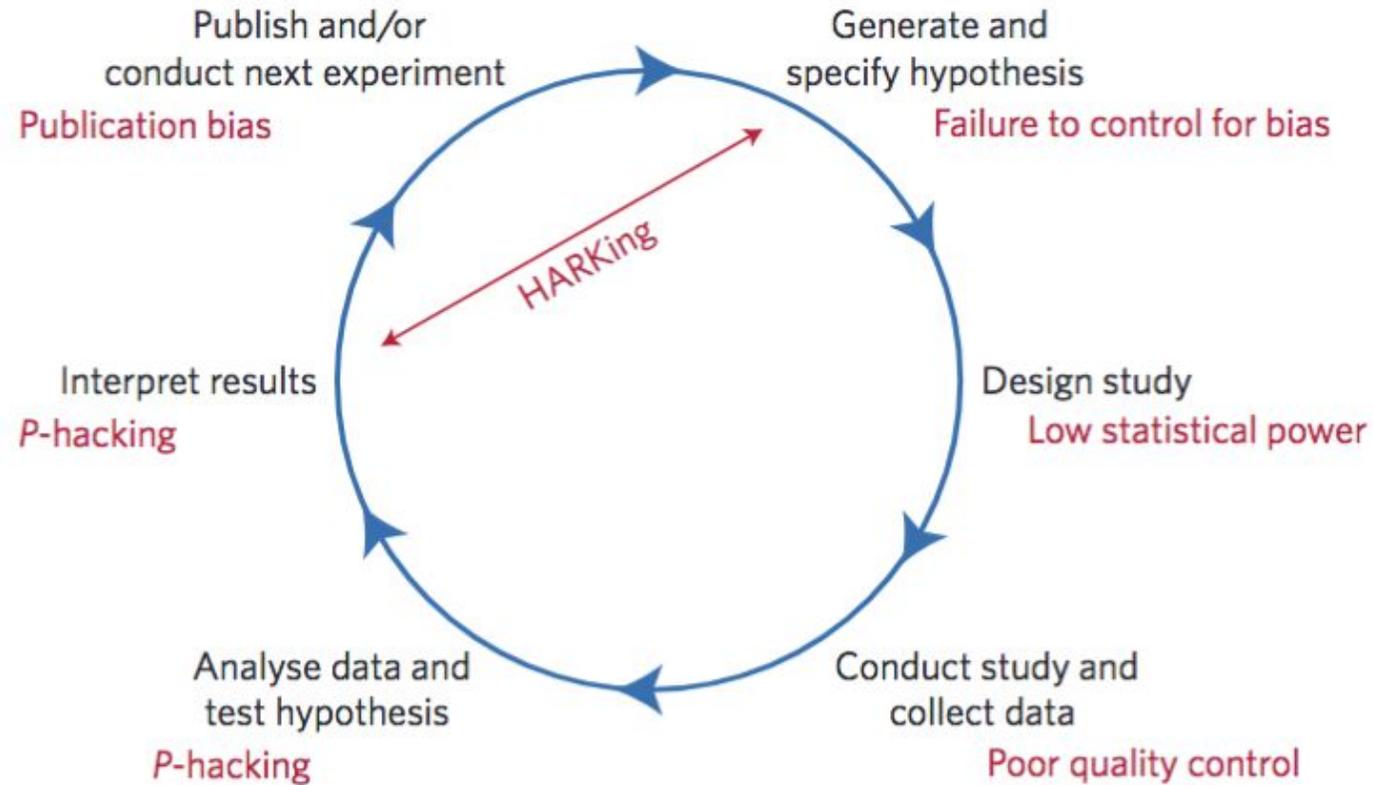
Open science: A vision for collaborative, reproducible and reusable research

“True open science demands more than simply making data available: it needs to concern itself with providing information on how to repeat or verify an analysis performed over given datasets, producing results that can be reused by others for comparison, confirmation or simply for deeper understanding and inspiration. This requires runnable examples of how the research was performed, accompanied by software, documentation, runnable scripts, notebooks, workflows and compute environments. It is often too late to try to document research in such detail once it has been published.”

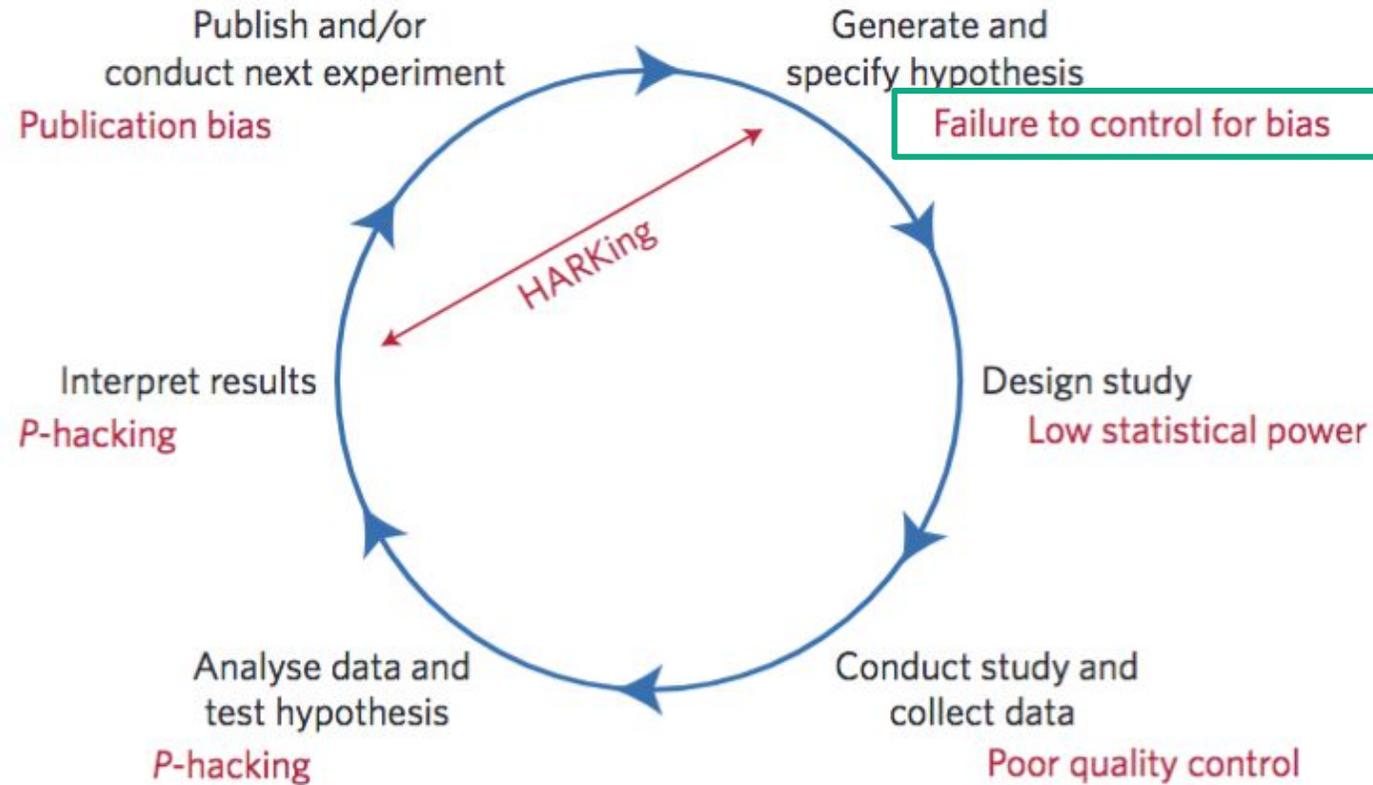


<https://cerncourier.com/a/open-science-a-vision-for-collaborative-reproducible-and-reusable-research/>

The scientific method and threats to reproducibility



The scientific method and threats to reproducibility ⇒ failure to control for bias



Types of bias

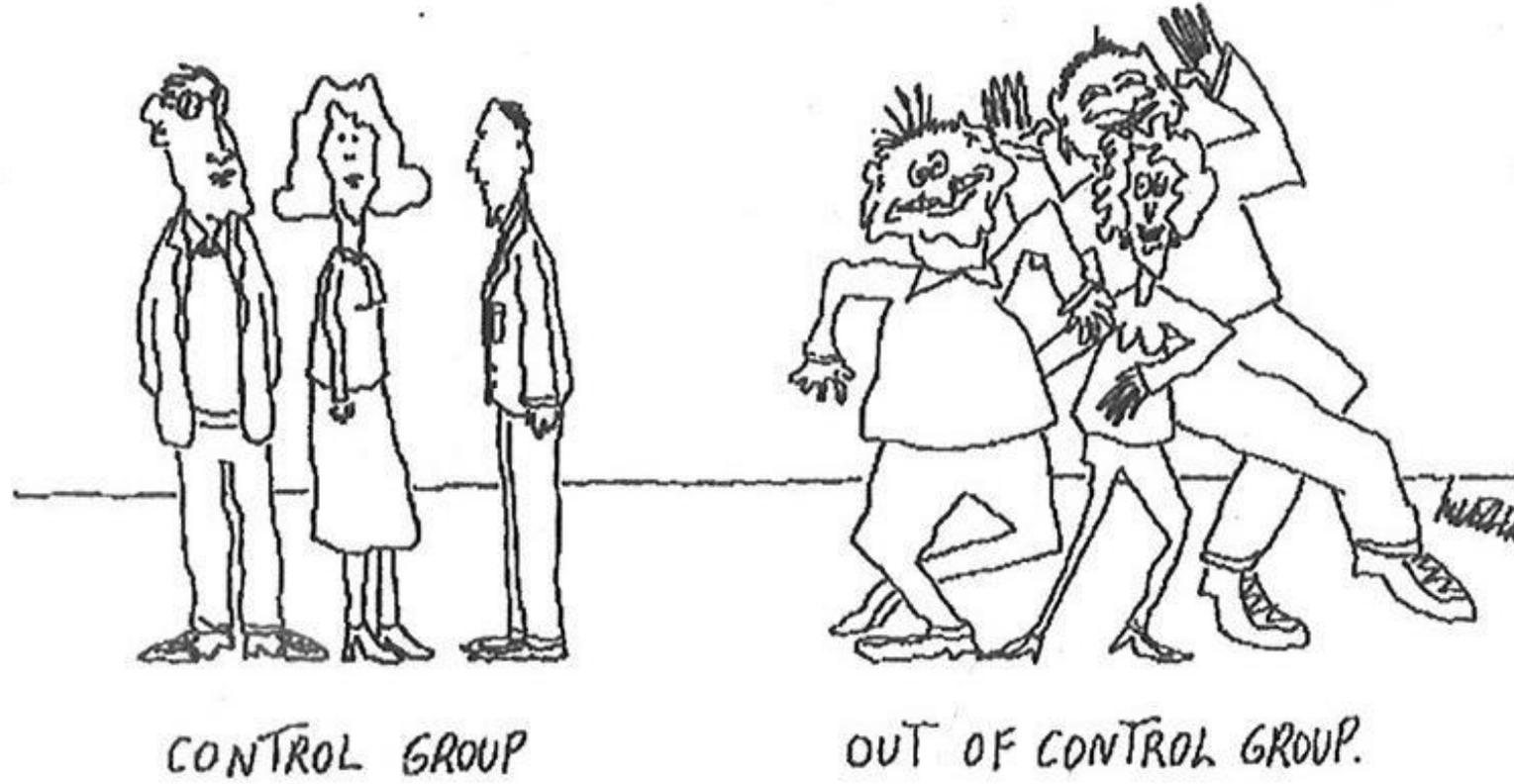
D. Sackett, Bias in Analytic Research, J Chron Dis, 1979, 32, 51-63

- 
1. In reading up on the field
 2. In specifying and selecting the study sample
 3. In executing the experimental manouevre (or exposure)
 4. In measuring exposures and outcome
 5. In analyzing the data
 6. In interpreting the analysis
 7. In publishing the results

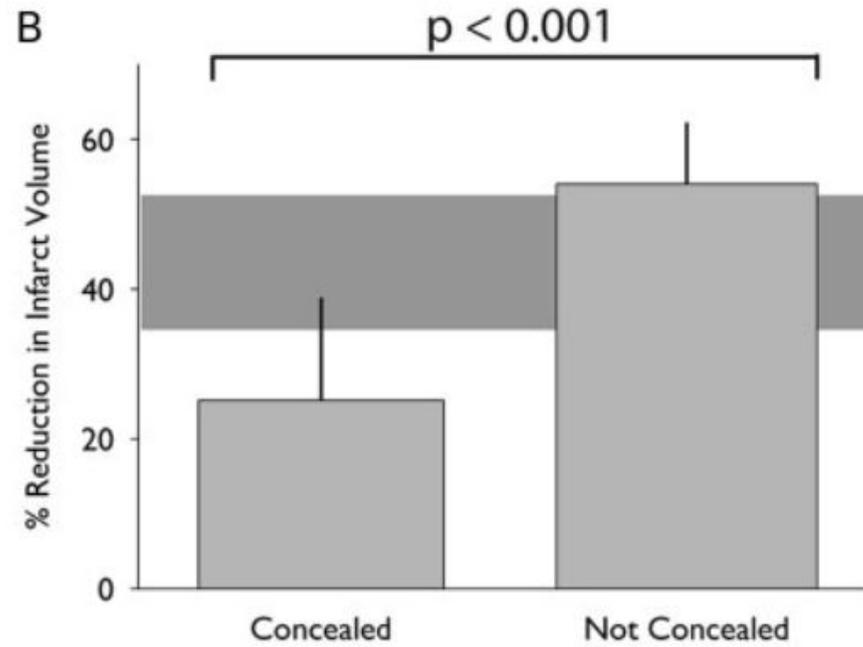
Designing studies in order to reduce bias

- Randomization: selection bias
- Predefined inclusion and exclusion criteria: execution bias
- Blinding interventions and outcome assessment: measurement bias
- Carefully choose how to measure: measurement bias

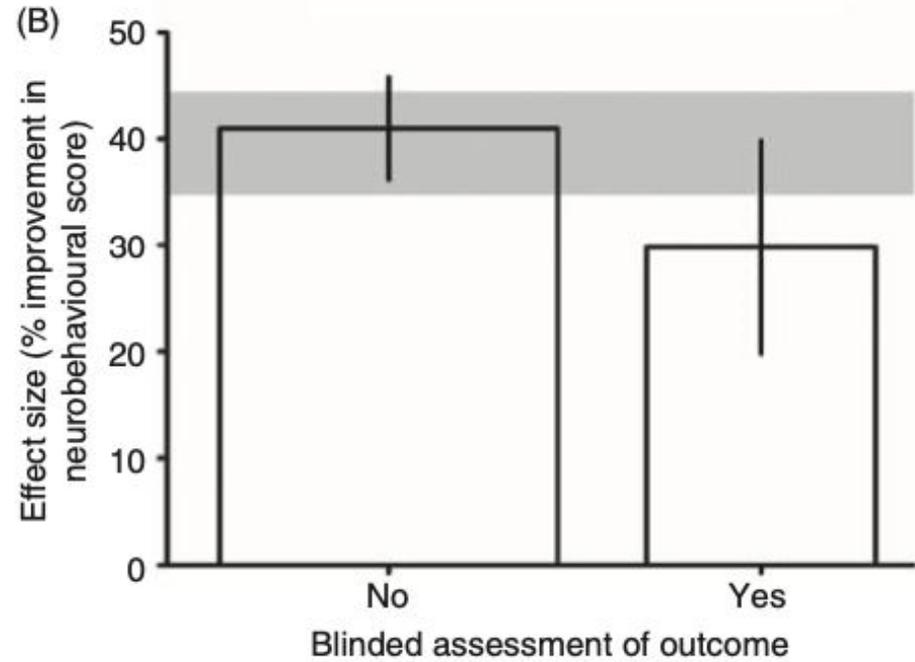
Avoid procedure selection bias by randomization



Effects of blinding



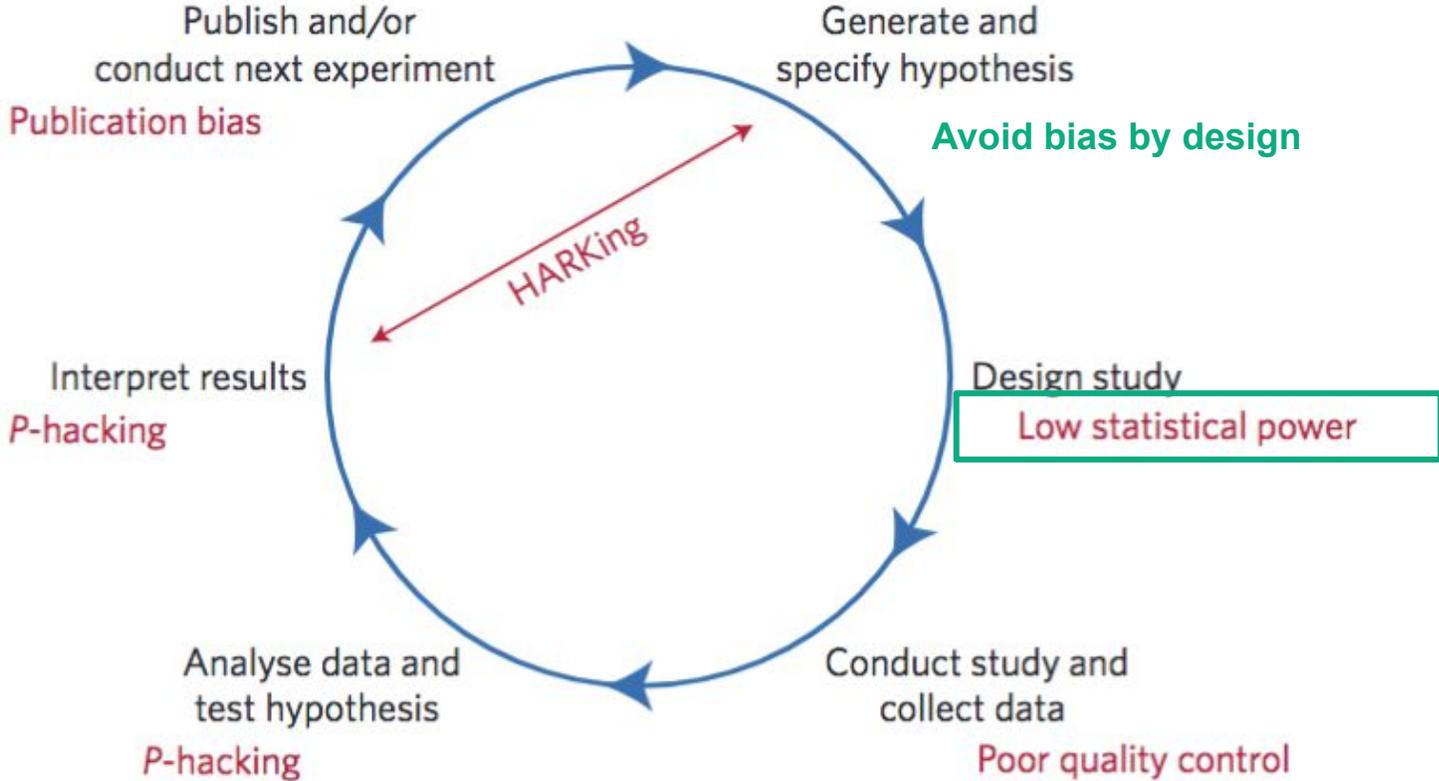
[Stroke: Link to paper](#)



[MS: Link to paper](#)

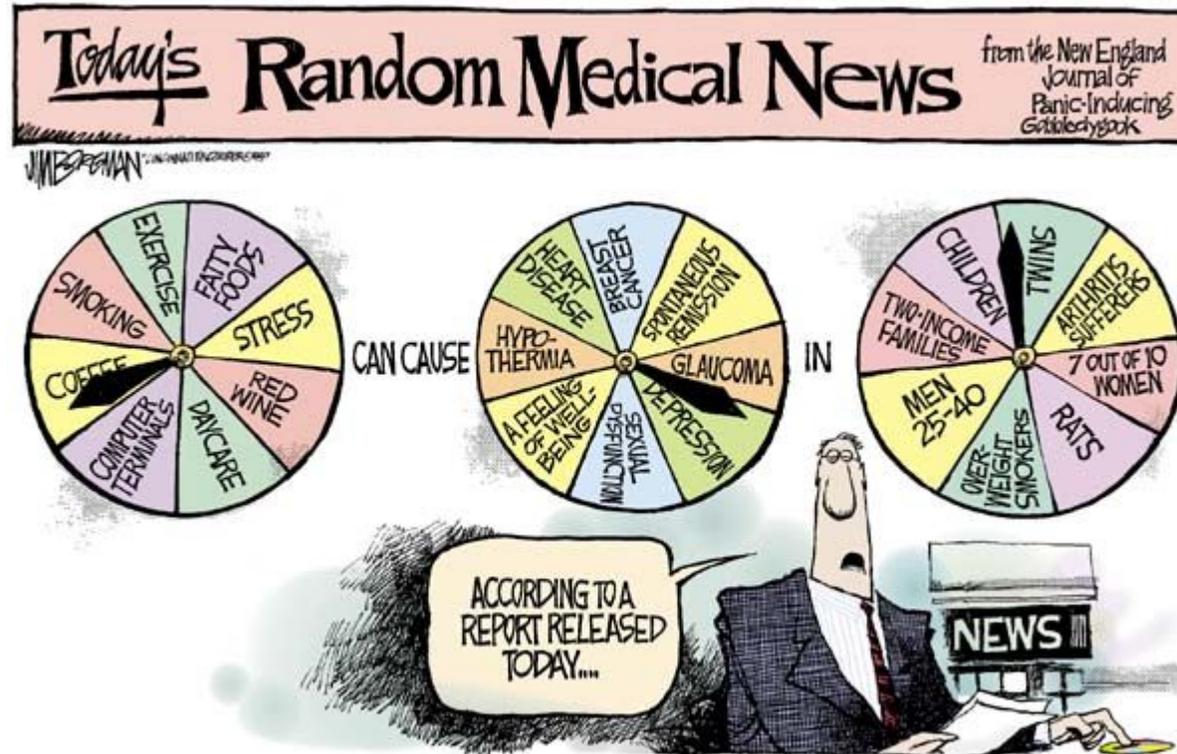
The scientific method and threats to reproducibility

⇒ low statistical power



Planning studies in order to avoid low power

How **likely** are **results** from scientific research?



Cartoon by Jim Borgman, first published by the Cincinnati Inquirer and King Features Syndicate 1997 Apr 27; Forum section: 1

Unlikely results: see the video



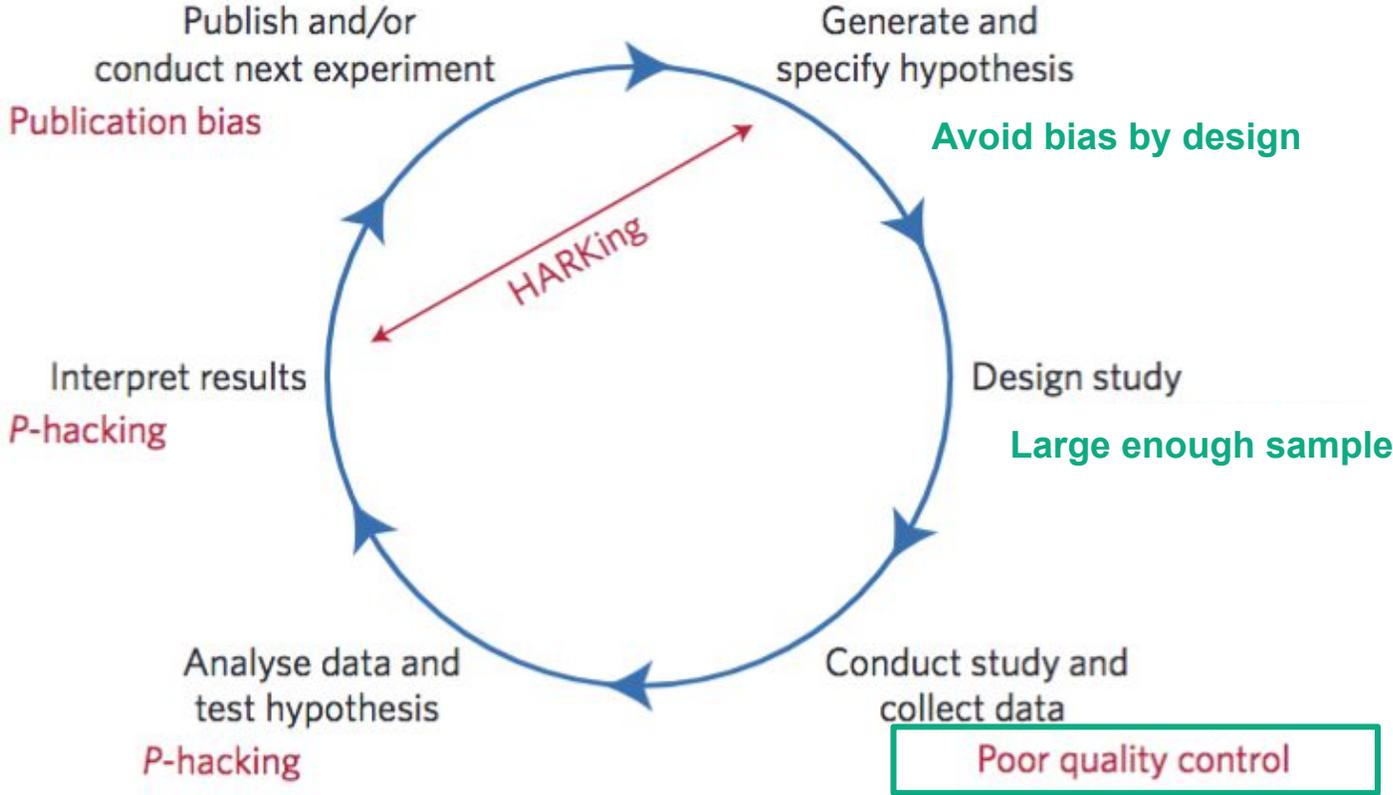
The Economist

<https://youtu.be/TosyACdsh-g>

<https://www.dailymotion.com/video/x6fbmod>

The scientific method and threats to reproducibility

⇒ **Poor quality control**



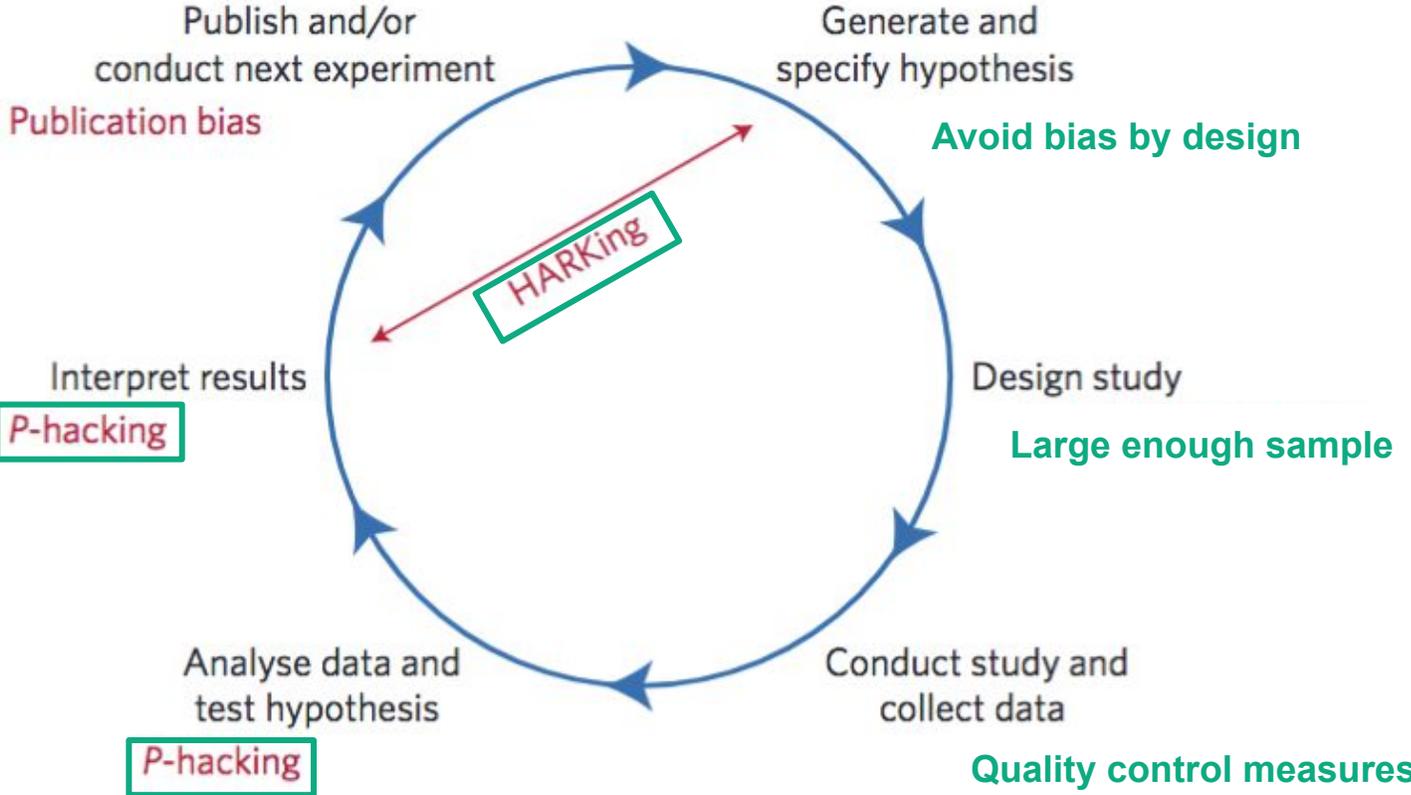
Open hypothesis through pre-registration

Measures to ensure quality control

- Use detailed experimental protocols, standardized operating procedures, and checklists
- Follow a predefined data management plan, including appropriate data recording techniques
- Use electronic lab notebook if possible with backup and collaboration possibilities
- Establish procedures for critical incident reporting

The scientific method and threats to reproducibility

⇒ P-hacking HARKing



Open hypothesis through pre-registration

Open and FAIR data

p-hacking



HARKing (hypothesizing after the results are known)



Exploratory vs. confirmatory research

Exploratory research

No hypothesis, or only vague

Generate new hypothesis from data

High sensitivity desired,
i.e. minimizing false negatives

New discoveries and finding the
unexpected

*For example: Testing of new
compounds in mice*

Confirmatory research

Clear hypothesis required

Test a priori hypothesis with new data

High specificity desired,
i.e. minimizing false positives

Strong evidence and confirming the
expected

*For example: Assessing the efficacy of a
drug in humans*

(Pre)- Registration

Time-stamped read-only research **protocol** created before the study containing as a **minimum**:

- **Hypotheses**
- Description of population, inclusion/exclusion criteria, **sample size**
- Data collection procedure or database used
- General design
- Variables (primary vs. secondary, explanatory vs. dependent variables, raw vs manipulated variables)
- Specify exactly how the key confirmatory analyses will be conducted under all probable scenarios: **Statistical Analysis Plan**

Why should you (pre)-register your study?

- Add credibility to your research
- Set a time-stamped record of your ideas
- Lets you think more deeply about your research and planning
- Helps you remember your exact a-priori hypotheses
- Can save you a lot of time
- Documents your research and your career
- Allows your study to be included in meta research projects

Clinical trials

Registration of clinical trials **has become a standard** since the late 1990. It is a scientific, ethical and moral responsibility for all trials because:

- Informed decisions are difficult under **publication bias and selective reporting**
 - ⇒ Declaration of Helsinki: "Every clinical trial must be registered [...]"
- Describing clinical trials in progress simplifies identification of research gaps
- The early identification of potential problems contributes to **improvements in the quality**

Registries (non-exhaustive list)

NIH U.S. National Library of Medicine

ClinicalTrials.gov

Registry for clinical trials since 1997

<https://clinicaltrials.gov/>



World Health Organization

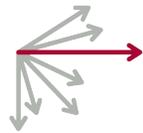
International Clinical Trials Registry Platform (ICTRP)

<https://www.who.int/ictrp/network/primary/>



Research management tool (not just for preregistration), embargo possible for up to 4 years

<https://osf.io/>



AS PREDICTED

Protocols can be private forever

<https://aspredicted.org/>

PRECLINICALTRIALS.EU

International register of preclinical trial protocols

Comprehensive listing of preclinical animal study protocols

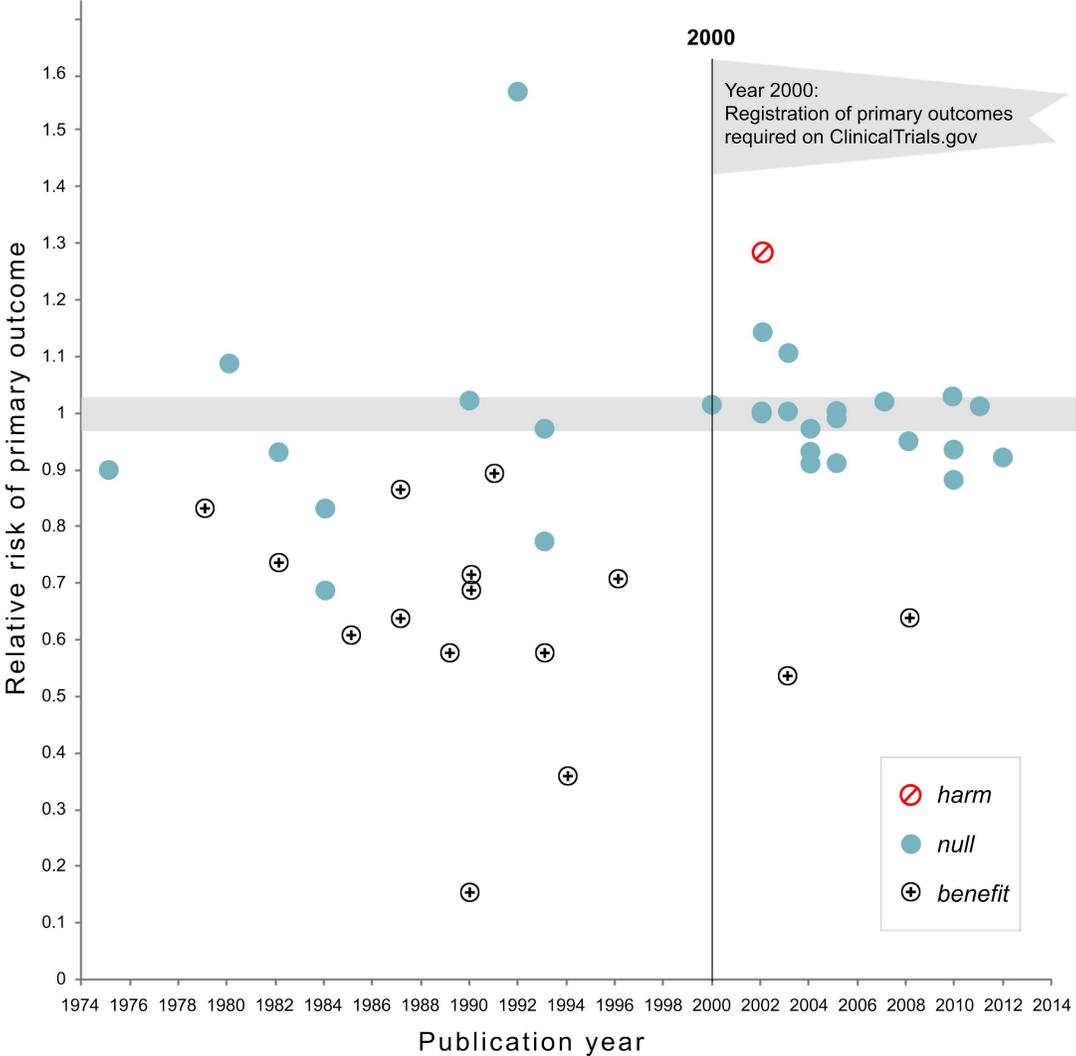
<https://preclinicaltrials.eu/>

NIHR | National Institute for Health Research

PROSPERO International prospective register of systematic reviews

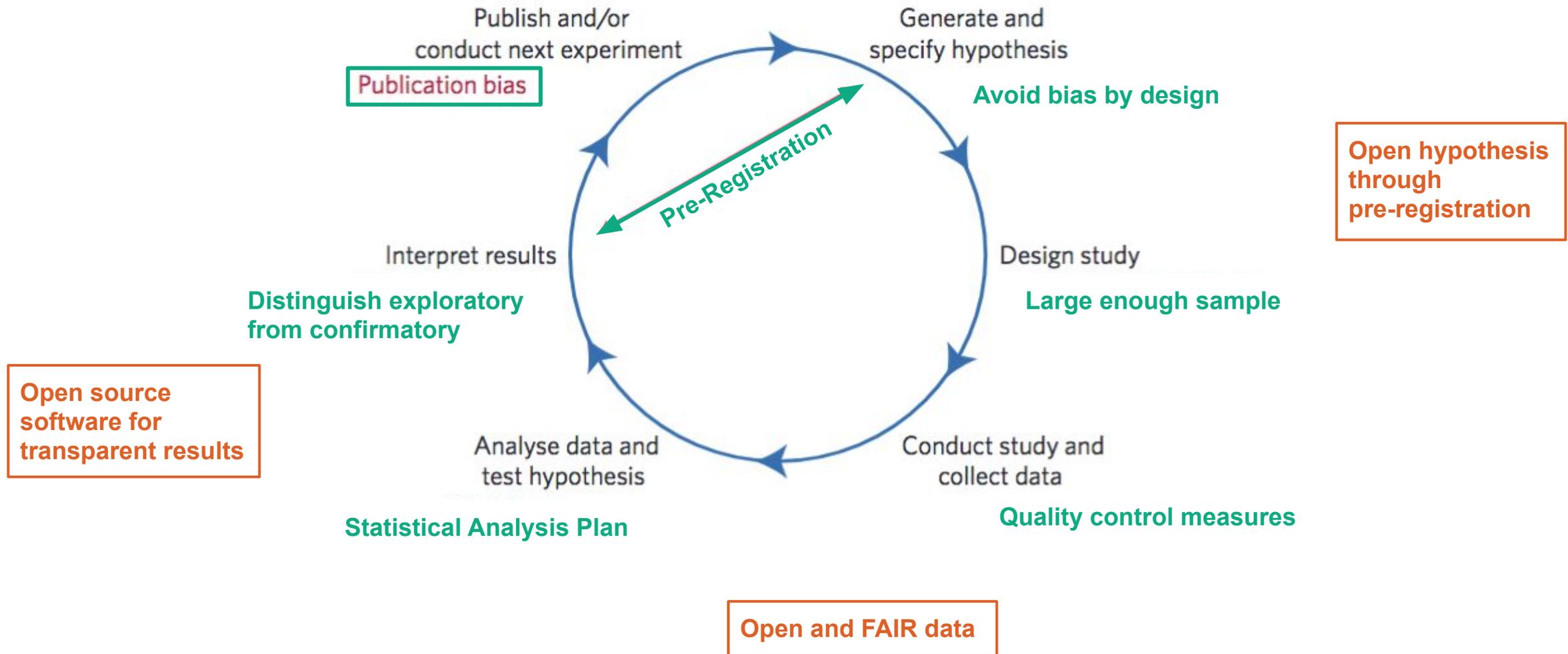
<https://www.crd.york.ac.uk/prospero/>

Registration shows an effect

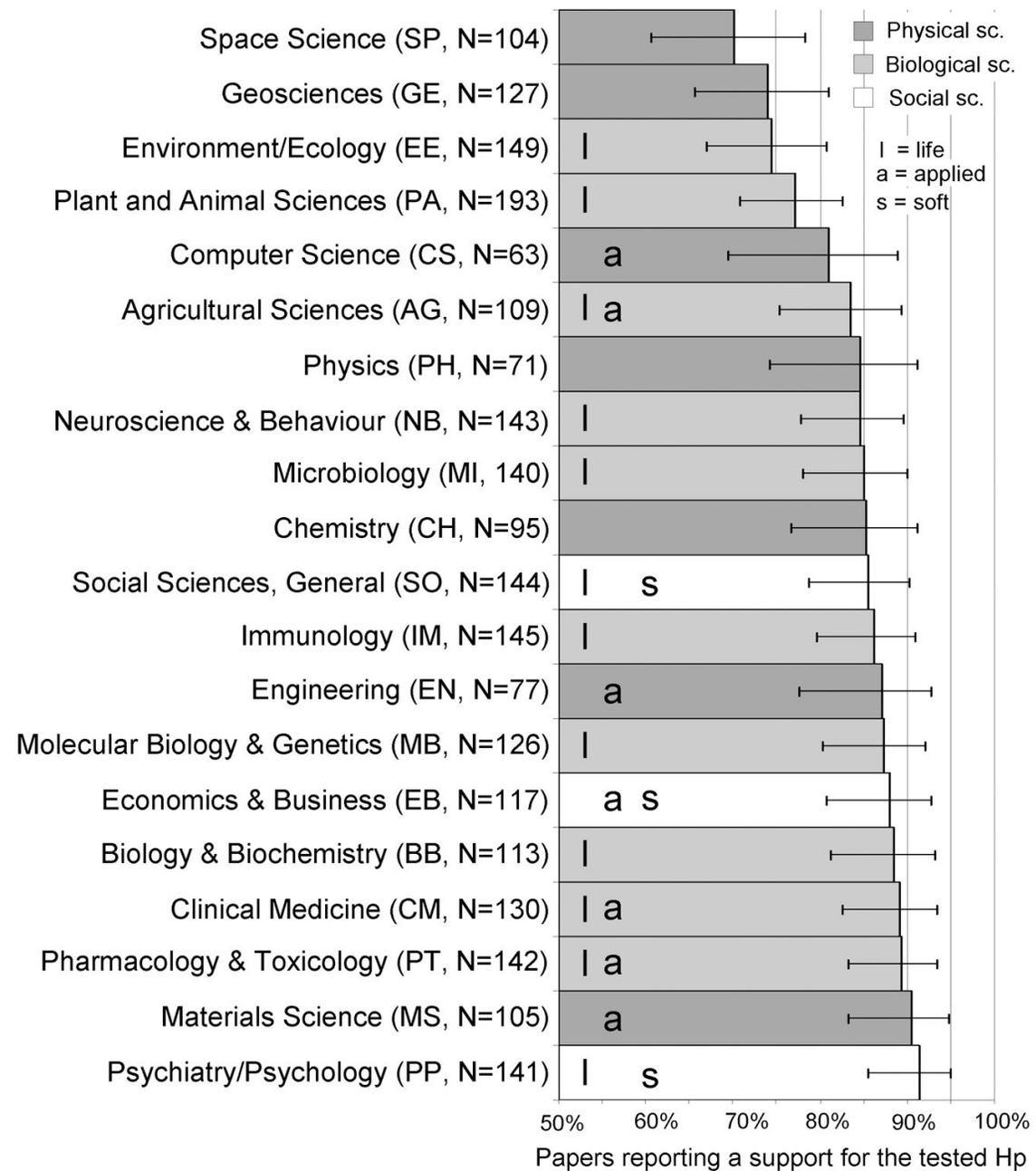


[Kaplan and Irvin, 2015, PLOS One](#)

The scientific method and threats to reproducibility



Publication Bias



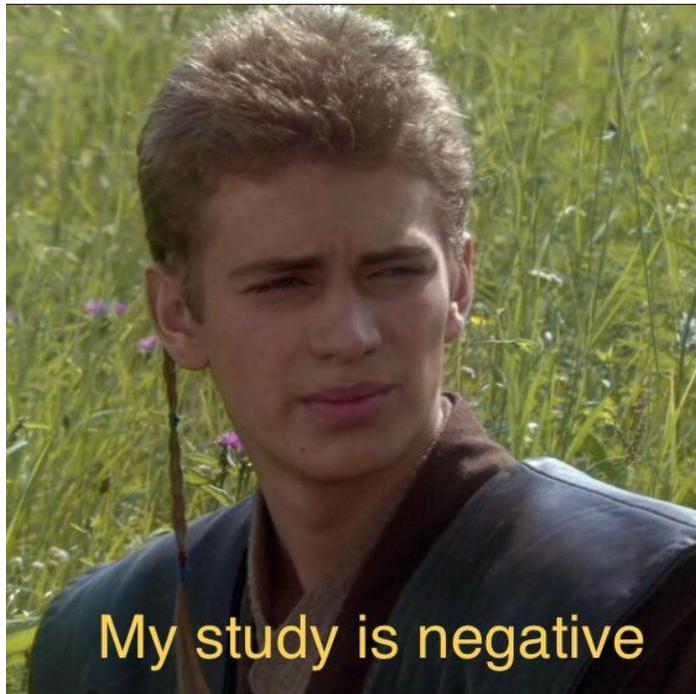
Example of publication bias

In the article “Selective Publication of Antidepressant Trials and Its Influence on Apparent Efficacy” the authors obtained reviews from the Food and Drug Administration (FDA) for studies of 12 antidepressant agents involving 12,564 patients. They conducted a systematic literature search to identify matching publications.

Among 74 FDA-registered studies 38 were considered having a positive result by the FDA and 36 a negative result. The resulting publications were:

Positive	Published	Not published	Published as positive	Total
yes	37	1		38
no	3	22	11	36

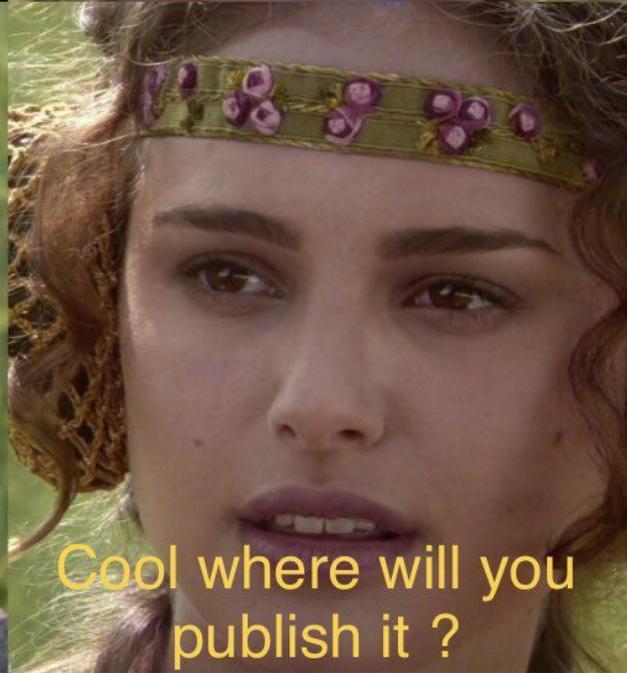
<https://www.nejm.org/doi/full/10.1056/nejmsa065779>



My study is negative



Cool where will you publish it ?



Cool where will you publish it ?

Registered reports

Two stage review

First stage

protocol with hypotheses, methods and analysis plan is reviewed
⇒ in-principle acceptance

Second stage

Authors resubmit after completion of study incorporating first-stage review recommendations, paper is quality-controlled before publication



Editorial

Registered Reports: A new publishing initiative at Cortex

Christopher D. Chambers

Cardiff University Brain Research Imaging Centre (CUBRIC), School of Psychology, Cardiff University, United Kingdom

⇒ Dozens of journals already implemented RR: *Cortex*, *BMJ Journals*, *Nature Hum Behav.*, *eNeuro*, etc., see <https://cos.io/rr/>

Reporting guidelines

- Simple, structured tool to use while writing manuscripts.
- Providing a minimum list of information needed to ensure a manuscript can be, for example:
 - understood by a reader
 - replicated by a researcher
 - used by a doctor to make a clinical decision
 - included in a systematic review
- Guiding authors in reporting a specific type of research
- Developed using explicit methodology



Examples

 Reporting guidelines for main study types		
<u>Randomised trials</u>	<u>CONSORT</u>	<u>Extensions</u>
<u>Observational studies</u>	<u>STROBE</u>	<u>Extensions</u>
<u>Systematic reviews</u>	<u>PRISMA</u>	<u>Extensions</u>
<u>Study protocols</u>	<u>SPIRIT</u>	<u>PRISMA-P</u>
<u>Diagnostic/prognostic studies</u>	<u>STARD</u>	<u>TRIPOD</u>
<u>Case reports</u>	<u>CARE</u>	<u>Extensions</u>
<u>Clinical practice guidelines</u>	<u>AGREE</u>	<u>RIGHT</u>
<u>Qualitative research</u>	<u>SRQR</u>	<u>COREQ</u>
<u>Animal pre-clinical studies</u>	<u>ARRIVE</u>	
<u>Quality improvement studies</u>	<u>SQUIRE</u>	
<u>Economic evaluations</u>	<u>CHEERS</u>	



AT THE
NATIONAL
ACADEMIES

The MDAR (Materials Design Analysis Reporting) Framework for transparent reporting in the life sciences

Malcolm Macleod^{a,1}, Andrew M. Collings^b, Chris Graf^c, Veronique Kiermer^d, David Mellor^{e,1}, Sowmya Swaminathan^f, Deborah Sweet^g, and Valda Vinson^h

<https://www.pnas.org/content/118/17/e2103238118>

<http://www.equator-network.org/reporting-guidelines/>

Examples

Journal Article Reporting Standards for Quantitative Research in Psychology: The APA Publications and Communications Board Task Force Report

Mark Appelbaum
University of California, San Diego

Harris Cooper
Duke University

Rex B. Kline
Concordia University, Montréal

Evan Mayo-Wilson
Johns Hopkins University

Arthur M. Nezu
Drexel University

Stephen M. Rao
Cleveland Clinic, Cleveland, Ohio

[American Psychologist, 73, 2018, 3-25](#)
or <https://apastyle.apa.org/jars/quantitative>

⇒ also available [qualitative](#) and [mixed methods](#)

Guidelines for reporting an fMRI study

Russell A. Poldrack,^{a,*} Paul C. Fletcher,^b Richard N. Henson,^c Keith J. Worsley,^d Matthew Brett,^c and Thomas E. Nichols^e

^aDepartment of Psychology, Department of Psychiatry and Biobehavioral Sciences, and Brain Research Institute, University of California Los Angeles, Los Angeles, CA 90095, USA

^bBrain Mapping Unit, Department of Psychiatry, University of Cambridge, Cambridge, UK

^cMRC Cognition and Brain Sciences Unit, Cambridge, UK

^dDepartment of Mathematics and Statistics, McGill University, Montreal, Québec, Canada H3A 2K6

^eGlaxoSmithKline Clinical Imaging Centre, London, UK

Received 25 July 2007; revised 9 October 2007; accepted 1 November 2007

Available online 8 December 2007

[NeuroImage, 40, 2008, Pages 409-414](#)



OPEN

Guidelines for clinical trial protocols for interventions involving artificial intelligence: the SPIRIT-AI extension

Samantha Cruz Rivera^{1,2,3}, Xiaoxuan Liu^{3,4,5,6,7}, An-Wen Chan⁸, Alastair K. Denniston^{1,3,4,5,6,9}, Melanie J. Calvert^{1,2,3,4,10,11,12}, The SPIRIT-AI and CONSORT-AI Working Group^{*}, SPIRIT-AI and CONSORT-AI Steering Group and SPIRIT-AI and CONSORT-AI Consensus Group

[Nat Med 26, 1351–1363, 2020](#)

Wizard of Oz Studies in HRI: A Systematic Review and New Reporting Guidelines

Laurel D. Riek

University of Notre Dame

[Journal of Human-Robot Interaction, 1, 2012, 119-136](#)

Examples

New Author Guidelines for Displaying Data and Reporting Data Analysis and Statistical Methods in Experimental Biology

 Martin C. Michel, T.J. Murphy, and  Harvey J. Motulsky

Department of Pharmacology, Johannes Gutenberg University, Mainz, Germany (M.C.M.); Partnership for the Assessment and Accreditation of Scientific Practice, Heidelberg, Germany (M.C.M.); Department of Pharmacology and Chemical Biology, Emory University, Atlanta, Georgia (T.J.M.); and GraphPad Software, Los Angeles, California (H.J.M.)

Received November 22, 2019; accepted November 22, 2019

[Drug Metab Dispos 48:64–74, January 2020](#)

Toward Good *In Vitro* Reporting Standards

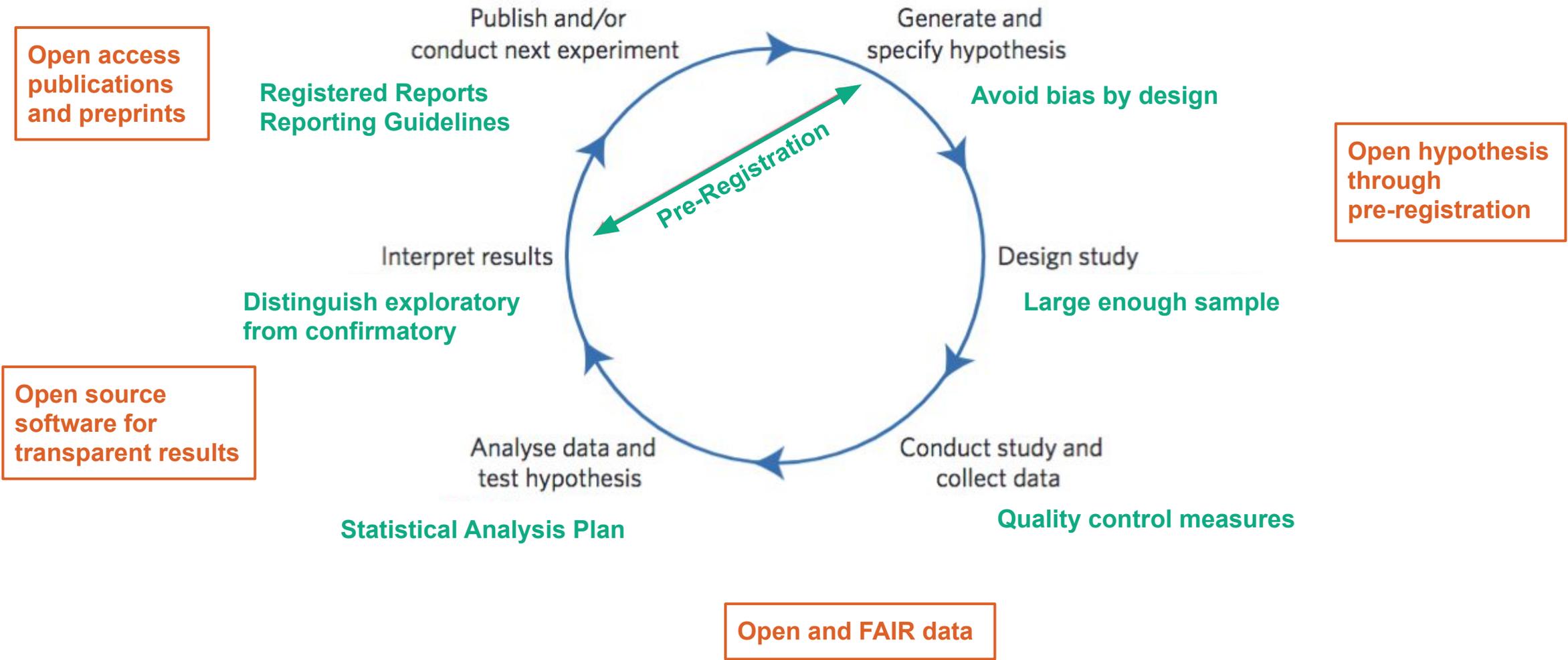
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