Reproducible Science
Origins & Definitions

Cyril Pernet
Melanie Ganz
Robert Oostenveld

Rules of engagement

- you can stop me anytime to ask questions
- whenever a gray rectangle appears, an activity/answer is needed, often in small groups (say 3 people)
- group yourselves now

Question box

Essay

Why Most Published Research Findings Are False

John P. A. Ioannidis

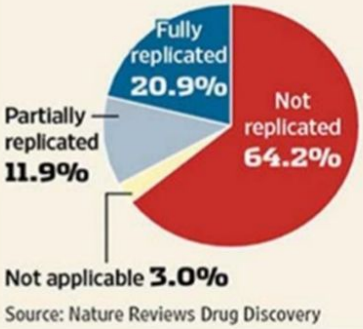
2005. PLoS Medicine, 2(8), e124. doi: 10.1371/journal.pmed.0020124

"There is increasing concern about the reliability of biomedical research, with recent articles suggesting that up to 85% of research funding is wasted."

Bustin, S. A. (2015). The reproducibility of biomedical research: Sleepers awake! *Biomolecular Detection and Quantification*

No Cure

When Bayer tried to replicate results of 67 studies published in academic journals, nearly two-thirds failed.



Source: Nature Reviews Drug Discovery

THE LANCET

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Research: increasing value, reducing waste

Published: January 8, 2014

nature International weekly journal of science

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News & Comment > News > 2015 > May > Article

NATURE | NEWS

First results from psychology's largest reproducibility test

Bishop (2016) https://t.co/b2Au8I4Eus

The scientific truth

A scientific theory is based on testing hypotheses, i.e. predictions.

Testing of hypotheses is done via experiments following the scientific method.

Where can lack of reproducibility happen in this ‘cycle’ ? and why it matters if one wants to get to the (current) truth

Implications can be huge (practically and financially)

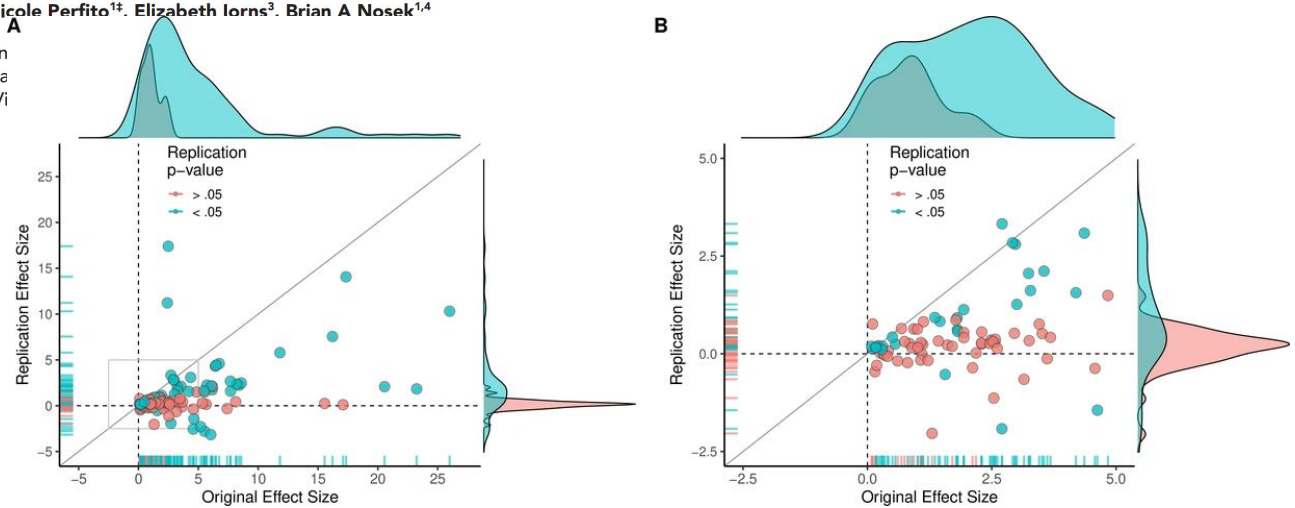
eLife

50 experiments from 23 papers, 158 effects
the median effect size in the replications was 85% smaller
For positive effects, 40% of replications (39/97)
For null effects 80% of replications (12/15)

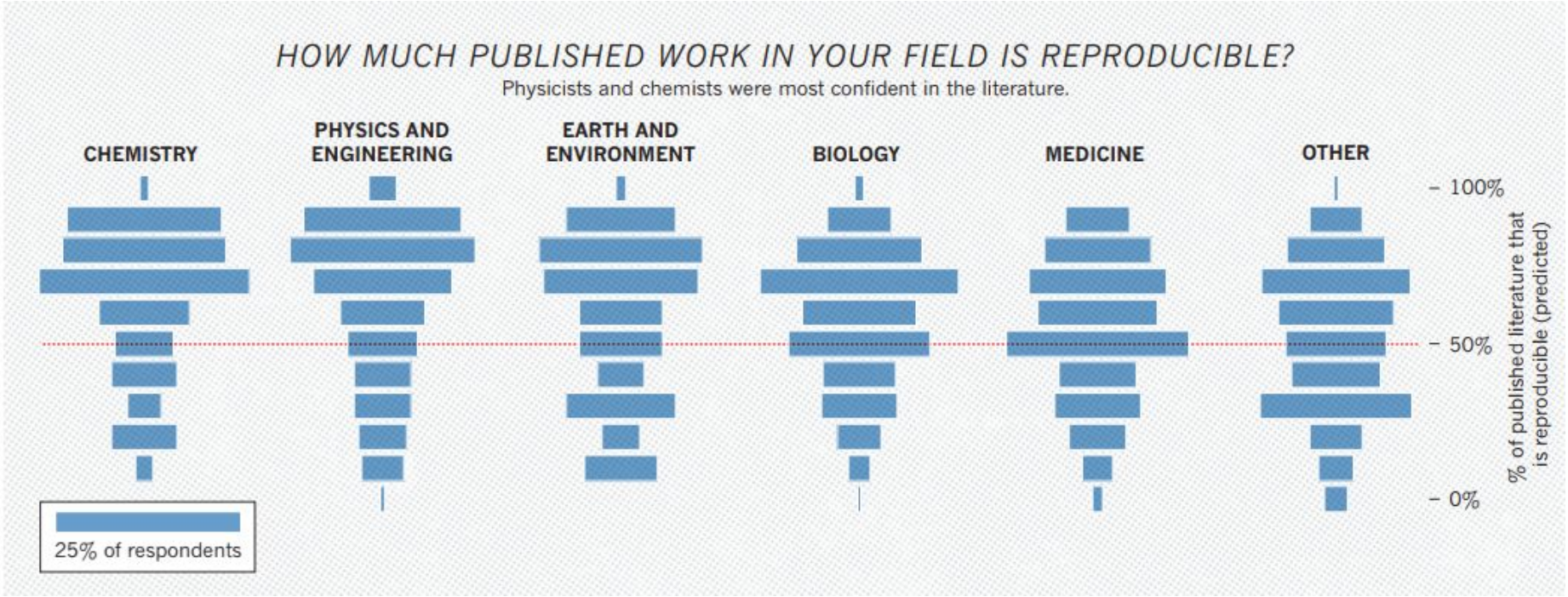
Investigating the replicability of preclinical cancer biology

Timothy M Errington[1]*, Maya Mathur[2], Courtney K Soderberg[1], Alexandria Denis[1†], Nicole Perfito[1‡], Elizabeth Iorns[3], Brian A Nosek[1,4]

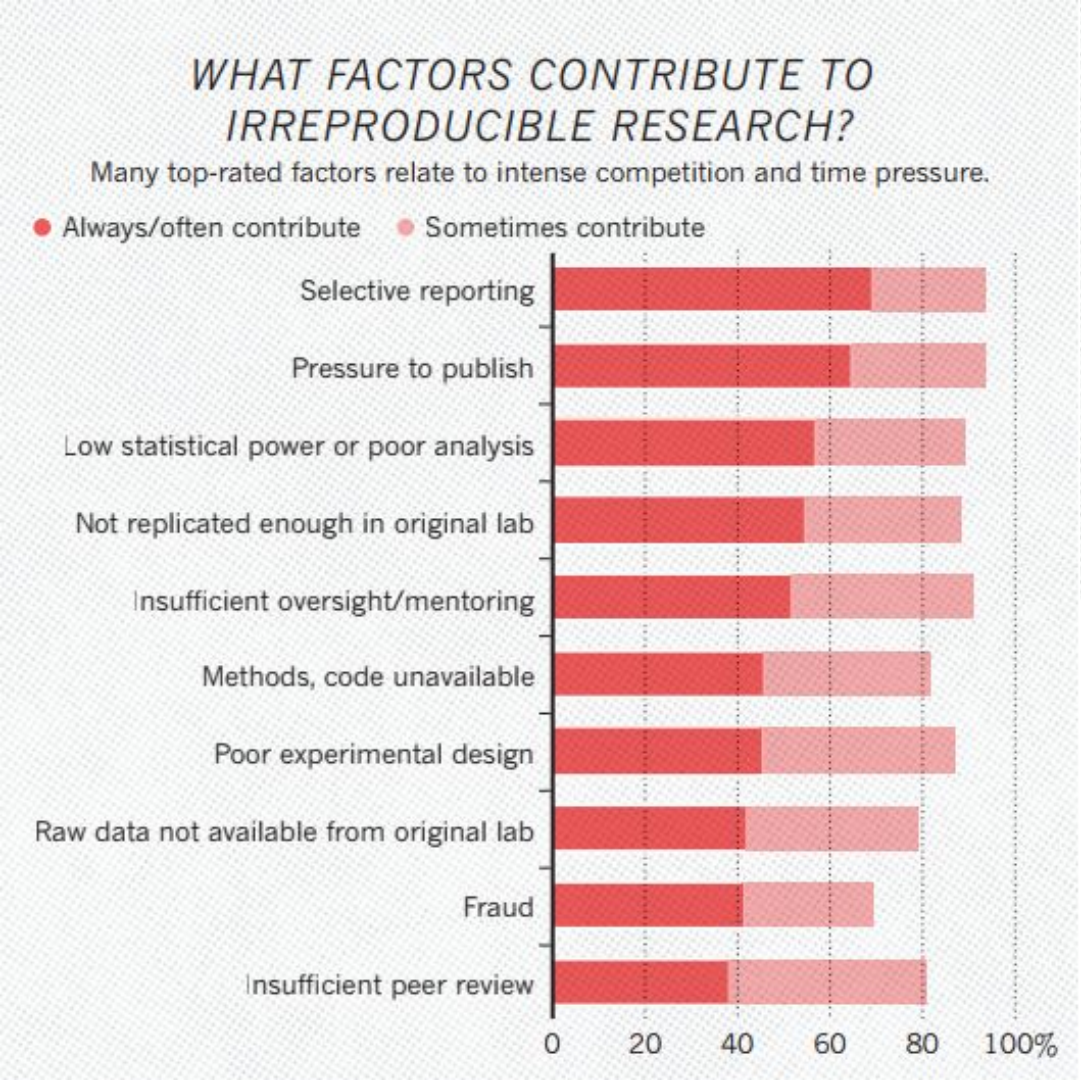
[1]Center for Open Scien
Stanford University, Sta
States; [4]University of Vi

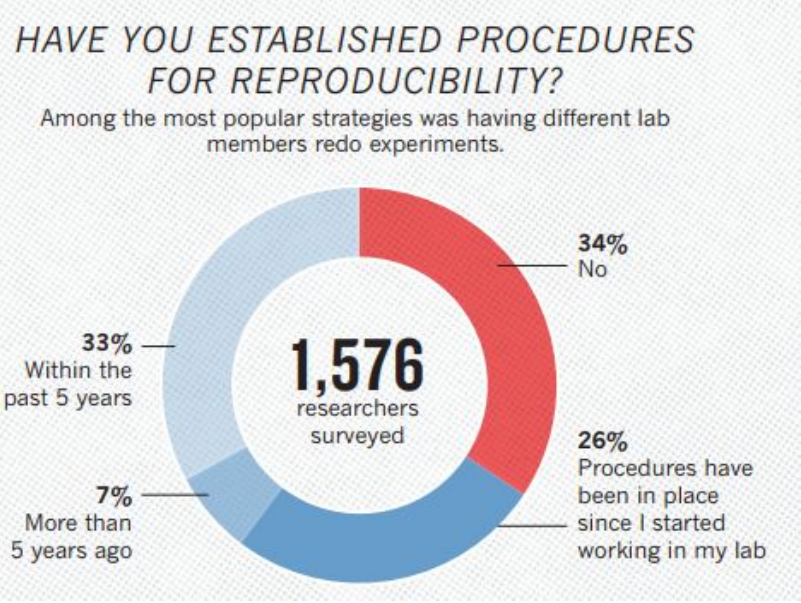


Nature survey 2016. N = 1500



https://www.nature.com/articles/533452a





Learning about organizing your data, sharing data, good code practices, code sharing, computational reproducibility, and few stats tricks will greatly enhance the reproducibility of your work.

What can we not redo?

- There is a problem in science, research is not **repeatable**, **replicable**, **reproducible**, **generalizable**.

Are those terms interchangeable?
What are your definitions?
- 5 minutes brain storming -

Reproducibility, repeatability and replicability

- Repeatability: repeat evaluations under identical conditions (can you re-run your own analysis?)
- Reproducibility: re-compute the same things (is your research transparent so that someone can re-do your analysis?)
- Replicability: achieve consistent results (using a new sample can we obtain the same results?)
- Statistical analyses aim at statistical generalizability: inferring from a sample to a target population.
- Scientific generalizability, on the other hand, refers to applying a model based on a particular target population to other populations.

Kenett & Shmueli (2015). Nature Methods 12

Reproducibility (again)

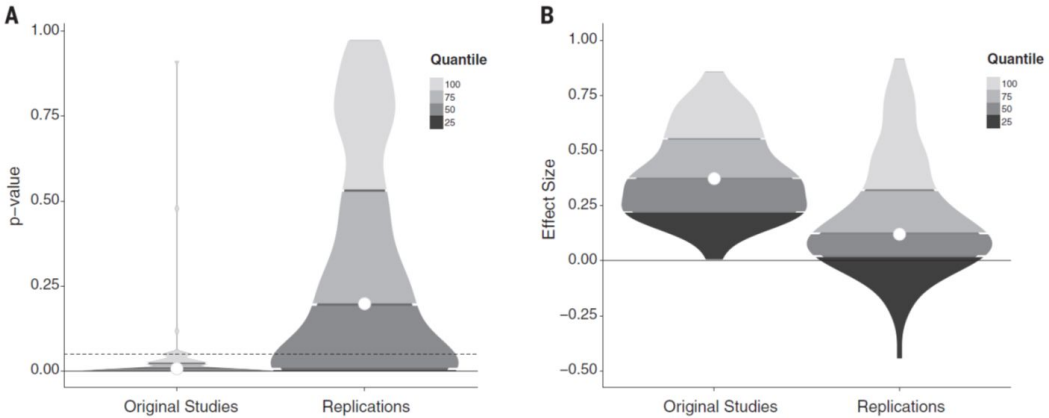
- Reproducibility gives credibility to a result while replicability increases evidential weight.
- With *Method reproducibility*, we need to ensure that someone else can redo the same (=sharing data and code), while with *result reproducibility (i.e. replicability),* we want the same results from different data. In this case, only equivalence of effect sizes matter and not binary results (significant or not) really matter. *Inferential reproducibility* refers to conclusions obtained vis-à-vis a hypothesis of interest and is best obtained by using cumulative evidence.

Goodman, Fanelli & Ioannidis (2016). Science Translational Medicine 8

Why focus on effect sizes?

PSYCHOLOGY

Estimating the reproducibility of psychological science

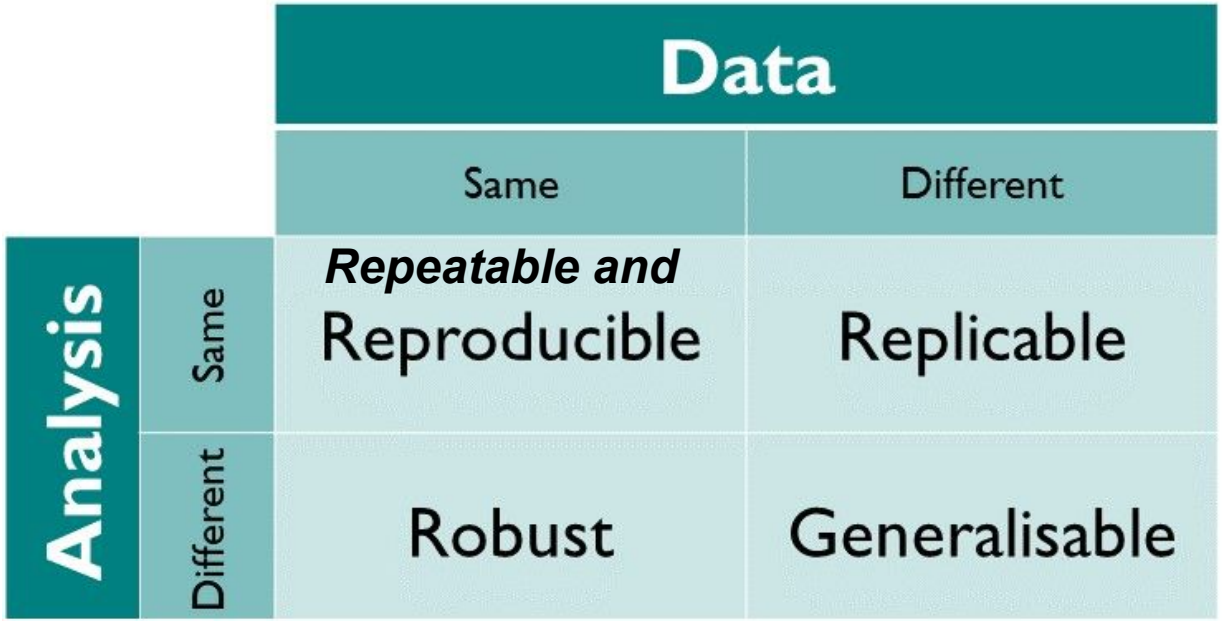


Most of research is evaluated using null hypothesis significance testing, i.e. P(data|null). When there is no effect, p-values are uniformly distributed so we expect to publish false positives!

Focusing on effect size, i.e. quantifying effect allows focusing prediction of quantities allowing building models. → check the p_value folder in the github repo

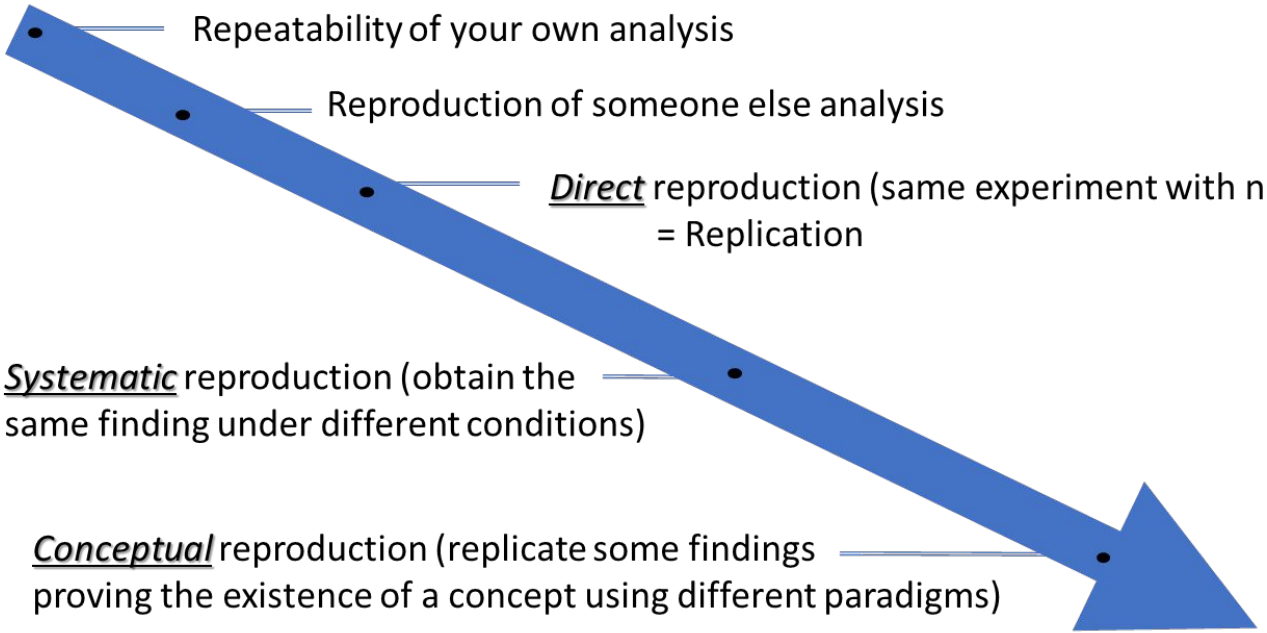
https://www.science.org/doi/10.1126/science.aac4716

More definitions: the Turing Way



The Turing Way: A Handbook for Reproducible Data Science (Version v0.0.4). Zenodo.
http://doi.org/10.5281/zenodo.3233986
https://the-turing-way.netlify.app/reproducible-research/overview/overview-definitions.html

Reproduction as a continuum



Pernet & Poline (2014). G*igaScience 4-15*

Markowetz *Genome Biology* (2015) 16:274
DOI 10.1186/s13059-015-0850-7

Genome Biology

COMMENT Open Access

Five selfish reasons to work reproducibly

Florian Markowetz

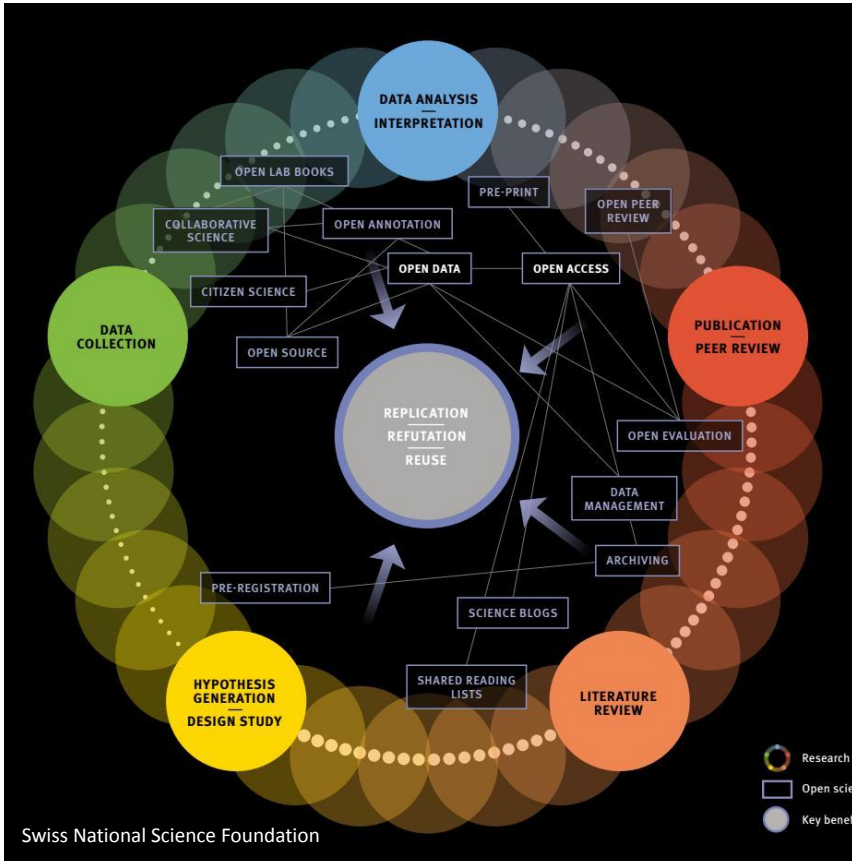
1. helps to avoid disaster (publish spurious result, cannot repeat your experiment)
2. makes it easier to write papers (redo an analysis, get someone else to check and do things)
3. helps reviewers see it your way (understand your fancy new analysis)
4. enables continuity of your work (pick-up work and redo - improve)
5. helps to build your reputation (citation advantage https://doi.org/10.1371/journal.pone.0230416)

A word on replicating studies and analyses

- ‘No isolated experiment, however significant in itself, can suffice for the experimental demonstration of any natural phenomenon' (Fisher, 1960)
- If a study hasn’t been replicated, nothing warranties results are true – replication allows saving time and money in the long run.
- ‘A means for acquainting yourself with the methods used in a study, the original author's line of thinking, the complications he or she must have faced, and the solutions they devised to those problems’ (Gary King, Harvard univ.)

Open Science

What is open science ?



Open science is the movement to make **scientific research, data and dissemination** accessible to all levels of an inquiring society, amateur or professional. https://en.wikipedia.org/wiki/Open_science

Open publication
Open evaluation

arXiv
bioRxiv beta
OPEN ACCESS

Open hypothesis-design
= pre-registration

OpenTrials
All the Data, on All the Trials, Linked
Open Science Framework

Journals !

Open data
- Data sharing
- Code sharing

GitHub

NLSP
OpenNEURO
DRYAD

Data Sharing

“Experience has shown the advantage of occasionally rediscussing statistical conclusions, by starting from the same documents as their author. I have begun to think that no one ought to publish biometric results, without lodging a well arranged and well bound manuscript copy of all his data, in some place where it should be accessible, under reasonable restrictions, to those who desire to verify his work.”

Galton Biometry. Biometrika. 1901;1(1):7–10.

What is open data useful for?

Code Sharing

Behavioral Ecology and Sociobiology (2021) 75: 103
https://doi.org/10.1007/s00265-021-03036-x

EDITORIAL

Why sharing data and code during peer review can enhance behavioral ecology research

Esteban Fernández-Juricic[1]

What is code sharing useful for?

For the rest of the course …

nature human behaviour

PERSPECTIVE

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OPEN

A manifesto for reproducible science

Marcus R. Munafò[1,2*], Brian A. Nosek[3,4], Dorothy V. M. Bishop[5], Katherine S. Button[6], Christopher D. Chambers[7], Nathalie Percie du Sert[8], Uri Simonsohn[9], Eric-Jan Wagenmakers[10], Jennifer J. Ware[11] and John P. A. Ioannidis[12,13,14]

Improving the reliability and efficiency of scientific research will increase the credibility of the published scientific literature and accelerate discovery. Here we argue for the adoption of measures to optimize key elements of the scientific process: methods, reporting and dissemination, reproducibility, evaluation and incentives. There is some evidence from both simulations and empirical studies supporting the likely effectiveness of these measures, but their broad adoption by researchers, institutions, funders and journals will require iterative evaluation and improvement. We discuss the goals of these measures, and how they can be implemented, in the hope that this will facilitate action toward improving the transparency, reproducibility and efficiency of scientific research.

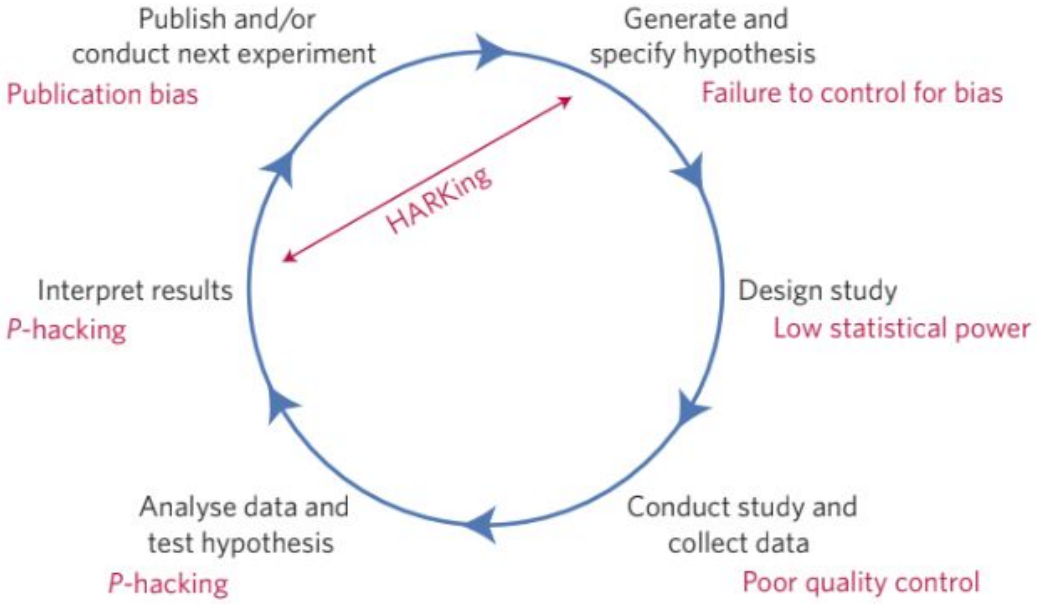

Figure 1 | Threats to reproducible science. An idealized version of the hypothetico-deductive model of the scientific method is shown. Various potential threats to this model exist (indicated in red), including lack of replication[5], hypothesizing after the results are known (HARKing)[7], poor study design, low statistical power[2], analytical flexibility[51], *P*-hacking[4], publication bias[3] and lack of data sharing[6]. Together these will serve to undermine the robustness of published research, and may also impact on the ability of science to self-correct.

The various lectures and tools and exercises aim at providing you with the conceptual and practical tools to make more reproducible science and therefore advance science in general.