Evidence-based decision making

The scientific method(s)

Rui Mata, FS 2025

Version: Feb 17, 2025

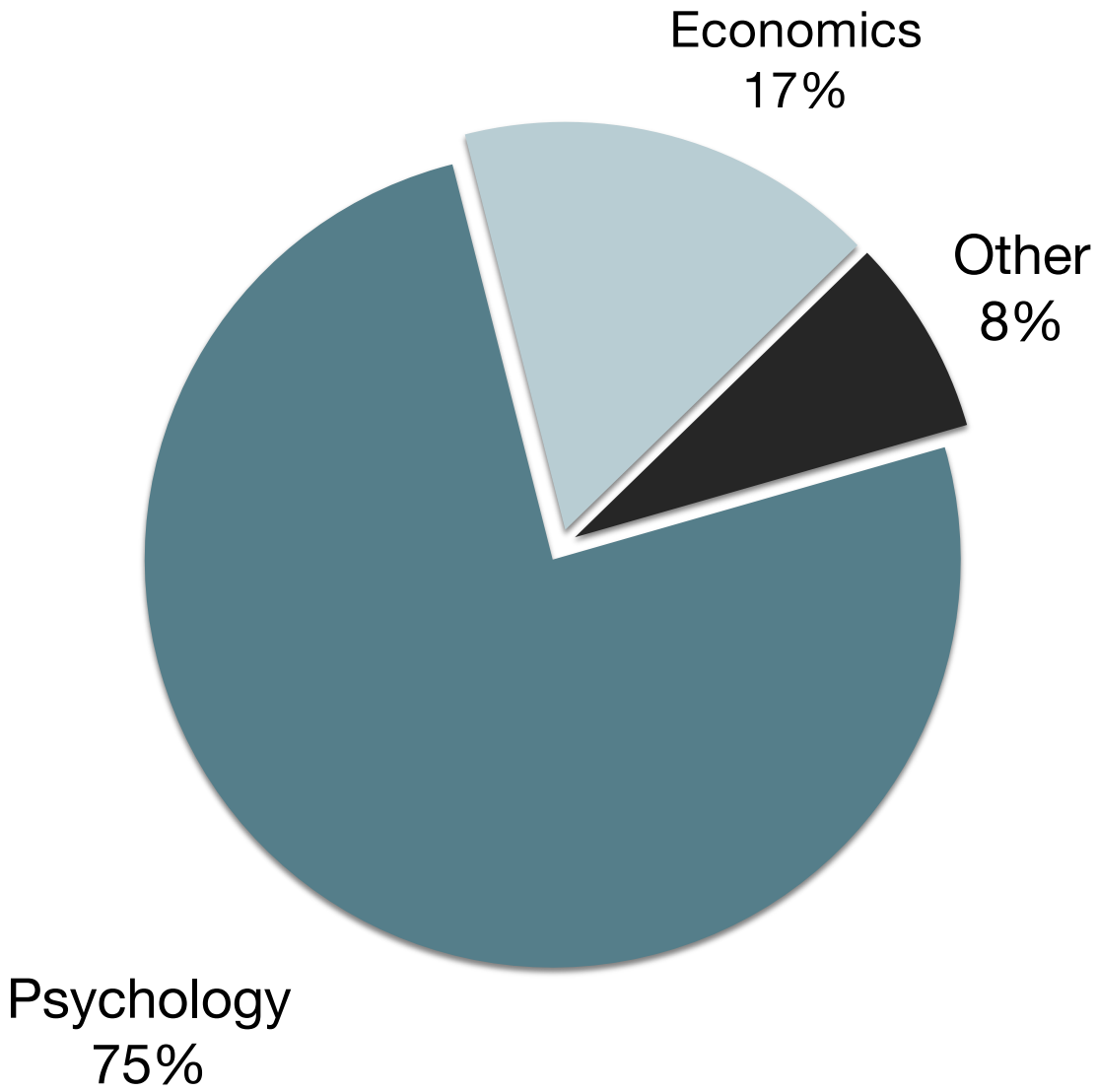
Course instructors

Loreen Tisdall

Rui Mata

http://cds.unibas.ch

You!



Goals for today

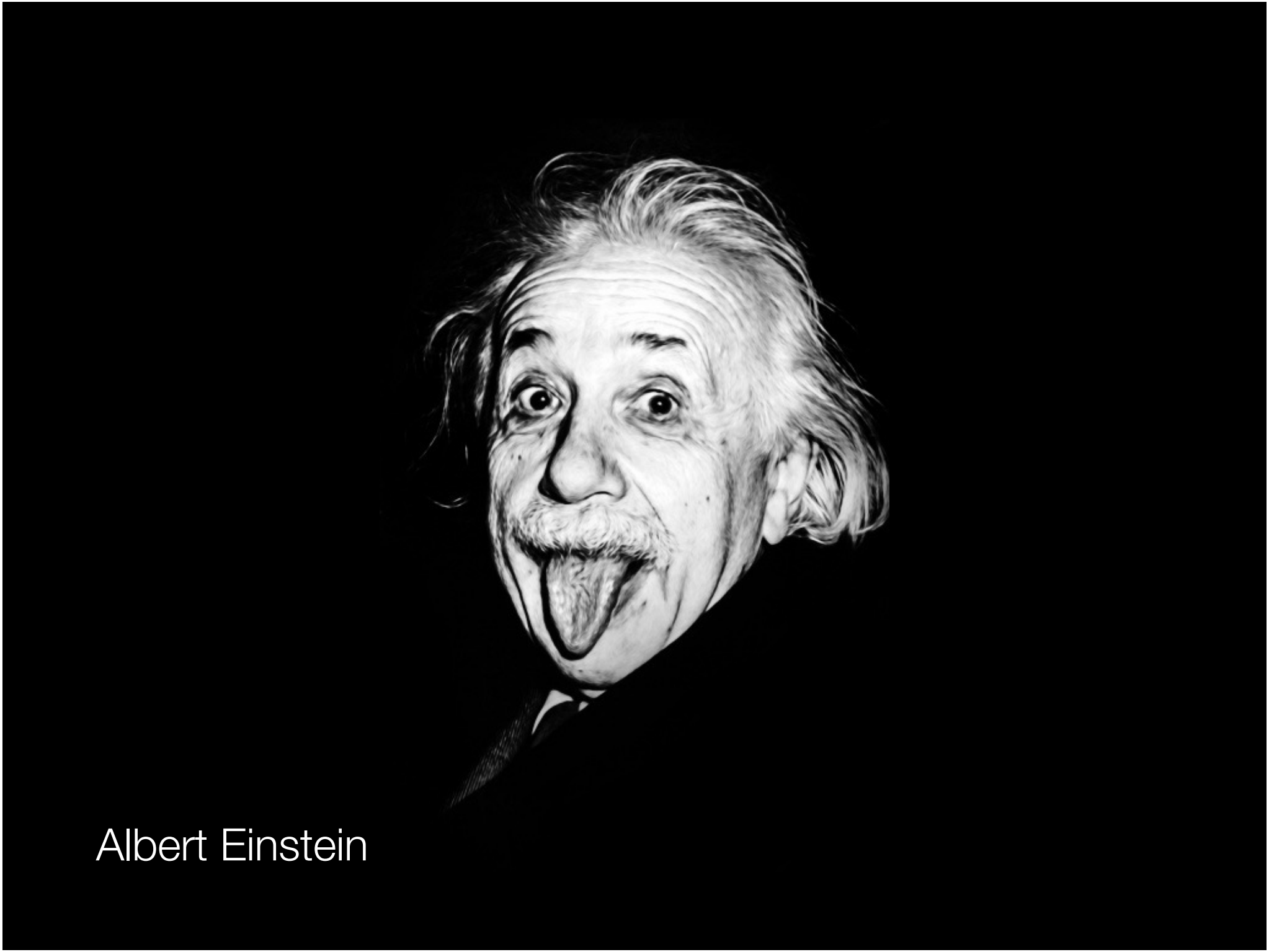
- Discuss the possible reasons why **WE** should trust science (e.g., the scientific method, scientific objectivity, scientists' ethos, the track-record of scientific research, organization of the scientific production of evidence)

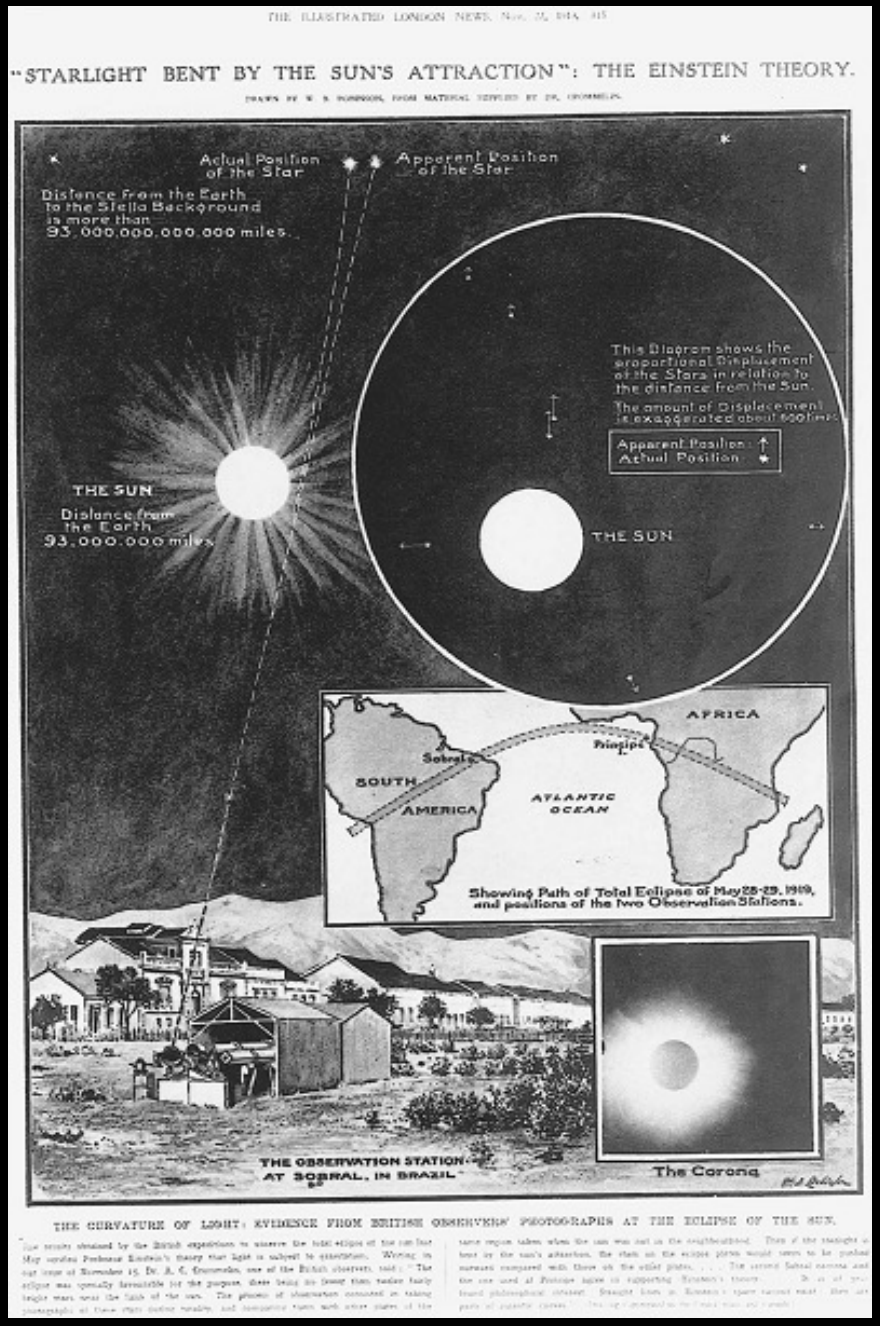
- Discuss reasons why **YOU** should care about science and evidence-based practices

- Understand the course structure and website

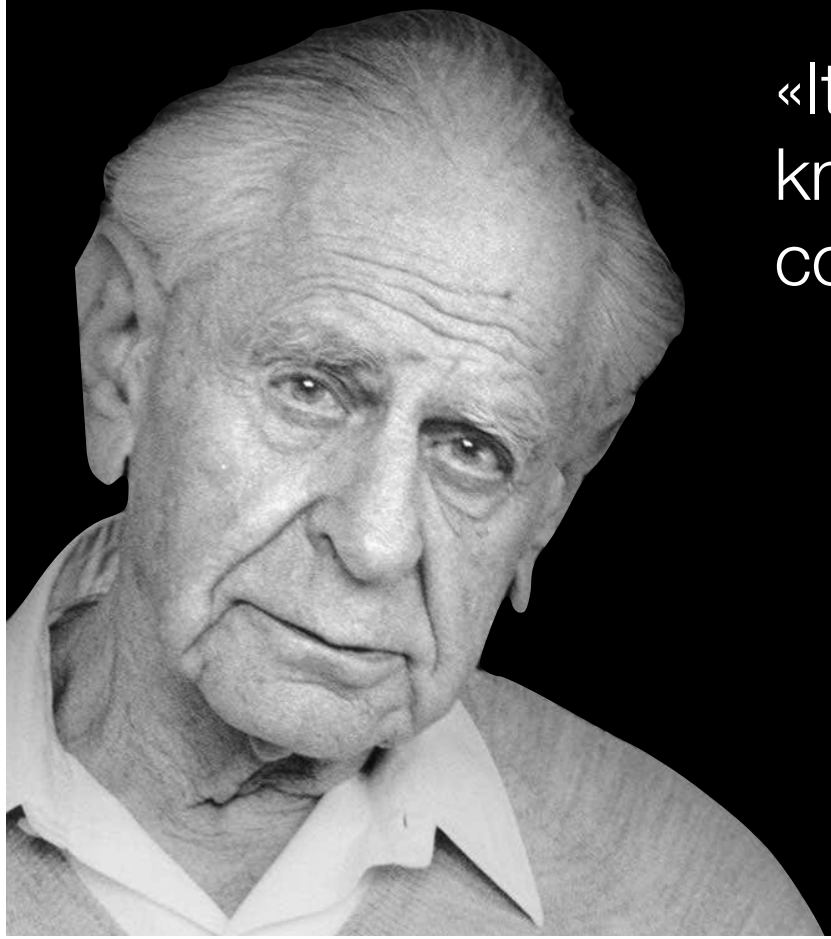
WHY TRUST SCIENCE?

the scientific **method…**


Albert Einstein

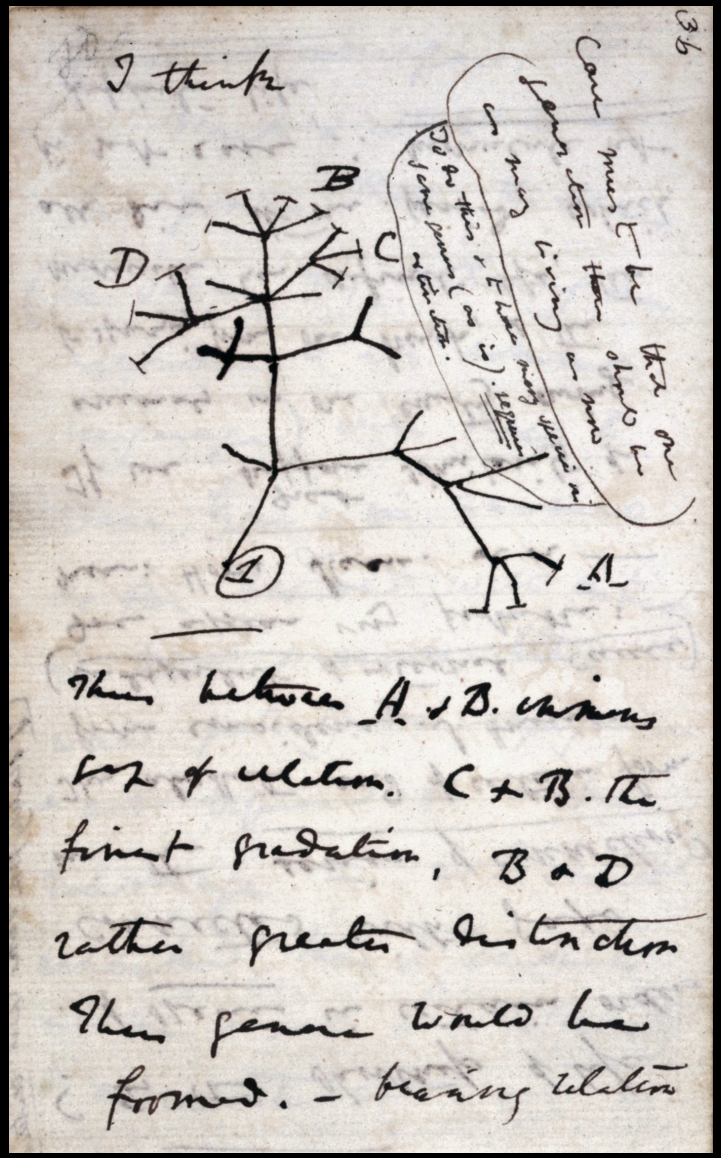


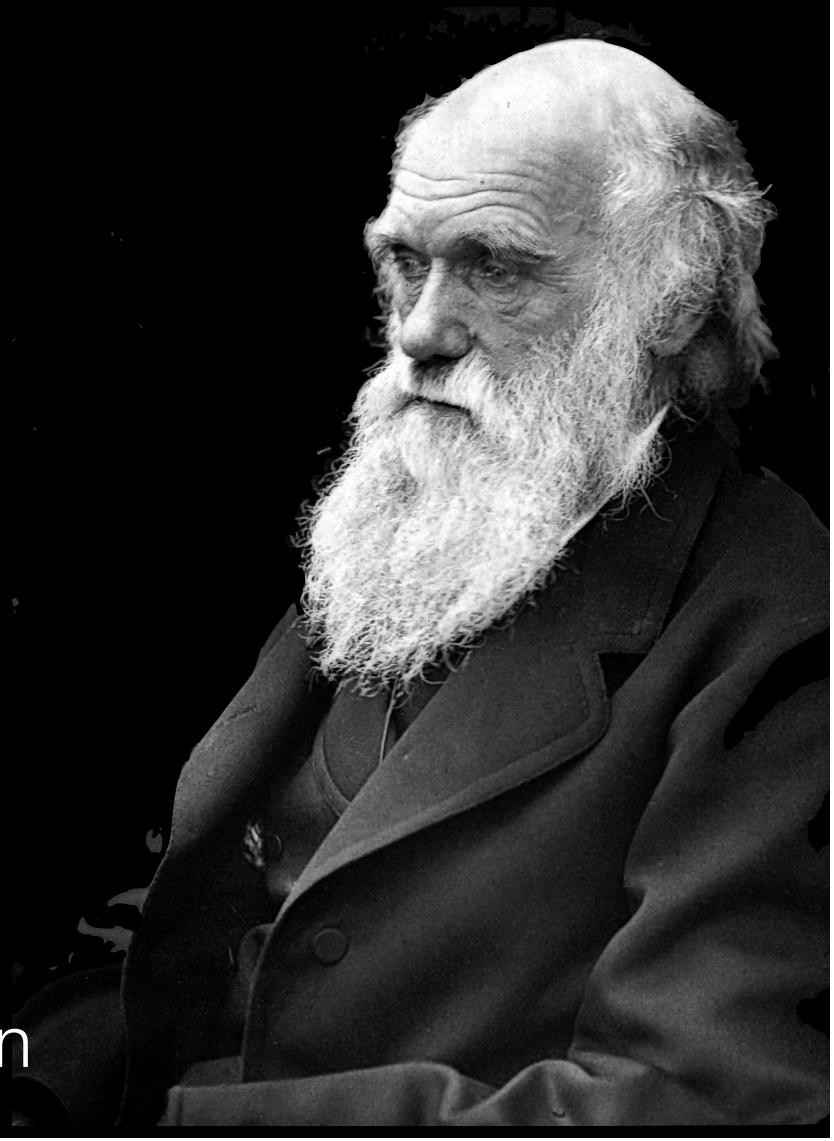
Crispino, L. C. B., & Kennefick, D. J. (2019). A hundred years of the first experimental test of general relativity. *Nature Physics, 15*(5), 416–419. http://doi.org/10.1038/s41567-019-0519-3



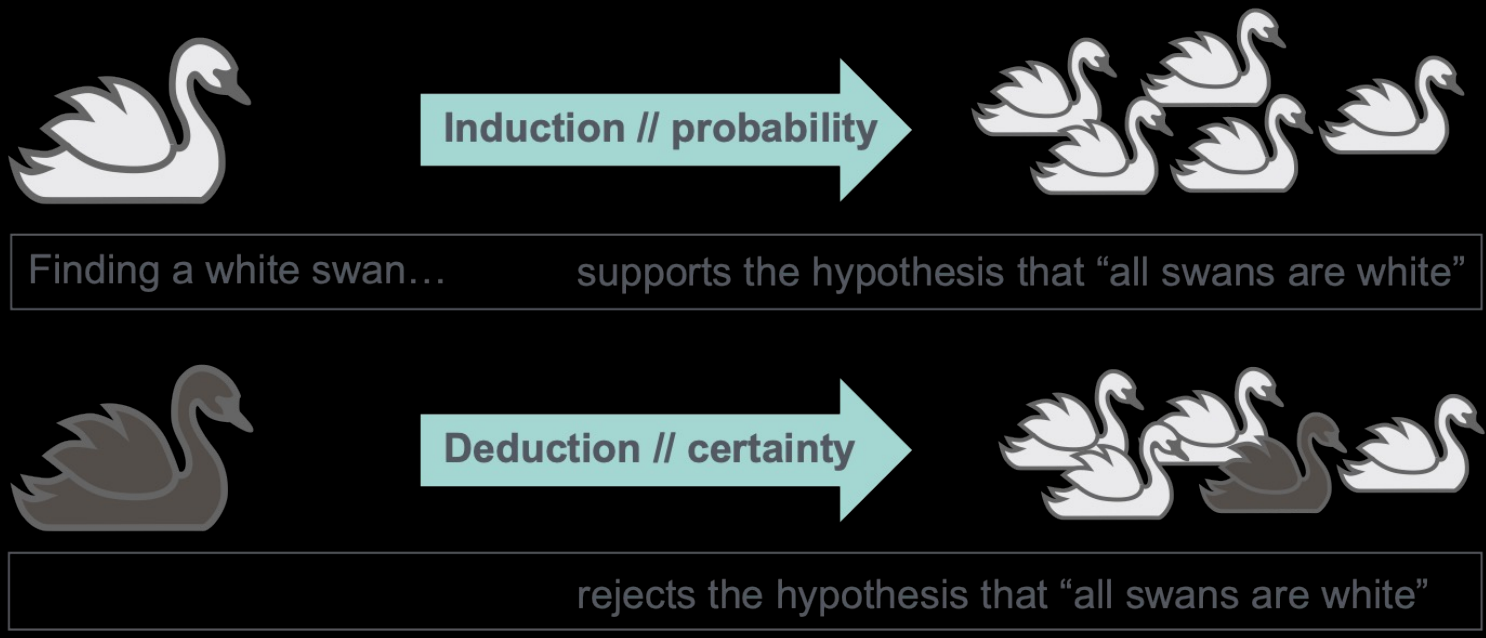
«It is part of my thesis that all our knowledge grows only through the correcting of our mistakes.»

Karl Popper





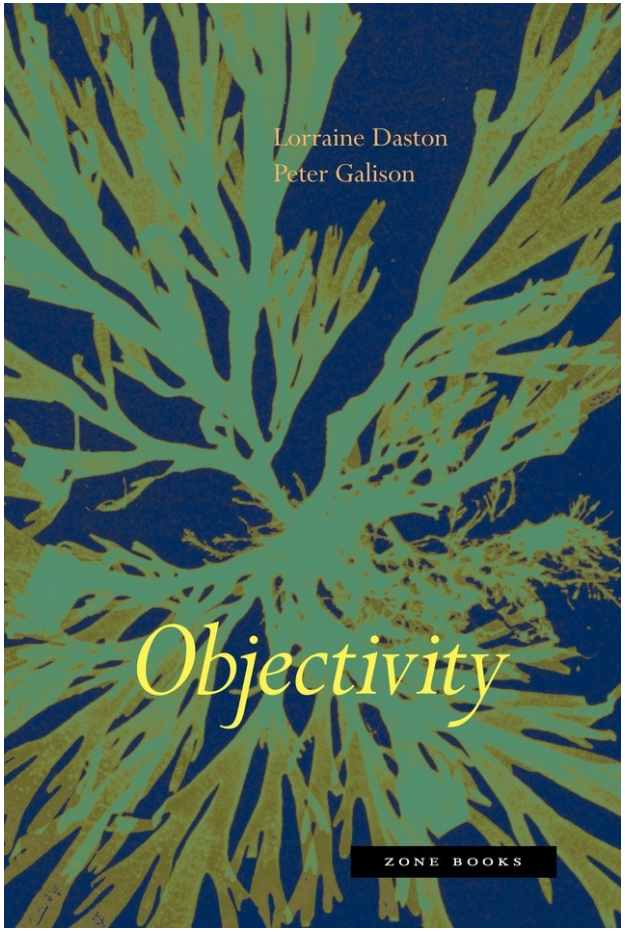
Charles Darwin


Induction // probability
Finding a white swan…
supports the hypothesis that “all swans are white”
Deduction // certainty
rejects the hypothesis that “all swans are white”

«The only principle that does not inhibit progress is: anything goes.»

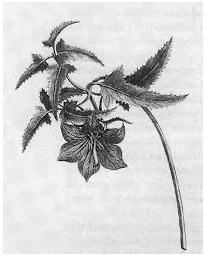
Paul Feyerabend

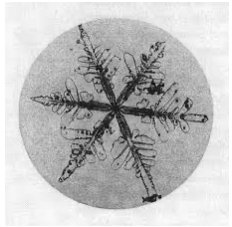
science is objective…

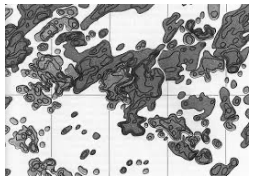


The meaning of **objectivity** has changed over time…

- **truth-to-nature**: aims to extract a universal truth
- **mechanical objectivity**: an automated reproduction of particulars (not universals) that is free of personal opinion
- **trained judgement**: expert identifies meaningful patterns and creates appropriate visualizations to generate insight







https://press.princeton.edu/books/paperback/9781890951795/objectivity

More on scientific objectivity…

https://plato.stanford.edu/entries/scientific-objectivity/

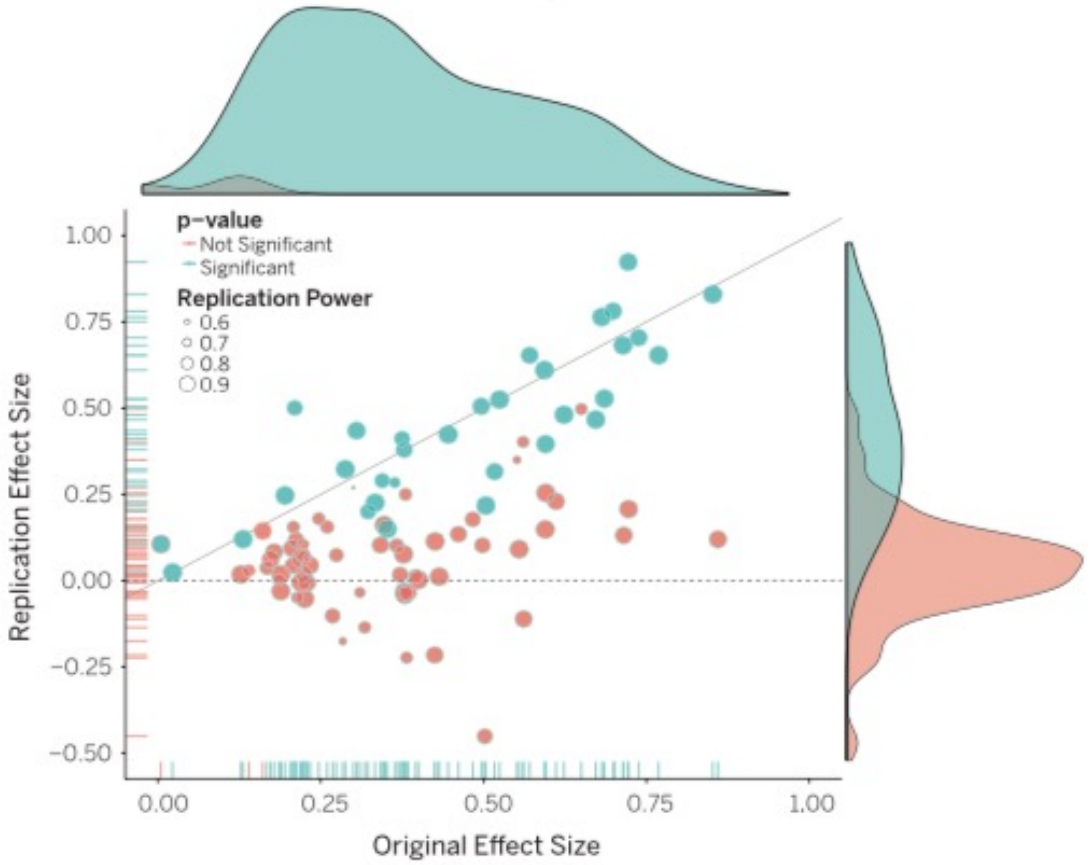
"We have shown that it is hard to define scientific objectivity in terms of a view from nowhere, value freedom, or freedom from personal bias. It is a lot harder to say anything positive about the matter. Perhaps it is related to a thorough critical attitude concerning claims and findings, as Popper thought. Perhaps it is the fact that many voices are heard, equally respected and subjected to accepted standards, as Longino defends. Perhaps it is something else altogether, or a combination of several factors discussed in this article.(…) Work on this problem is an ongoing project, and so is the quest for understanding scientific objectivity."

science always gets it right…

Ioannidis, J. P. A. (2005). Why most published research findings are false. ***PLoS Medicine, 2***(8), e124–6. http://doi.org/10.1371/journal.pmed.0020124

Ioannidis, J. (2005). Contradicted and initially stronger effects in highly cited clinical research. *JAMA, 294*(2), 218–228. http://doi.org/10.1001/jama.294.2.218

Replicability Crisis in Psychology and Economics



Original study effect size versus replication effect size (correlation coefficients). Diagonal line represents replication effect size equal to original effect size. Dotted line represents replication effect size of 0. Points below the dotted line were effects in the opposite direction of the original. Density plots are separated by significant (blue) and nonsignificant (red) effects.

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science, 349(6251)*, aac4716–aac4716. http://doi.org/10.1126/science.aac4716

Replicability Crisis in Psychology and Economics

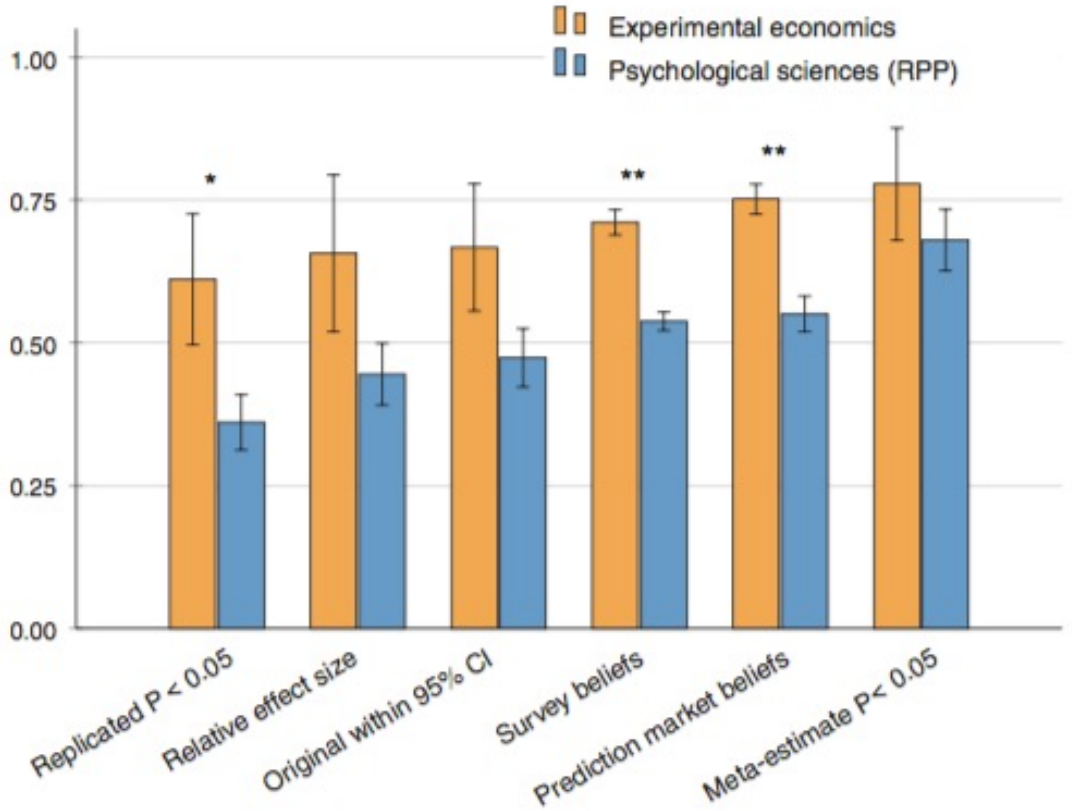
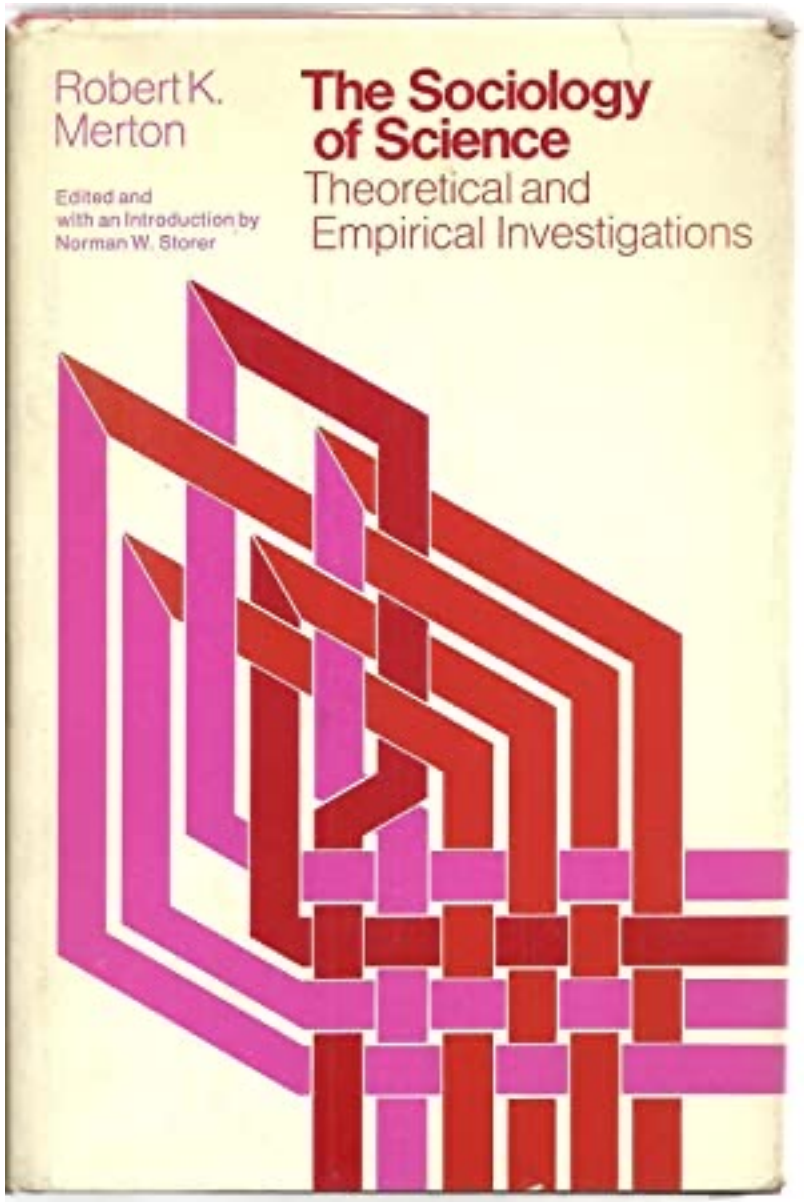


Fig. 4. A comparison of replicability indicators in experimental economics (this study) and psychological sciences (RPP). The graph shows means ± SE for replicability indicators. All six replicability indicators are higher for experimental economics; this difference is significant for three of the replicability indicators. The average difference in replicability across the six indicators is 19 percentage points. Details about the statistical tests are included in the supplementary materials. *$P < 0.05$; **$P < 0.01$.

Camerer, C. F., Dreber, A., Forsell, E., Ho, T.-H., Huber, J., Johannesson, M., et al. (2016). Evaluating replicability of laboratory experiments in economics. ***Science, 351***(6280), 1433–1436. http://doi.org/10.1126/science.aaf0918

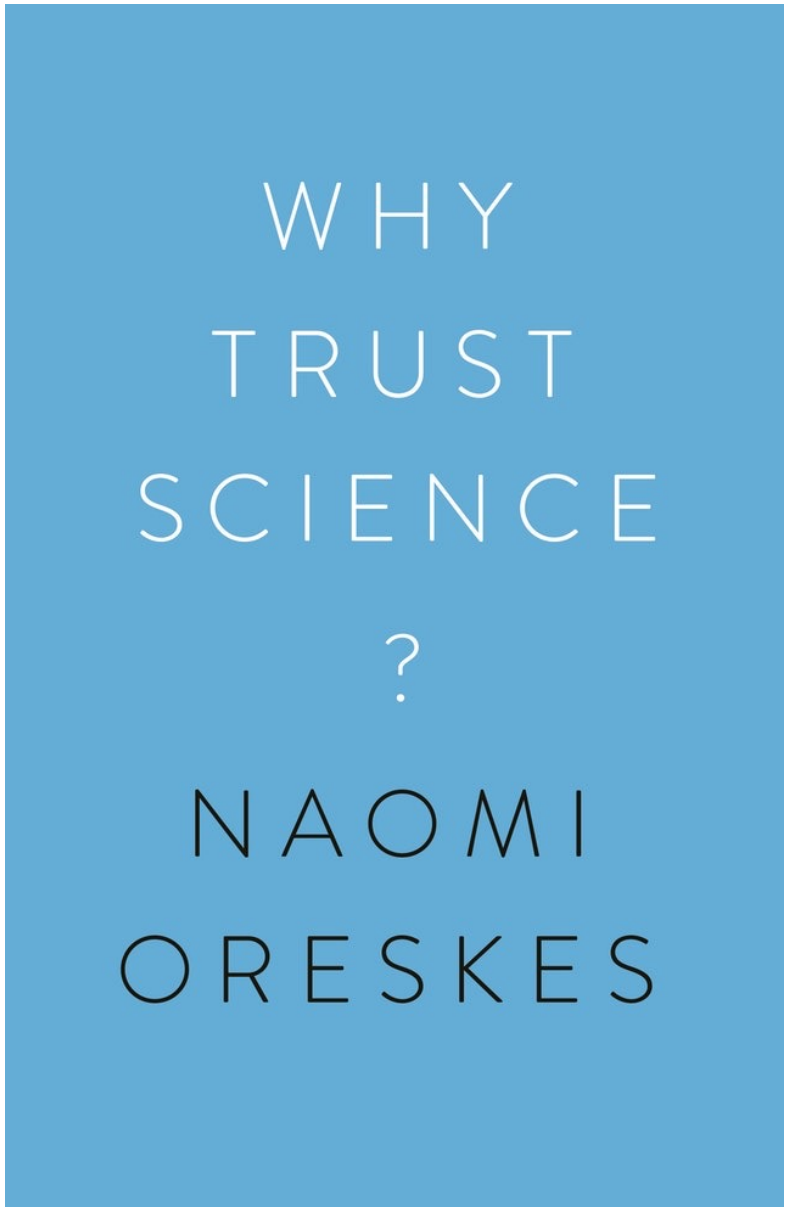
scientists have an ethos…



The Ethos of Science (aka, the Mertonian norms):

- Universalism: it's not about who is doing the science
- Communism/Communality: scientists share!
- Disinterestedness: scientists don't have egos or financial interests, only thirst for knowledge
- Organized skepticism: no claim is accepted at face value…

https://en.wikipedia.org/wiki/Mertonian_norms



Trust in science is **NOT** warranted because there is a singular scientific method that is objective and infallible; science consists of communities of people, making decisions for reasons that can be biased and self-interested, using diverse methods…

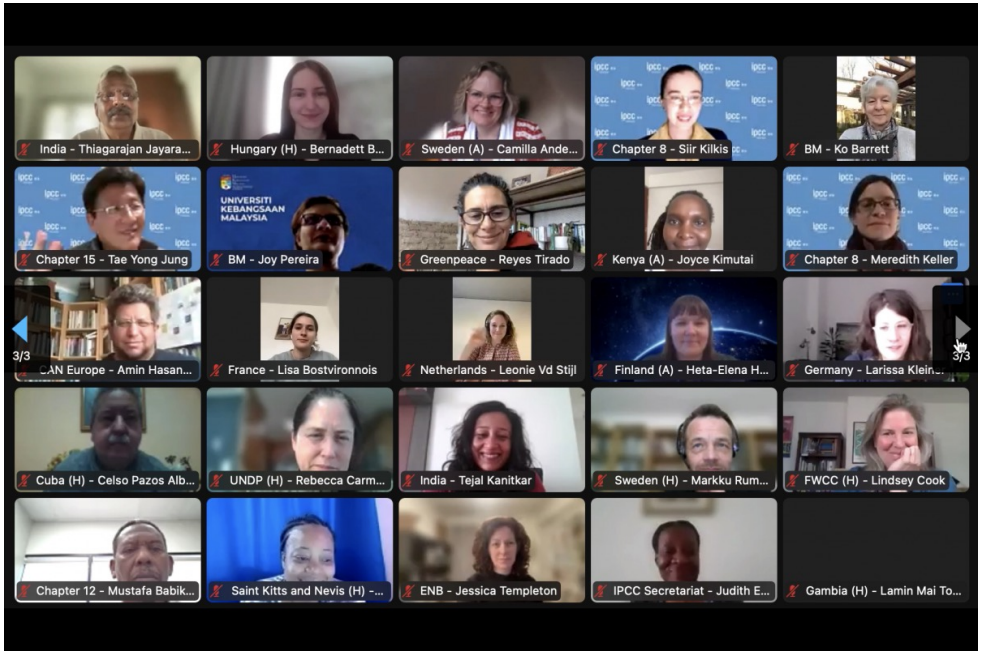
There are however some reasons to **TRUST** science, specifically:

- its sustained engagement with testable empirical phenomena;
- its social and organized character – a form of organized skepticism that is not dependent on single individuals and tends to self-correction in the long run.

ipcc

INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP



https://www.ipcc.ch

Why YOU should care about evidence-based practices to…

1. do science well
2. tackle societal challenges
3. be ready for the jobs of the future
4. do your work right

1

nature human behaviour

PERSPECTIVE

PUBLISHED: 10 JANUARY 2017 | VOLUME: 1 | ARTICLE NUMBER: 0021

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.

Munafò, M. R., Nosek, B. A., Bishop, D. V. M., Button, K. S., Chambers, C. D., Sert, du, N. P., et al. (2017). A manifesto for reproducible science. *Nature Human Behaviour, 1*, 1–9. http://doi.org/10.1038/s41562-016-0021

Table 1 | A manifesto for reproducible science.

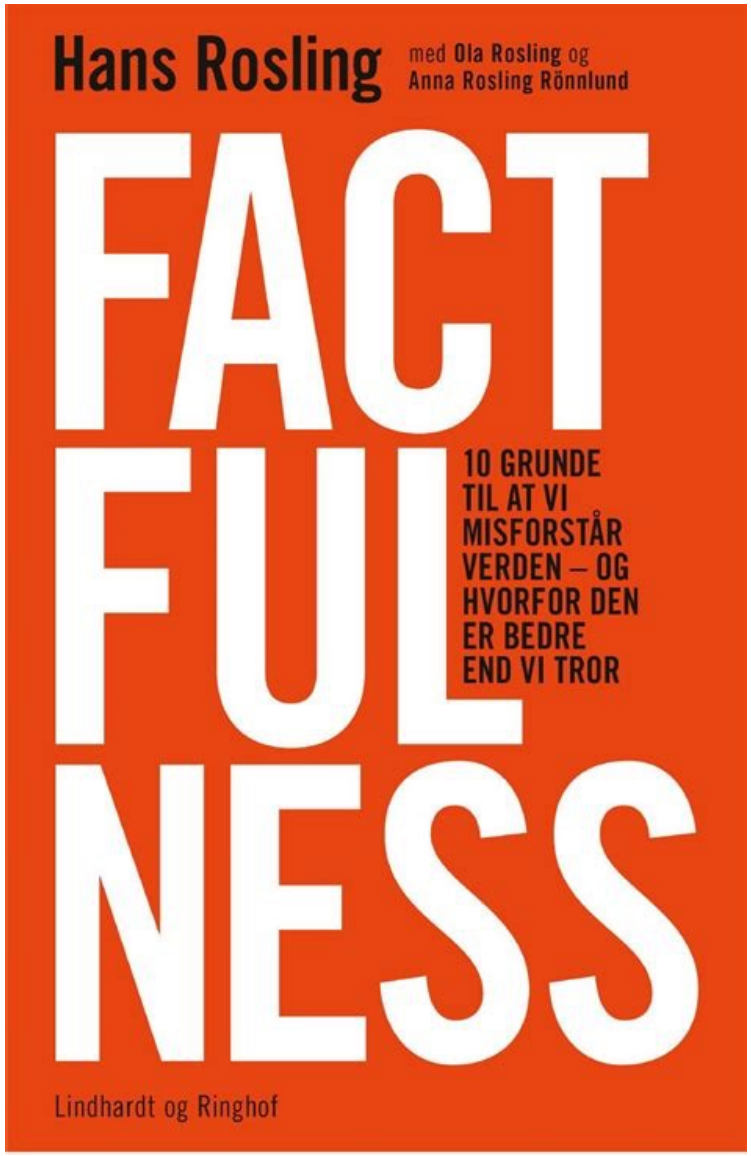
Theme	Proposal	Examples of initiatives/potential solutions (extent of current adoption)	Stakeholder(s)
Methods	Protecting against cognitive biases	All of the initiatives listed below (* to ****) Blinding (**)	J, F
	Improving methodological training	Rigorous training in statistics and research methods for future researchers (*) Rigorous continuing education in statistics and methods for researchers (*)	I, F
	Independent methodological support	Involvement of methodologists in research (**) Independent oversight (*)	F
	Collaboration and team science	Multi-site studies/distributed data collection (*) Team-science consortia (*)	I, F
Reporting and dissemination	Promoting study pre-registration	Registered Reports (*) Open Science Framework (*)	J, F
	Improving the quality of reporting	Use of reporting checklists (**) Protocol checklists (*)	J
	Protecting against conflicts of interest	Disclosure of conflicts of interest (***) Exclusion/containment of financial and non-financial conflicts of interest (*)	J
Reproducibility	Encouraging transparency and open science	Open data, materials, software and so on (* to **) Pre-registration (**** for clinical trials, * for other studies)	J, F, R
Evaluation	Diversifying peer review	Preprints (* in biomedical/behavioural sciences, **** in physical sciences) Pre- and post-publication peer review, for example, Publons, PubMed Commons (*)	J
Incentives	Rewarding open and reproducible practices	Badges (*) Registered Reports (*) Transparency and Openness Promotion guidelines (*) Funding replication studies (*) Open science practices in hiring and promotion (*)	J, I, F

Estimated extent of current adoption: *, <5%; **, 5–30%; ***, 30–60%; ****, >60%. Abbreviations for key stakeholders: J, journals/publishers; F, funders; I, institutions; R, regulators.

Munafò, M. R., Nosek, B. A., Bishop, D. V. M., Button, K. S., Chambers, C. D., Sert, du, N. P., et al. (2017). A manifesto for reproducible science. *Nature Human Behaviour, 1*, 1–9. http://doi.org/10.1038/s41562-016-0021

2


SOCIAL NEWS
SOCIAL
MILLELDING NEWS
NEWS
MILLELDING NEWS HEADDES
MISINFORMATION
NEWS



https://www.gapminder.org/ignorance/

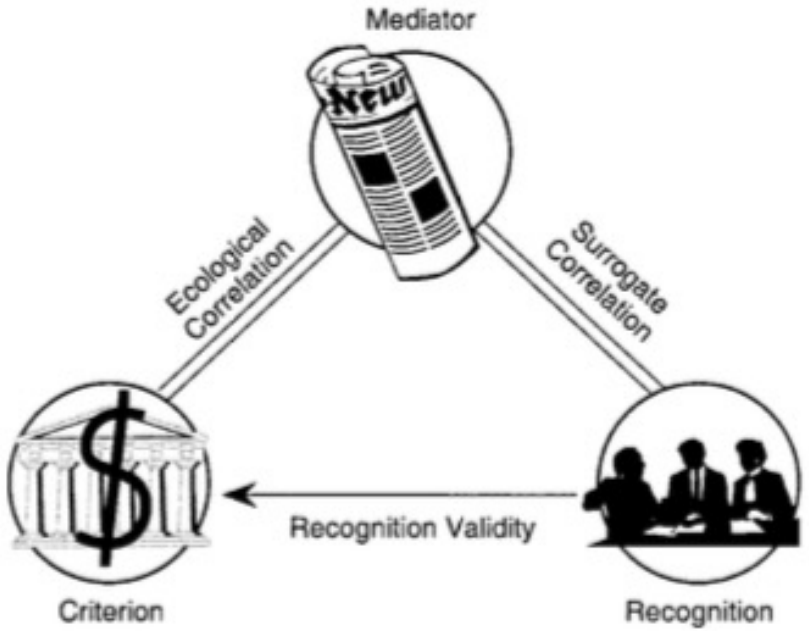


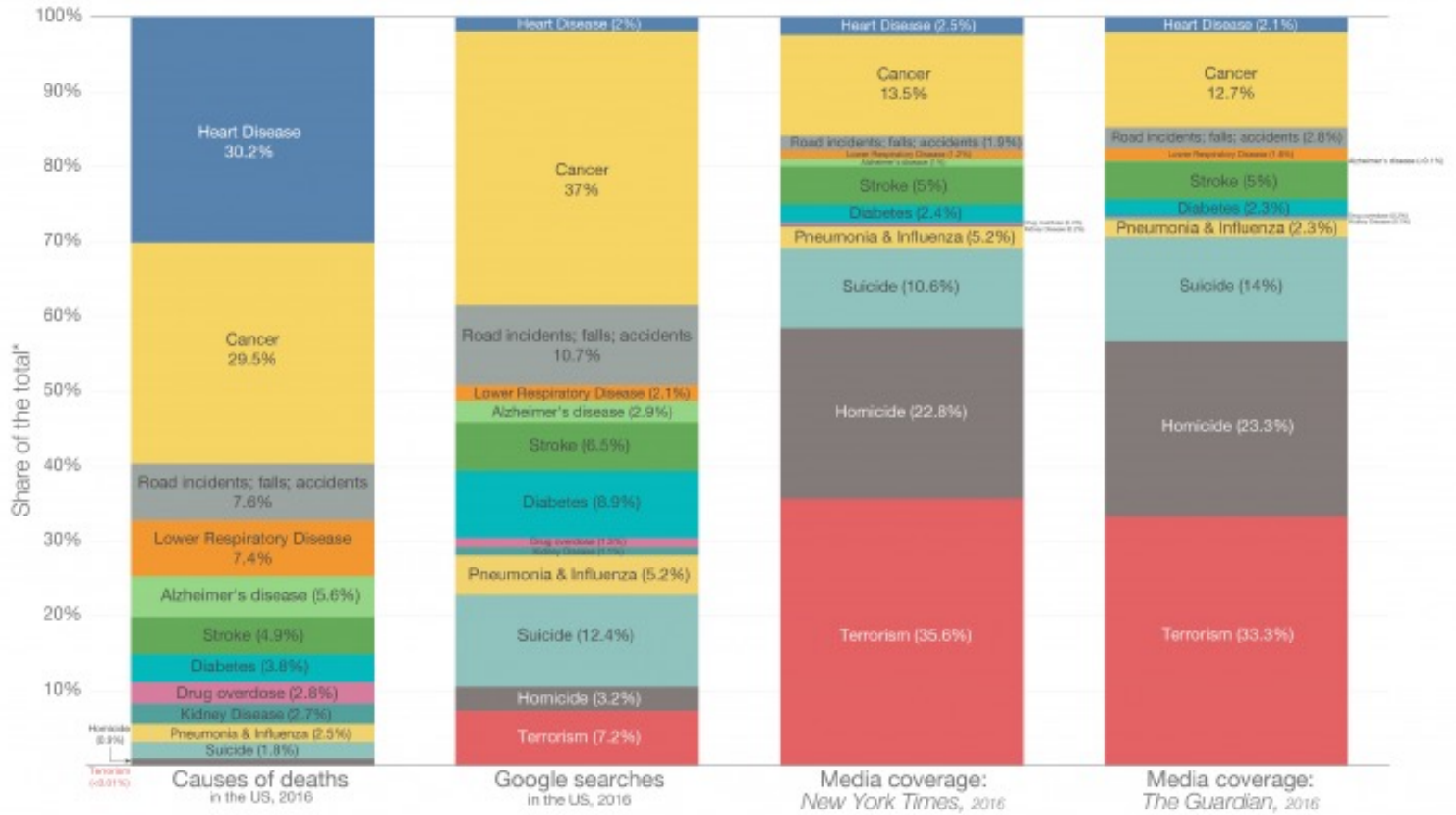
Figure 1. The ecological rationality of the recognition heuristic. An inaccessible criterion (e.g., the endowment of an institution) is reflected by a mediator variable (e.g., the number of times the institution is mentioned in the news), and the mediator influences the probability of recognition. The mind, in turn, uses recognition to infer the criterion.

Goldstein, D. G., & Gigerenzer, G. (2002). Models of ecological rationality: The recognition heuristic. ***Psychological Review, 109***(1), 75–90. http://doi.org/10.1037//0033-295X.109.1.75

Causes of death in the US

What Americans die from, what they search on Google, and what the media reports on

Our World in Data



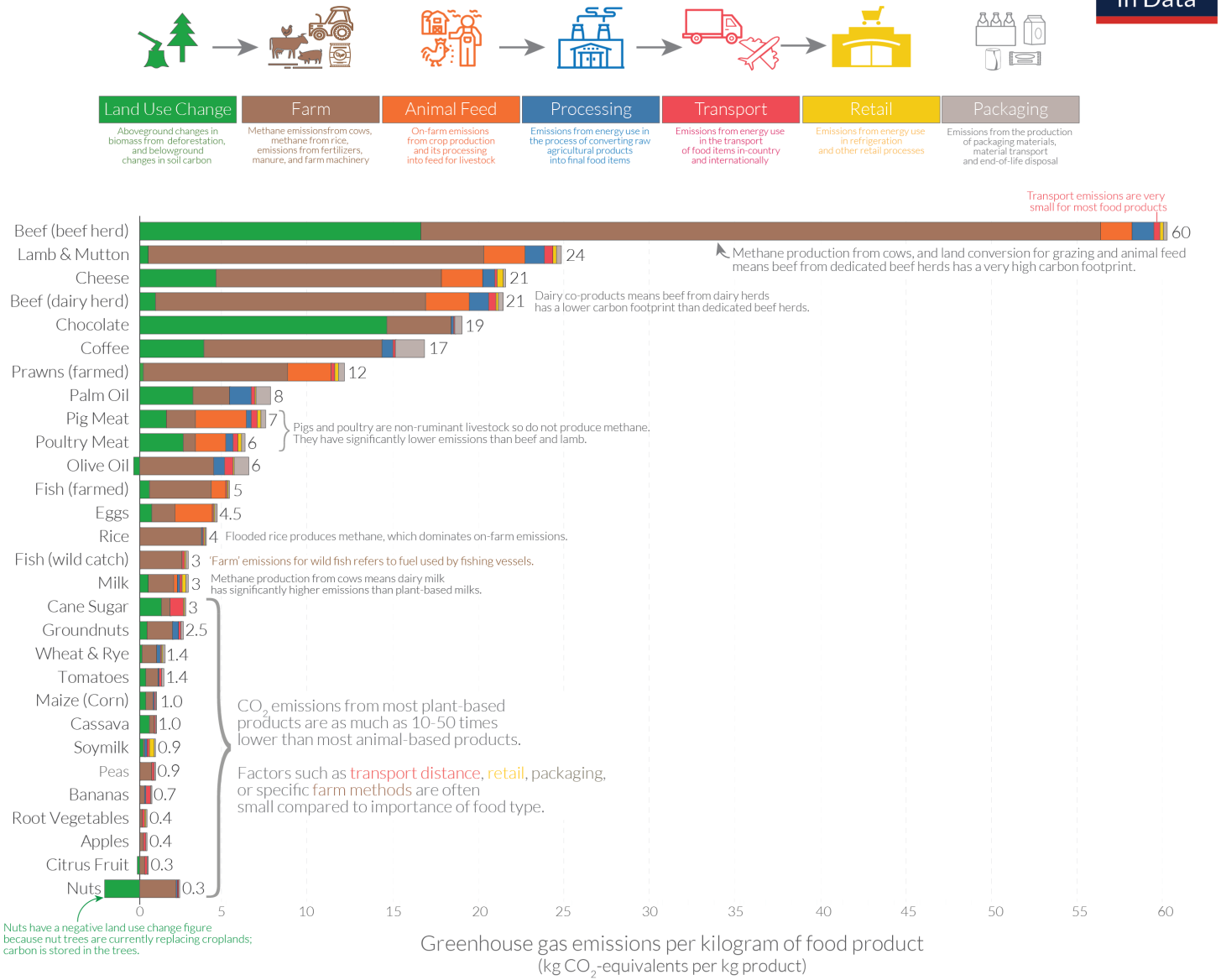
*This represents each causes's share of the top ten causes of death in the US plus homicides, drug overdoses and terrorism. Collectively these 13 causes accounted for approximately 88% of deaths in the US in 2016. Full breakdown of causes of death can be found at the CDC's WONDER public health database: https://wonder.cdc.gov/

Based on data from Shen et al (2018) – Death: reality vs. reported. *All data available at: https://owenshen24.github.io/charting-death*
All data refers to 2016.
Not all causes of death are shown: Shown is the data on the ten leading causes of death in the United States plus drug overdoses, homicides and terrorism.
All values are normalized to 100% so they represent their relative share of the top causes, rather than absolute counts (e.g. 'deaths' represents each causes' share of deaths within the 13 categories shown rather than total deaths). The causes of death shown here account for approximately 88% of total deaths in the United States in 2016.

https://ourworldindata.org/does-the-news-reflect-what-we-die-from

Food: greenhouse gas emissions across the supply chain

Our World in Data



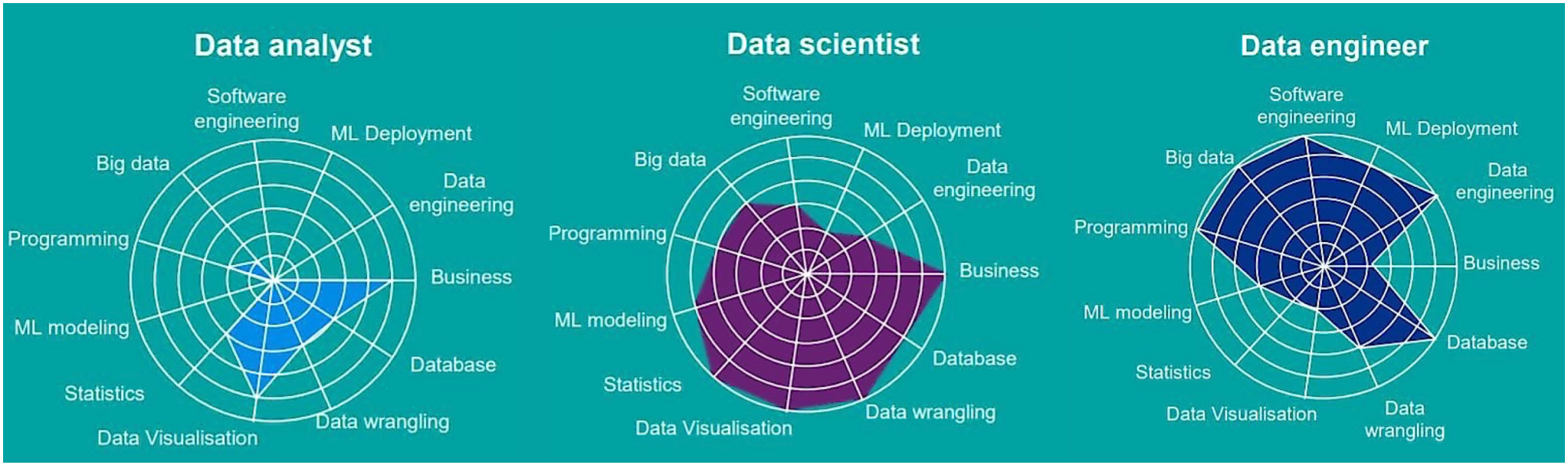
Note: Greenhouse gas emissions are given as global average values based on data across 38,700 commercially viable farms in 119 countries.
Data source: Poore and Nemecek (2018). Reducing food's environmental impacts through producers and consumers. *Science*. Images sourced from the Noun Project.
OurWorldinData.org – Research and data to make progress against the world's largest problems.

https://ourworldindata.org/food-choice-vs-eating-local

3


The Economist
Crunch time in France
Ten years on: banking after the crisis
South Korea's unfinished revolution
Biology, but without the cells
MAY 6TH–12TH 2017
The world's most valuable resource
amazon
Microsoft
Google
TESLA
UBER
Data and the new rules of competition

Data science is not (only) machine learning and AI



Policy Statement on Evidence-Based Practice in Psychology

The following statement was approved as policy of the American Psychological Association (APA) by the APA Council of Representatives during its August, 2005 meeting.

Evidence-based practice in psychology (EBPP) is the integration of the best available research with clinical expertise in the context of patient characteristics, culture, and preferences. This definition of EBPP closely parallels the definition of evidence-based practice adopted by the Institute of Medicine (2001, p. 147) as adapted from Sackett and colleagues (2000): "**Evidence-based practice is the integration of best research evidence with clinical expertise and patient values**." The purpose of EBPP is to promote effective psychological practice and enhance public health by applying empirically supported principles of psychological assessment, case formulation, therapeutic relationship, and intervention.

Best research evidence refers to scientific results related to intervention strategies, assessment, clinical problems, and patient populations in laboratory and field settings as well as to clinically relevant results of basic research in psychology and related fields. A sizeable body of evidence drawn from a variety of research designs and methodologies attests to the effectiveness of psychological practices. Generally, evidence derived from clinically relevant research on psychological practices should be based on systematic reviews, reasonable effect sizes, statistical and clinical significance, and a body of supporting evidence. The validity of conclusions from research on interventions is based on a general progression from clinical observation through systematic reviews of randomized clinical trials, while also recognizing gaps and limitations in the existing literature and its applicability to the specific case at hand (APA, 2002). Health policy and practice are also informed by research using a variety of methods in such areas as public health, epidemiology, human development, social relations, and neuroscience.

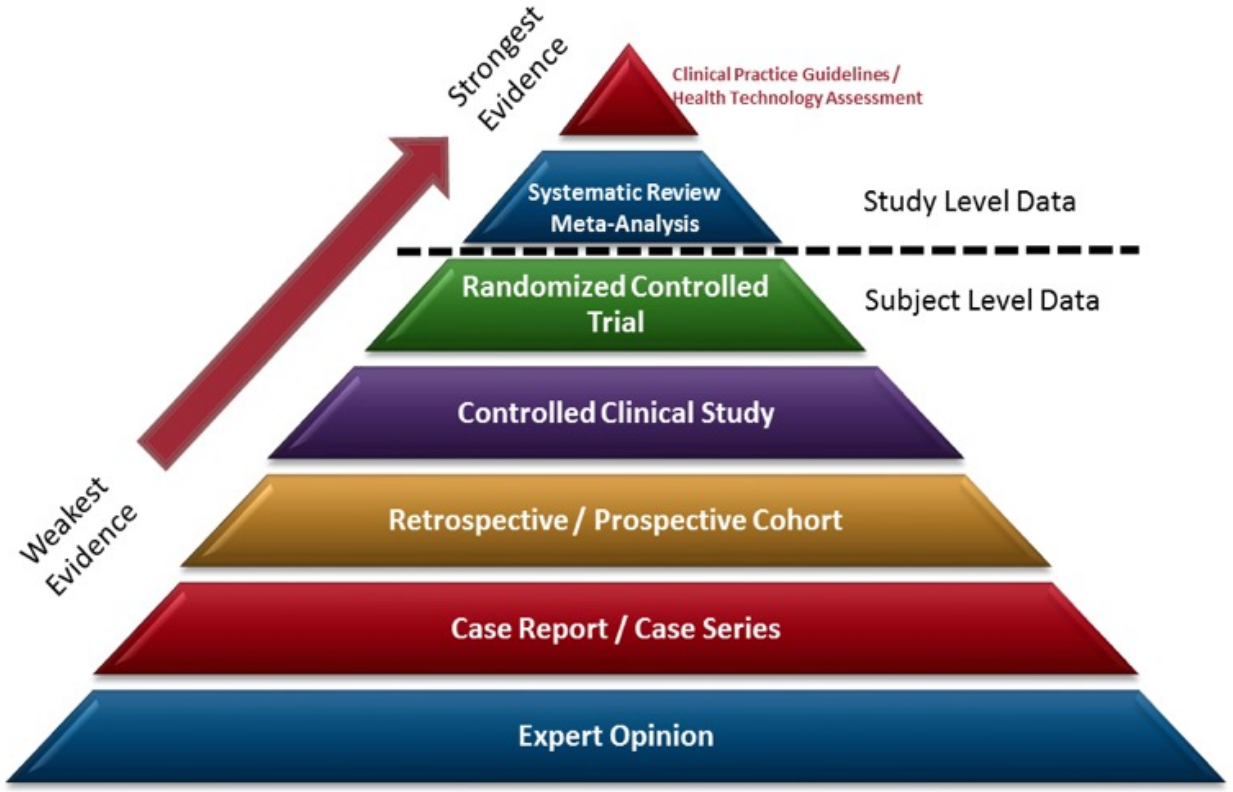
Researchers and practitioners should join together to ensure that the research available on psychological practice is both clinically relevant and internally valid. It is important not to assume that interventions that have not yet been studied in controlled trials are ineffective. However, widely used psychological practices as well as innovations developed in the field or laboratory should be rigorously evaluated and barriers to conducting this research should be identified and addressed.

http://www.apa.org/practice/guidelines/evidence-based-statement.aspx

Why YOU should care about evidence-based practices to…

1. do science well
2. tackle societal challenges
3. be ready for the jobs of the future
4. do your work right

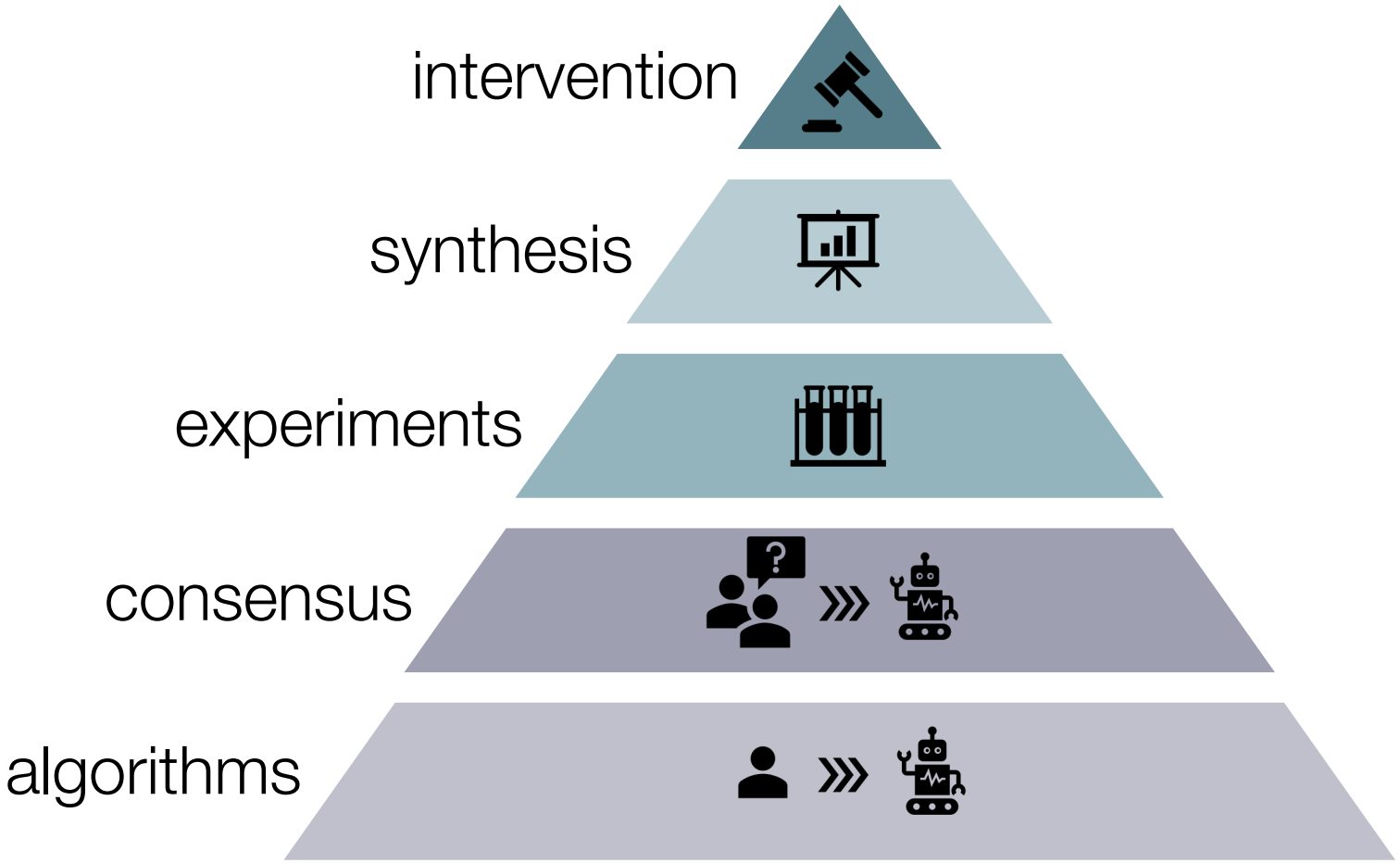
Course structure



https://en.wikipedia.org/wiki/Hierarchy_of_evidence

The course is inspired in the idea of a hierarchy of evidence – starting with expert opinion and ending with sytematic reviews and evidence-based interventions

Course structure



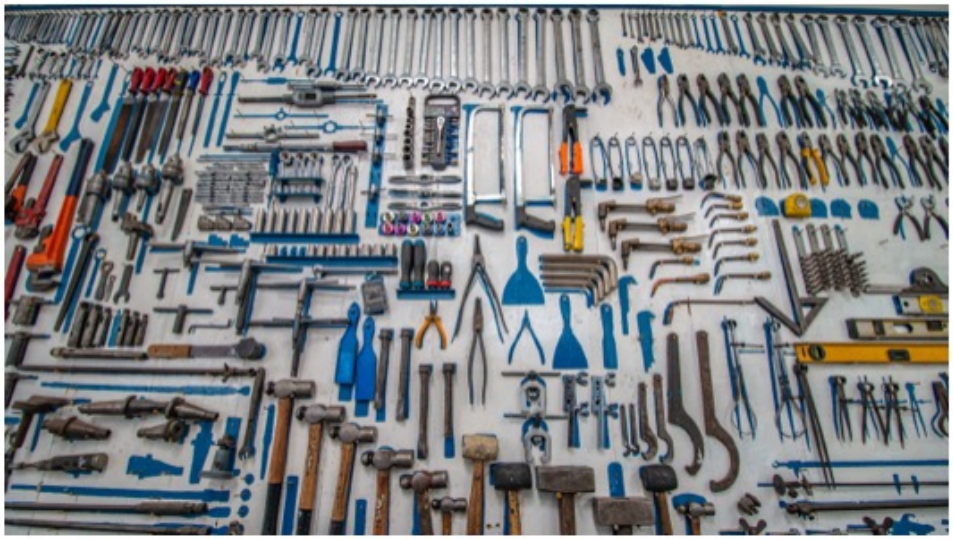
Course website

EBDM

Welcome to the website for *Evidence-based decision making* FS25 (11230-01)

Instructors: Loreen Tisdall and Rui Mata, University of Basel

WEBSITE UNDER CONSTRUCTION: Last updated Wed Jan 22 10:10:08 2025



Very much like a spread of tools, science offers a plethora of strategies...
photo by Cesar Carlevarino Aragon on Unsplash

https://matarui.github.io/ebdm/

Summary

- **No such thing as THE scientific method:** It's perhaps a bit too much to say that, in science, "anything goes" (cf. Feyerabend). And yet, there is no such thing as THE scientific method. There is always a debate between induction (e.g., Darwin) and deduction (e.g., Einstein), with many ways of producing knowledge…

- **Science as a mutable but self—correcting method:** The changes in the meaning of objectivity are a good example of how the scientific enterprise is mutable. Further, scientists make mistakes and, on occasion, even mislead; the scientific discourse and methods can also be co-opted by industry and other interests. As a consequence, science can get it wrong (phlogiston) or be confusing (climate change debates) which can lead to an erosion of trust.

- **Fighting (bad) science with science**: Yet science has a track-record of developing systems to ensure adequacy of principles and explanations such as new theories (e.g., relativity), practices (e.g., pre-registration), and forms of organization (e.g., team science). For all its flaws, as a whole, and in the long-run, the scientific enterprise tends to come up with new ideas that provide better accounts of real-world phenomena and produce useful technology (e.g., lasers, vaccines).

- **Evidence-based decision making**: The course is inspired by two ideas. One is that of a pyramid of evidence, going from expert knowledge to evidence-based interventions. Another that of science as a set of tools – a toolbox – each with a certain function and some strengths (and weaknesses) for understanding and interacting with the world – we can profit from having an overview of these tools to be able to apply each and, ultimately, make better, informed decisions both as individuals and groups.