

Cautionary tales from Metascience

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TEMET

Theoretical and Empirical METascience lab
"temet nosce"



comCensus™

This talk in a nutshell

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 - AKA If you don't know it's broken, don't try to fix it.

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 - Metascience has been getting reproducibility and integrity at least partially wrong
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 - AKA If you don't know it's broken, don't try to fix it.
 - Policy reforms in science: light and adaptive, if any

Science in reproducibility crisis?

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Study	Discipline, sample/design	% “success”
Klein 2014	13 Psychology studies, each replicated in 36 labs	85%
Schweinsberg 2016	10 new effects in Psychology, each in 25 labs	80%
Aarts 2016	100 Social and Cognitive Psychology studies	37-68%
Klein 2018	28 Psychology classics, each in 36 labs	54%
Camerer 2016	18 Behavioural Economics experiments	61-89%
Camerer 2018	21 Social Sc. Exp. published in Nature and Science	57-67%
Cova 2018	40 Exp. Philosophy studies	70-78%
Errington 2021	158 effects, from 23 papers in Cancer Biology	25-79%
Davis 2023	10 Operations Management papers	70%

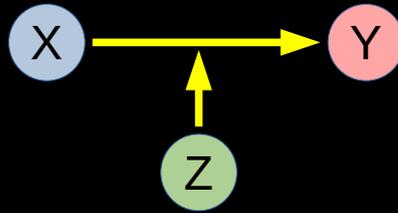
Suggested **natural** (not QRP) causes of irreproducibility

- alignment of verbal and statistical expressions of hypothesis
- base rate of true effects
- between-site variation
- biological variation
- boundedness of truth
- centralized scientific community
- checking assumptions prior to running a test
- comparability and strength of manipulations
- comparability of measurement procedures
- complexity
- complexity of statistical software + flexibility of choices
- conceptual practices: rigour with which hypotheses are articulated
- context-dependency of relevant vs irrelevant characteristics
- cumulative theoretical framework
- dependency on learning
- Environmental Effect Ratio (EER)
- generalization bias
- heterogeneity
- High base-rate of false hypotheses
- illusion of exact replication
- measurement error
- misclassification of outcome
- modification by genetic or environment factors
- multiple trials
- multiplicity
- NHST misuse
- nuisance factors – falsity of null hypothesis
- overlooking variability and change
- regression to the mean
- repeated testing
- small and non-representative samples (of experimental units, settings, treatments, and measurements)
- small sample sizes
- small samples, high variation, small effects
- species coverage
- strength of link between theories and empirical tests
- substituting species
- theoretical vs empirical hypotheses
- type of data analysis
- underlying mixture distribution of effect size
- underpowered replication studies
- undetected population stratification
- unknown unknowns
- using regression for bivariate relations
- vaguely specified hypotheses
- variation in linkage disequilibrium
- variation in observed effect sizes
-

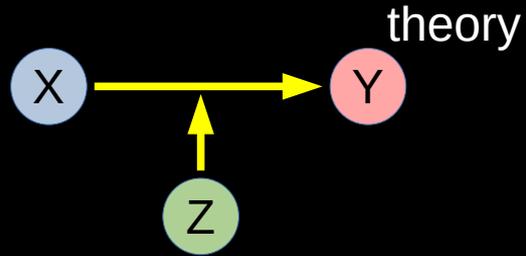
(Fanelli, review in progress)

The **complexity** of science

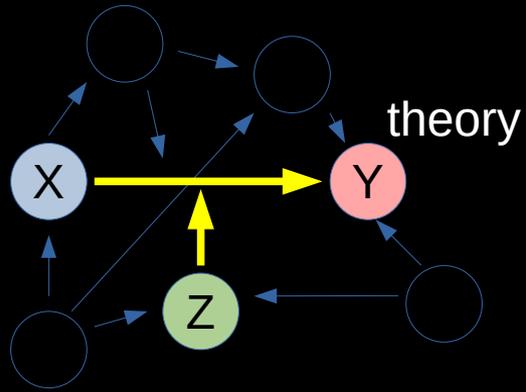
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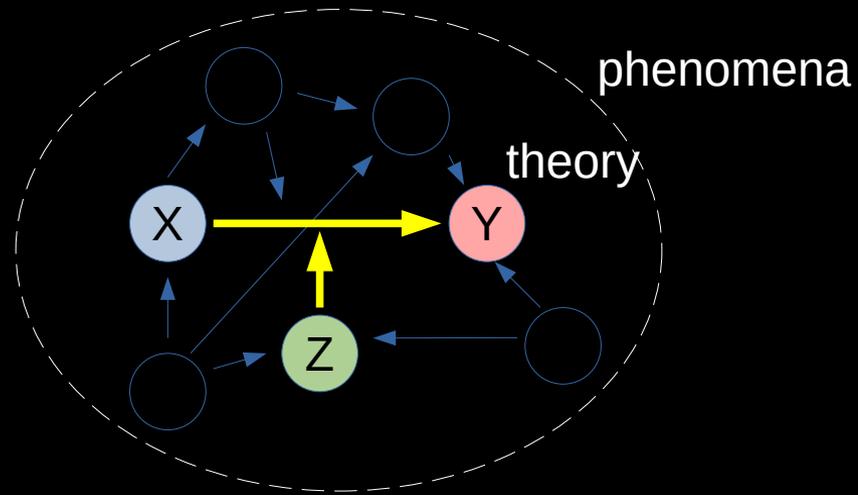
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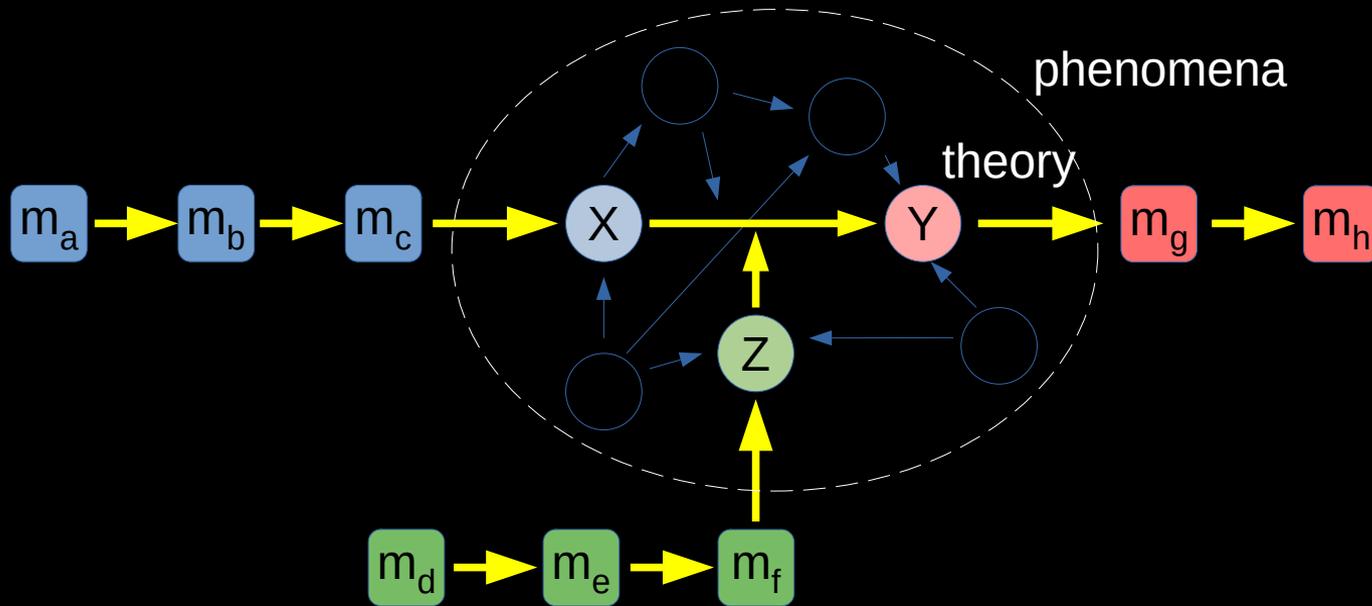
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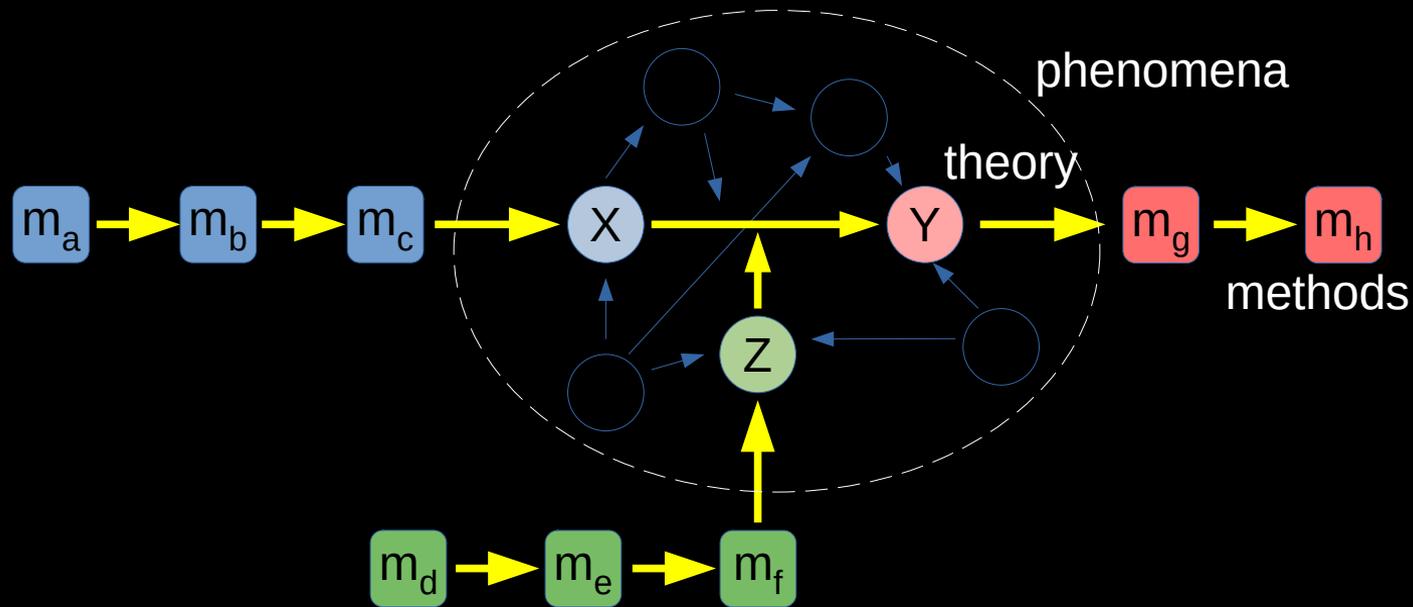
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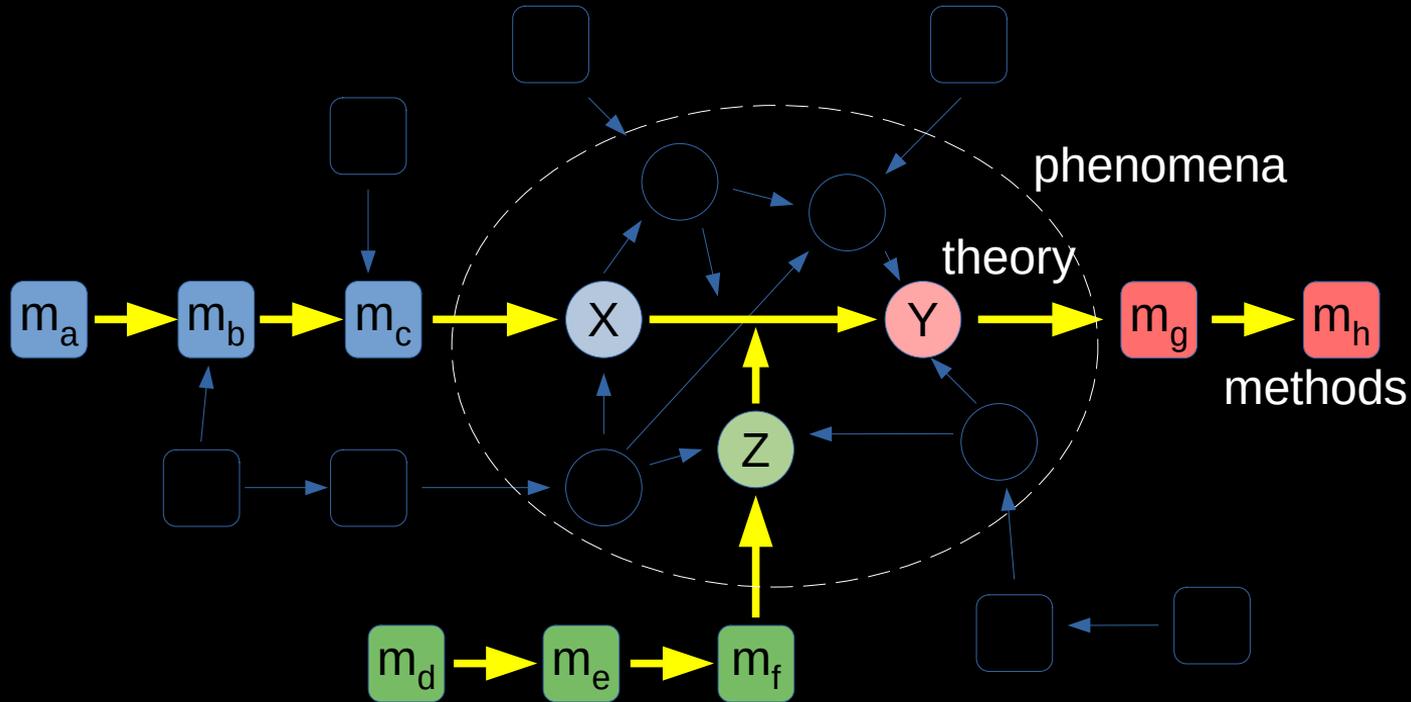
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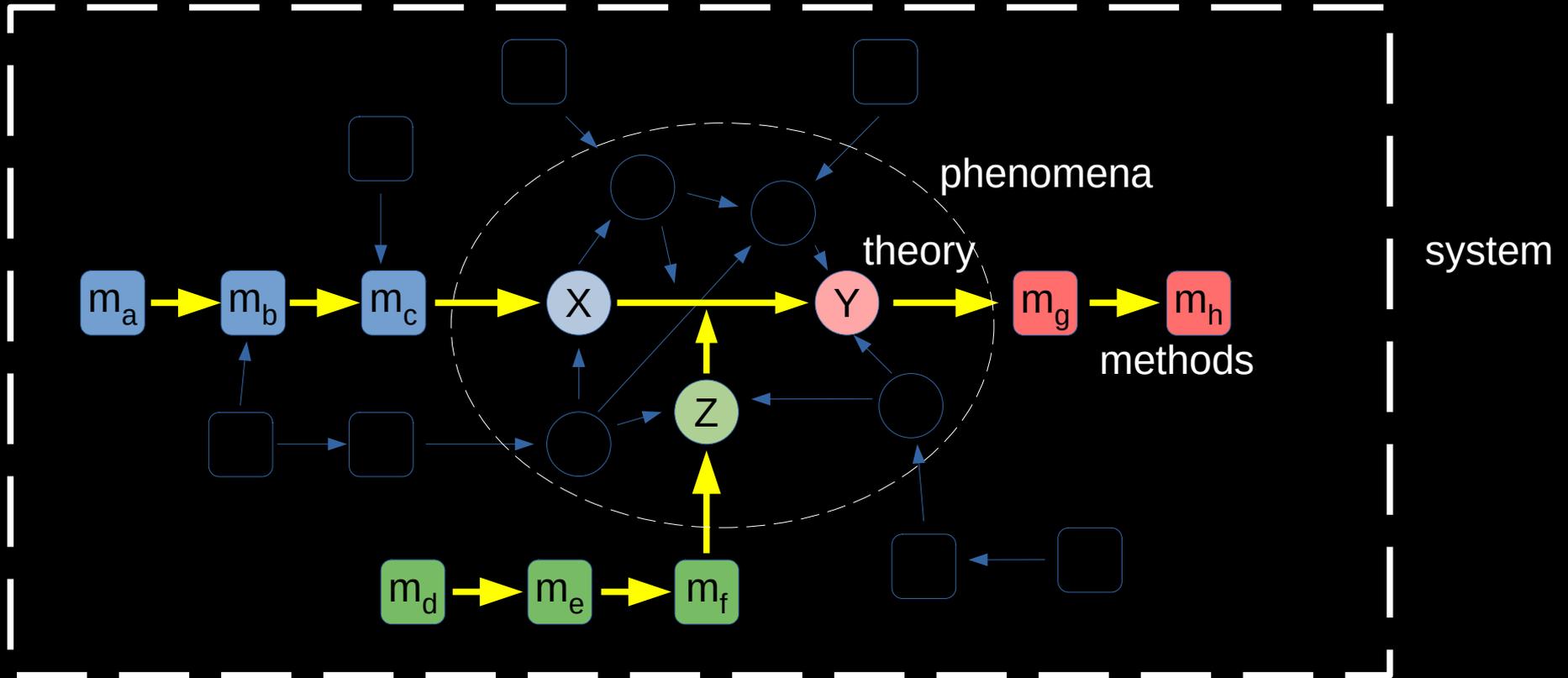
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Academia

Industry

Academia

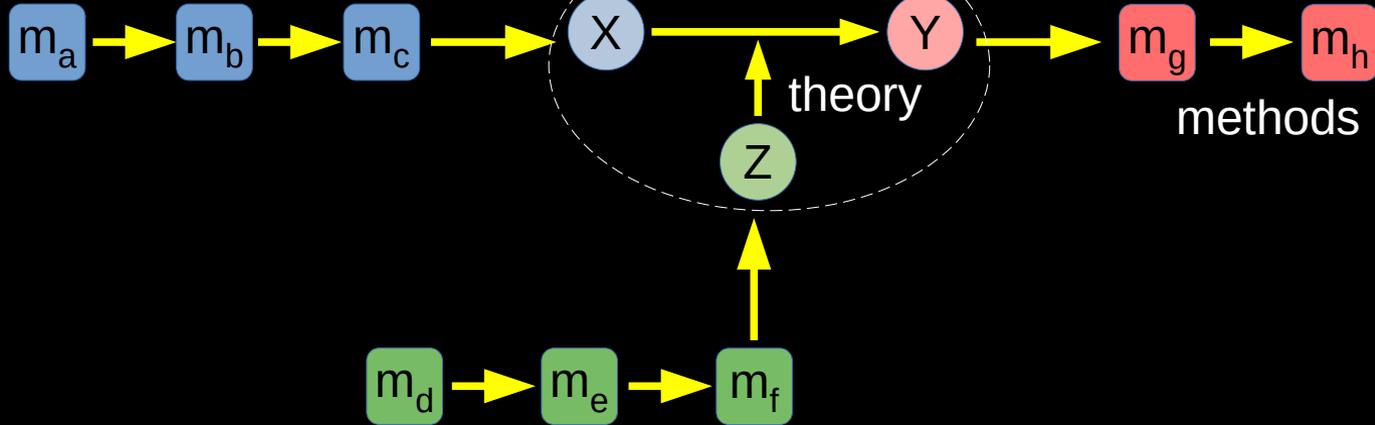
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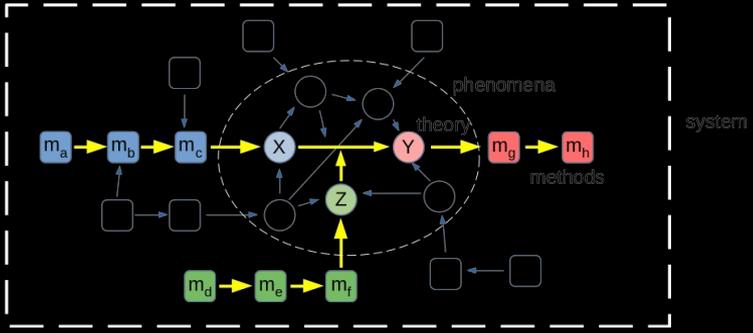
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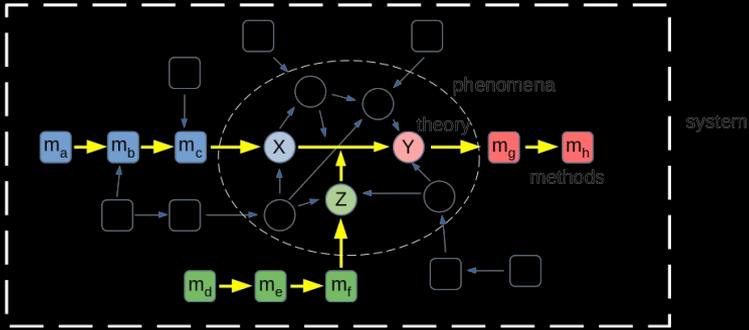
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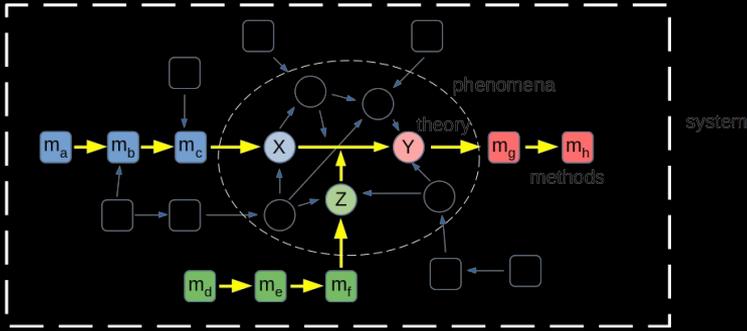
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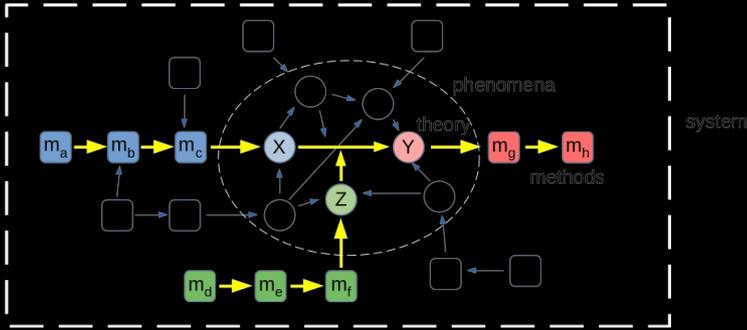




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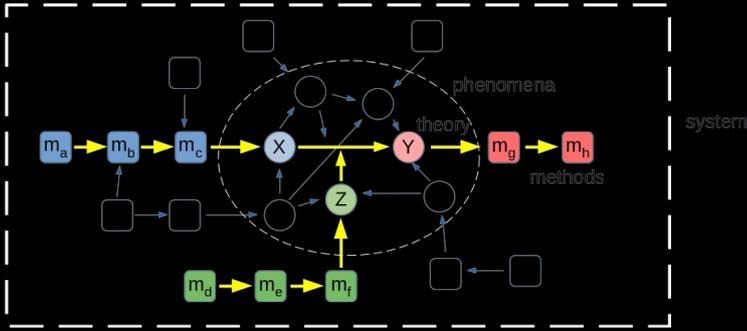


- Structure & complexity **differs** across:
 - Study / field / discipline



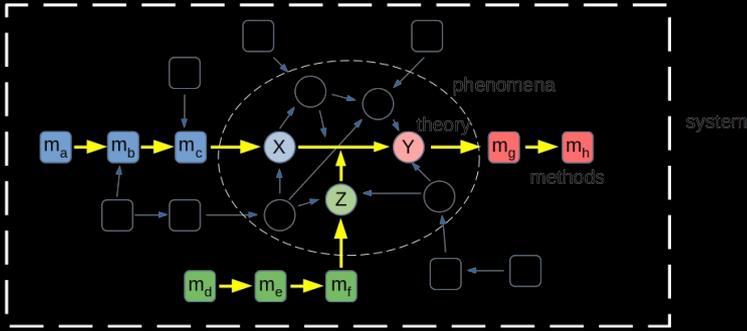
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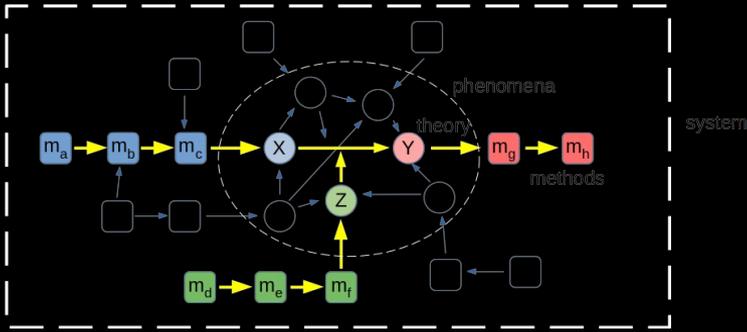
- Study / field / discipline
- Level of consensus / maturity
- Social / economic / cultural context



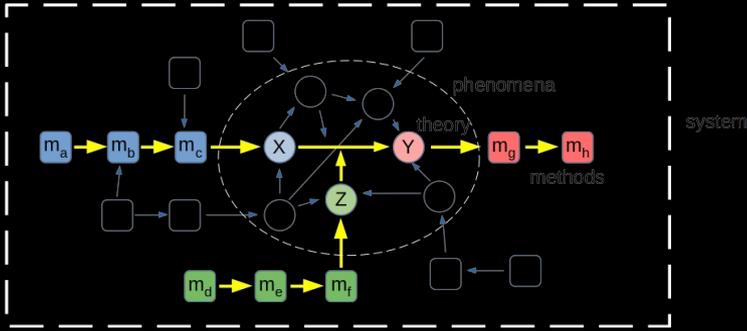
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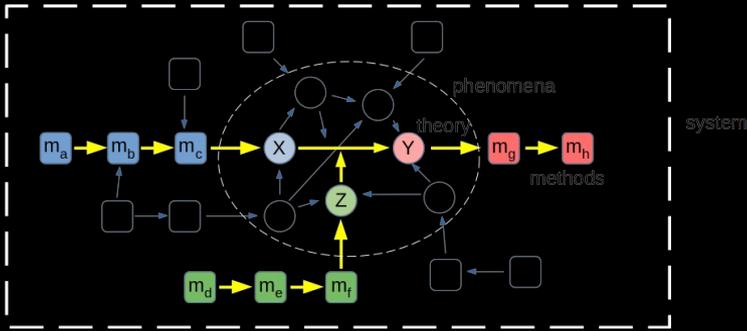
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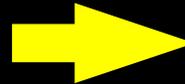
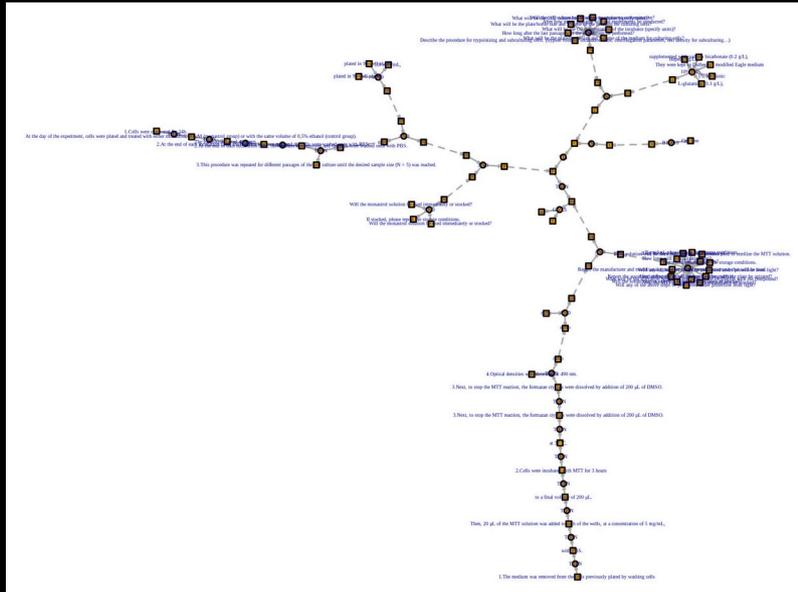
- Reproducibility / robustness / generalizability
- Research practices / standards / expectations
- Effects of incentives / interventions / policies

Protocol complexity predicts repr.
(Preregistered test, Braz. Repr. Init. data)

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Replication protocol's complexity



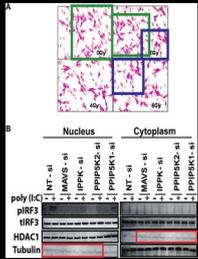
	b	se	t
α	7.522	5.00	1.481
$\log \frac{1}{2 + D(\tau)}$	1.01	0.496	2.035
$\sqrt{N_{\text{orig}}}$	-0.541	0.573	-0.943
$\sqrt{N_{\text{rep}}}$	-0.527	0.452	-1.164
$P > 0.01$	-0.374	0.916	-0.408
<i>deviations, unwanted</i>	0.32	0.329	0.974
<i>deviations, wanted</i>	-0.354	0.567	-0.624

Random Eff.	Variance	St. Dev.
Lab intercept	0.81	0.9
Residual	10.27	3.2

(Fanelli, Amaral & Neves, in prep)

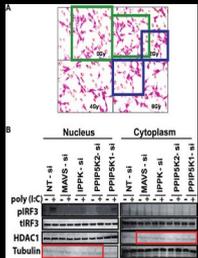
Effects of incentives, publication pressures etc. *vary* by country

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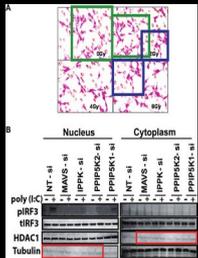
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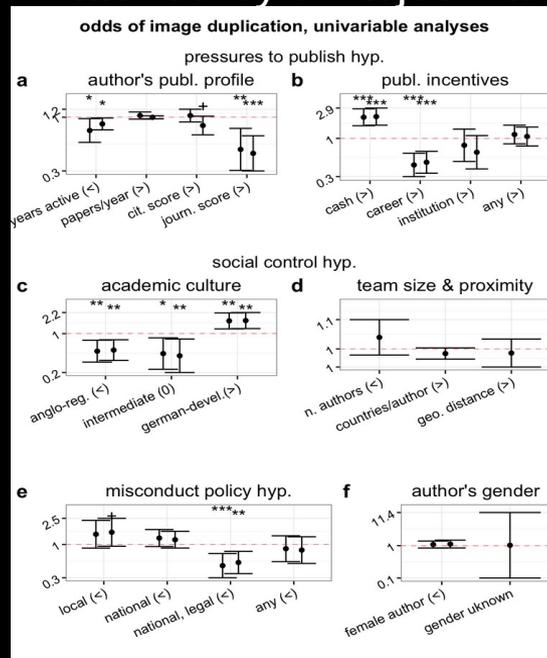
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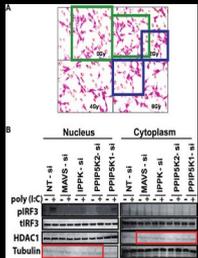
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Matched by time/journal



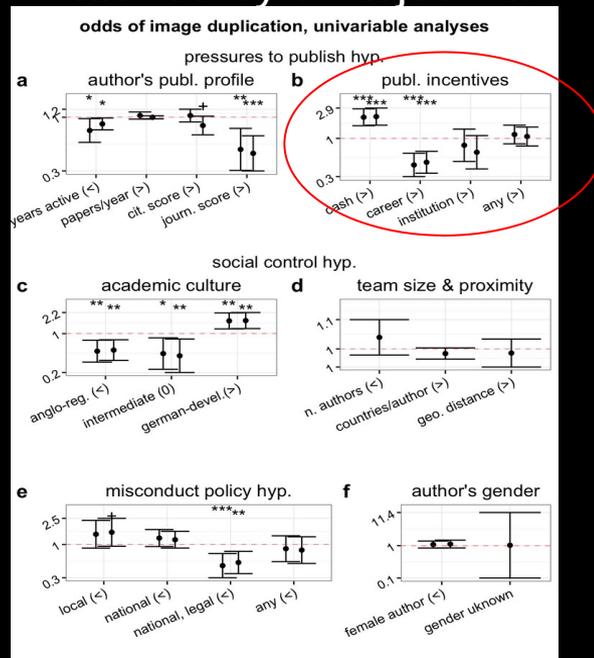
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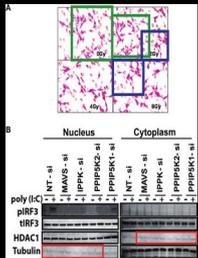
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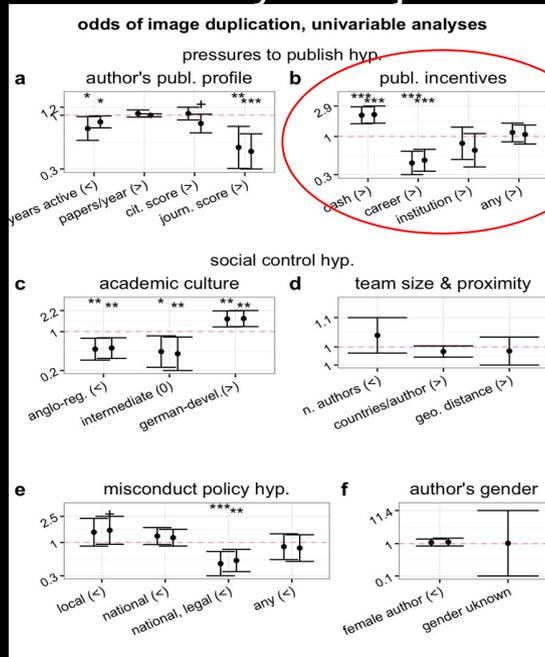
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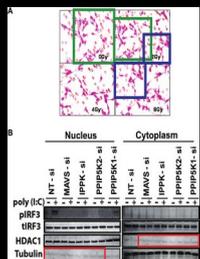
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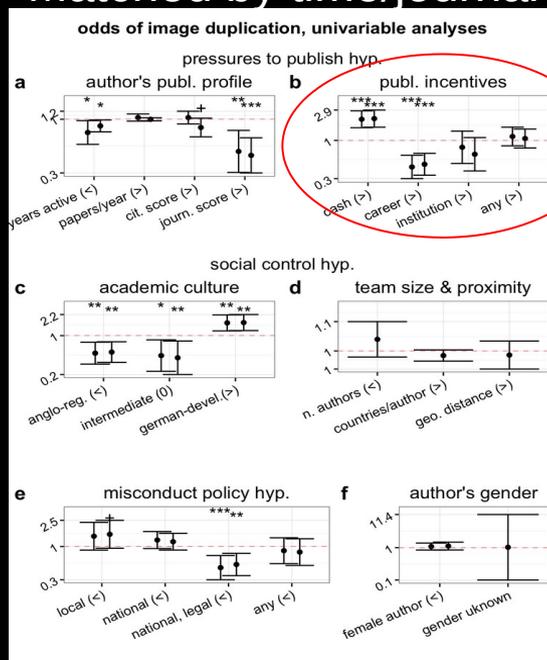
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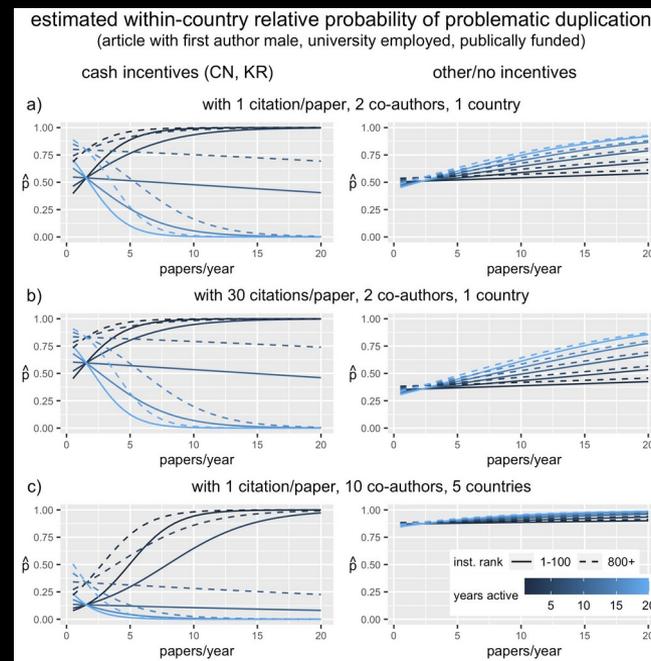
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(Fanelli et al. 2018, Sci Eng Ethics)

Matched by country



(Fanelli et al. 2022, PloS ONE)

Summary so far

- “Crisis” of reproducibility driven by problematic research practices?
 - Or misunderstanding due to incomplete theory and flawed assumptions?
- Reproducibility might not be lower than we should expect
 - Systems involved are variably complex
- Current Metascience **overlooks** important factors, e.g. :
 - Replication protocol complexity predicts irreproducibility
 - Predictors of misconduct are highly country-dependent

Policy-making in a complex world

Do we need TOP (-down)?

(an example of policy)

Summary of the eight standards and three levels of the TOP guidelines

Levels 1 to 3 are increasingly stringent for each standard. Level 0 offers a comparison that does not meet the standard.

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(Nosek et al. 2015, Science)

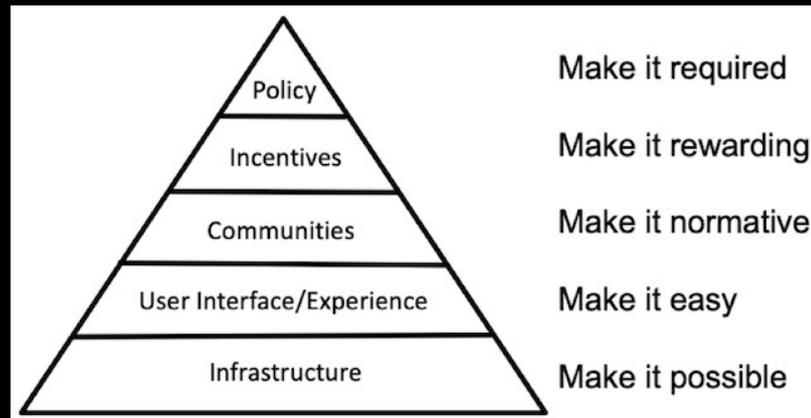
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- Costs
 - Time, labour, money...

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Design and analysis transparency	Journal encourages design and analysis transparency or says nothing.	Journal articulates design transparency standards.	Journal requires adherence to design transparency standards for review and publication.	Journal requires and enforces adherence to design transparency standards for review and publication.
Preregistration of studies	Journal says nothing.	Journal encourages preregistration of studies and provides link in article to preregistration if it exists.	Journal encourages preregistration of studies and provides link in article and certification of meeting preregistration badge requirements.	Journal requires preregistration of studies and provides link and badge in article to meeting requirements.
Preregistration of analysis plans	Journal says nothing.	Journal encourages preanalysis plans and provides link in article to registered analysis plan if it exists.	Journal encourages preanalysis plans and provides link in article and certification of meeting registered analysis plan badge requirements.	Journal requires preregistration of studies with analysis plans and provides link and badge in article to meeting requirements.
Replication	Journal discourages submission of replication studies—or says nothing.	Journal encourages submission of replication studies.	Journal encourages submission of replication studies and conducts blind review of results.	Journal uses Registered Reports as a submission option for replication studies with peer review before observing the study outcomes.

“Transparency”, “openness”, “pre-registration”, “replication” have

- Costs

- Time, labour, money...

- Drawbacks

- Privacy, competition, ethics...

Summary of the eight standards and three levels of the TOP guidelines

Levels 1 to 3 are increasingly stringent for each standard. Level 0 offers a comparison that does not meet the standard.

	LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
Citation standards	Journal encourages citation of data, code, and materials—or says nothing.	Journal describes citation of data in guidelines to authors with clear rules and examples.	Article provides appropriate citation for data and materials used, consistent with journal's author guidelines.	Article is not published until appropriate citation for data and materials is provided that follows journal's author guidelines.
Data transparency	Journal encourages data sharing—or says nothing.	Article states whether data are available and, if so, where to access them.	Data must be posted to a trusted repository. Exceptions must be identified at article submission.	Data must be posted to a trusted repository, and reported analyses will be reproduced independently before publication.
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- Privacy, competition, ethics...

- Effects

- Essential <> Useless <> Damaging

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“Transparency”, “openness”, “pre-registration”, “replication” have

- Costs

- Time, labour, money...

- Drawbacks

- Privacy, competition, ethics...

- Effects

- Essential <> Useless <> Damaging

Unequal across systems, contexts, conditions

All Journals

TOP Standard ^

- Total TOP Factor
- Data Citation
- Data Transparency
- Analysis Code Transparency
- Materials Transparency
- Design & Analysis Reporting Guidelines
- Study Preregistration
- Analysis Plan Preregistration
- Replication
- Registered Reports & Publication Bias
- Open Science Badges

Discipline v

Publisher v

Society v

	JOURNAL	TOTAL TOP FACTOR
1	Cadernos de Linguística	27
2	Meta-Psychology	27
3	Advances in Methods and Practices in Psychological Science	25
4	Peer Community in Registered Reports	25
5	Global Environmental Psychology	24
6	Personality Science	24
7	Comprehensive Results in Social Psychology	23
8	Cortex	23
9	European Journal of Personality	23
10	Journal of Experimental Psychology: Applied	22

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(topfactor.org/journals)

All Journals

TOP Standard ^

- Total TOP Factor
- Data Citation
- Data Transparency
- Analysis Code Transparency
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All Journals

TOP Standard ^

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- Analysis Plan Preregistration
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- Registered Reports & Publication Bias
- Open Science Badges

Discipline v

Publisher v

Society v

	JOURNAL	TOTAL TOP FACTOR
1	Annals of Physics	3
2	Applied Acoustics	3
3	Applied Radiation and Isotopes	3
4	Applied Surface Science	3
5	Applied Surface Science Advances	3
6	Astronomy and Computing	3
7	Astroparticle Physics	3
8	Atomic Data and Nuclear Data Tables	3
9	Diamond and Related Materials	3
10	European Journal of Mechanics - A/Solids	3

Rows per page: 10 1-10 of 55 < >

Physics less rigorous than Psychology?!

All Journals

TOP Standard

- Total TOP Factor
- Data Citation
- Data Transparency
- Analysis Code Transparency
- Materials Transparency
- Design & Analysis Reporting Guidelines
- Study Preregistration
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- Registered Reports & Publication Bias
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Discipline
Publisher
Society

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Rows per page: 10 1-10 of 3178

All Journals

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- Study Preregistration
- Analysis Plan Preregistration
- Replication
- Registered Reports & Publication Bias
- Open Science Badges

Discipline
Publisher
Society

JOURNAL	TOTAL TOP FACTOR
1 Annals of Physics	3
2 Applied Acoustics	3
3 Applied Radiation and Isotopes	3
4 Applied Surface Science	3
5 Applied Surface Science Advances	3
6 Astronomy and Computing	3
7 Astroparticle Physics	3
8 Atomic Data and Nuclear Data Tables	3
9 Diamond and Related Materials	3
10 European Journal of Mechanics - A/Solids	3

Rows per page: 10 1-10 of 55

Physics less rigorous than Psychology?!

All Journals

Search journals by title

TOP Standard

- Total TOP Factor
- Data Citation
- Data Transparency
- Analysis Code Transparency
- Materials Transparency
- Design & Analysis Reporting Guidelines
- Study Preregistration
- Analysis Plan Preregistration
- Replication
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- Open Science Badges

Discipline

Publisher

Society

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All Journals

Search journals by title

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Rows per page: 10 1-10 of 55

Or are TOP standards very **Psychology-specific**?

(topfactor.org/journals)

But even **within** any discipline...

All Journals

Search journals by title

TOP Standard	JOURNAL	TOTAL TOP FACTOR
<input checked="" type="radio"/> Total TOP Factor	1	27
<input type="radio"/> Data Citation	2	27
<input type="radio"/> Data Transparency	3	25
<input type="radio"/> Analysis Code Transparency	4	25
<input type="radio"/> Materials Transparency	5	24
<input type="radio"/> Design & Analysis Reporting Guidelines	6	24
<input type="radio"/> Study Pre-registration	7	23
<input type="radio"/> Analysis Plan Pre-registration	8	23
<input type="radio"/> Replication	9	23
<input type="radio"/> Registered Reports & Publication Bias	10	22
<input type="radio"/> Open Science Badges		

Discipline
Publisher
Society

Items per page: 10 1-10 of 3178



All Journals

Search journals by title

TOP Standard	JOURNAL	TOTAL TOP FACTOR
<input checked="" type="radio"/> Total TOP Factor	1	3
<input type="radio"/> Data Citation	2	3
<input type="radio"/> Data Transparency	3	3
<input type="radio"/> Analysis Code Transparency	4	3
<input type="radio"/> Materials Transparency	5	3
<input type="radio"/> Design & Analysis Reporting Guidelines	6	3
<input type="radio"/> Study Pre-registration	7	3
<input type="radio"/> Analysis Plan Pre-registration	8	3
<input type="radio"/> Replication	9	3
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<input type="radio"/> Open Science Badges		

Discipline
Publisher
Society

Items per page: 10 1-10 of 55

But even **within** any discipline...

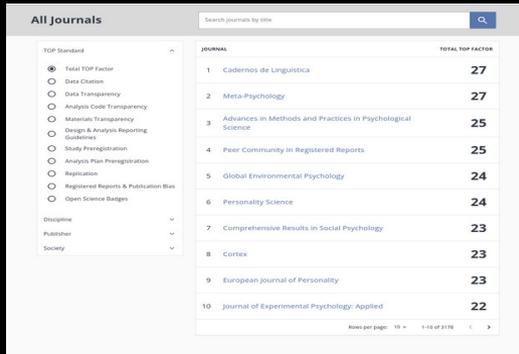
JOURNAL	TOTAL TOP FACTOR
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- Research areas (e.g. Cognitive vs Social)

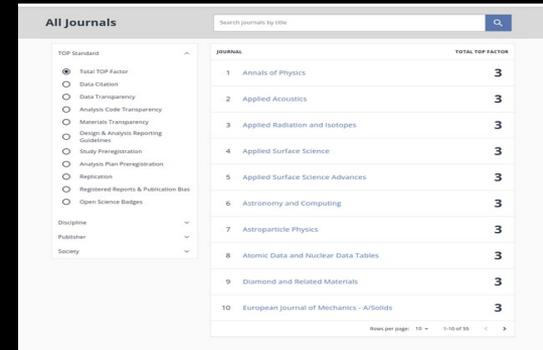
But even **within** any discipline...



The screenshot shows a search results page for 'All Journals' in the field of Psychology. The interface includes a search bar at the top, a sidebar with filters for 'TOP Standard' (Total TOP Factor, Data Citation, Data Transparency, Analysis Code Transparency, Materials Transparency, Design & Analysis Reporting Guidelines, Study Preregistration, Analysis Plan Preregistration, Replication, Registered Reports & Publication Bias, Open Science Badges), 'Discipline', 'Publisher', and 'Society'. The main table lists the top 10 journals by Total TOP Factor.

JOURNAL	TOTAL TOP FACTOR
1 Cadernos de Linguística	27
2 Meta-Psychology	27
3 Advances in Methods and Practices in Psychological Science	25
4 Peer Community in Registered Reports	25
5 Global Environmental Psychology	24
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10 Journal of Experimental Psychology: Applied	22

...



The screenshot shows a search results page for 'All Journals' in the field of Physics. The interface is identical to the Psychology screenshot, showing a search bar, a sidebar with filters, and a table of the top 10 journals by Total TOP Factor.

JOURNAL	TOTAL TOP FACTOR
1 Annals of Physics	3
2 Applied Acoustics	3
3 Applied Radiation and Isotopes	3
4 Applied Surface Science	3
5 Applied Surface Science Advances	3
6 Astronomy and Computing	3
7 Astroparticle Physics	3
8 Atomic Data and Nuclear Data Tables	3
9 Diamond and Related Materials	3
10 European Journal of Mechanics - A/Solids	3

- Research areas (e.g. Cognitive vs Social)
- Complex vs simpler phenomena?

But even **within** any discipline...

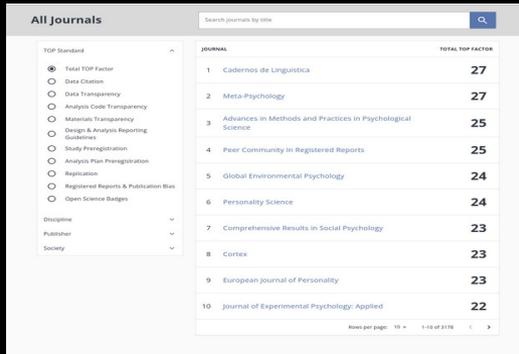
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7 Astroparticle Physics	3
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9 Diamond and Related Materials	3
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- Research areas (e.g. Cognitive vs Social)
- Complex vs simpler phenomena?
- Young vs mature theories/methods/research programs?

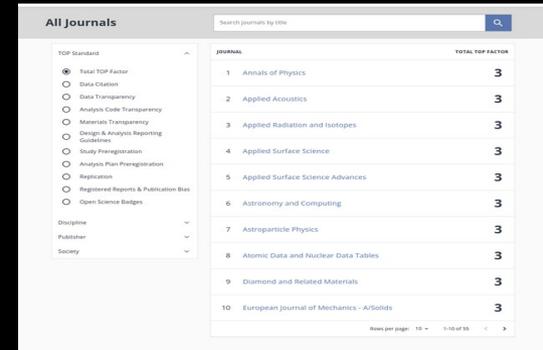
But even **within** any discipline...



The screenshot shows a search results page for journals in the field of psychology. The interface includes a search bar at the top, a sidebar with filters for TOP Standard, Discipline, Publisher, and Society, and a main table listing journals by their Total TOP Factor. The table is sorted in descending order of the factor.

JOURNAL	TOTAL TOP FACTOR
1 Cadernos de Linguística	27
2 Meta Psychology	27
3 Advances in Methods and Practices in Psychological Science	25
4 Peer Community in Registered Reports	25
5 Global Environmental Psychology	24
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8 Cortex	23
9 European Journal of Personality	23
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• • •



The screenshot shows a search results page for journals in the field of physics. The interface is similar to the psychology example, with a search bar, a sidebar with filters, and a main table listing journals by their Total TOP Factor.

JOURNAL	TOTAL TOP FACTOR
1 Annals of Physics	3
2 Applied Acoustics	3
3 Applied Radiation and Isotopes	3
4 Applied Surface Science	3
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6 Astronomy and Computing	3
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8 Atomic Data and Nuclear Data Tables	3
9 Diamond and Related Materials	3
10 European Journal of Mechanics - A/Solids	3

- Research areas (e.g. Cognitive vs Social)
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- ...

TOP standards aren't met ?

TOP standards aren't met ?

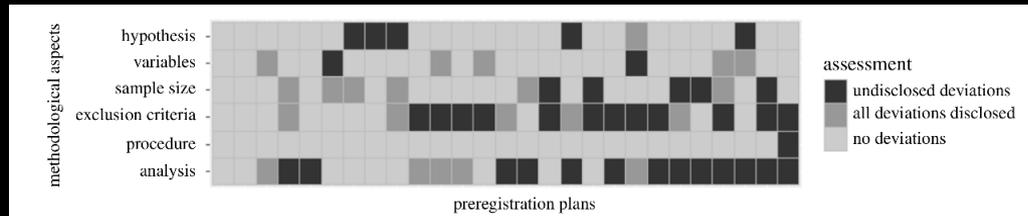


Figure 2. Tile plot of the assessment of each methodological aspect per preregistration plan. Only the 27 studies that were accessible and included the minimal number of methodological details required for our adherence assessment are shown.

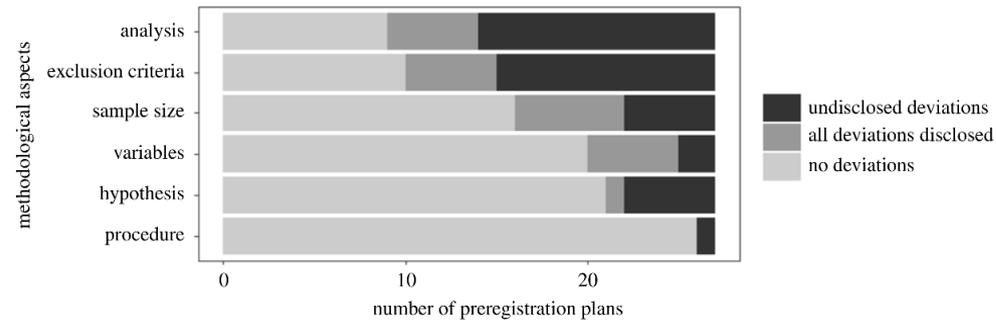


Figure 3. An overview of adherence per methodological aspect.

TOP standards aren't met ?

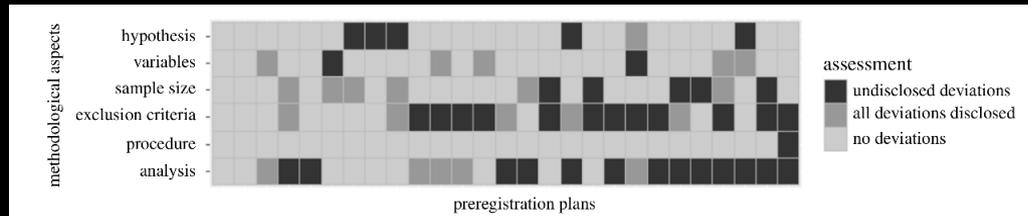


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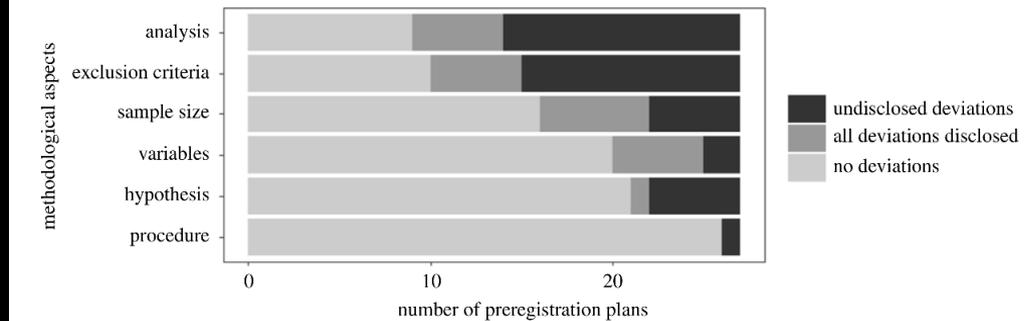


Figure 3. An overview of adherence per methodological aspect.

Ask: **where** should they?

(Caesen et al 2021, R. Soc. Open Science)

Policies have consequences...

nature

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News | Published: 01 September 2017

Brain researchers in uproar over NIH clinical-trials policy

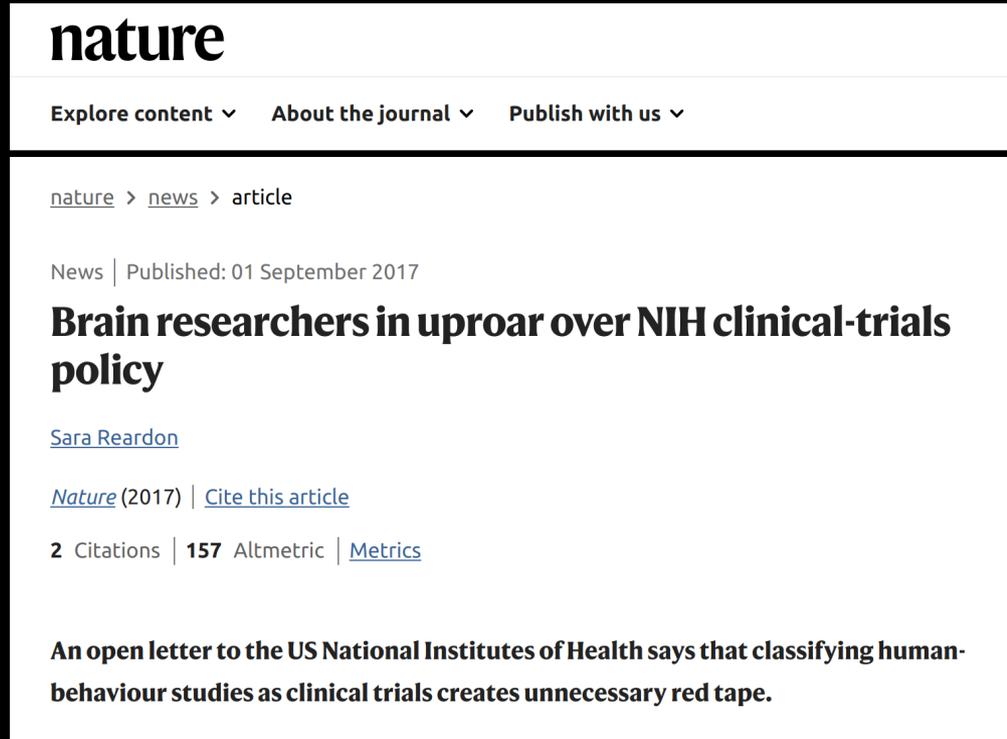
[Sara Reardon](#)

[Nature](#) (2017) | [Cite this article](#)

2 Citations | 157 Altmetric | [Metrics](#)

An open letter to the US National Institutes of Health says that classifying human-behaviour studies as clinical trials creates unnecessary red tape.

Policies have consequences...

A screenshot of a news article from the journal Nature. The page features the journal's logo at the top, navigation links, and a breadcrumb trail. The main headline is about brain researchers' concerns over NIH clinical-trials policy. Below the headline, the author's name, publication date, and citation information are visible. A short summary of the article is provided at the bottom of the screenshot.

nature

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[nature](#) > [news](#) > article

News | Published: 01 September 2017

Brain researchers in uproar over NIH clinical-trials policy

[Sara Reardon](#)

[Nature](#) (2017) | [Cite this article](#)

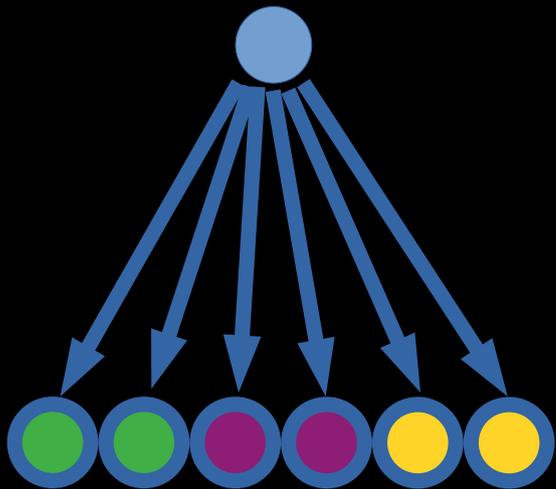
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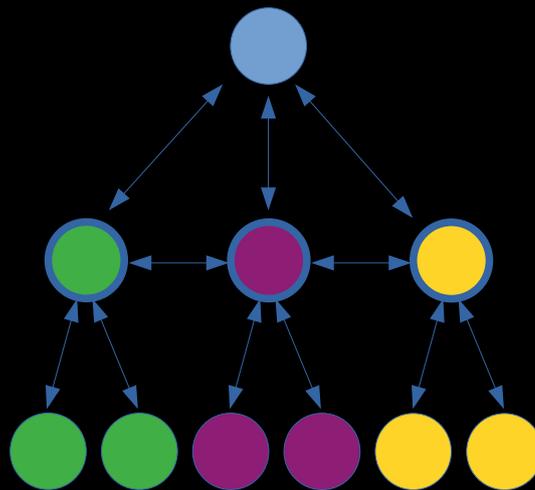
...that we might **never** realise in time.

Light and **adaptive** policy making

From



To





Where we start



Where we start



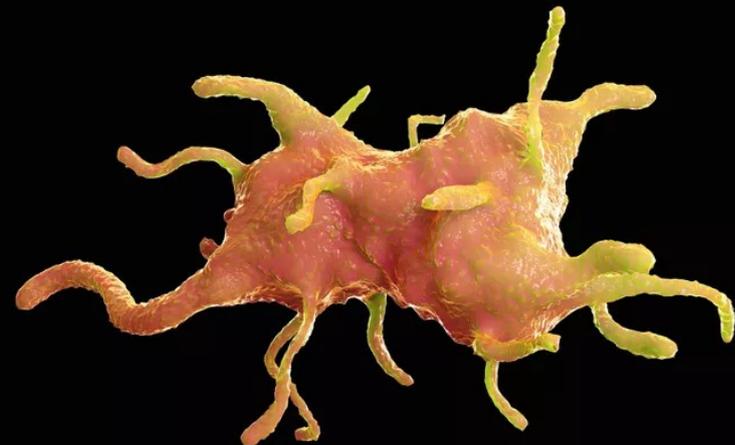
What we think we want



Where we start



What we think we want



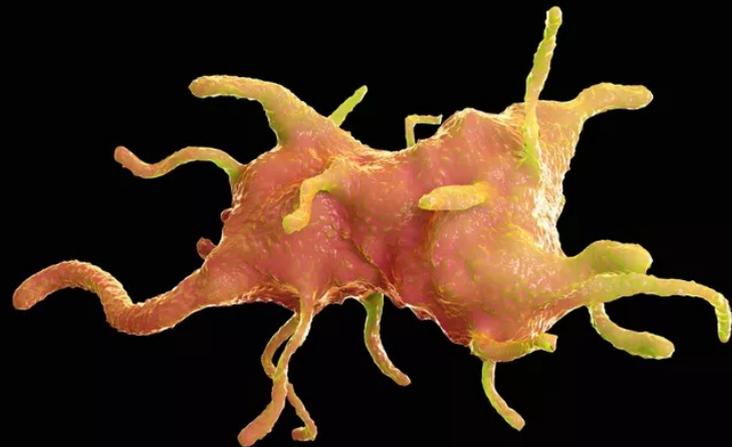
What we really want



Where we start



What we think we want



What we really want

email@danielefanelli.com

