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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  - Metascience has been getting reproducibility and integrity at least partially wrong

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- We don’t know what we don’t know until we know it.
  - Metascience has been getting reproducibility and integrity at least partially wrong
- We shouldn’t do what we don’t know that we are doing.
  - 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 unites, 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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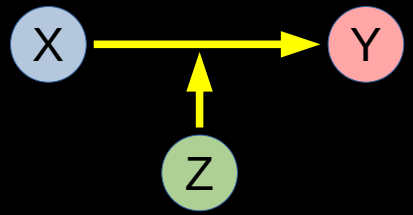

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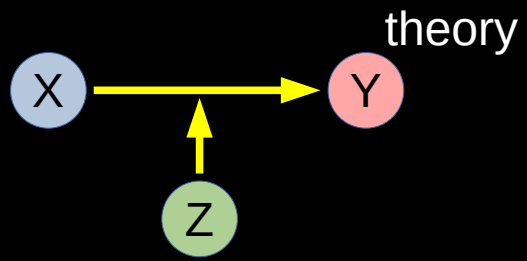

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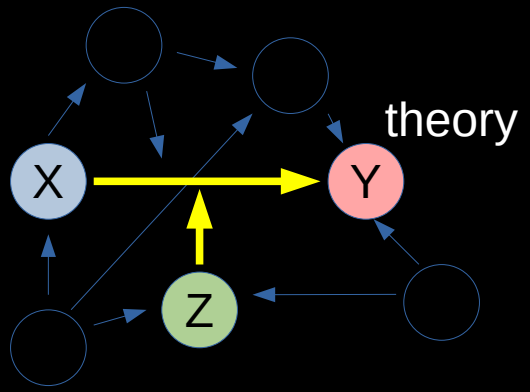

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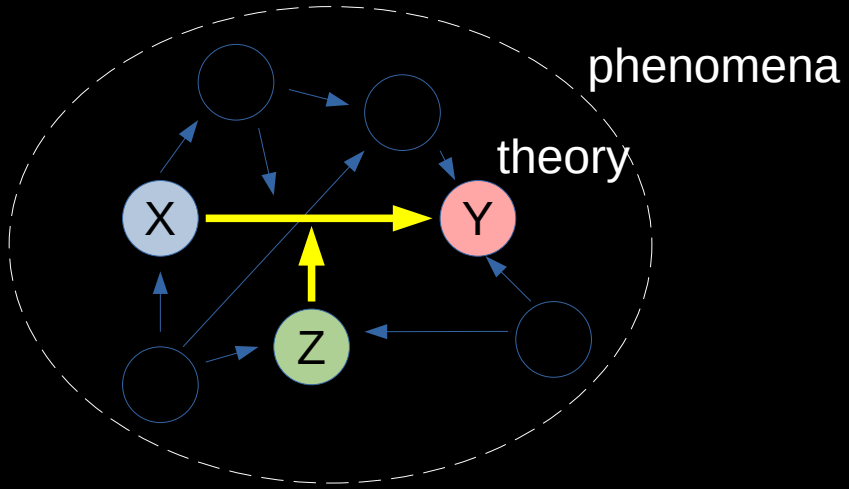

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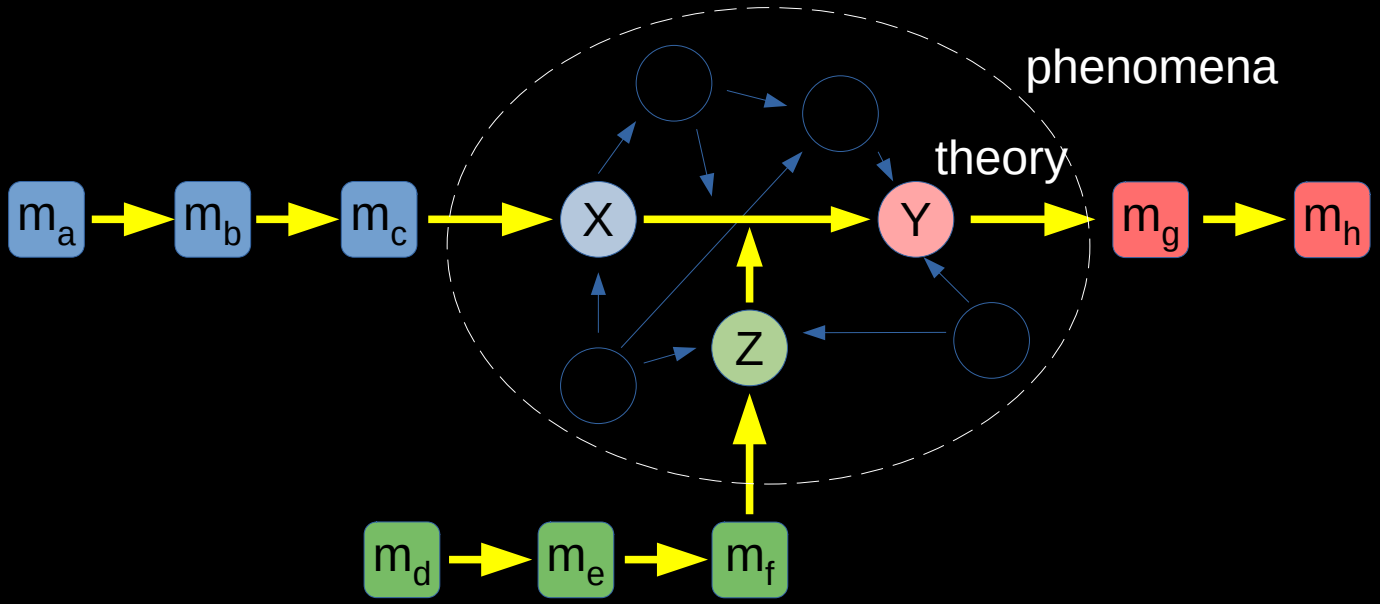

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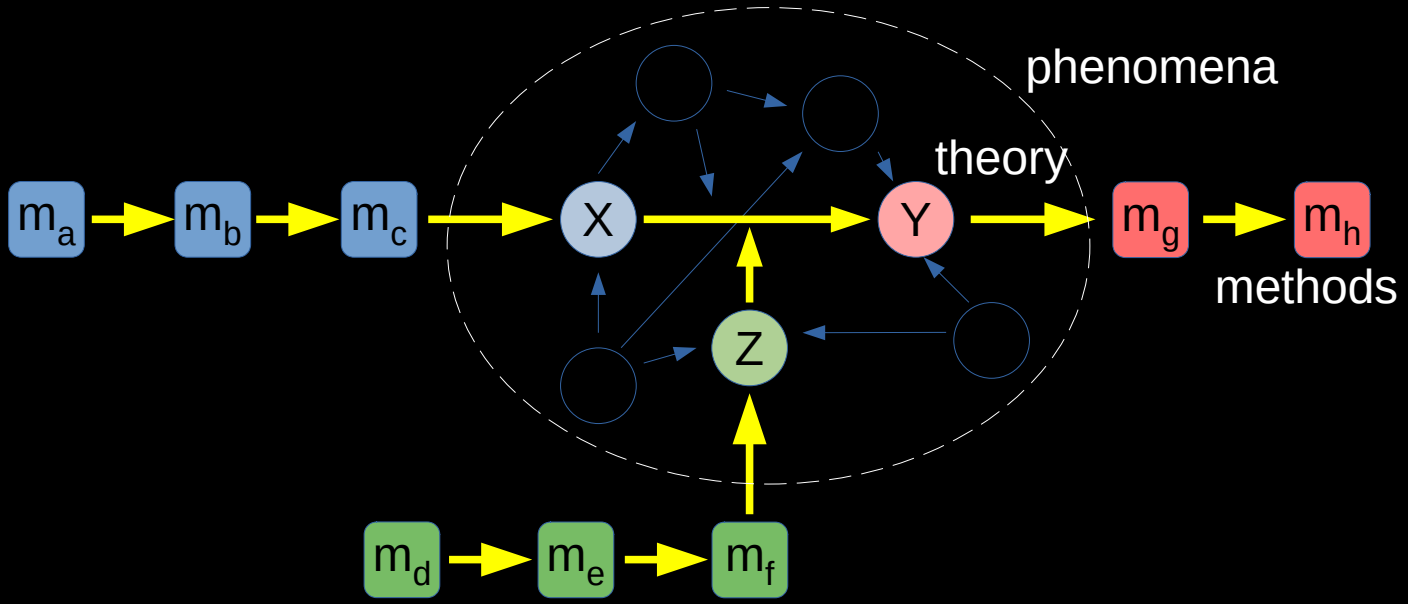

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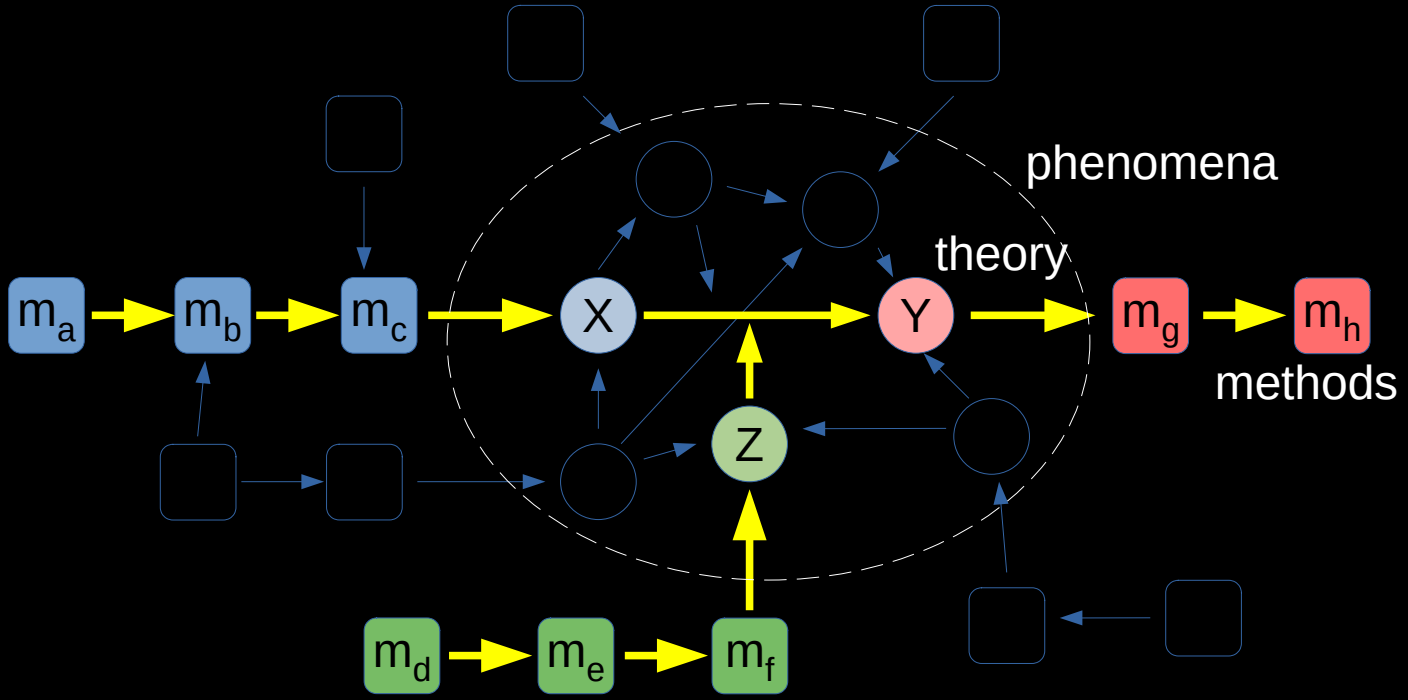

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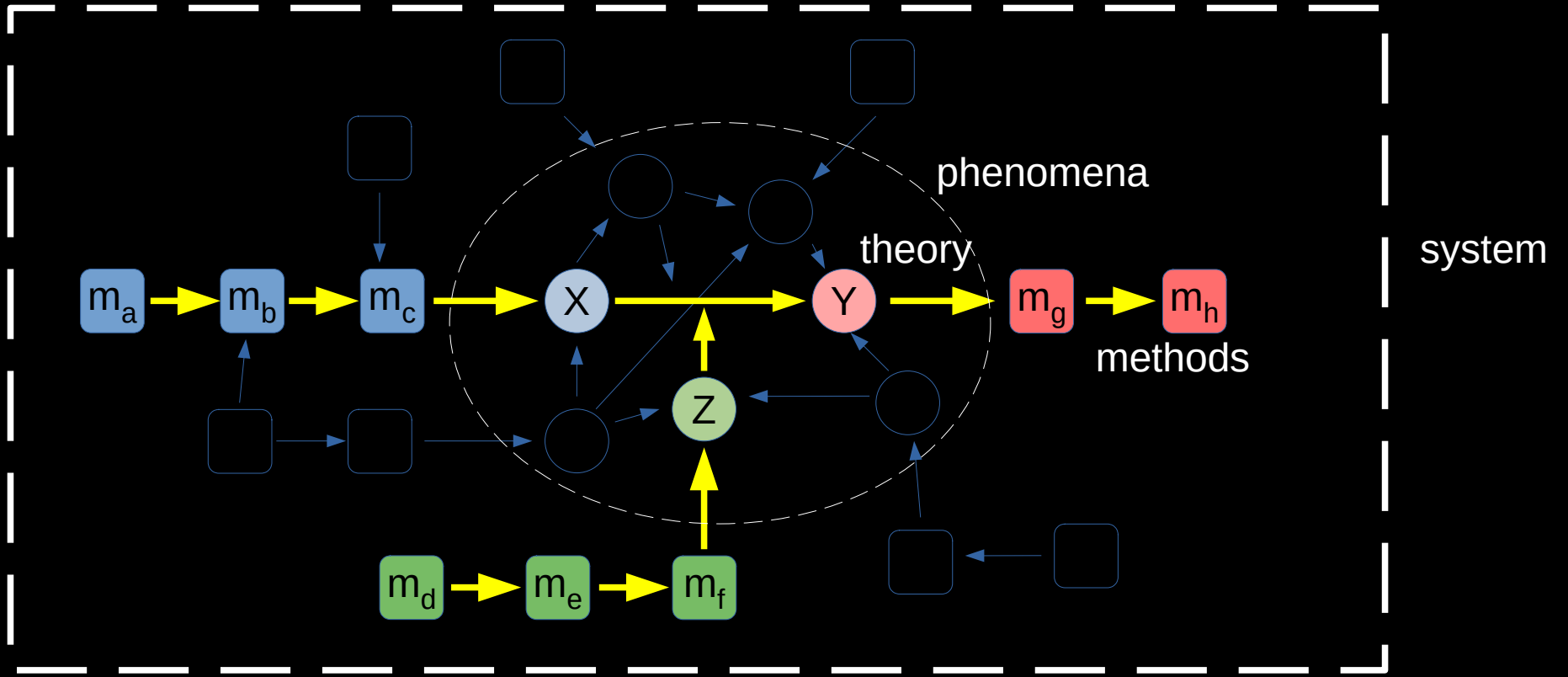
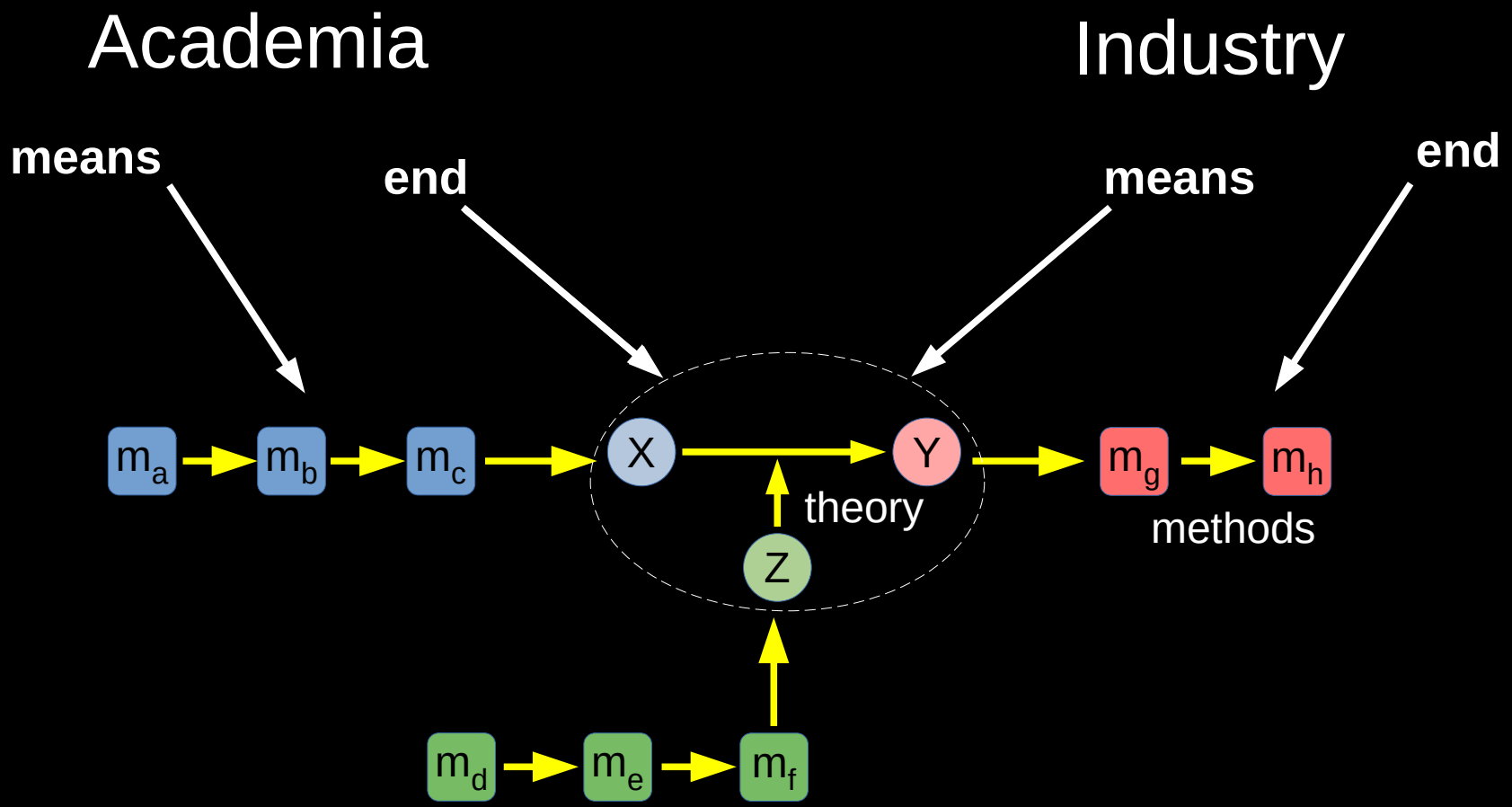


Academia

Industry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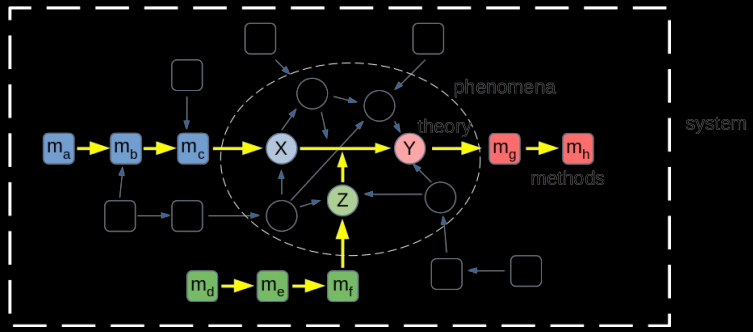
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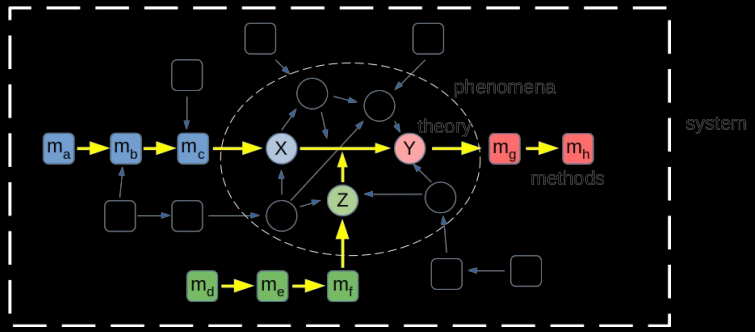

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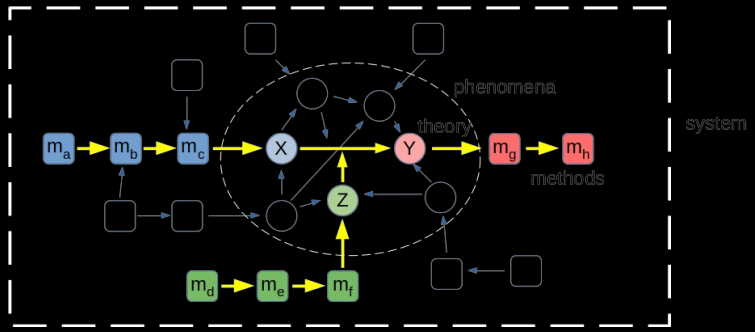

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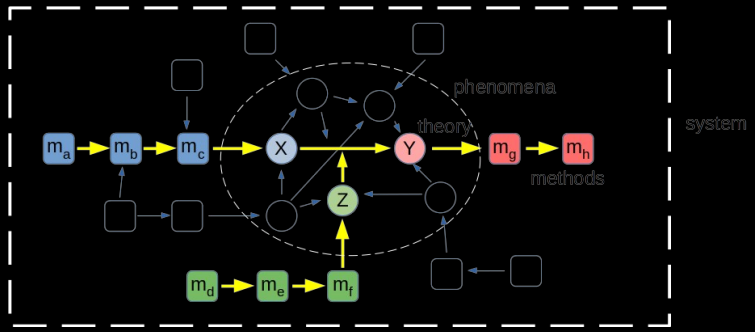

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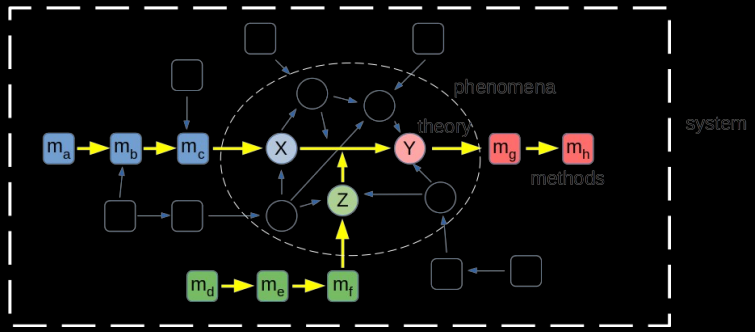

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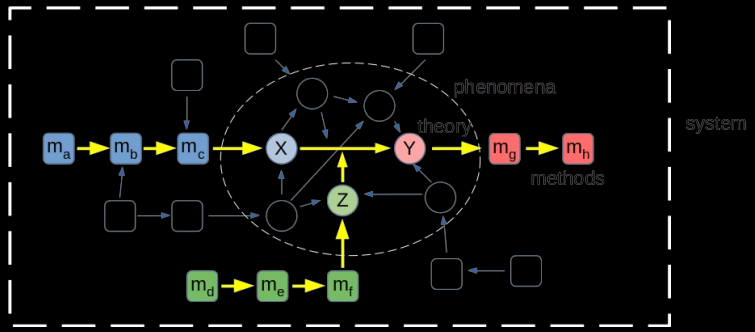

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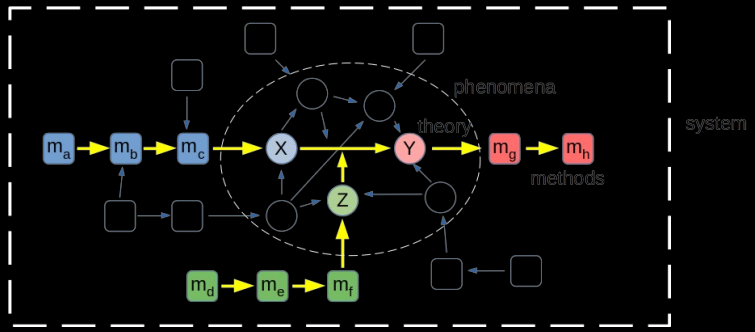

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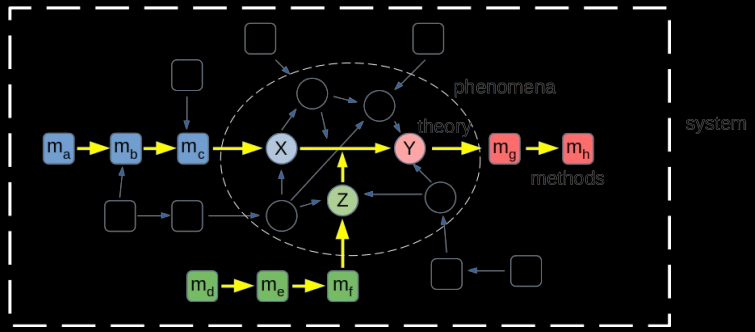

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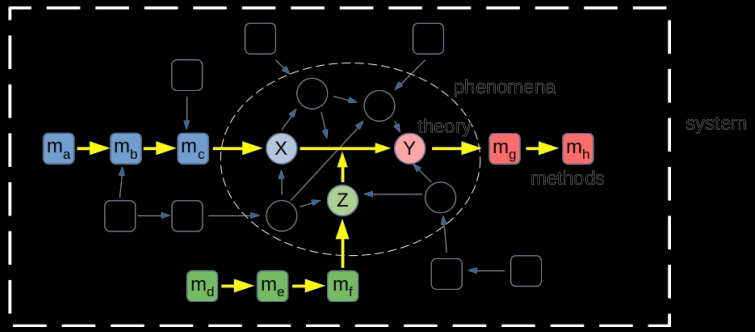

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  - Effects of incentives / interventions / policies

Protocol complexity predicts repr.

(Preregistered test, Braz. Repr. Init. data)

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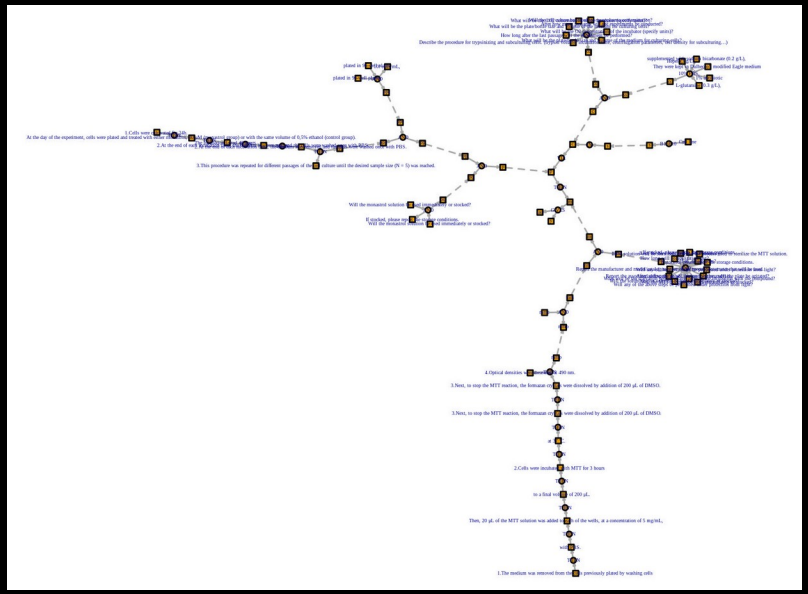
Replication protocol's complexity



(Fanelli, Amaral & Neves, in prep)

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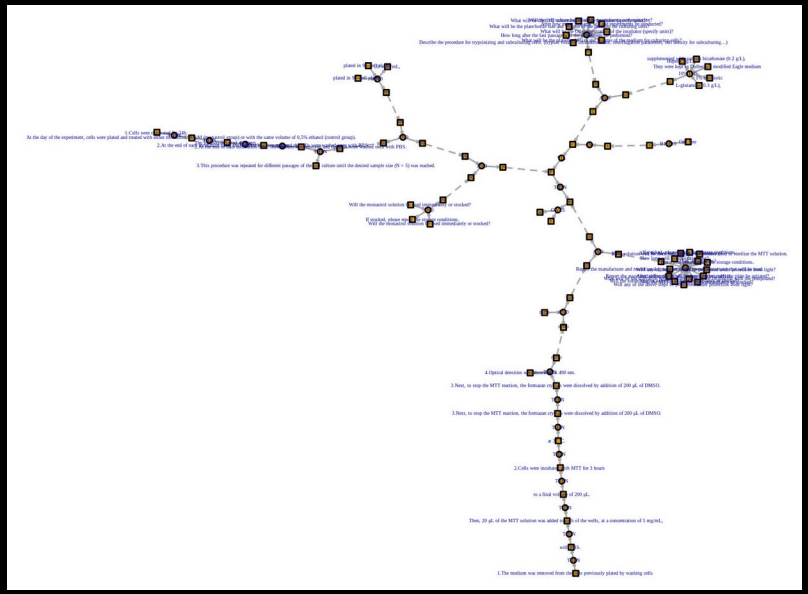

	b	se	t
α	7.522	5.08	1.481
$\log \frac{1}{2 + D(\tau)}$	1.01	0.496	2.035
$\sqrt{N_{orig}}$	-0.541	0.573	-0.943
$\sqrt{N_{rep}}$	-0.527	0.452	-1.164
$P > 0.01$	-0.374	0.916	-0.408
deviations, unwanted	0.32	0.329	0.974
deviations, wanted	-0.354	0.567	-0.624

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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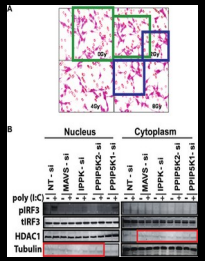

(Bik et al. 2016, mBio)

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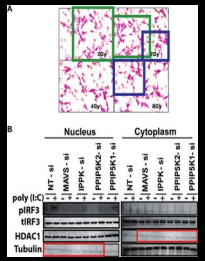

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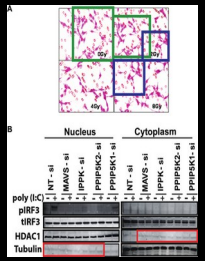

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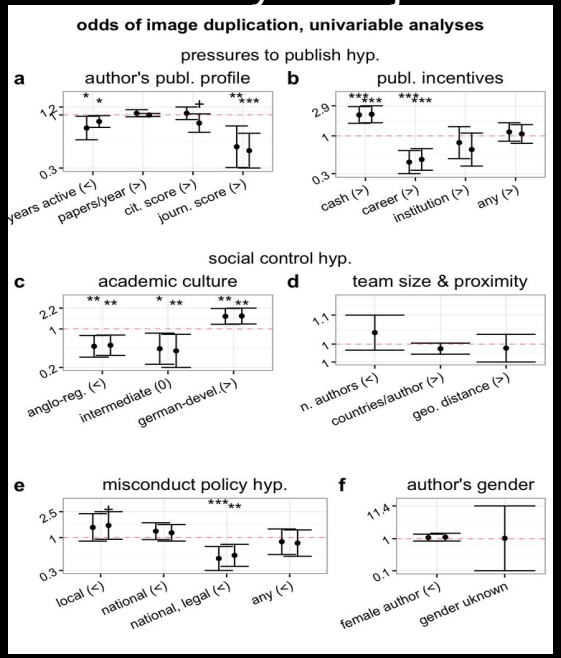

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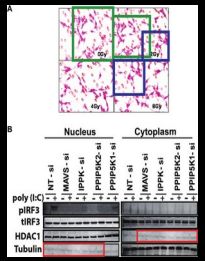

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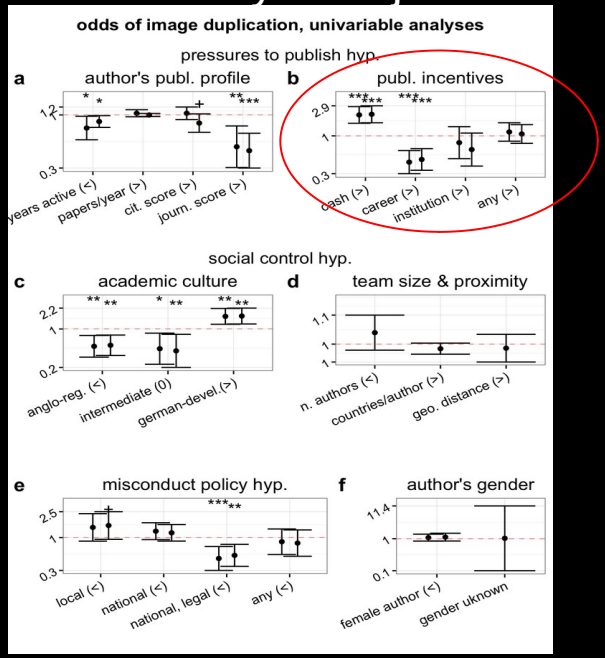

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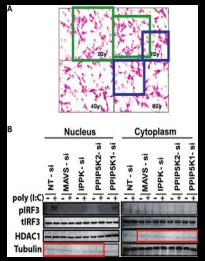

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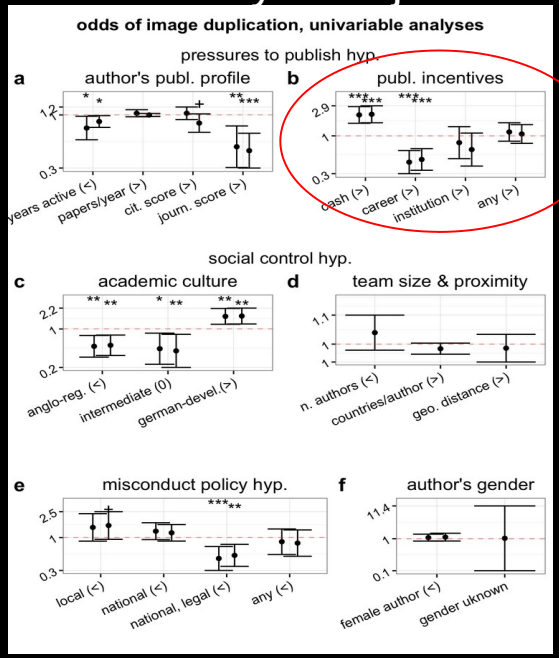

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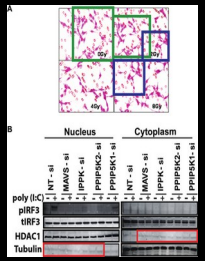

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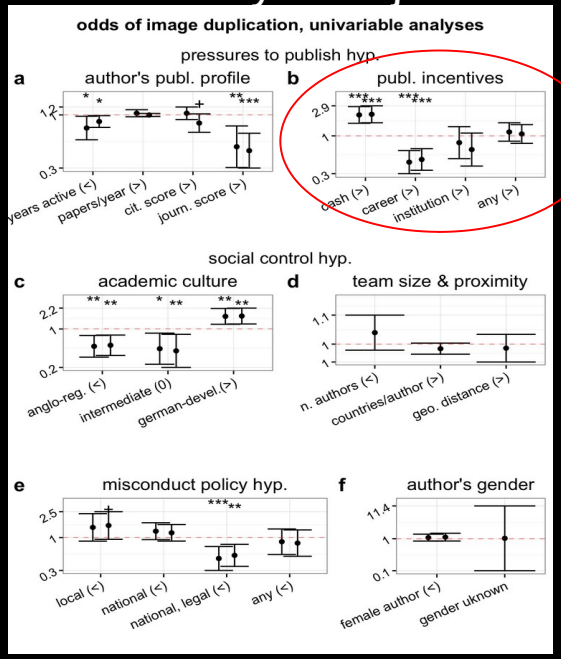

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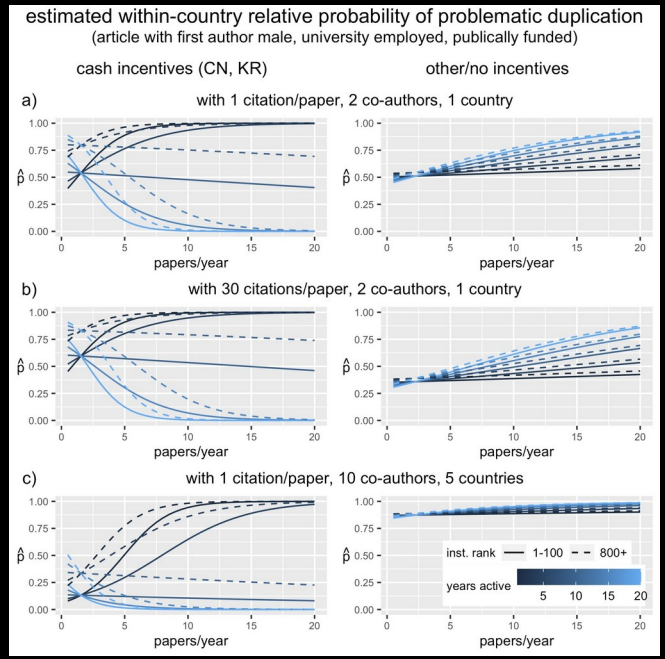

(Fanelli et al. 2022, PloS ONE)

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.

	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.
Analytic methods (code) transparency	Journal encourages code sharing—or says nothing.	Article states whether code is available and, if so, where to access them.	Code must be posted to a trusted repository. Exceptions must be identified at article submission.	Code must be posted to a trusted repository, and reported analyses will be reproduced independently before publication.
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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.
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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.

(Nosek et al. 2015, Science)

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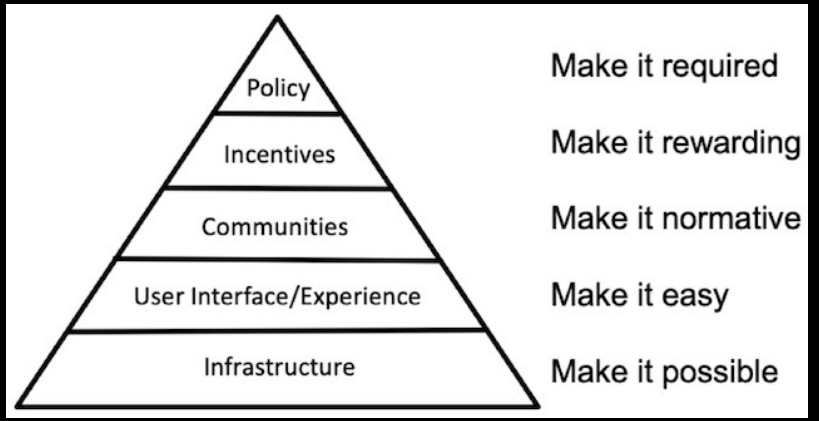

(Nosek 2019, COS blog)

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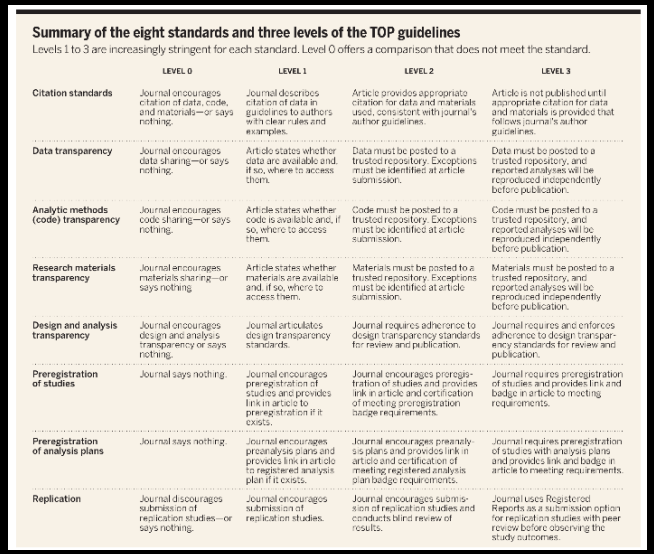

Summary of the eight standards and three levels of the TOP guidelines

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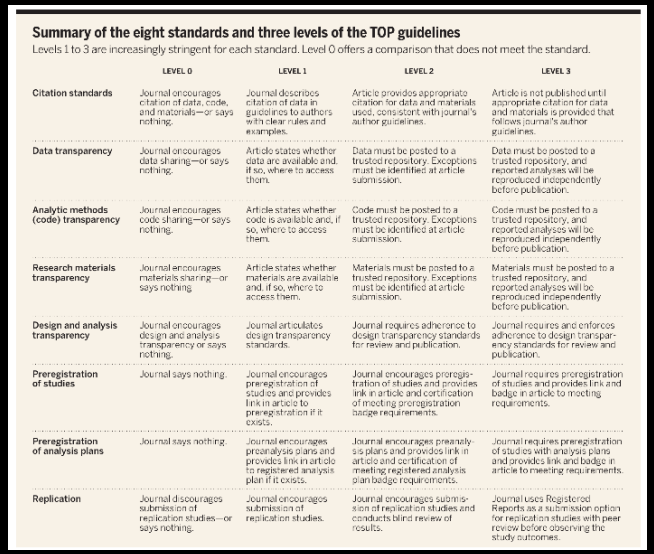

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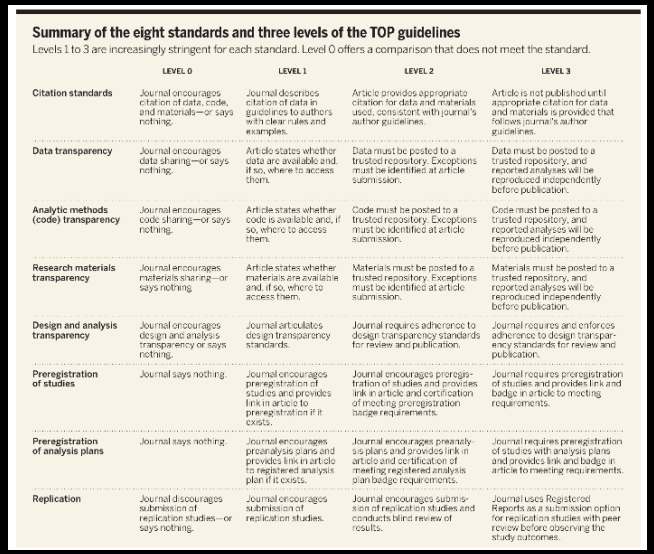

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- Costs
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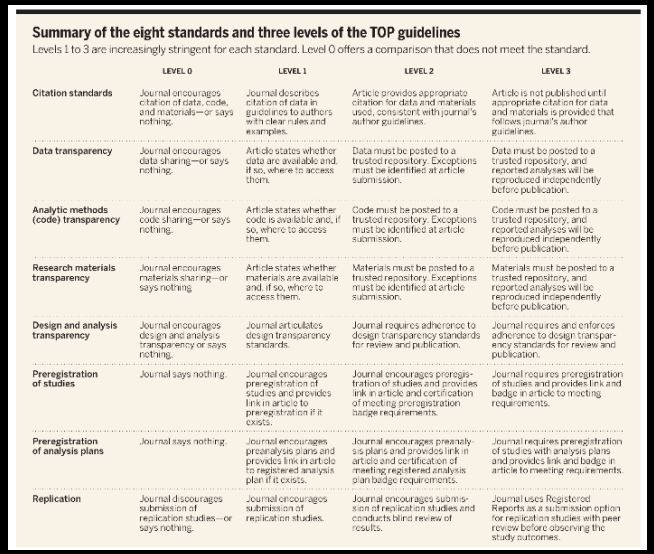

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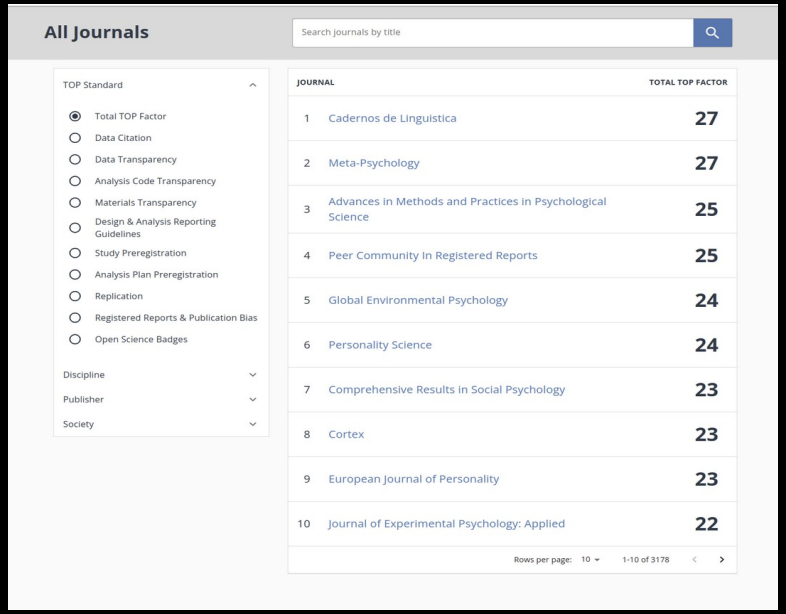
Unequal across systems, contexts, conditions



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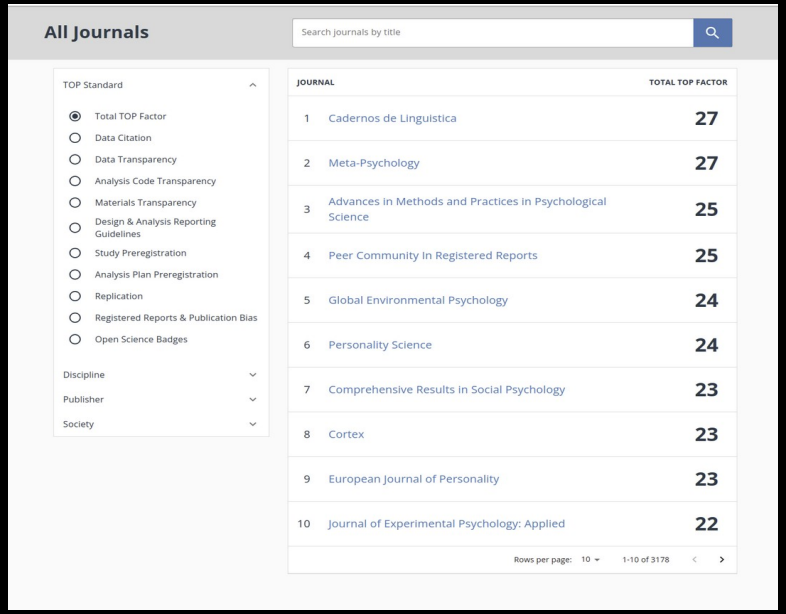

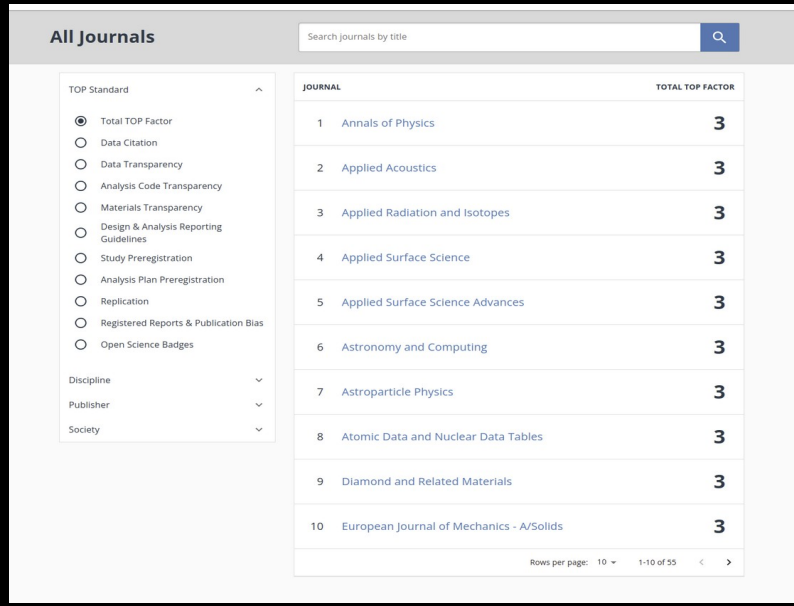

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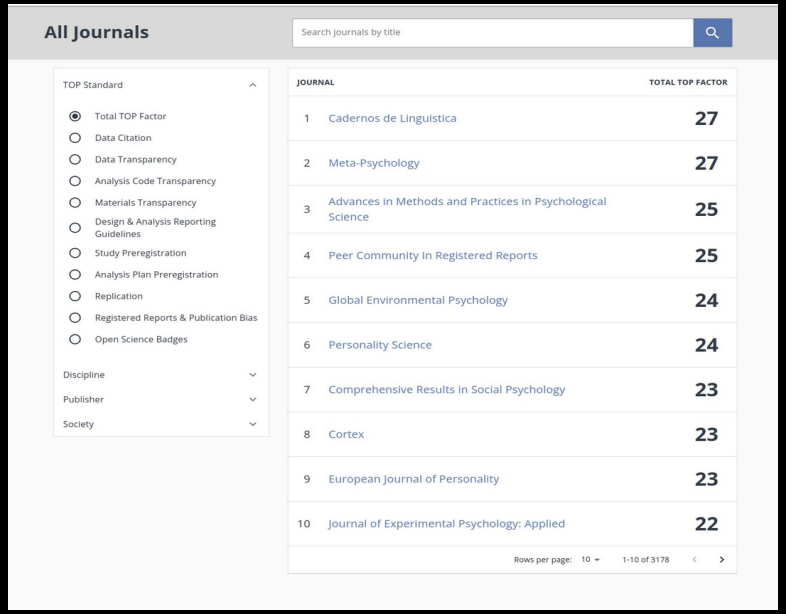
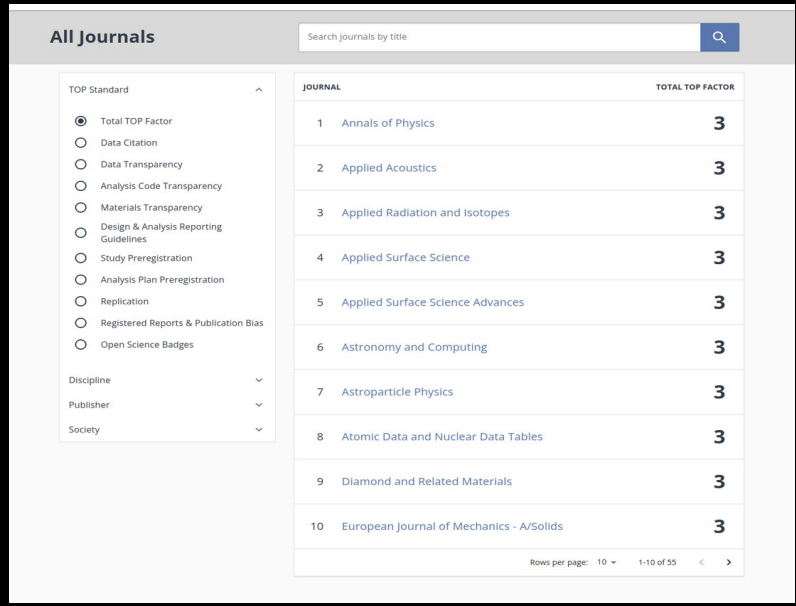
Physics less rigorous than Psychology?!





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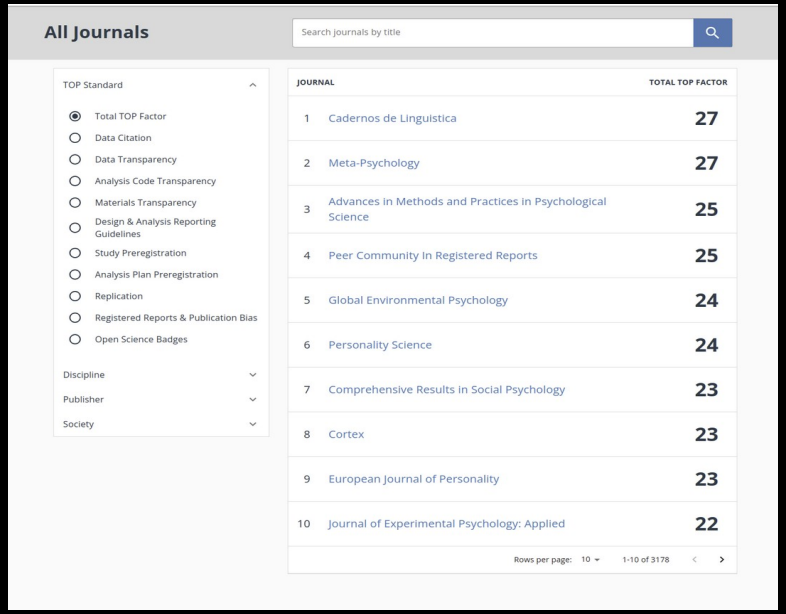
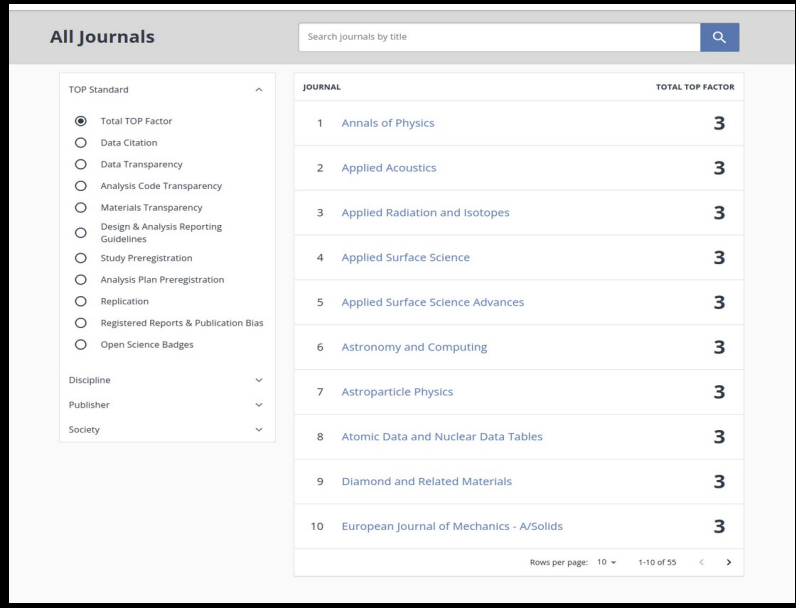
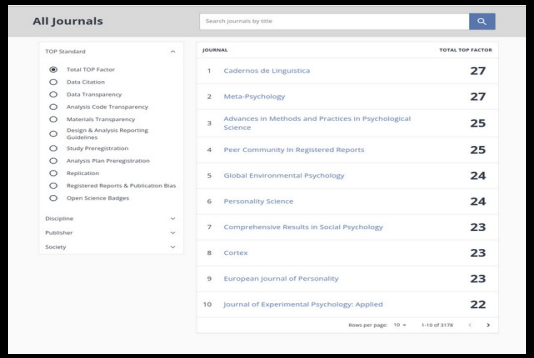




Or are TOP standards very Psychology-specific?

(topfactor.org/journals)

But even within any discipline...



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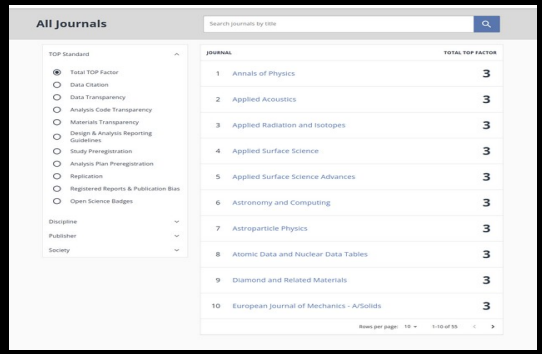

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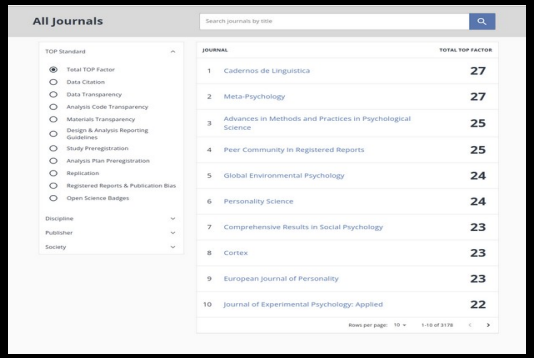

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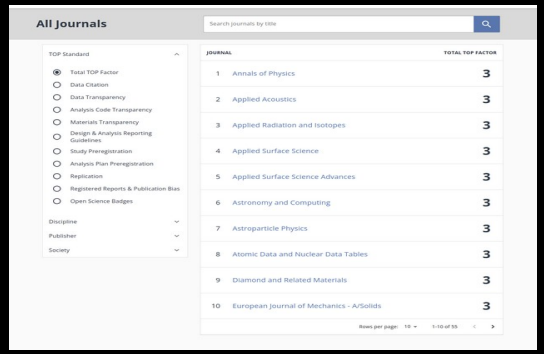

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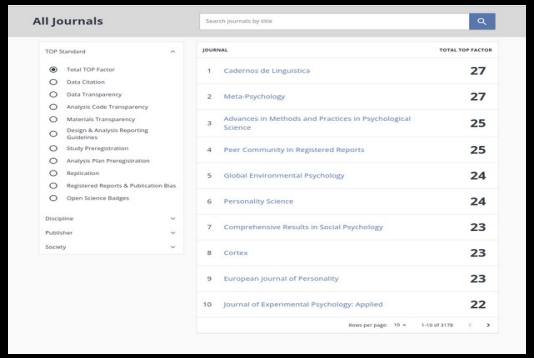

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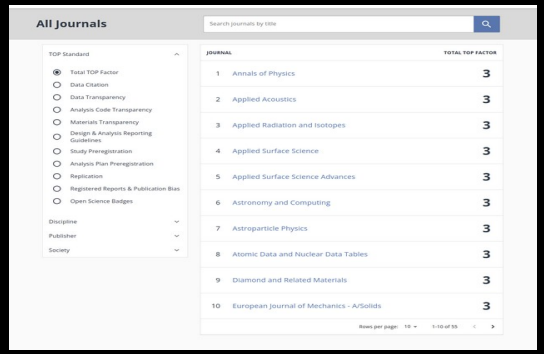

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- Complex vs simpler phenomena?

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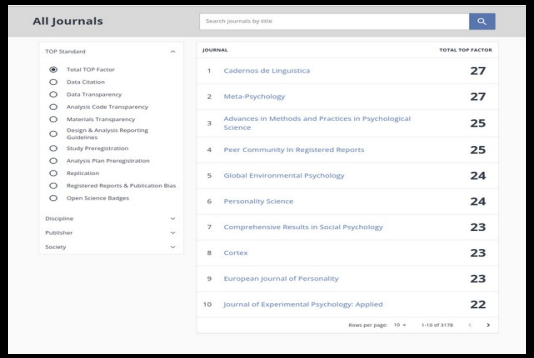

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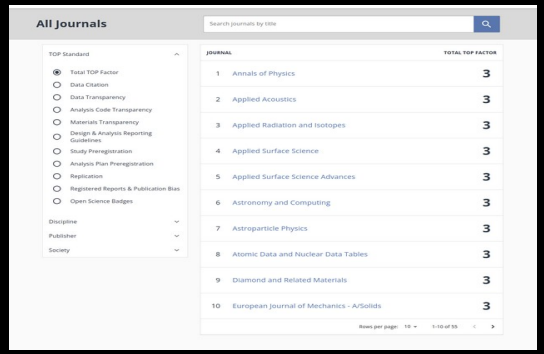

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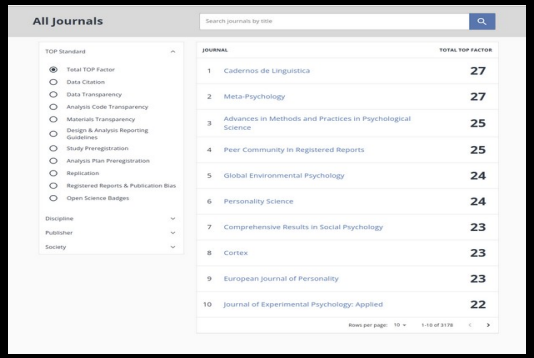

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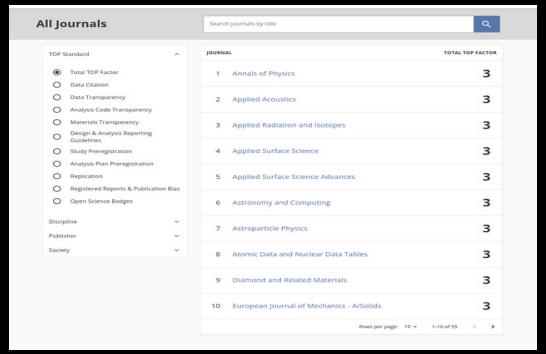

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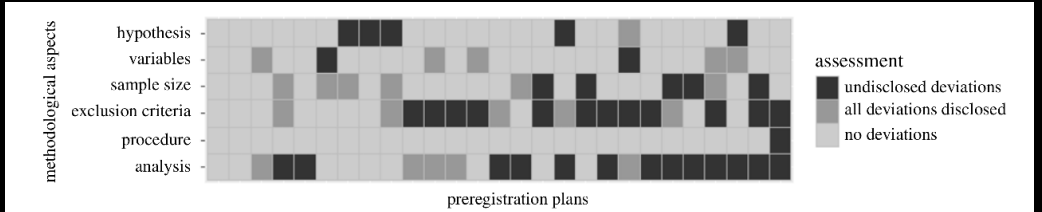

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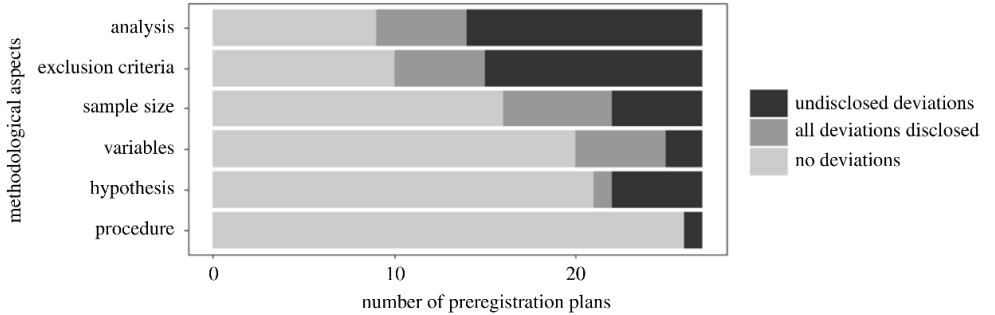

Figure 3. An overview of adherence per methodological aspect.

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

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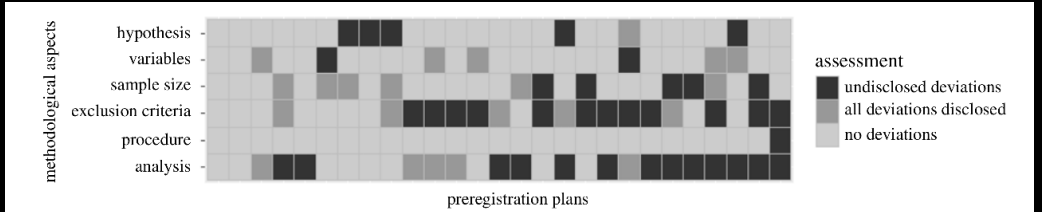

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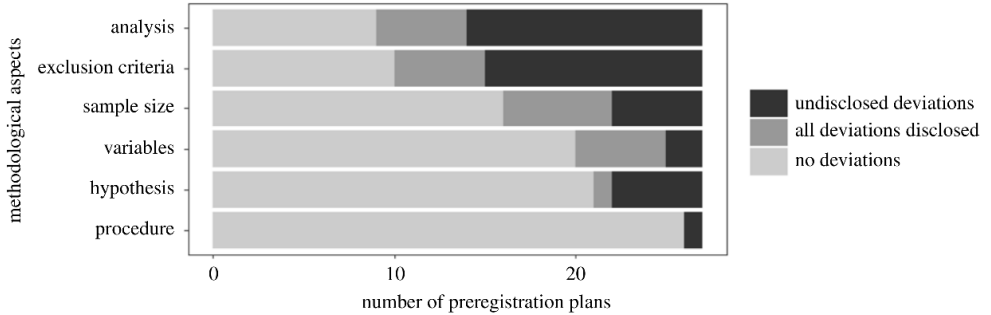

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Ask: where should they?

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

Policies have consequences...

nature

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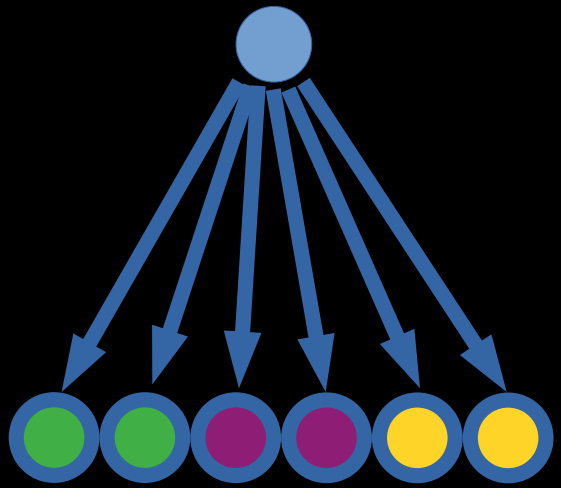
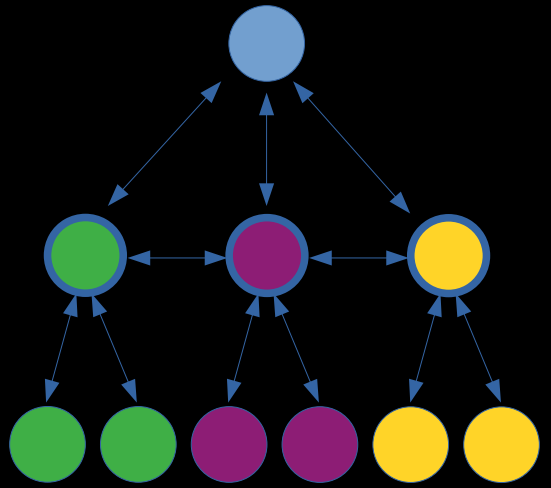
Light and adaptive policy making

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

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