



K O N I N K L I J K E N E D E R L A N D S E
A K A D E M I E V A N W E T E N S C H A P P E N

REPLICATION STUDIES
IMPROVING REPRODUCIBILITY IN THE EMPIRICAL
SCIENCES

Jean Philippe de Jong, PhD

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Background

- Royal Netherlands Academy of Arts and Sciences (KNAW) advises on proper conduct of science
- Concerns about lack of reproducibility of study results
- KNAW installed a committee 'Replication studies' to advise on replication studies
- Advice is based on scientific literature, reports by other advisory bodies, interviews with experts, an invitational workshop and its own deliberations
- This presentation contains preliminary findings.
- Report: October 2017



KNAW Committee replication studies

- Prof. dr. J.P. (Johan) Mackenbach (Erasmus MC), chair
- Prof. dr. C.M. (Cock) van Duijn (Erasmus MC)
- Prof. dr. H.R. (Harry) Büller (Academisch Medisch Centrum)
- Prof. dr. A.W. (Aad) van der Vaart (Universiteit Leiden)
- Prof. dr. E.J. (Eric-Jan) Wagenmakers (Universiteit van Amsterdam)
- Dr. P.Y.W. (Patricia) Dankers (Technische Universiteit Eindhoven)
- Prof. dr. L.M. (Lex) Bouter (Vrije Universiteit Amsterdam)
- Dr. J.Ph. (Jean Philippe) de Jong (KNAW), secretary



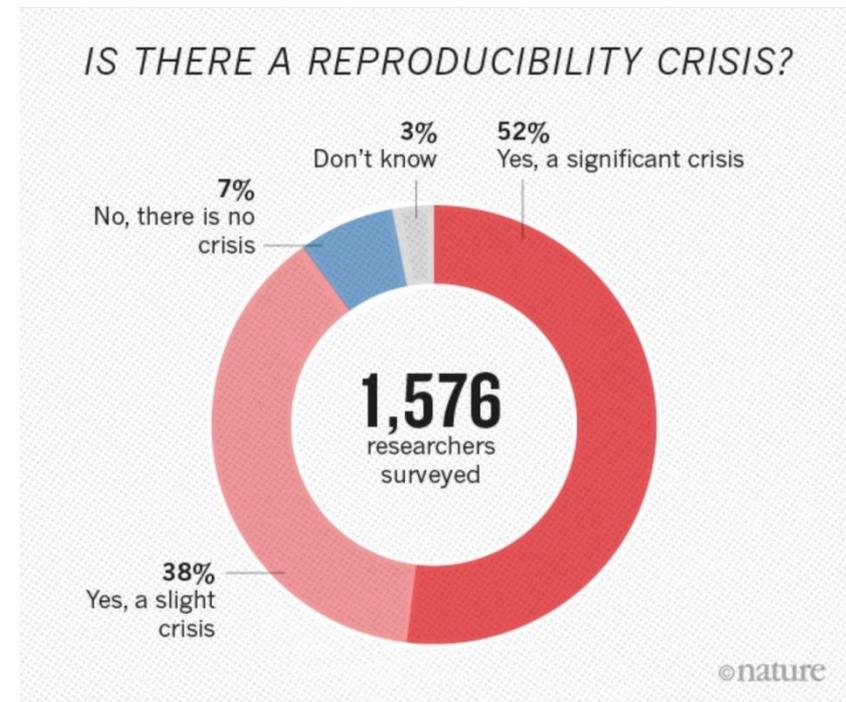
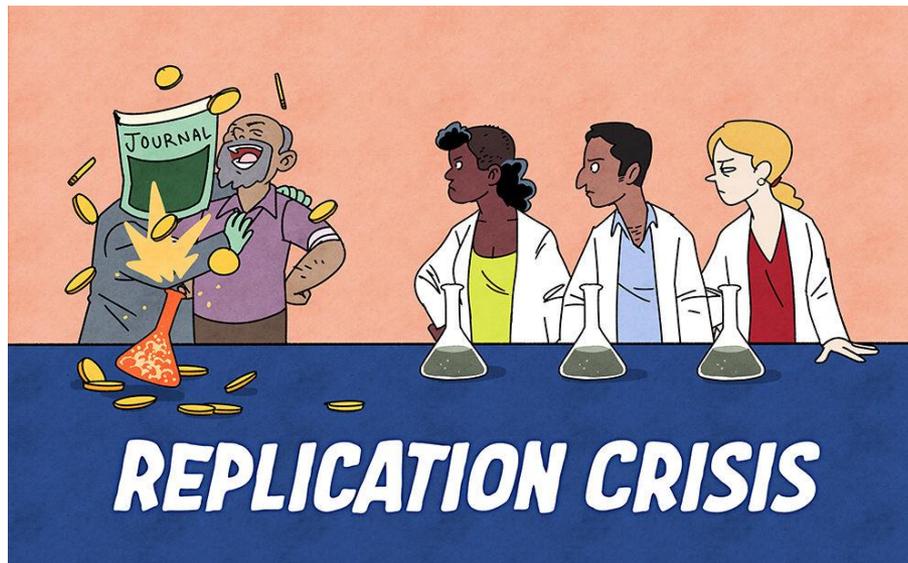
Scientific progress requires that results are reproducible

- No data across science ...
- Open Science Collaboration (psychology): 36%
- Bayer HealthCare: 25%
- Amgen: 11%
- High quality randomized clinical trials: 85%





The scientific community is concerned about the current degree of non-reproducibility of important research findings





Definitions

- A *replication study* is designed to test the reproducibility of the results of a previous study
- The *methods* should be similar, otherwise a meaningful assessment of reproducibility is impossible
- Results are *reproduced* if they are similar enough not to raise concerns about the methodologies and assumptions
- A replication study is not replication *within* a study, the results of which would not be published separately



Truth and reproducibility

- So, similar studies should lead to similar results

However:

- Reproducible results are not necessarily true
 - but can increase confidence in findings
- Non-reproducible results are not necessarily untrue
 - but can decrease confidence and require a good explanation (potentially leading to important insights)



Impact of non-reproducibility

- Delaying scientific progress
- Polluting drug pipeline
- Unethical use of test subjects
- Wasting resources
- Diminishing public trust
- Harming individuals and environment





Non-reproducibility has many causes

- Setting up/conducting a study: random error/noise, human error, biases, changes in conditions
- Analysis of results: data dredging/p-hacking, and outcome-driven data collection
- Reporting results: failing to publish or only partially publishing results
- Underlying factors:
 - lack of proper training
 - incentive structure (funding and publications) disproportionately rewarding novel, positive results over robust approaches





Unavoidable and avoidable causes of non-reproducibility

- Some factors are inherent to the scientific endeavor and even rigorously conducted studies will yield a proportion of published results that cannot be reproduced
- Others factors are avoidable and can be considered 'questionable research practices'



Approaches to improving reproducibility: prevention

- **Improve study methods**
 - Researchers should strengthen quality control mechanisms through automation, guidelines, checklists, validation studies and internal replications.
 - Institutions should improve researchers' skills in rigorous study design, analysis and interpretation of results.
 - Institutions should provide independent methodological support and oversight on studies.
- **Improving study reporting**
 - Institutions and funders should require pre-registration of hypothesis-testing studies.
 - Journals should issue detailed guidelines and checklist for how to report study methods.
 - Institutions and journals should require storage of study data and methods in a repository.
- **Improve the organization and culture of research**
 - Journals should publish more studies with 'negative' results.
 - Funders should provide more long-term funding for researchers.
 - Institutions should reward researchers' peer review activities and efforts to improve rigorous study execution.



Approaches to improving reproducibility: replication

- A certain degree of non-reproducibility cannot be avoided upfront
- Replication studies will therefore are thus necessary to:
 - check the results of an individual study and to get nearer to the truth
 - gain insight into and improve the functioning of science



Kinds of replication studies, three choices:

- Who will execute the study: the original investigator team, an independent team, a collaboration?
- What aspects of a study to replicate: sample collection, data collection, measurements, analysis, interpretation?
- How precisely to follow the original study: a considerable degree of similarity is needed, but a perfect copy might neither be desirable nor feasible?



What percentage of research efforts should be replication studies?

- Limited data on occurrence of replication studies
- At most a few percent in various disciplines
- Is this enough/too much?



The desired rate of replication studies depends on:

- the actual degree of non-reproducible results/likelihood that a results is non-reproducible
- to what extent conducting replication studies will contribute to societal goals
- whether it is an efficient use of research funds
- A comparison to alternatives:
 - doing innovative studies
 - taking 'preventive' measures to improve reproducibility.



Good replication practices require:

1. Information sharing
2. Know-how
3. Incentivizes



researchers need to adequately share information about original and replication studies

However...

- Publication bias distorts current evidence
- Lack of detail in reporting of methods and data of original study





researchers need to know when and how to perform a replication study

However...

- Difficulties in assessing the need for replications in terms of benefits and costs
- Insufficient skills in choosing study designs and interpreting results in terms of reproducibility



researchers need to experience the proper incentivizes

However...

- Researchers prefer 'creative' and 'original' studies
- Researchers view replications as an attack on colleagues
- Funding agencies focus on 'innovative' research
- Journals have a criterion of 'originality'
- Career evaluations are based on (high impact) publications, funding and new findings





Recommendations to researchers

- Conduct replication studies when appropriate.
- Researchers should generate data on reproducibility and replication studies.





Recommendations to funders

- Funders should assess the need for replication studies within fields based on benefits, costs and alternatives.
- Funders should create better funding opportunities for replication studies.



Recommendations to journals

- Journals should encourage the submission of replication studies.
- Journals should issue detailed guidelines and checklist for how to report study methods
- Journals (and institutions) should require storage of study data and methods in a repository



Recommendations to institutions

- Institutions (and funders) should require pre-registration of hypothesis-testing studies
- Institutions should educate researchers on how to design replication studies and assess reproducibility.
- Institutions should credit replication studies in career evaluations and awards.



THANK YOU

Email me at:

jean.philippe.de.jong@knaw.nl