Training 5: Transparent and Reproducible Research

Aleksandr Michuda

Center for Data Science for Enterprise and Society, Cornell University

Introduction

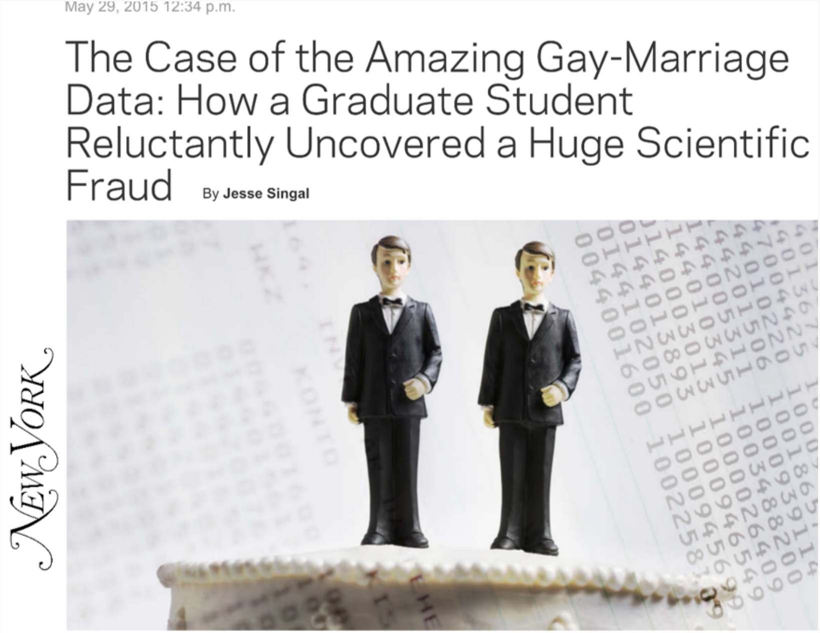
Special Thanks to Oscar Barriga-Cabanillas and Matthieu Stigler!

- Welcome!
  - Training 5: Transparency and Reproducibility in Research (You are here.)
  - Training 6: Data Management
  - Training 6a: Dynamic Documents

Training 5: Transparency and Reproducibility in Research

- Is there a problem with replicability and statistical validity?
- Is there a reproducibility crisis?
- How can we counter-act this?
- Replicability
  - Not a problem of results being intentionally falsified, although there are cases
  - There is a lack of incentives to replicate / validate
- Statistical Validity
  - P-hacking
  - Multiple testing
  - Workflow
  - Null results are not a failure
- Exercises

Replication Disincentives



May 29, 2015 12:34 p.m.

The Case of the Amazing Gay-Marriage Data: How a Graduate Student Reluctantly Uncovered a Huge Scientific Fraud

By **Jesse Singal**

Replication Disincentives

- The persistence of David Broockman led to the discovery of data falsification
- Michael LeCour falsified the data of his thesis:
    - Subjects interviewed about their acceptance of gay marriage
    - Treatment: Revealing interviewer's sexual orientation before asking questions
- LeCour received an offer from Princeton because of his job as thesis, which was published in *Science* in 2014
- Received media coverage; organizations changed their policies because of this
- Many people were suspicious, but the inclusion of names recognized in the publication acted as shielding - people wanted to believe them

Replication Disincentives

- How did Broockman find out?
- Wanted to write a similar study; replication
- He first wanted to replicate it
- The cost and logistics were not within the reach of a grad student
    - LeCours would have to have a budget of over $1,000,000 to carry the design
        - 10,000 respondents paid $100 a piece
- Things unravelled from there. . .
- His own study didn't end up being consistent
- Raw data was too "orderly"

So What?

- No incentive to carry out replications
- But there isn't much reward to questioning results
    - Either "shamelessly taking down a big name."
    - Or being unfair/critical to peers
- Until recently, not really considered "science"
- Points to structural issue
- How do we change it?

Journal of Comments and Replications in Economics

PEER-REVIEWED. OPEN ACCESS. NO AUTHOR FEES.

But Also...

- That's an extreme example
- Biggest problems are the things we do as part of standard research practices
  - Cutting/subsetting/"exploring" sample until we find an "interesting" (read: stat. sig.) result
    - Or rather, not being clear about when cutting is part of our *a priori* understanding of the model vs. exploratory work
  - Not considering null results as interesting
  - Not commenting code/making it easier for someone to read/run our code
  - Not taking version control seriously (`paper_1_new_final_final2_changed_final12.docx`)

Preview of Solutions

- *Cutting/subsetting/"exploring" sample until we find an "interesting" (read: stat. sig.) result*

  Solution: Multiple Hypothesis Testing; Pre-analysis Plans
- *Not considering null results as interesting*

  Solution: Registered Reports (Also, the idea of *precise zeros*)
- *Not commenting code/making it easier for someone to read/run our code*

  Solution: dynamic documents, code commenting, docker
- *Not taking version control seriously*

  Solution: `git`

Null Results

The problem:

- The publication of null effects is disappearing over time, in all disciplines. (Fanelli 2011) .
- Valuable information is being lost

Null Results

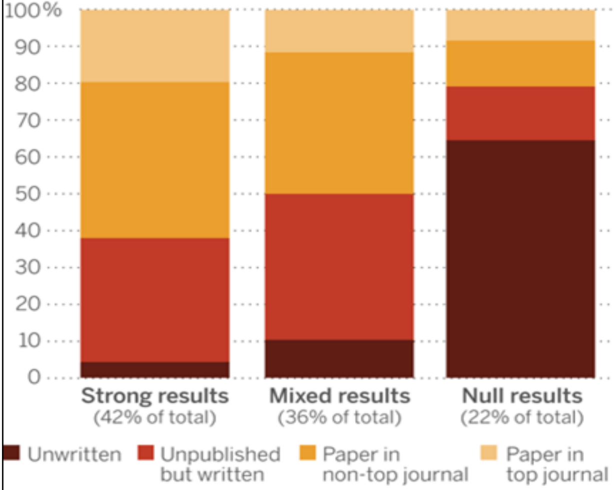
Null results are archived

- They are not published
- They are not registered

Nulls are needed to understand full distribution of results!

Most null results are never written up

The fate of 221 social science experiments



Source: A. Franco *et al.*, *Science* (28 August)

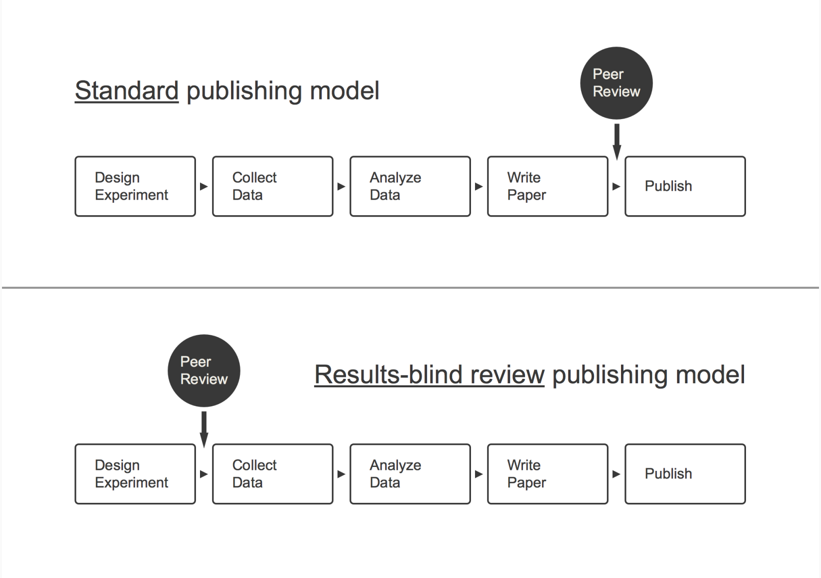
Registered Reports

- AKA Registered Reports, change time to peer review before the data collection, analysis and results.
  - Design a study
  - Send to a journal
  - Review based on the importance of the question and design quality
  - Get acceptance
  - Run the study, and publish even with null results

Hundreds of Journals Participating ▸ Link

Including. . . JDE!

What’s the Difference?



Standard publishing model

Peer Review

Design Experiment ▶ Collect Data ▶ Analyze Data ▶ Write Paper ▶ Publish

Peer Review

Results-blind review publishing model

Design Experiment ▶ Collect Data ▶ Analyze Data ▶ Write Paper ▶ Publish

Pre-registration

- And if that doesn't work, pre-register your studies!
- Gives credibility to work that you're doing
- Puts you "on the map" as having thought of the idea
- Can even do it for secondary data

Precise Nulls

- A null result can be interesting too!
- How to make sure that a null result is actually $\mathbf{0}$?
    - Review design
    - Check that no-reject is not due to a small sample with respect to the effect size

Definition (Minimum detectable effect size)

The smallest actual effect, which can be detected for a certain level of power and statistical significance.

Multiple Testing

- Consequences of always looking for p-values < 0.05:
  - Fraud
  - p-hacking: systematic search for significant results
  - unconscious bias: accept without criticism H_1, examine H_0 meticulously
- This usually happens through constant testing of hypotheses

Multiple Testing

- False Positive: Rejecting H_0 when it is in fact not significant
- What is the probability of a false positive? Type I error: α (usually 5%)
- What about with m hypotheses?
  - R_i rejecting null hypothesis i

$P\{\text{at least one } H_i^0 \text{ rejected} \mid \text{all } H_i^0 \text{ correct}\}$

$$\begin{aligned} =&1 - P\{\text{No rejections}\} \\ =&1 - P\{\bar{R}_1 \cap \bar{R}_2 \cap \ldots \cap \bar{R}_m | H_i^0\} \\ =&1 - (1-\alpha)^m \qquad\qquad \text{if independent} \end{aligned}$$

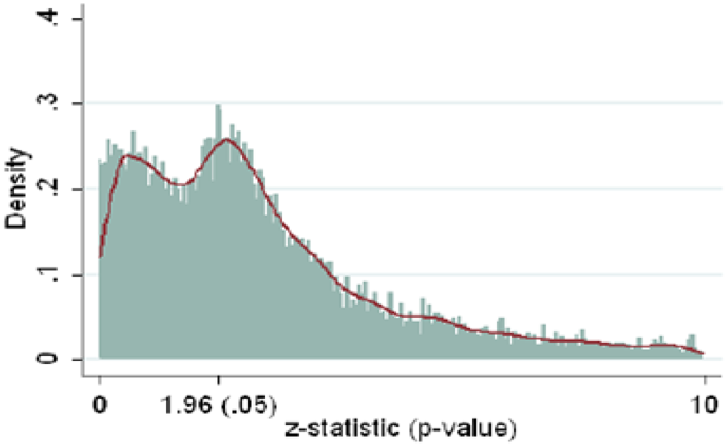
M=# tests:	1	2	3	5	10	20	50
	5%	10%	14%	22%	40%	64%	92%

P-hacking

> Systematic search for significant results on multiple combinations of i) dependent variables ii) combinations of independent variables; reporting only significant results. If we test enough hypotheses it is certain that we can reject at least one hypothesis, even if it is a false positive!!

P-hacking is Real

(b) Unrounded distribution of z-statistics.



P-hacking is Real

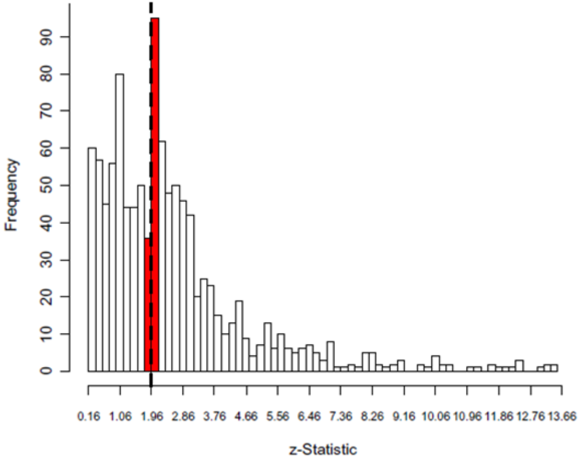


Figure 1(a). Histogram of z-statistics, *APSR & AJPS* (Two-Tailed). Width of bars (0.20) approximately represents 10% caliper. Dotted line represents critical z-statistic (1.96) associated with $p = 0.05$ significance level for one-tailed tests.

Multiple Hypothesis Testing

$$\begin{aligned} P\{\#R_i \geq 1 | H_i^0 \,\forall i\} =& 1 - P\{\text{No rejections}\} \\ =& 1 - P\{\bar{R}_1 \cap \bar{R}_2 \cap \ldots \cap \bar{R}_m | H_i^0\} \\ =& 1 - (1-\alpha)^m \qquad\qquad \text{if independent} \end{aligned}$$

The Bonferroni inequality:

$$P\{\#R_i \geq 1 | H_i^0 \,\forall i\} \leq m \cdot \alpha$$

Multiple Hypothesis Testing

	Number of Tests					
	1	2	3	5	10	20
False Positive	5%	10%	14%	22%	40%	64%
No Adjustment	5%	5%	5%	5%	5%	5%
Bonferroni	5%	2.5%	1.67%	1.25%	1%	0.8%

Multiple Hypothesis Testing

- Controlling for false positives:
  - Bonferroni: use the Boolean inequality $\mathrm{P}\left\{\right\} < \alpha \cdot m \Rightarrow$ use $\alpha = \frac{\alpha}{m}$.

Problem: it is very conservative!

With $m = 50$, $\alpha = 0.001$ is used instead of 0.05!

Holmes: iterative procedure, not as conservative than Bonferroni

Control of the false discovery rate, the proportion of false positives: Benjamini – Hochberg

When to use it?

- When to Use multiple corrections?
  - Tables with multiple results
  - After having explored many combinations of models
- Connects to idea of pre-analysis plans
  - plan for the number of tests you'll do so that the correction doesn't cause too much of a penalty

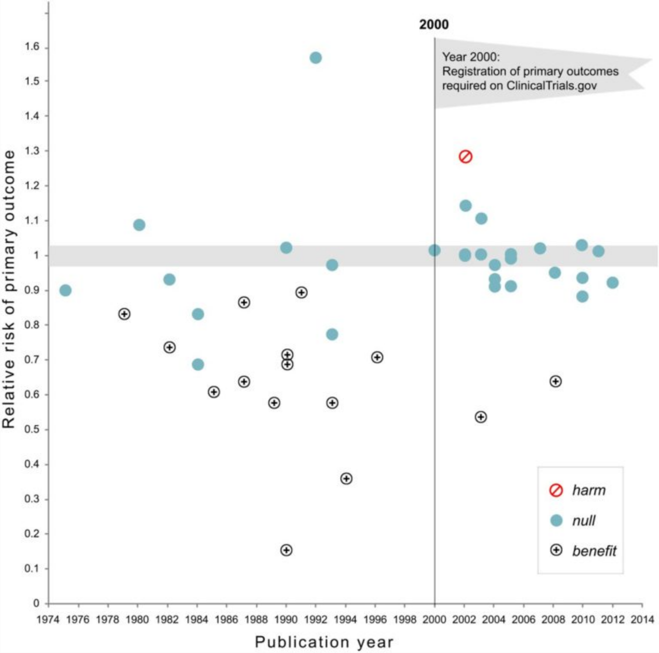
Pre-analysis Plans

> **Pre-analysis Plan**
> Detailed description of the analyses to be conducted (hypotheses, variables, equations, controls, etc): This description is written before viewing the data.

By specifying the details before viewing the results, the plan is a safeguard against p-hacking.

Where do you register?

- AEA Registry, actualmente solo para RCTs.
  - `https://socialscienceregistry.org`
- EGAP
  - `https://egap.org/design-registration`
- 3ie
  - `https://ridie.3ieimpact.org`
- Open Science Framework
  - `https://osf.io`

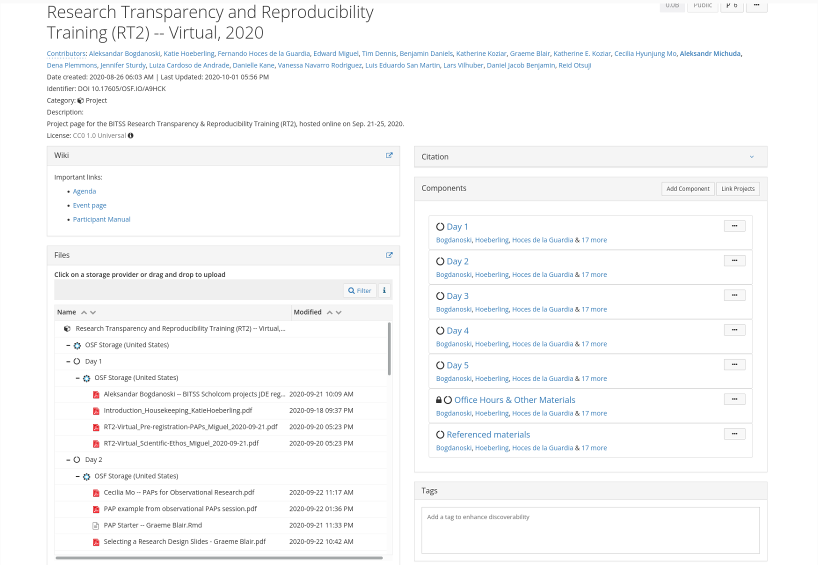

2000
Year 2000:
Registration of primary outcomes
required on ClinicalTrials.gov
Relative risk of primary outcome
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014
Publication year
harm
null
benefit

Pre-analysis Plans

In a pre-analysis plan, a very clear distinction is made between two types of analysis:

- Confirmatory analysis : test the pre-registered hypotheses. If it is well done, it balances the false positive problem and which hypotheses are most important.
- Exploratory analysis : results not pre-registered. They come in a different section, and have less credibility (could be false positives).

OSF



Research Transparency and Reproducibility Training (RT2) -- Virtual, 2020

Contributors: Aleksandar Bogdanoski, Katie Hoeberling, Fernando Hoces de la Guardia, Edward Miguel, Tim Dennis, Benjamin Daniels, Katherine Koziar, Graeme Blair, Katherine E. Koziar, Cecilia Hyunjung Mo, **Aleksandr Michuda**, Dena Plemmons, Jennifer Sturdy, Luiza Cardoso de Andrade, Danielle Kane, Vanessa Navarro Rodriguez, Luis Eduardo San Martin, Lars Vilhuber, Daniel Jacob Benjamin, Reid Otsuji

Date created: 2020-08-26 06:03 AM | Last Updated: 2020-10-01 05:56 PM

Identifier: DOI 10.17605/OSF.IO/A9HCK

Category: Project

Description:

Project page for the BITSS Research Transparency & Reproducibility Training (RT2), hosted online on Sep. 21-25, 2020.

License: CC0 1.0 Universal

Wiki

Important links:

- Agenda
- Event page
- Participant Manual

Files

Click on a storage provider or drag and drop to upload

Name	Modified
Research Transparency and Reproducibility Training (RT2) -- Virtual,...	
− OSF Storage (United States)	
− Day 1	
− OSF Storage (United States)	
Aleksandar Bogdanoski -- BITSS Scholcom projects JDE reg...	2020-09-21 10:09 AM
Introduction_Housekeeping_KatieHoeberling.pdf	2020-09-18 09:37 PM
RT2-Virtual_Pre-registration-PAPs_Miguel_2020-09-21.pdf	2020-09-20 05:23 PM
RT2-Virtual_Scientific-Ethos_Miguel_2020-09-21.pdf	2020-09-20 05:23 PM
− Day 2	
− OSF Storage (United States)	
Cecilia Mo -- PAPs for Observational Research.pdf	2020-09-22 11:17 AM
PAP example from observational PAPs session.pdf	2020-09-22 01:36 PM
PAP Starter -- Graeme Blair.Rmd	2020-09-21 11:33 PM
Selecting a Research Design Slides - Graeme Blair.pdf	2020-09-22 10:42 AM

Citation

Components

Day 1
Bogdanoski, Hoeberling, Hoces de la Guardia & 17 more

Day 2
Bogdanoski, Hoeberling, Hoces de la Guardia & 17 more

Day 3
Bogdanoski, Hoeberling, Hoces de la Guardia & 17 more

Day 4
Bogdanoski, Hoeberling, Hoces de la Guardia & 17 more

Day 5
Bogdanoski, Hoeberling, Hoces de la Guardia & 17 more

Office Hours & Other Materials
Bogdanoski, Hoeberling, Hoces de la Guardia & 17 more

Referenced materials
Bogdanoski, Hoeberling, Hoces de la Guardia & 17 more

Tags

Add a tag to enhance discoverability

OSF

- “One-stop Shop” for Research
- Provides Integration with Github, cloud services
- Keeps track of your project and files changing
- **An easy place to write Pre-Analysis Plans and Registered Reports!**

Exercise

- Take the time now to start a registered report, pre-registration or pre-analysis plan for your own project.