Webinar on increasing openness and reproducibility

April Clyburne-Sherin
Reproducible Research Evangelist

contact@cos.io

Today's webinar

1. Plan for reproducibility before you start

- Create a study plan
- Set-up a reproducible project
- Preregistration

2. Keep track of things

- Version control
- Documentation
- Connect your research services

3. Contain bias

- Reporting

4. Archive + share your materials

What is the problem?

CORRESPONDENCE

Believe it or not: how much can we rely on published data on potential drug targets?

Florian Prinz, Thomas Schlange and Khusru Asadullah

A recent report by Arrowsmith noted that the success rates for new development projects in Phase II trials have fallen from 28% to 18% in recent years, with insufficient efficacy being the most frequent reason for failure (Phase II failures: 2008–2010. *Nature Rev. Drug Discov.* **10**, 328–329 (2011))[1]. This indicates the limitations of the predictivity of disease models and also that the validity of the targets being investigated is frequently questionable, which is a crucial issue to address if success rates in clinical trials are to be improved.

to 'feasible/marketable', and the financial co of pursuing a full-blown drug discovery a development programme for a particular t get could ultimately be hundreds of millions Euros. Even in the earlier stages, investmer in activities such as high-throughput scre ing programmes are substantial, and thus t validity of published data on potential targ is crucial for companies when deciding to st novel projects.

To mitigate some of the risks of such inve ments ultimately being wasted, most ph

LINK TO ORIGINAL ARTICLE

Power failure: why small sample size undermines the reliability of neuroscience

Katherine S. Button[1,2], John P. A. Ioannidis[3], Claire Mokrysz[1], Brian A. Nosek[4], Jonathan Flint[5], Emma S. J. Robinson[6] and Marcus R. Munafò[1]

Abstract | A study with low statistical power has a reduced chance of detecting a true effect, but it is less well appreciated that low power also reduces the likelihood that a statistically significant result reflects a true effect. Here, we show that the average statistical power of studies in the neurosciences is very low. The consequences of this include overestimates of effect size and low reproducibility of results. There are also ethical dimensions to this problem, as unreliable research is inefficient and wasteful. Improving reproducibility in neuroscience is a key priority and requires attention to well-established but often ignored methodological principles.

Open access, freely available online

Essay

Why Most Published Research Findings Are False

John P. A. Ioannidis

Summary

There is increasing concern that most current published research findings are false. The probability that a research claim is true may depend on study power and bias, the number of other studies on the same question, and, importantly, the ratio of true to no relationships among the relationships probed in each scientific field. In this framework, a research finding is less likely to be true when the studies conducted in a field are smaller; when effect sizes are smaller; when there is a greater number and lesser preselection of tested relationships; where there is greater flexibility in designs, definitions, outcomes, and analytical modes; when there is greater financial and other interest and prejudice; and when more teams are involved in a scientific field in chase of statistical significance.

It can be proven that most claimed research findings are false.

factors that influence this problem and some corollaries thereof.

Modeling the Framework for False Positive Findings

Several methodologists have pointed out [9–11] that the high rate of nonreplication (lack of confirmation) of research discoveries is a consequence of the convenient, yet ill-founded strategy of claiming conclusive research findings solely on the basis of a single study assessed by formal statistical significance, typically for a *p*-value less than 0.05. Research is not most appropriately represented and summarized by *p*-values, but, unfortunately, there is a widespread notion that medical research articles

should be interpreted based only on *p*-values. Research findings are defined here as any relationship reaching formal statistical significance, e.g., effective interventions, informative predictors, risk factors, or associations. "Negative" research is also very useful. "Negative" is actually a misnomer, and the misinterpretation is widespread. However, here we will target relationships that investigators claim exist, rather than null findings.

As has been shown previously, the probability that a research finding is indeed true depends on the prior probability of it being true (before doing the study), the statistical power of the study, and the level of statistical significance [10,11]. Consider a 2 × 2 table in which research findings are compared against the gold standard of true relationships in a scientific field. In a research field both true and false hypotheses can be made about the presence of relationships. Let R be the ratio of the number of "true relationships" to "no relationships" among those tested in the field. R is characteristic of the field and can vary a lot depending on whether the field targets highly likely relationships or searches for only one or a few true relationships among thousands and millions of hypotheses that may be postulated. Let us also consider, for computational simplicity, circumscribed fields where either there is only one true relationship (among many that can be hypothesized) or the power is similar to find any of the several existing true relationships. The pre-study probability of a relationship being true is $R/(R + 1)$. The probability of a study finding a true relationship reflects the power $1 - \beta$ (one minus the Type II error rate). The probability of claiming a relationship when none truly exists reflects the Type I error rate, α. Assuming that c relationships are being probed in the field, the expected values of the 2 × 2 table are given in Table 1. After a research finding has been claimed based on achieving formal statistical significance, the post-study probability that it is true is the positive predictive value, PPV. The PPV is also the complementary probability of what Wacholder et al. have called the false positive report probability [10]. According to the 2 × 2 table, one gets $PPV = (1 - \beta)R/(R - \beta R + \alpha)$. A research finding is thus

Citation: Ioannidis JPA (2005) Why most published research findings are false. PLoS Med 2(8): e124.

Abbreviation: PPV, positive predictive value

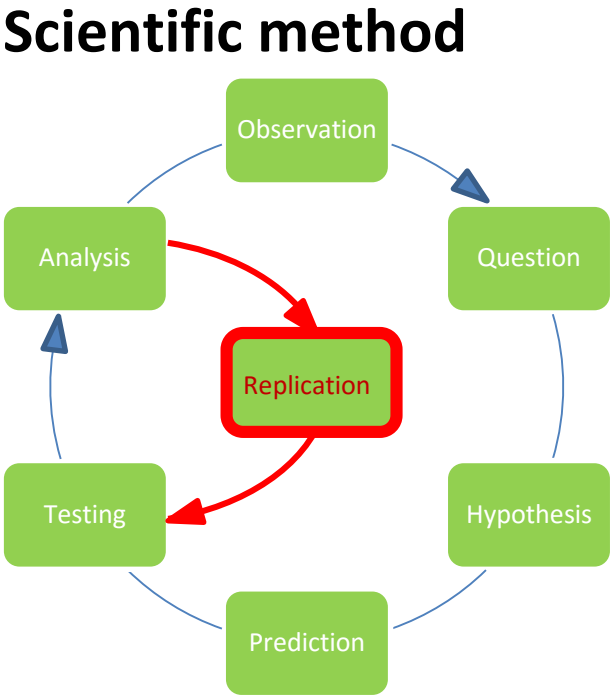
John P. A. Ioannidis is in the Department of Hygiene and Epidemiology, University of Ioannina School of Medicine, Ioannina, Greece, and Institute for Clinical Research and Health Policy Studies, Department of Medicine, Tufts-New England Medical Center, Tufts University School of Medicine, Boston, Massachusetts, United States of America. E-mail: jioannid@cc.uoi.gr

Competing Interests: The author has declared that no competing interests exist.

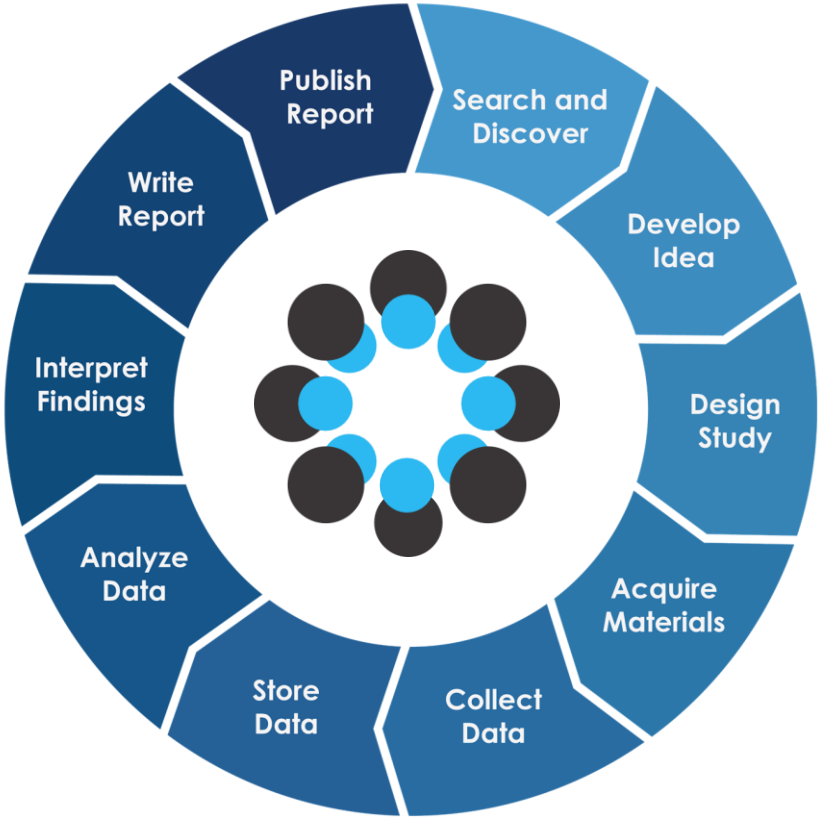
DOI: 10.1371/journal.pmed.0020124

What is reproducibility?

- Computational reproducibility
- Empirical reproducibility
- Conceptual reproducibility



What are the barriers?



Why practice reproducibility?

The idealist

- **Shoulders of giants!**
- Validates scientific knowledge
- Allows others to build on your findings
- Improved transparency
- Increased transfer of knowledge
- Increased utility of your data + methods

The pragmatist

- Increased efficiency
- Reduces false leads based on irreproducible findings
- Data sharing citation advantage (Piwowar 2013)
- "It takes some effort to organize your research to be reproducible… the **principal beneficiary is generally the author herself**."- Schwab & Claerbout

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1. Plan for reproducibility before you start

Create a study plan

- **Create a study plan** before you gather your data
- Begin documentation early
- Shows evolution of study

How?

- Research questions + hypotheses
- Study design
  - Type of design
  - Sampling
  - Power and sample size
  - Randomization?
- Variables measured
  - Meaningful effect size
- Variables constructed
  - Data processing
- Data management
- Analyses
- Sharing

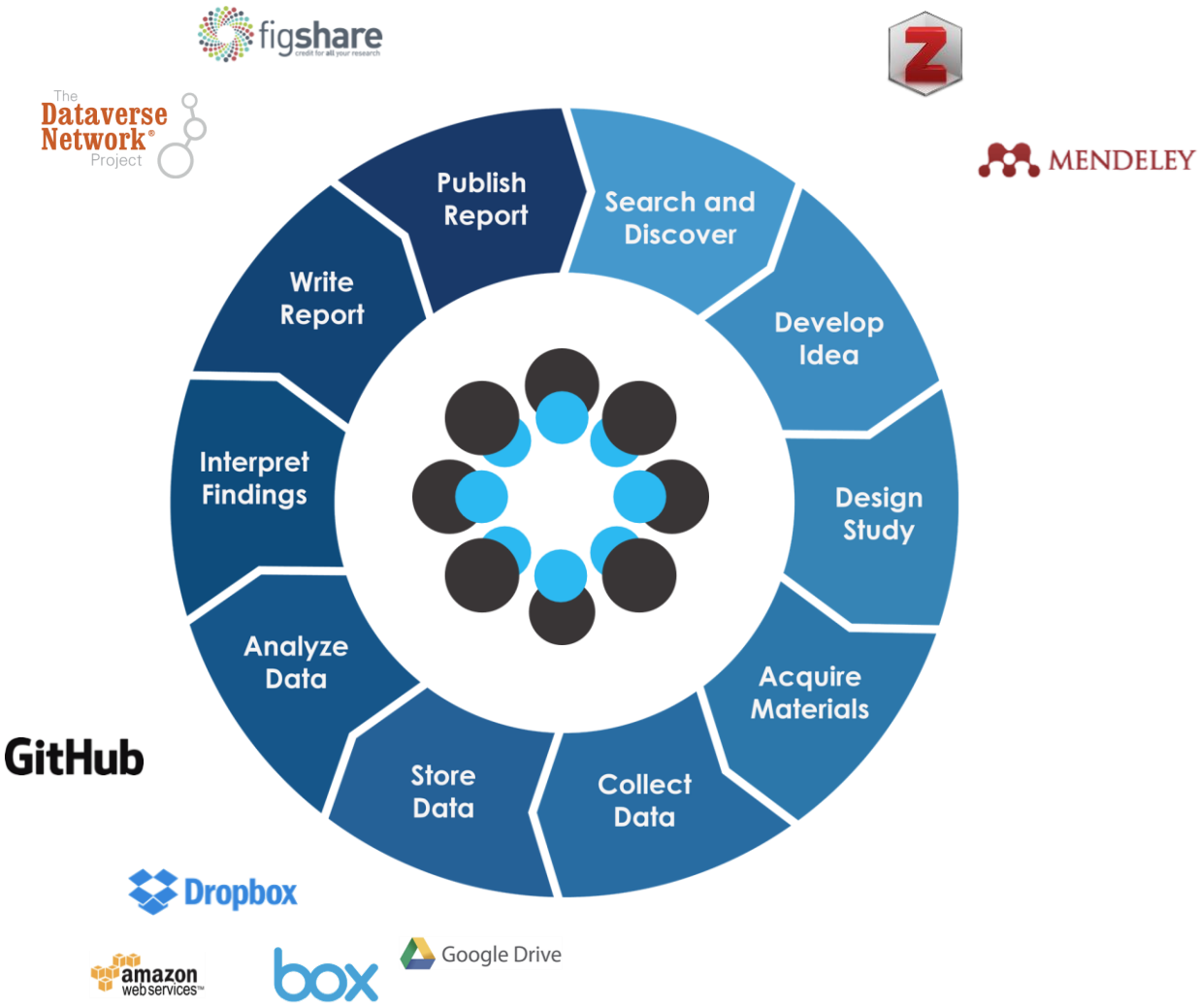
1. Plan for reproducibility before you start

Set-up a reproducible project

- **Set-up a centralized location for project management**
- Organization is especially important for collaboration
- Easily find the most recent file version
- Eases transition between lab members
- Allows for back-up and version control

How?

https://osf.io/


figshare
The Dataverse Network Project
MENDELEY
Publish Report
Search and Discover
Develop Idea
Design Study
Acquire Materials
Collect Data
Store Data
Analyze Data
Interpret Findings
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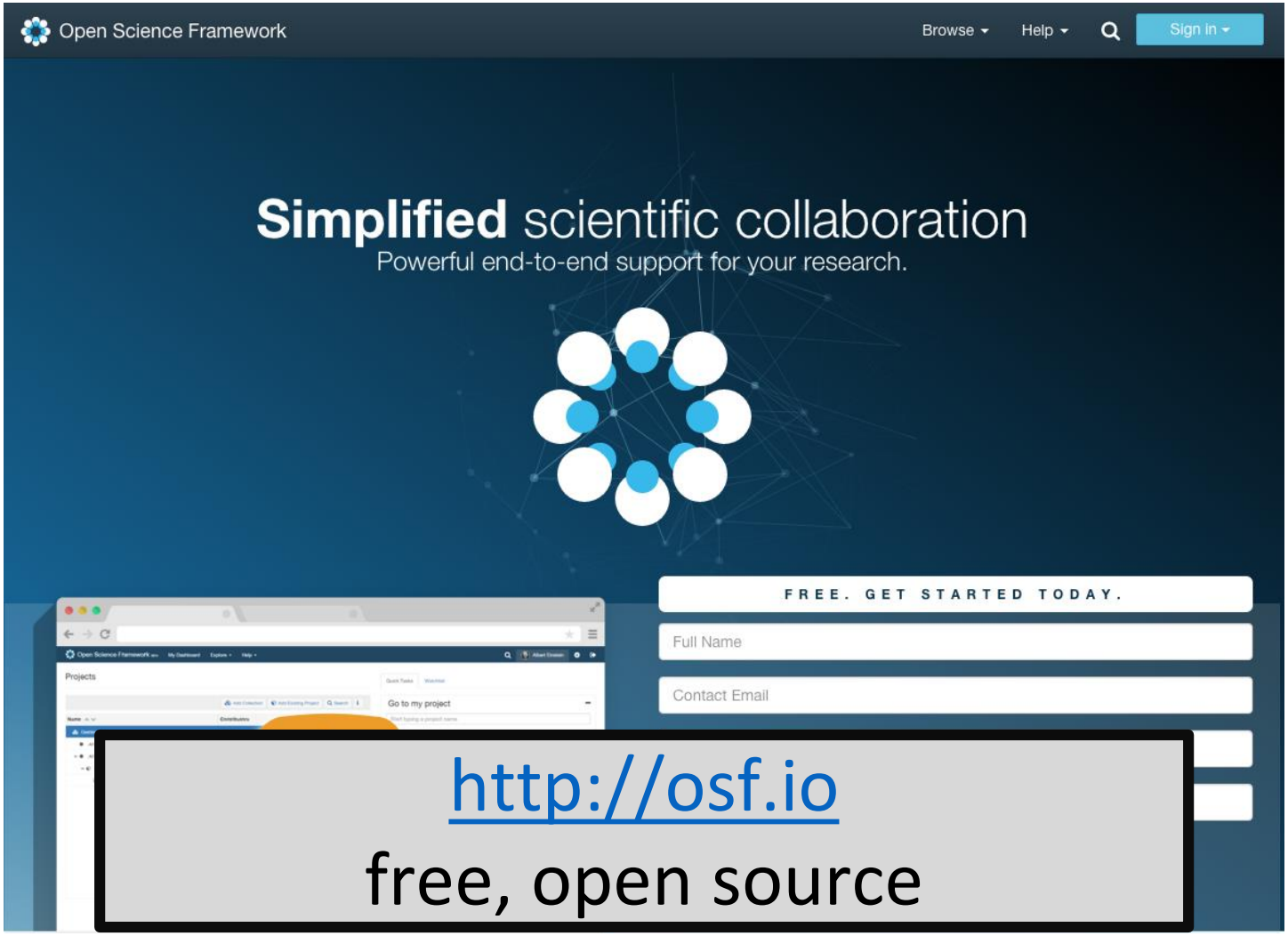
GitHub
Dropbox
amazon web services
box
Google Drive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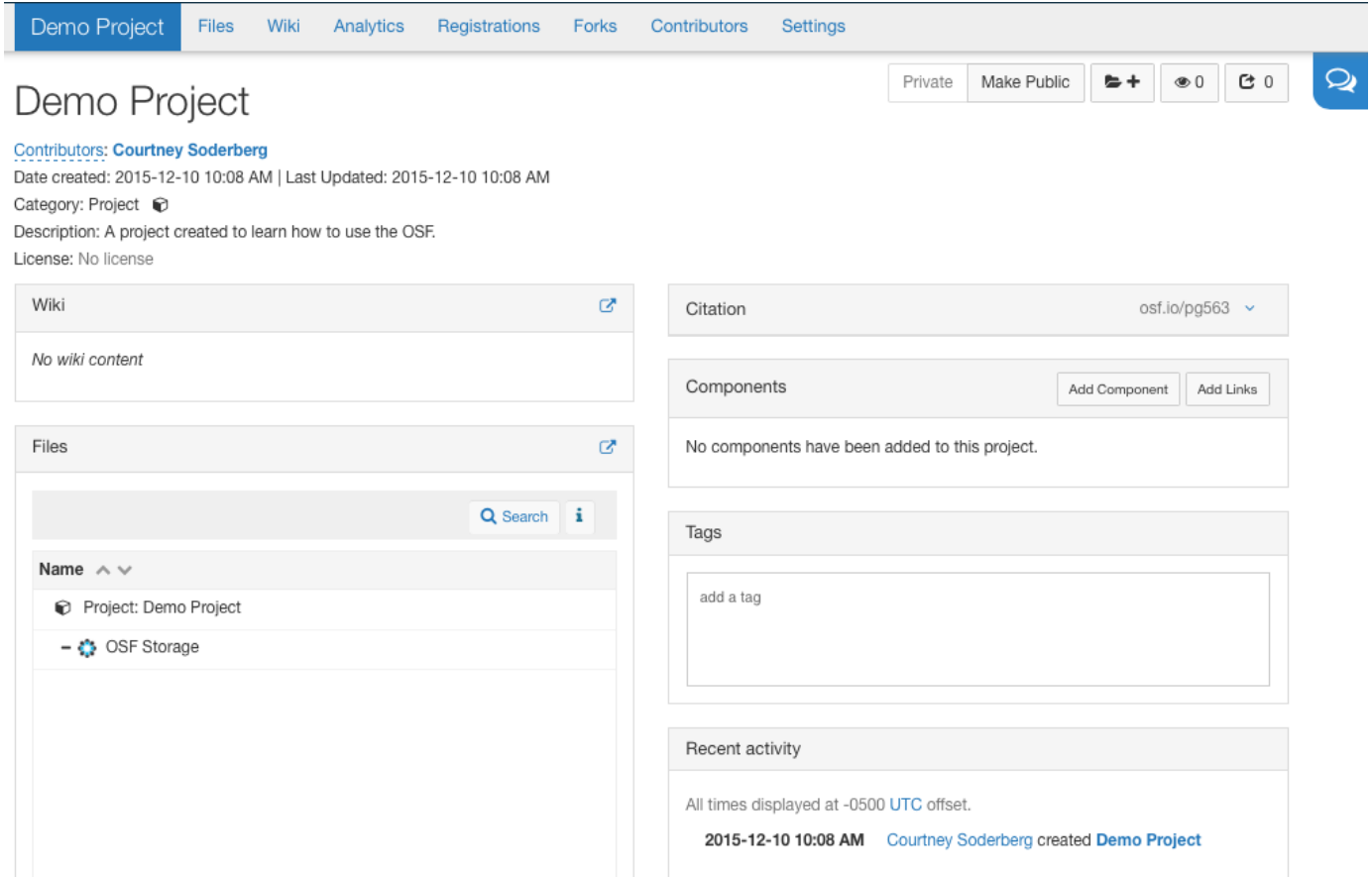
free, open source

1. Set-up a reproducible project



Persistent Citable Identifiers

Citation: osf.io/

APA

Klein, R. A., Rat… M. J., Bocian, K., et al. …abs" Replication Project. I…

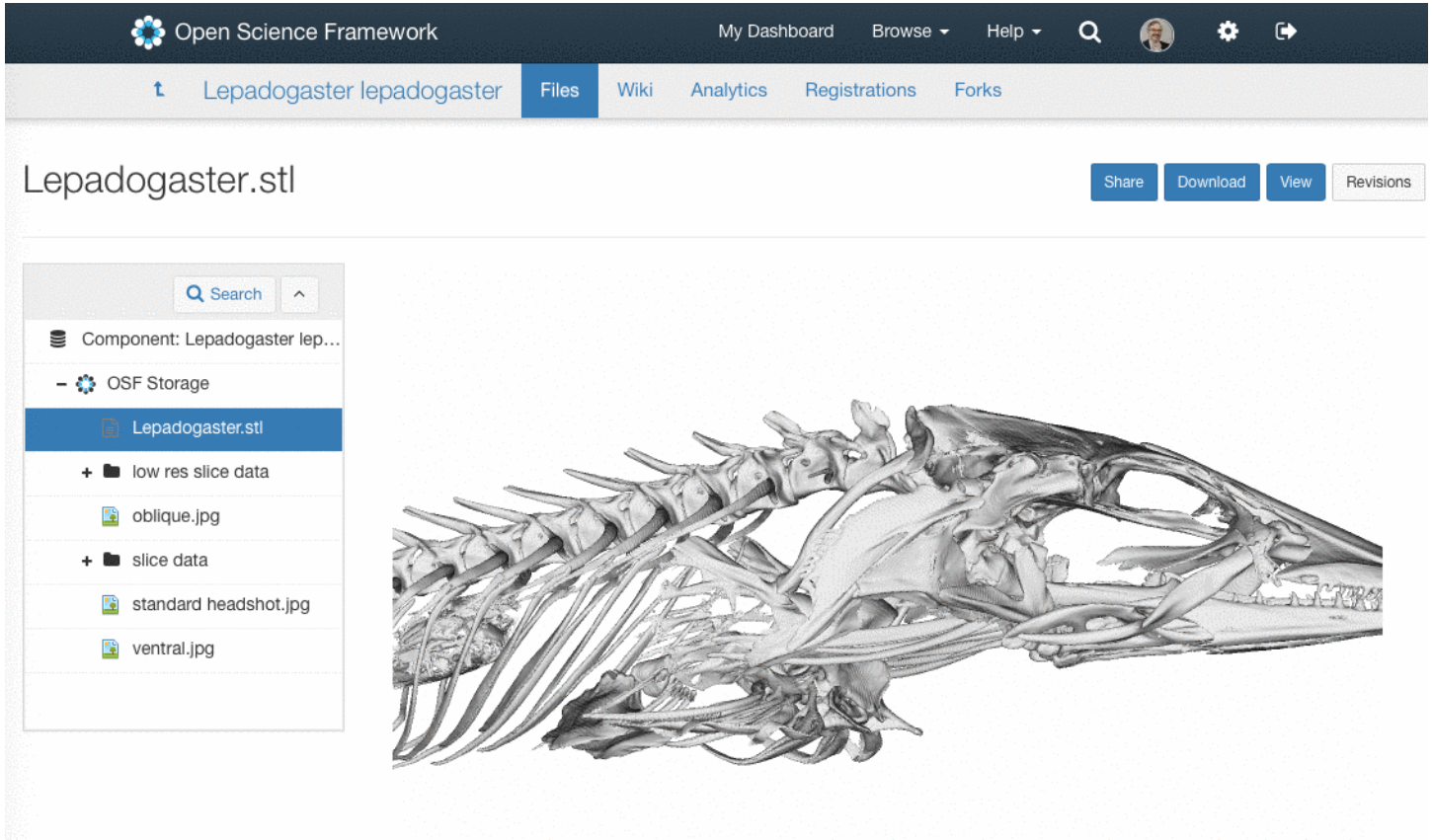
MLA

Klein, R. A., Rat… M. J., Bocian, K., et al. …eplication Project."

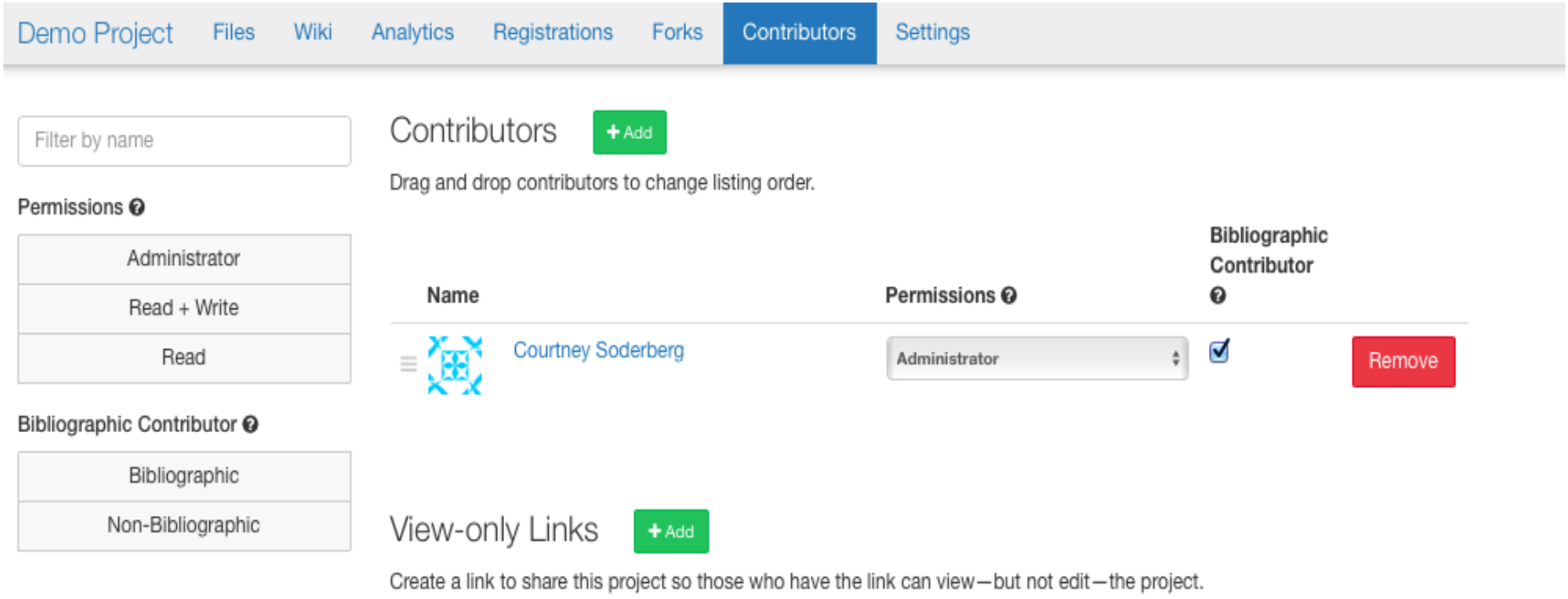
Chicago

Klein, R. A., Ratliff, K. A., Vianello, M., Adams, R. B., Bahník, , Bernstein, M. J., Bocian, K., et al. "Investigating Variation in Replicability: A "Many Labs" Replication Project." Open Science Framework (2014). osf.io/wx7ck

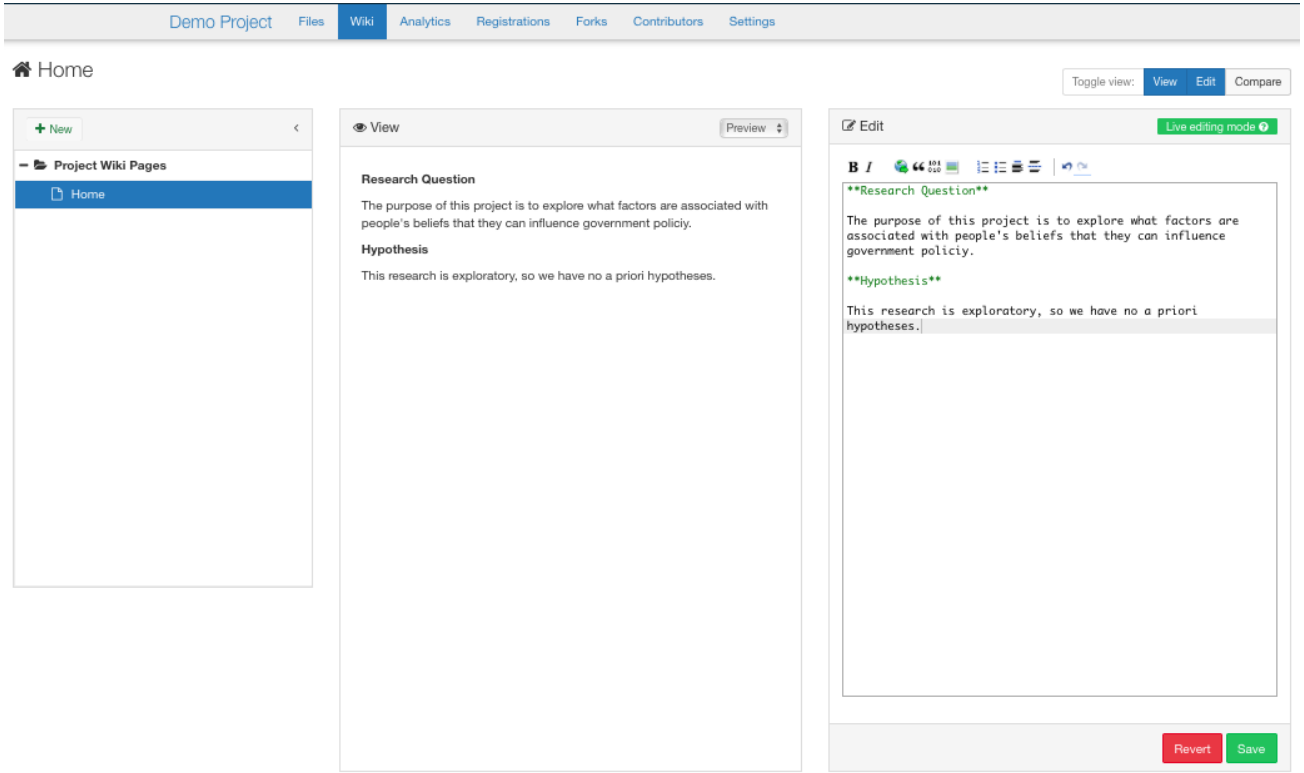
1. Put data, materials, and code on the OSF



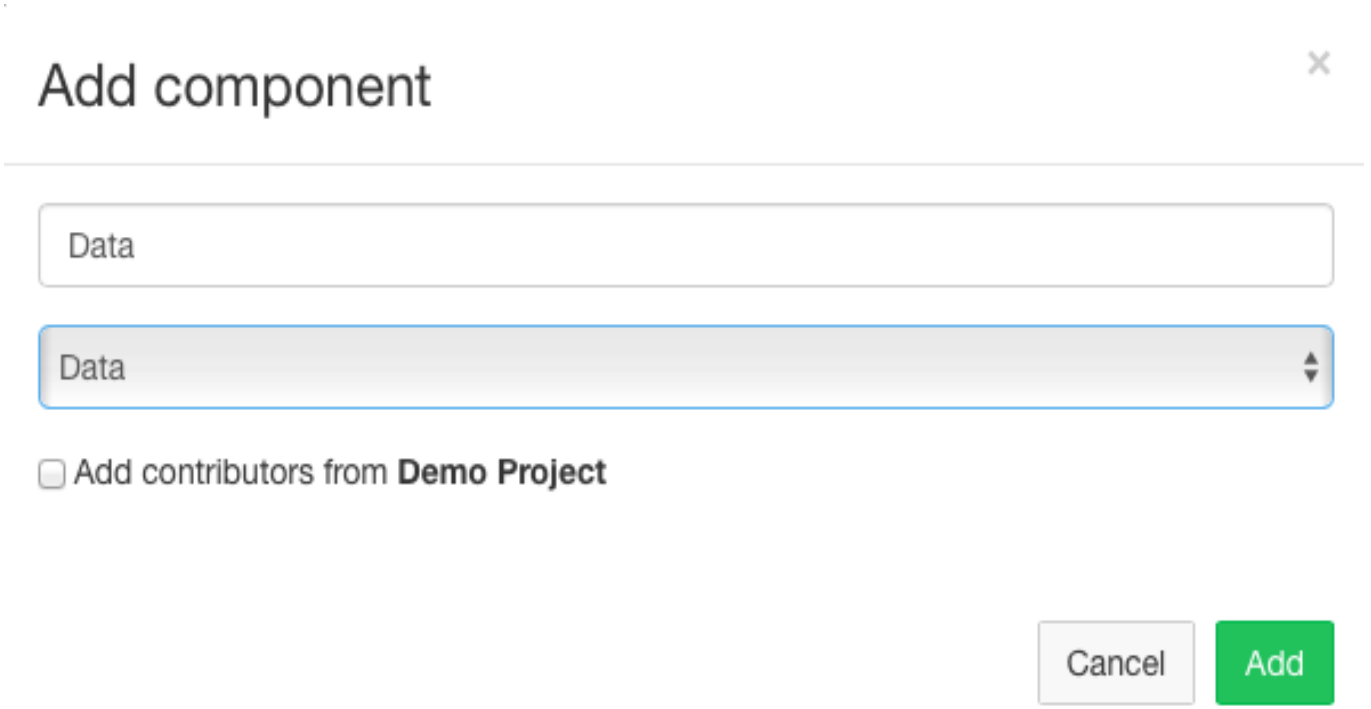
1. Giving contributors access



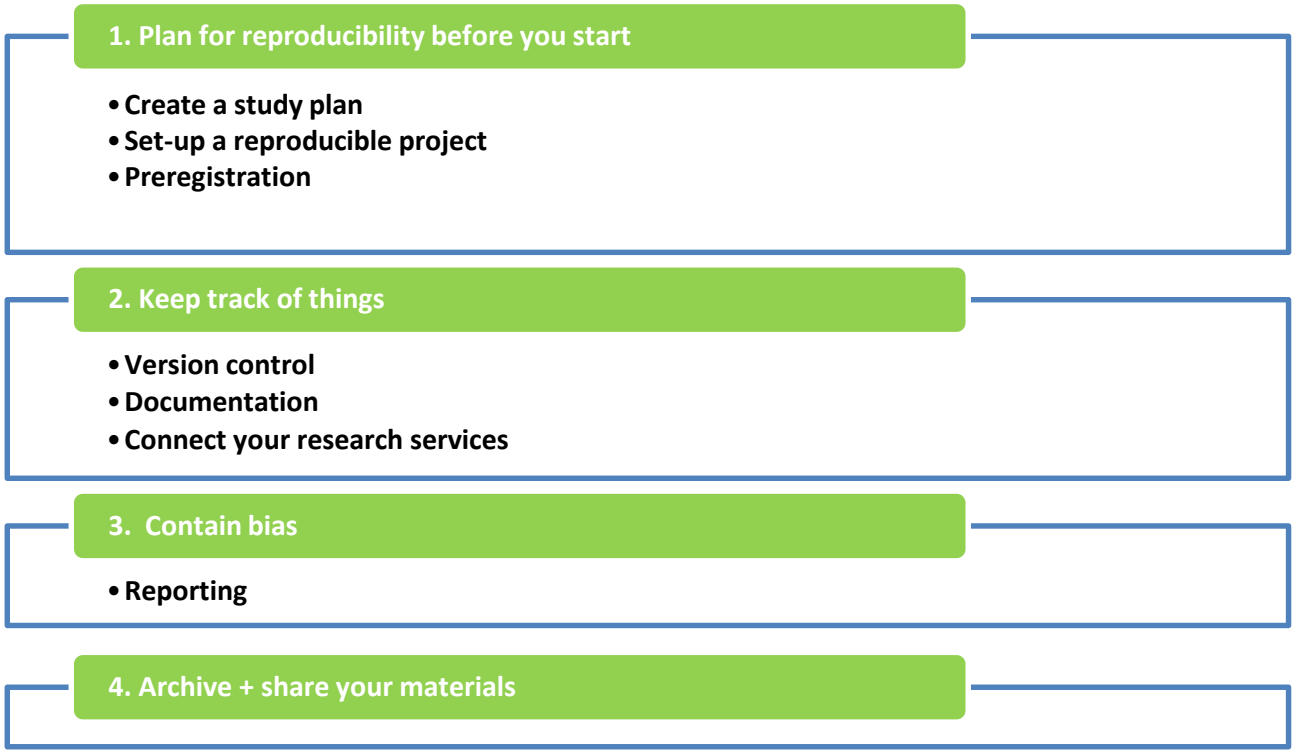
1. Creating a wiki



1. Adding organizational structure - components



How can you make your research reproducible?



1. Plan for reproducibility before you start

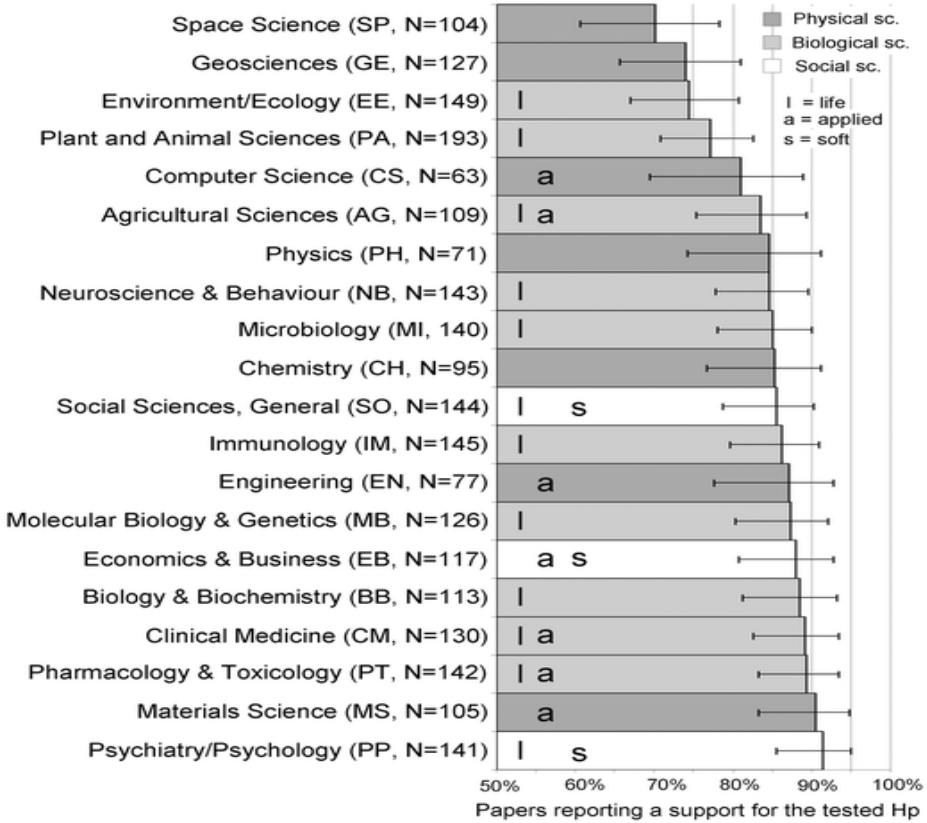
Preregister your study plan

- **Preregister your study plan** before you look at your data
- Distinguishes *a priori* design decisions from *post hoc*
- Counters selective reporting and outcome reporting bias
- Preregistration of all study plans helps counter publication bias

Preregister your analysis plan

- **Preregister your analysis plan** before you look at your data
- Defines your confirmatory analyses
- Decreases researcher degrees of freedom

Publication bias



Fanelli D (2010) “Positive” Results Increase Down the Hierarchy of the Sciences. PLoS ONE 5(4): e10068.

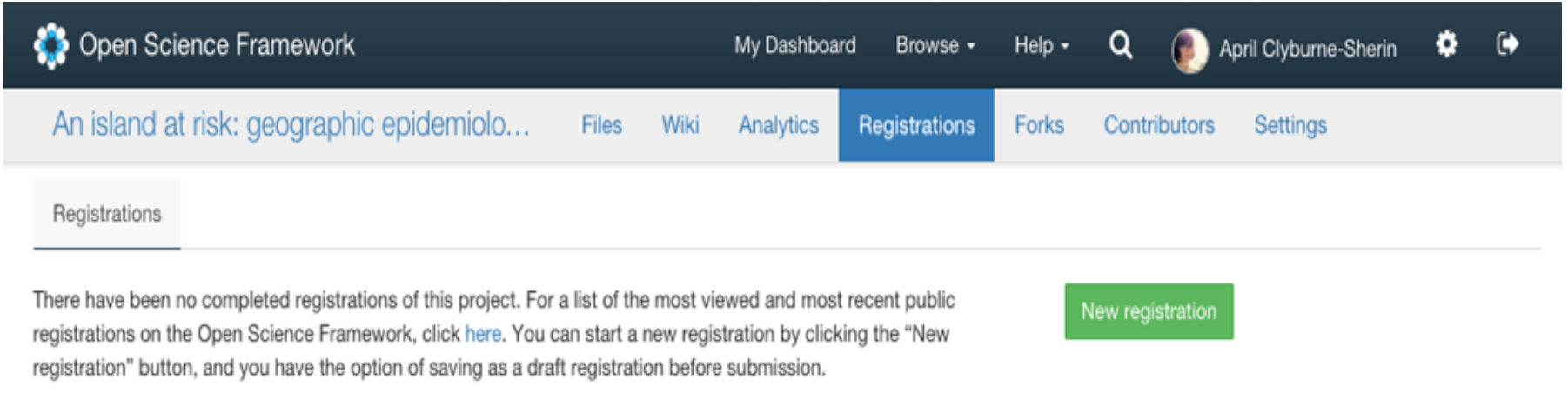
Researcher degrees of freedom

Table 1. Likelihood of Obtaining a False-Positive Result

	Significance level		
Researcher degrees of freedom	$p < .1$	$p < .05$	$p < .01$
Situation A: two dependent variables ($r = .50$)	17.8%	9.5%	2.2%
Situation B: addition of 10 more observations per cell	14.5%	7.7%	1.6%
Situation C: controlling for gender or interaction of gender with treatment	21.6%	11.7%	2.7%
Situation D: dropping (or not dropping) one of three conditions	23.2%	12.6%	2.8%
Combine Situations A and B	26.0%	14.4%	3.3%
Combine Situations A, B, and C	50.9%	30.9%	8.4%
Combine Situations A, B, C, and D	81.5%	60.7%	21.5%

Simmons, Nelson, & Simonsohn (2012)

1. How to preregister




https://osf.io/wx7ck/
https://osf.io/c97pd/
Register
Pregistration
after registration. Please be sure the project is complete and comprehensive for what you wish to register.
Type "register" if you are sure you want to continue

How can you make your research reproducible?

1. Plan for reproducibility before you start

- Create a study plan
- Set-up a reproducible project
- Preregistration

2. Keep track of things

- Version control
- Documentation
- Connect your research services

3. Contain bias

- Reporting

4. Archive + share your materials

2. Keep track of things

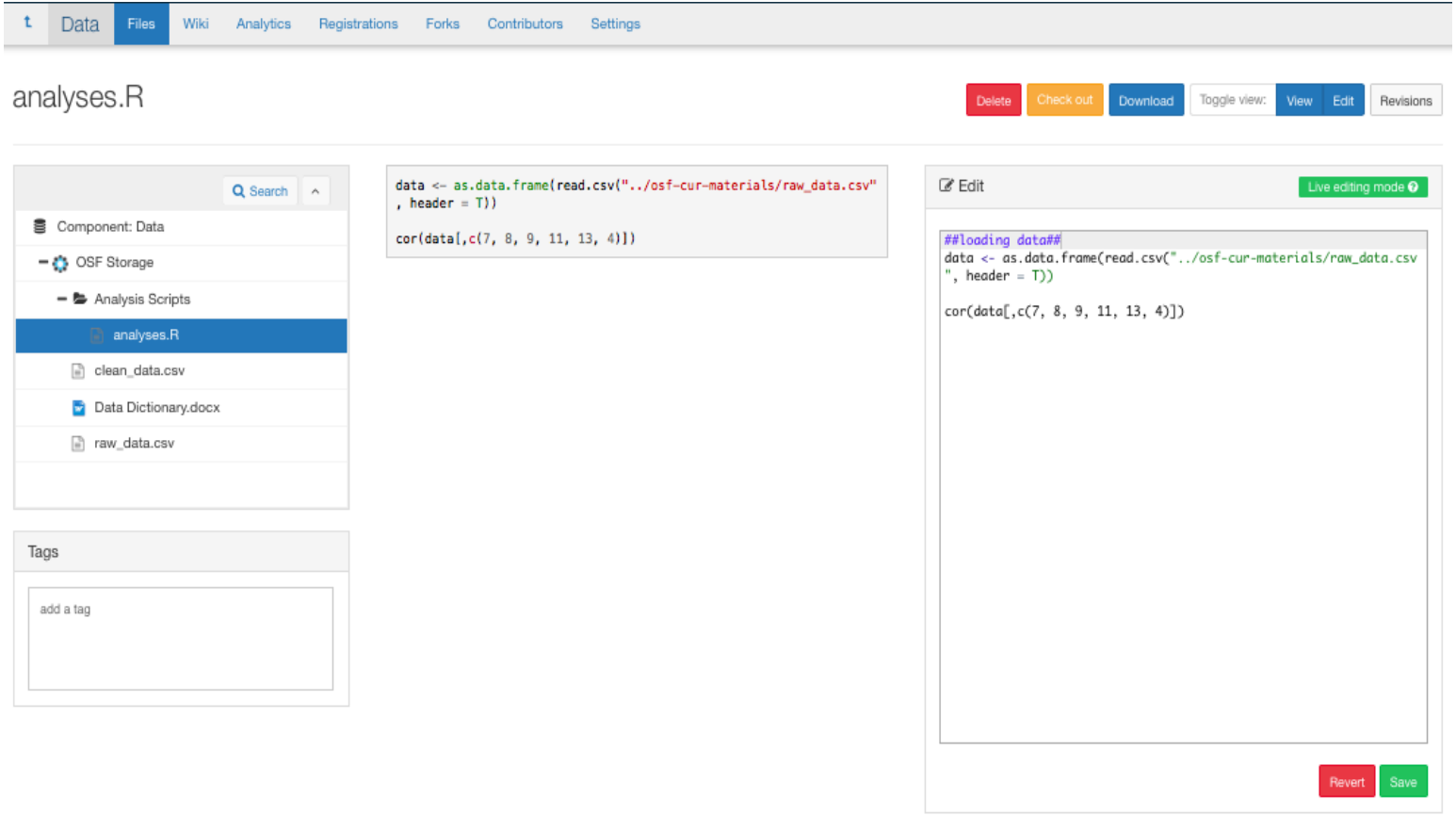
Version control

- **Track your changes**
- Everything created manually should use version control
- Tracks changes to files, code, metadata
- Allows you to revert to old versions
- Make incremental changes: commit early, commit often
- Git / GitHub / BitBucket

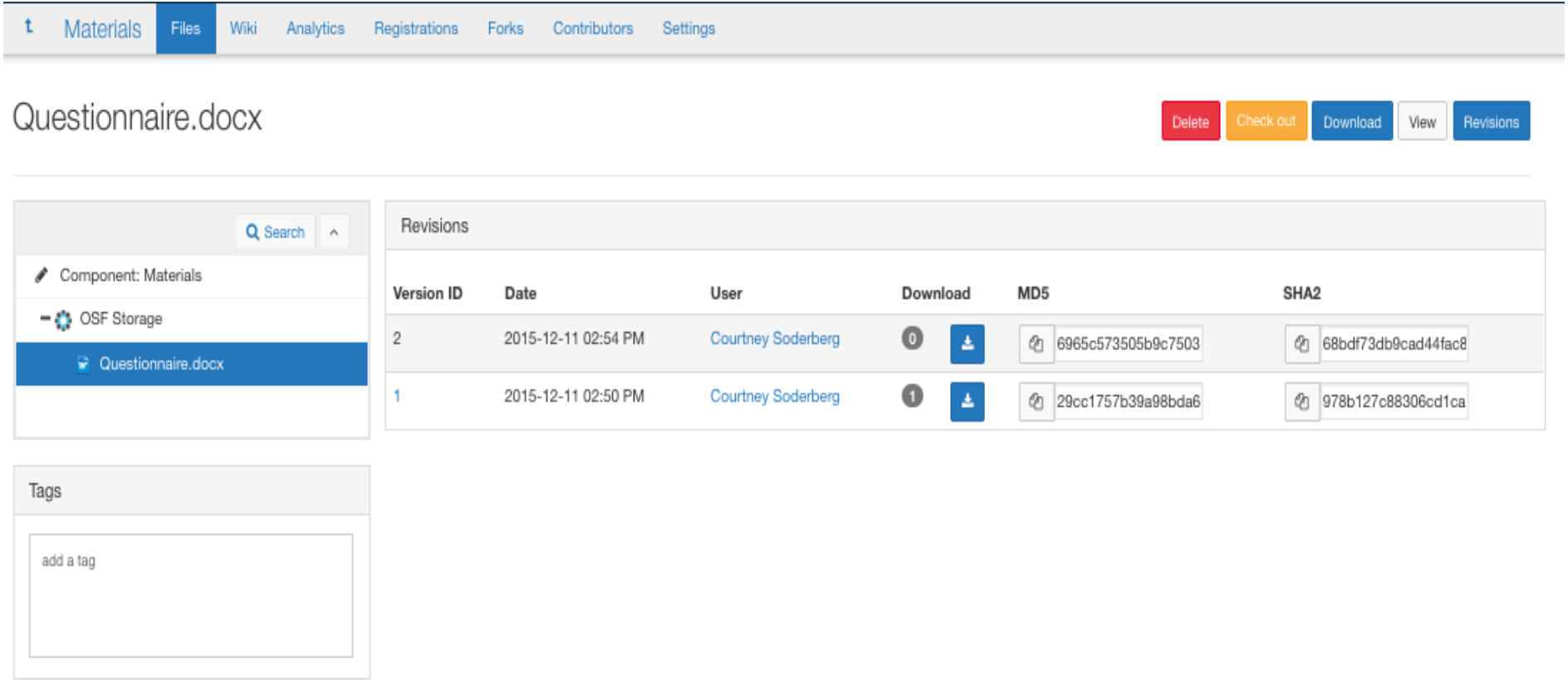
Version control for data

- Metadata should be version controlled

2. Version control



2. Version control



2. Keep track of things

Documentation

- **Document everything done by hand**
- Document your software environment (eg, dependencies, libraries, sessionInfo () in R)
- Everything done by hand or not automated from data and code should be precisely documented:
  - README files
- Make raw data read only
  - You won't edit it by accident
  - Forces you to document or code data processing
- Document in code comments

2. Keep track of things

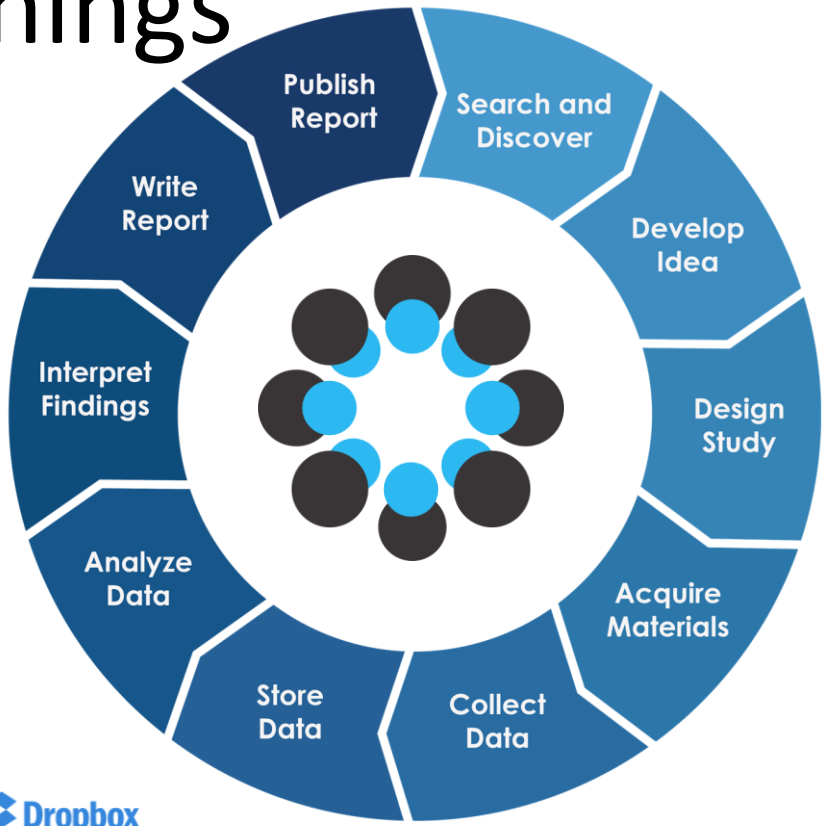
Connect your research services

figshare

The Dataverse Network® Project

Zotero

MENDELEY



GitHub

Dropbox

amazon web services

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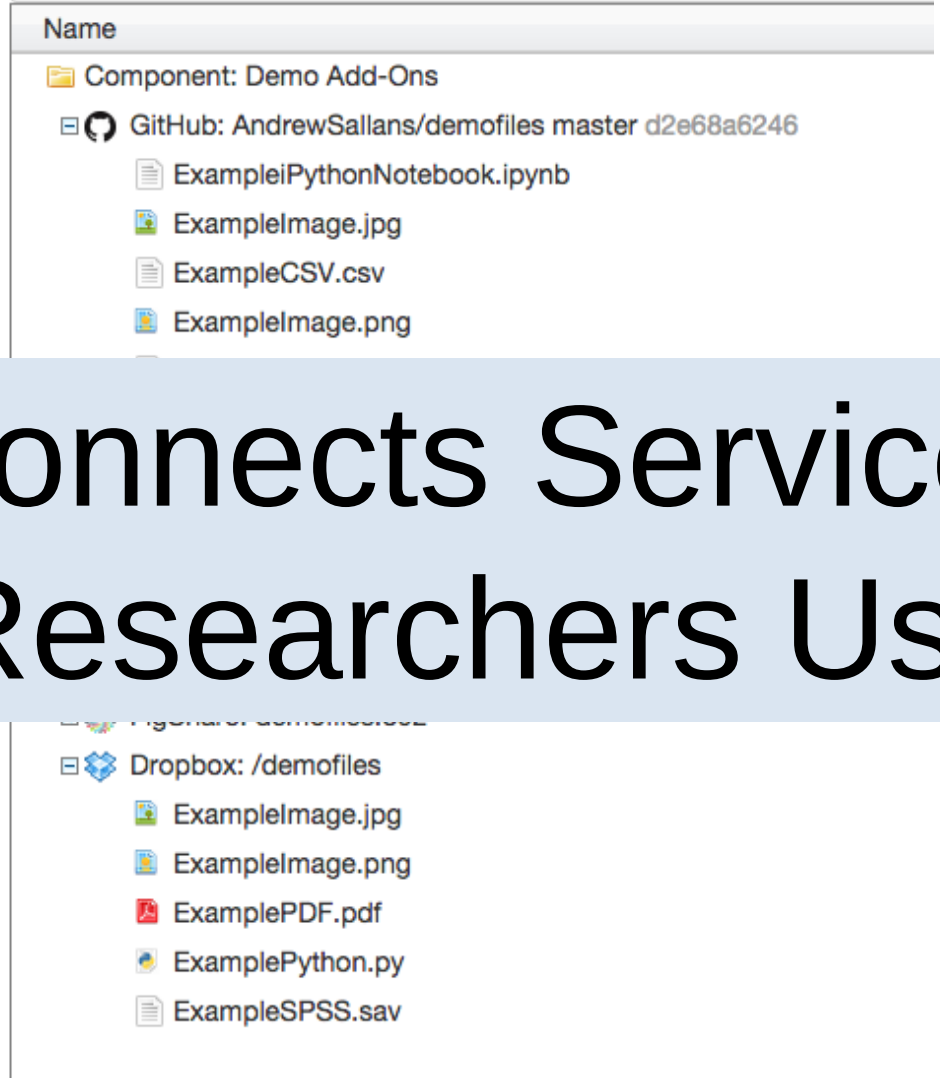
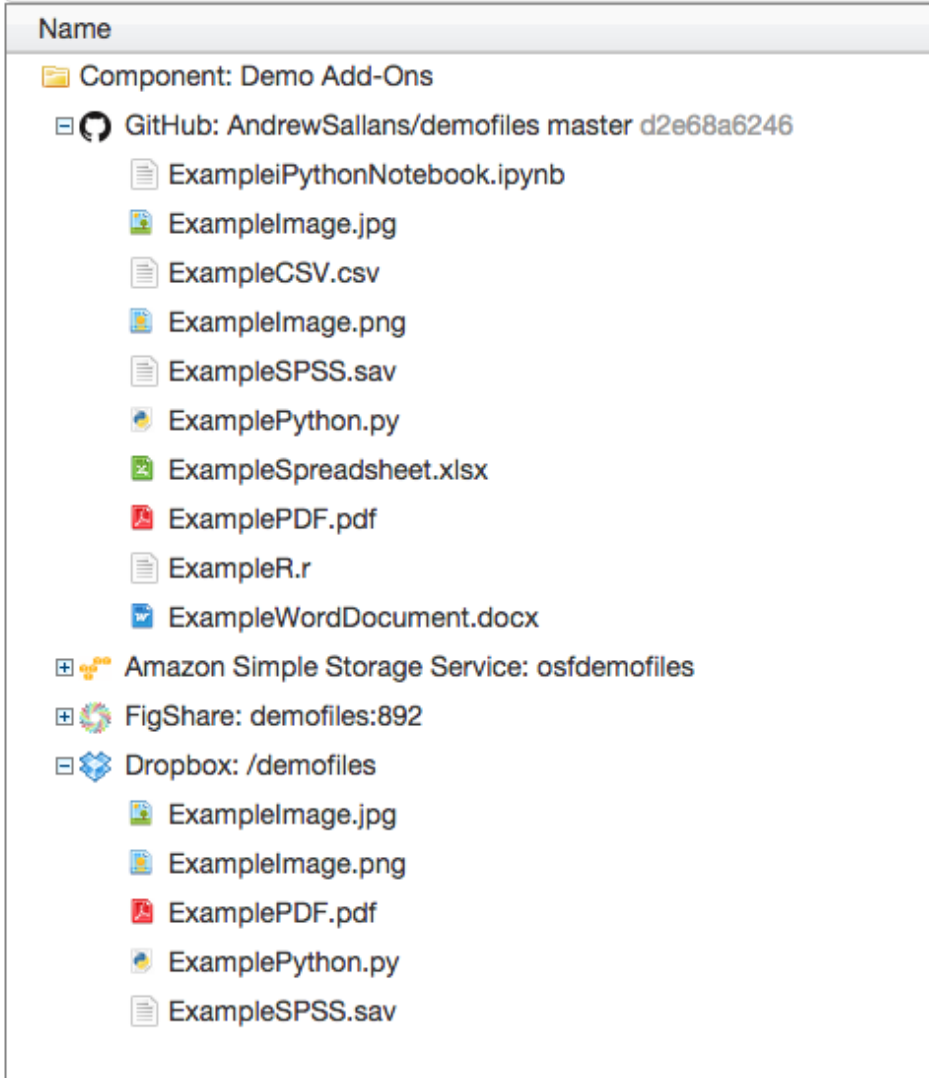
Google Drive



Connects Services Researchers Use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ExampleSPSS.sav

3. Contain bias

Reporting

- **Report transparently + completely**
- Transparently means:
  - Readers can use the findings
  - Replication is possible
  - Users are not misled
  - Findings can be pooled in meta-analyses
- Completely means:
  - All results are reported, no matter their direction or statistical significance

How?

- **Use reporting guidelines**
  - Avoid HARKing: Hypothesizing After the Results are Known
  - Report all deviations from your study plan
  - Report which decisions were made after looking at the data

4. Archive + share your materials

Share your materials

- **Where doesn't matter. That you share matters.**
- Get credit for your code, your data, your methods
- Increase the impact of your research

Open Science Framework

The Dataverse Project

figshare
credit for all your research

GitHub

DRYAD

Compo

Materia

Axt, Nosek &

Analysi

Axt, Nosek &

Procedure

Axt, Nosek & Ebersole

4 contributions

Merges Public-Private Workflows

Components

Add Component | Add Links

Materials

Axt, Nosek & Ebersole

4 contributions

Analysis Plan

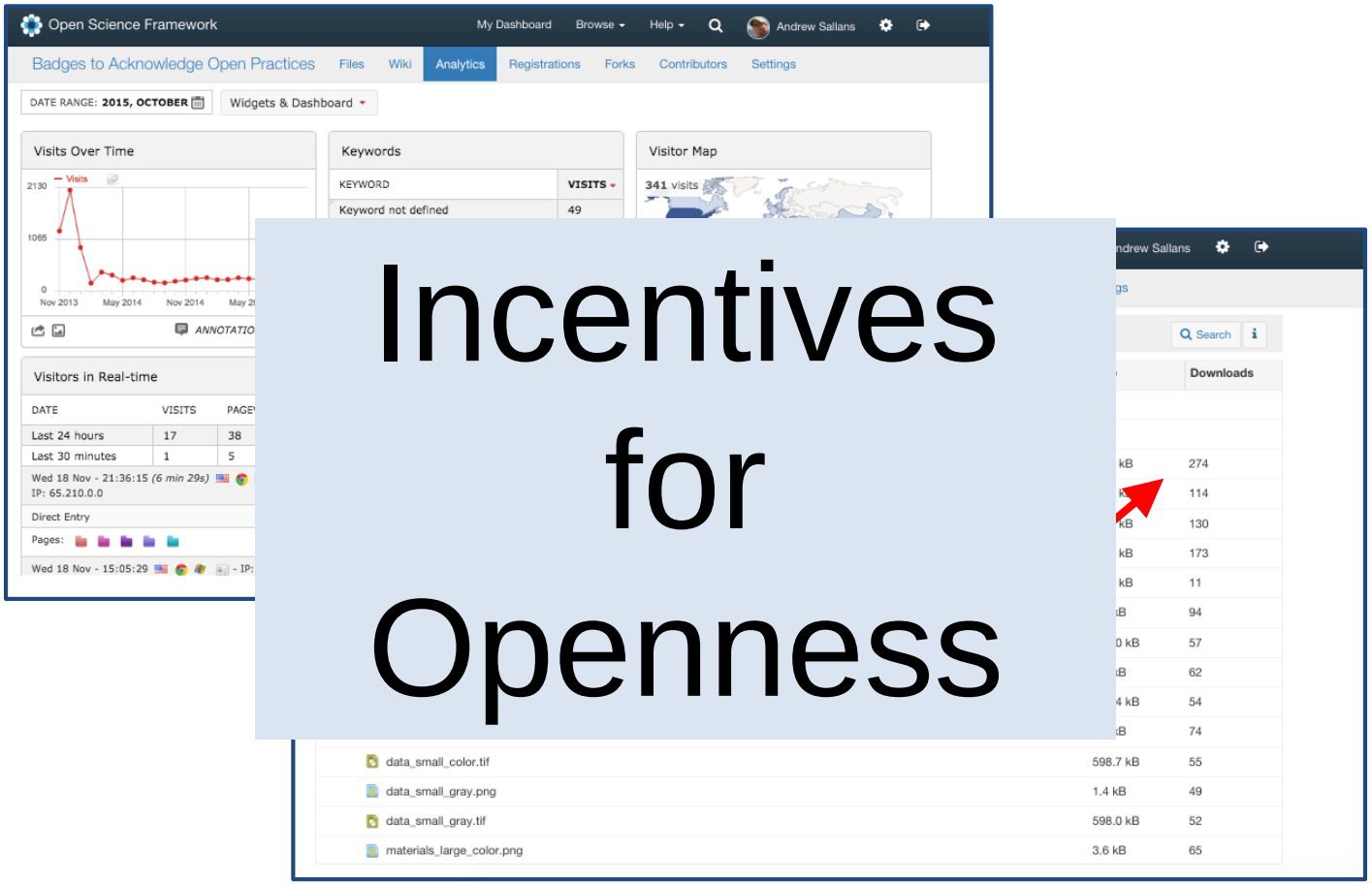
Axt, Nosek & Ebersole

4 contributions

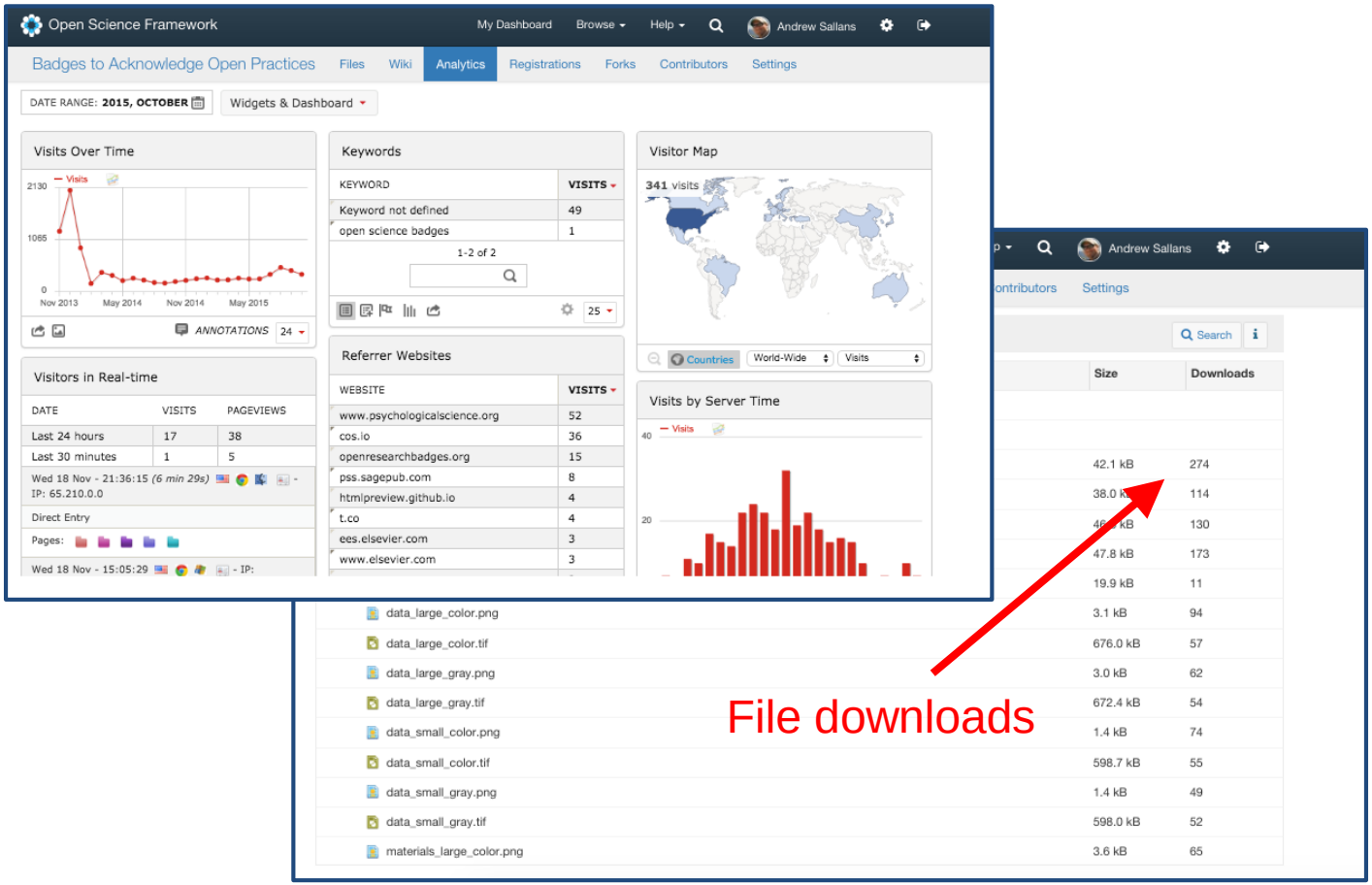
Procedure

Axt, Nosek & Ebersole

4 contributions



Incentives for Openness


Open Science Framework
My Dashboard
Browse
Help
Andrew Sallans
Badges to Acknowledge Open Practices
Files
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Analytics
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DATE RANGE: 2015, OCTOBER
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File downloads

How can you make your research reproducible?

1. Plan for reproducibility before you start

- **Create a study plan** – Begin documentation at study inception
- **Set-up a reproducible project** – Centralize and organize your project management
- **Registration** – Preregister your study + analysis plan

2. Keep track of things

- **Version control** – Track your changes
- **Documentation** – Document everything done by hand
- **Connect your research services** – Track all your materials in one place

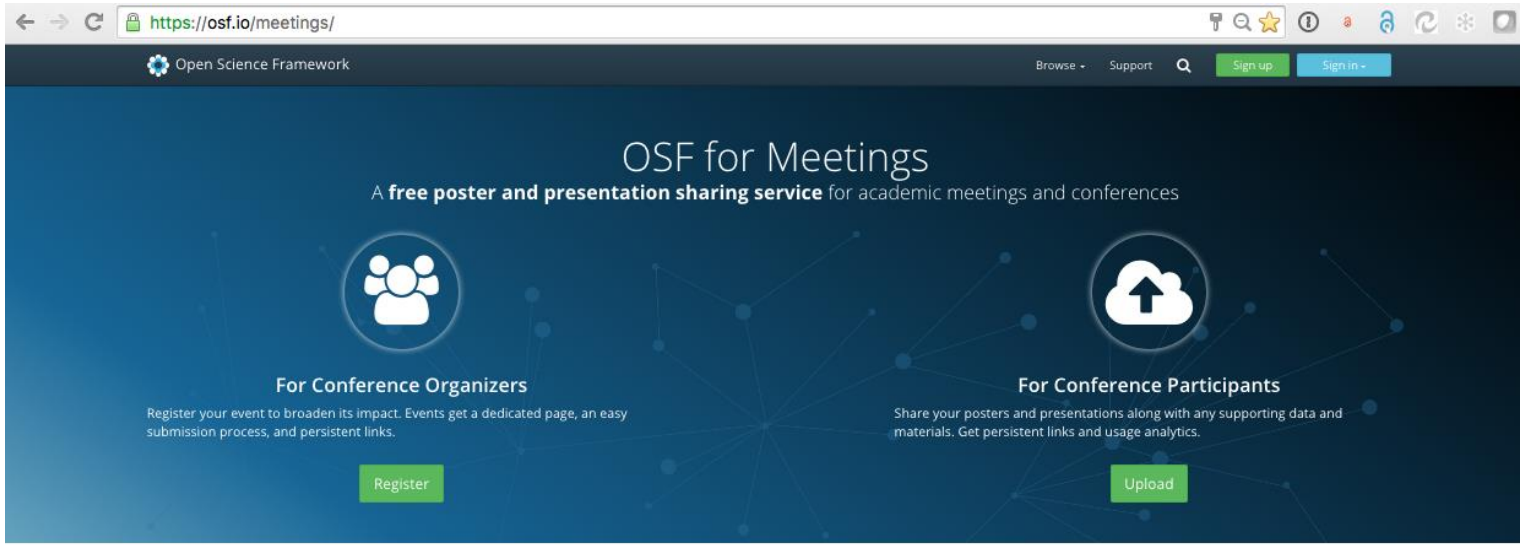
3. Contain bias

- **Reporting** – Report transparently + completely

4. Archive + share your materials

- **Where doesn't matter.** That you share matters.

OSF for Meetings



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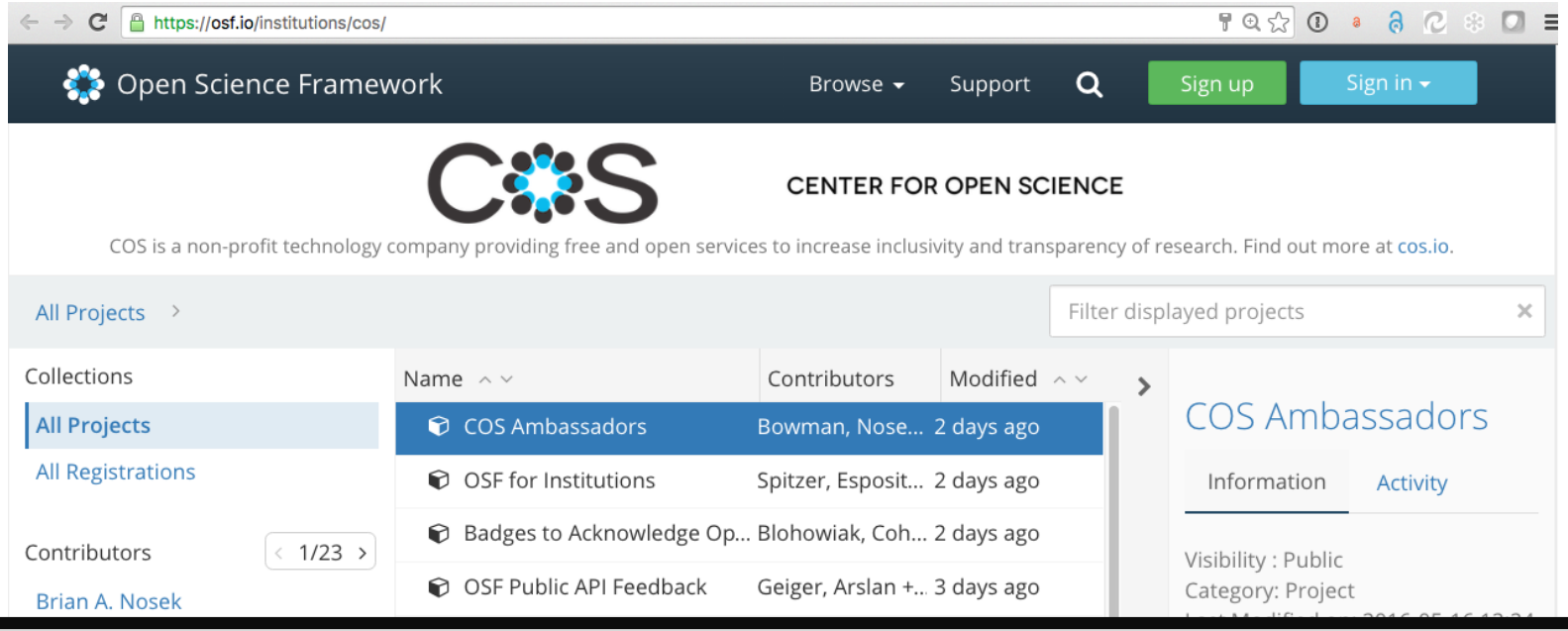
free poster + presentation service

OSF for Institutions



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integration with local services

Technology to *enable* change

Training to *enact* change

Incentives to *embrace* change

Stats + methods training

Statistical & Methodological Consulting

Scientists can improve the replicability of their own work through careful documentation, adherence to standards, and the use of open tools. We answer questions and provide training on open and reproducible tools, methodologies, and workflows. Some examples:

- ✔Using R
- ✔Conducting power analyses
- ✔Using the OSF
- ✔Learning Github
- ✔Conducting meta-analyses
- ✔Preregistering analysis plans

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free stats + methods training

Technology to *enable* change

Training to *enact* change

Incentives to *embrace* change

Transparency and Openness Promotion (TOP) Guidelines

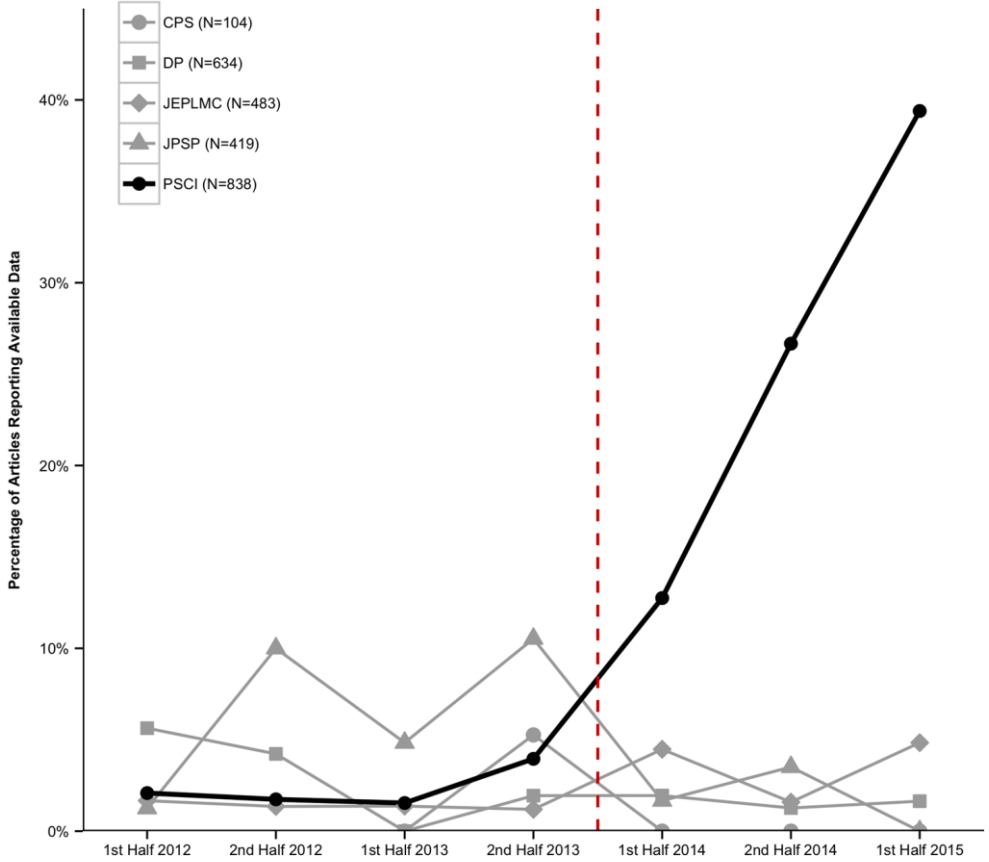
1. Data citation
2. Design transparency
3. Research materials transparency
4. Data transparency
5. Analytic methods (code) transparency
6. Preregistration of studies
7. Preregistration of analysis plans
8. Replication

http://cos.io/top

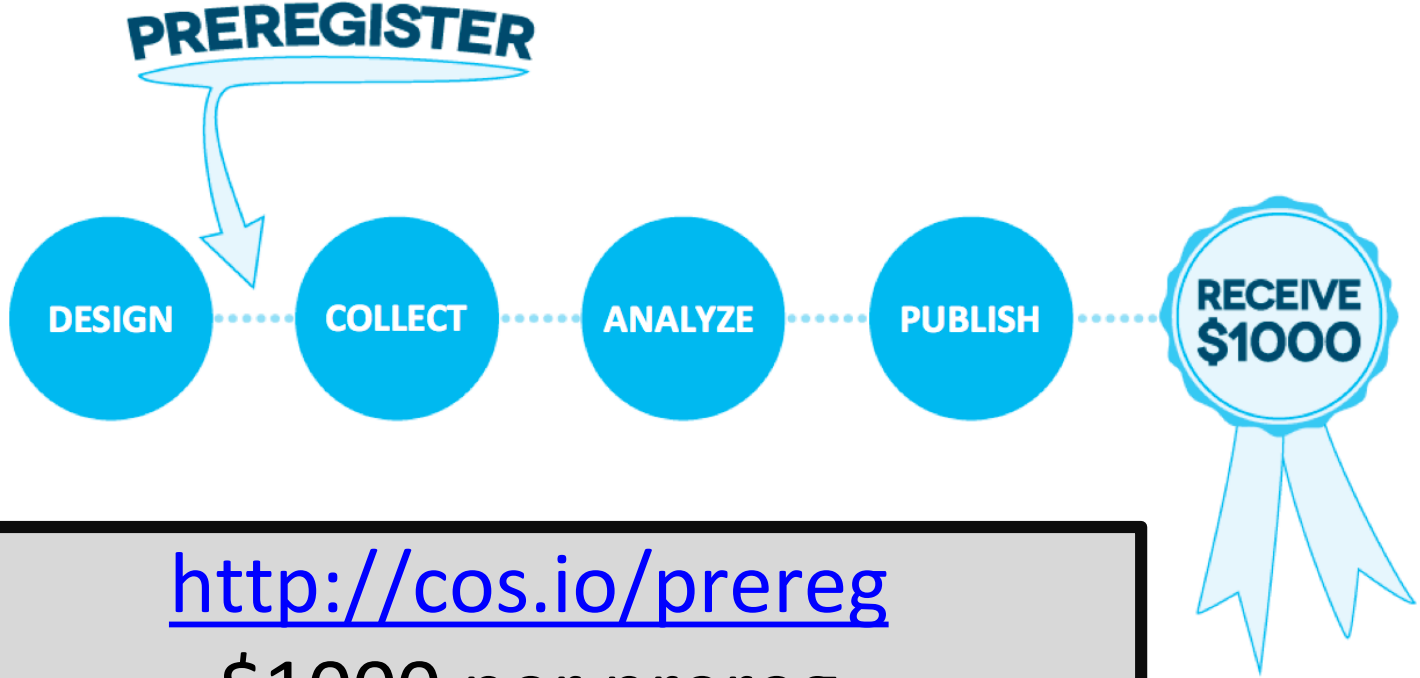
guidance on open policies

Badges: making behaviors visible promotes adoption

Case Study: Psychological Science



The Preregistration Challenge



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$1000 per prereg

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The $1,000,000 Preregistration Challenge

- The Big Picture
- The Challenge
- How to Earn the Prize
- Eligibility Criteria
- FAQ
- Eligible Journals
- Review Process

Begin a Preregistration

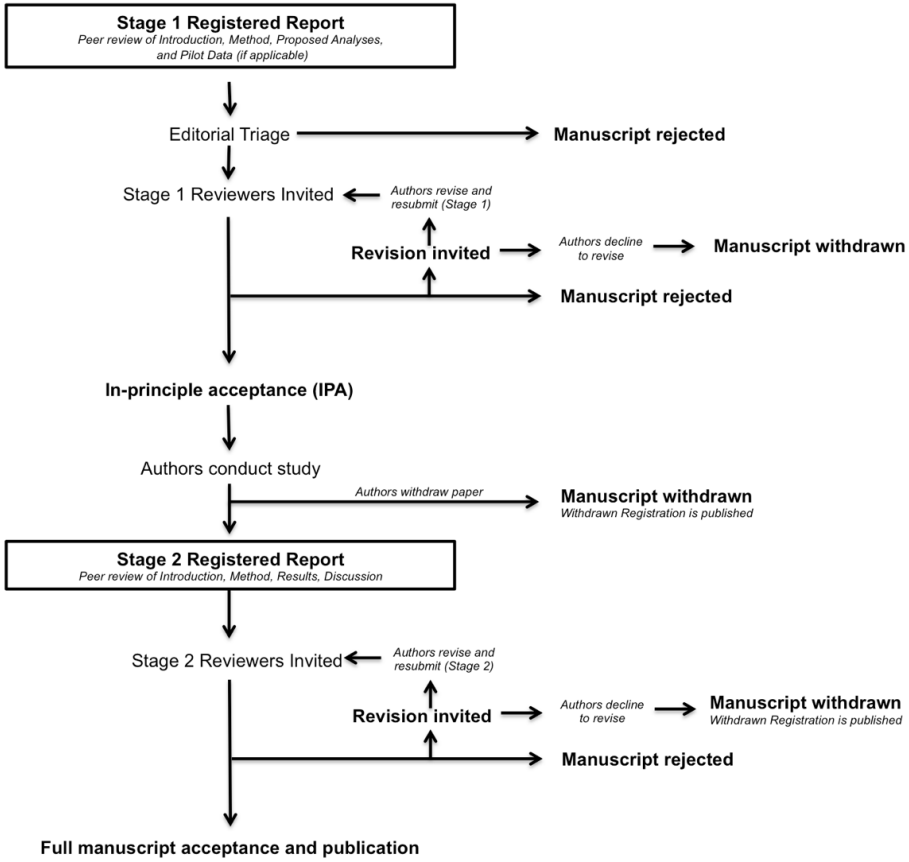
Preregistration increases the credibility of hypothesis testing by confirming in advance what will be analyzed and reported. For the Preregistration Challenge, one thousand researchers will win $1,000 each for publishing results of preregistered research.

Share this handout for a brief overview and links to more information, and begin your preregistration today!

http://cos.io/prereg

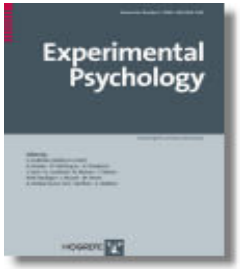
$1000 per prereg

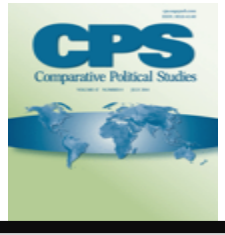
Registered Reports



Registered Reports

AIMS Neuroscience





eLIFE

http://osf.io/8mpji

list of journals with RRs

Technology to *enable* change

Training to *enact* change

Incentives to *embrace* change

Reproducible Research Practices

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