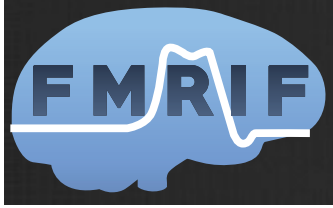
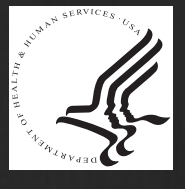
Open & Reproducible Neuroscience Workshop

Aug 1 & 2, 9 am – 5 pm

NIH Cloisters



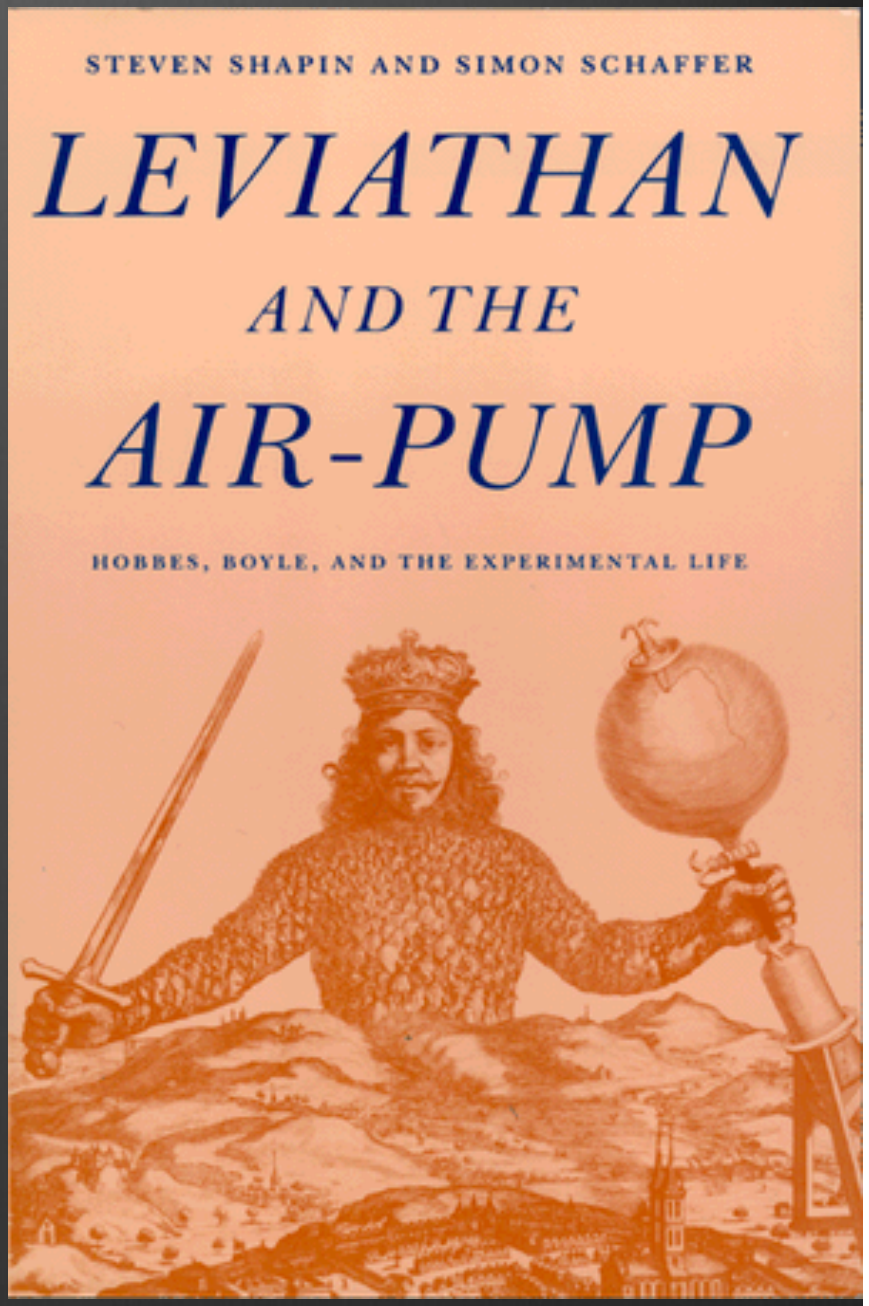


Outline

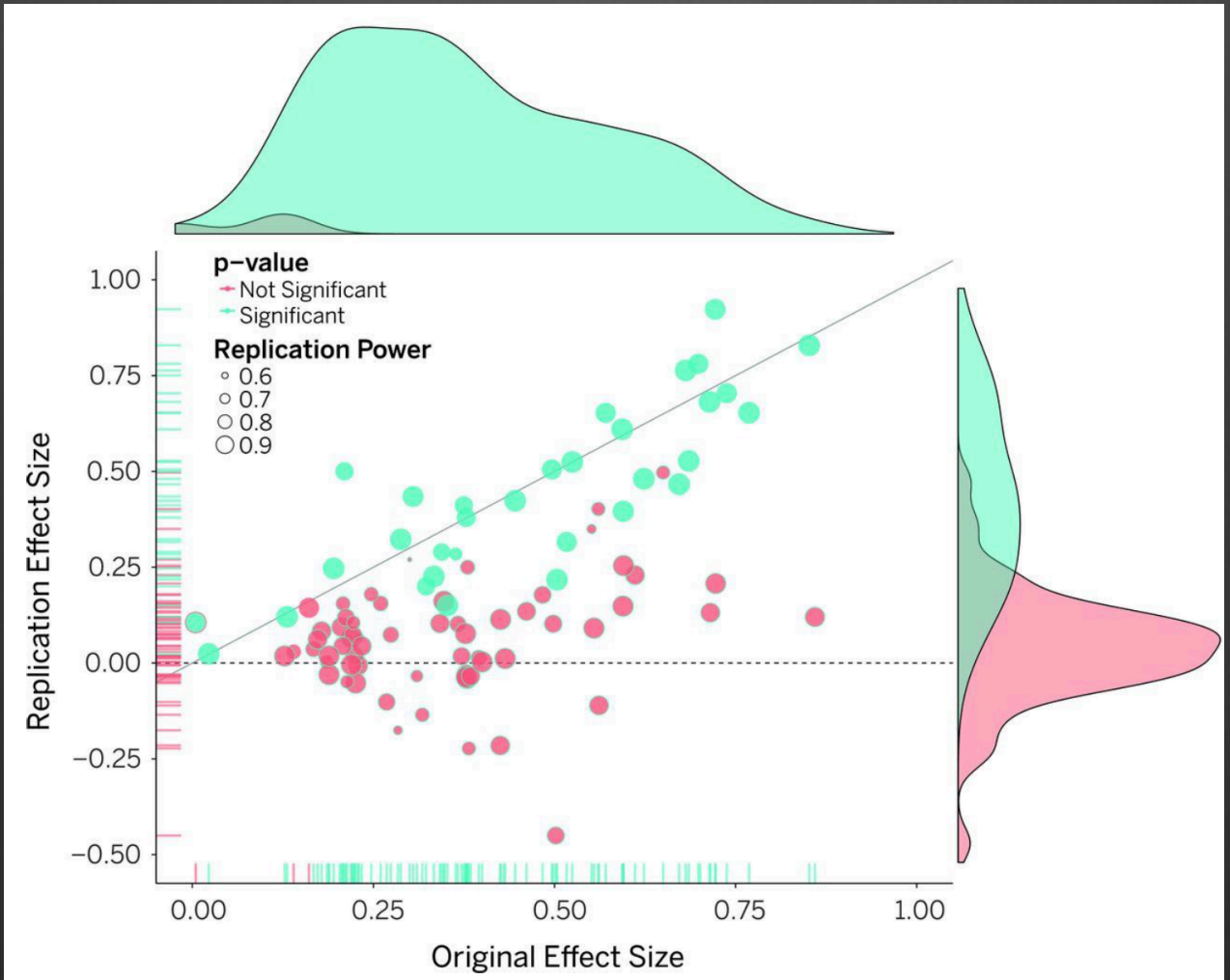
- Why are we here?
- Who are we?
- How will this work?

Why: Replicable vs. Reproducible

- Replication is the foundation of science
- "By repeating the same experiment over and over again, the certainty of fact will emerge."
  – Robert Boyle



Why: Replication are failing



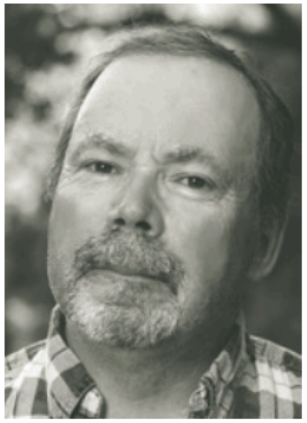
Nosek et al. (2015)

Why: The big-data revolution

PERSPECTIVE

Sustaining the big-data ecosystem

Organizing and accessing biomedical big data will require quite different business models, say **Philip E. Bourne, Jon R. Lorsch** *and* **Eric D. Green.**



Biomedical big data offer tremendous potential for making discoveries, but the cost of sustaining these digital assets and the resources needed to make them useful have received relatively little attention. Research budgets are flat or declining in inflation-

recorded. All of this means that absolute numbers are hard to interpret.

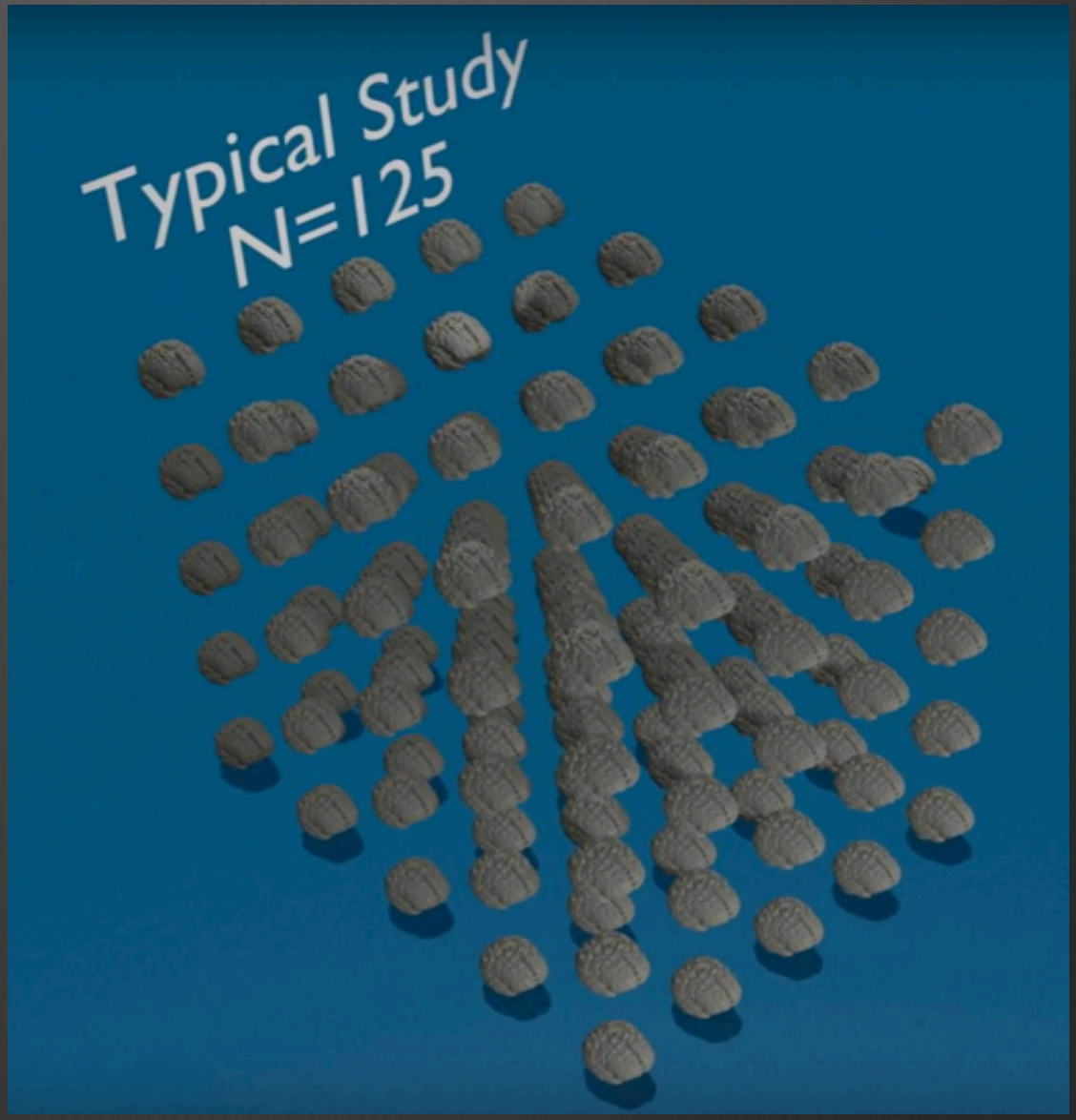
These caveats notwithstanding, more details of data usage are needed to inform funding decisions. Over time, such usage patterns could tell us how best to target annotation and curation efforts, establish which data should receive the most attention and therefore incur the largest cost, and determine which data should be kept in the longer term. The cost of data regeneration can also influence decisions about keeping data.

Funders should encourage the development of new metrics to ascertain the usage and value of data, and persuade data resources to provide such statistics for all of the data they maintain. We can learn here from the private sector: understanding detailed data usage patterns through data analytics forms the basis of highly successful companies such as Amazon and Netflix.

FAIR AND EFFICIENT

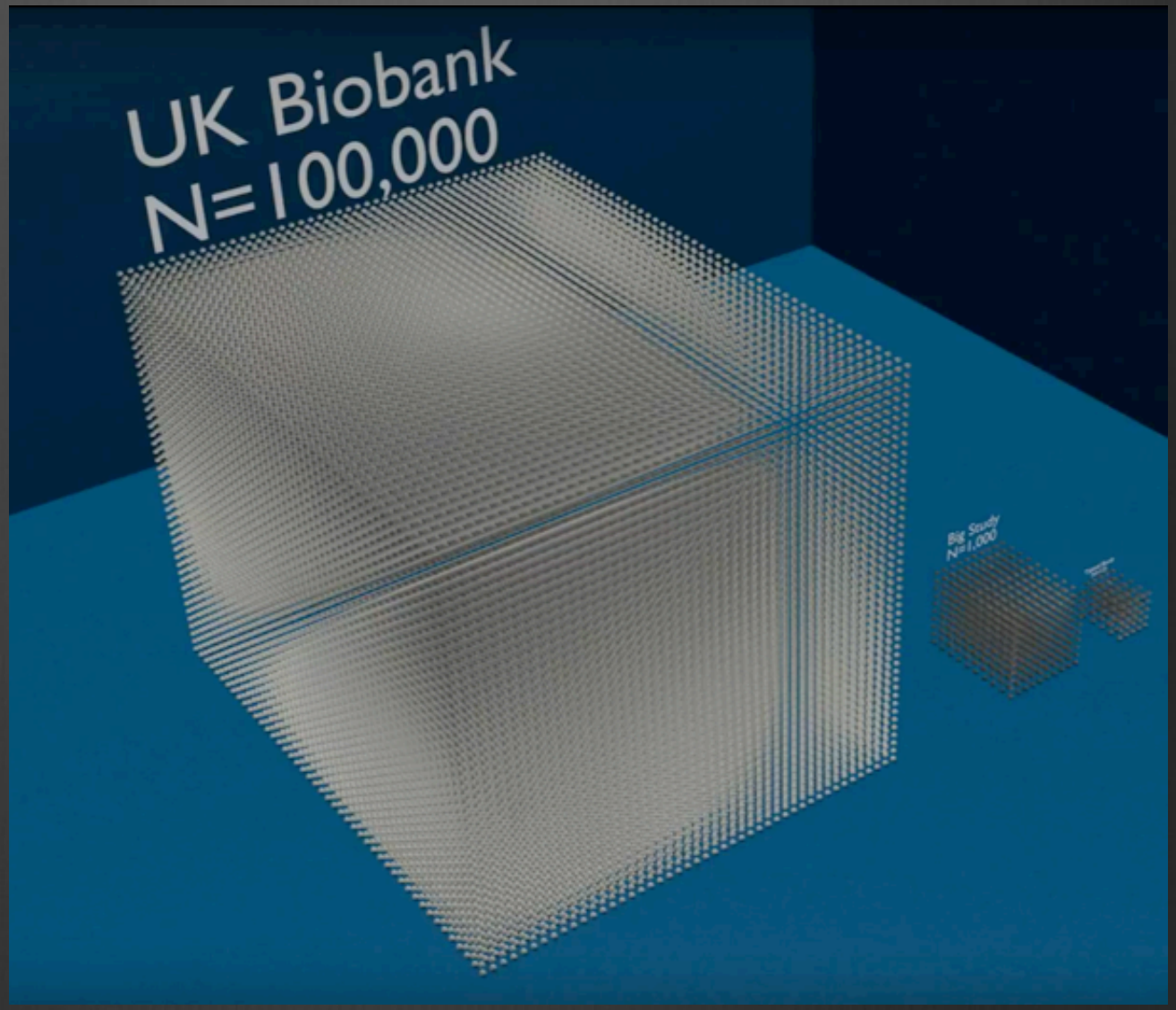
Why: The big-data revolution

UK Biobank Imaging Initiative



Why: The big-data revolution

UK Biobank Imaging Initiative



Problems: The big-data revolution

Obama's precision medicine initiative will aim to enroll a large number of people in a genetic database representing the U.S. population.

Amy West/Flickr (CC BY 2.0)

President Obama's 1-million-person health study kicks off with five recruitment centers

By Jocelyn Kaiser | Jul. 7, 2016 , 5:00 PM

What is Open Science?

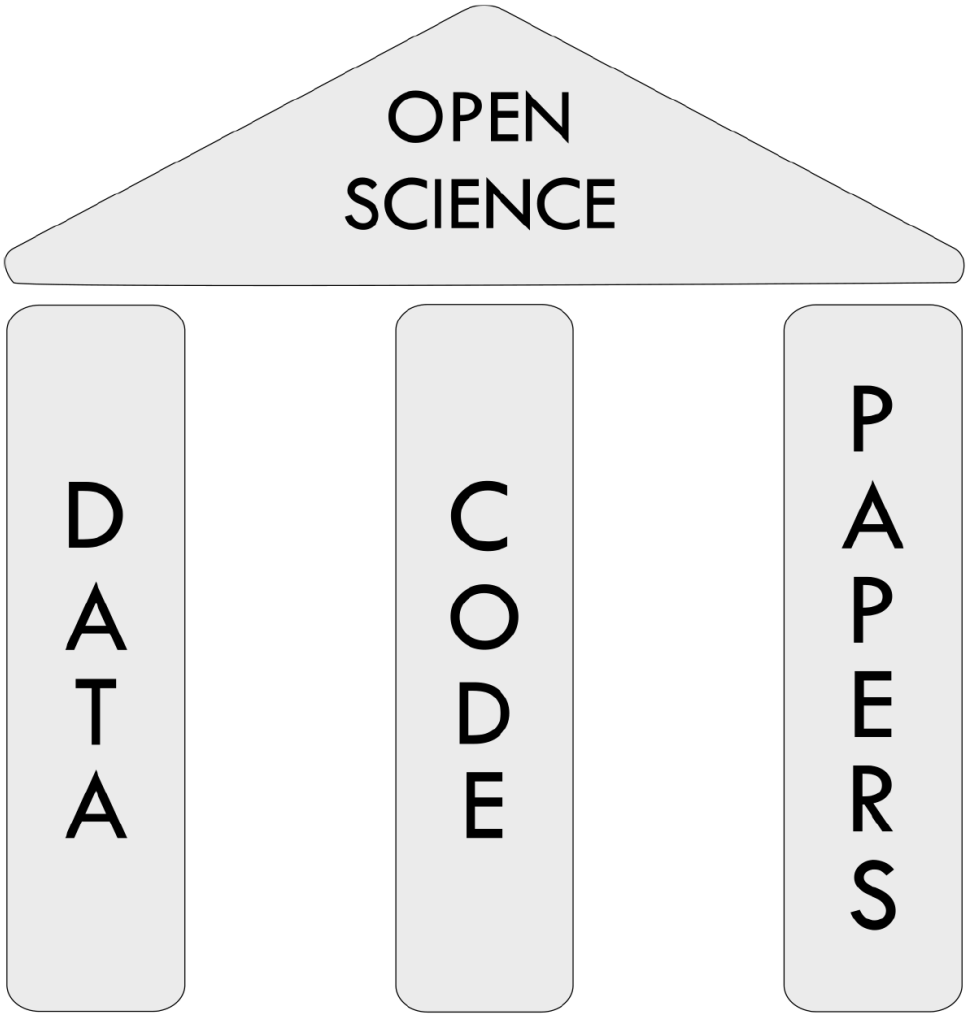


Fig 1. Three pillars of Open Science: data, code, and papers.

doi:10.1371/journal.pbio.1002506.g001

What is Open Code?

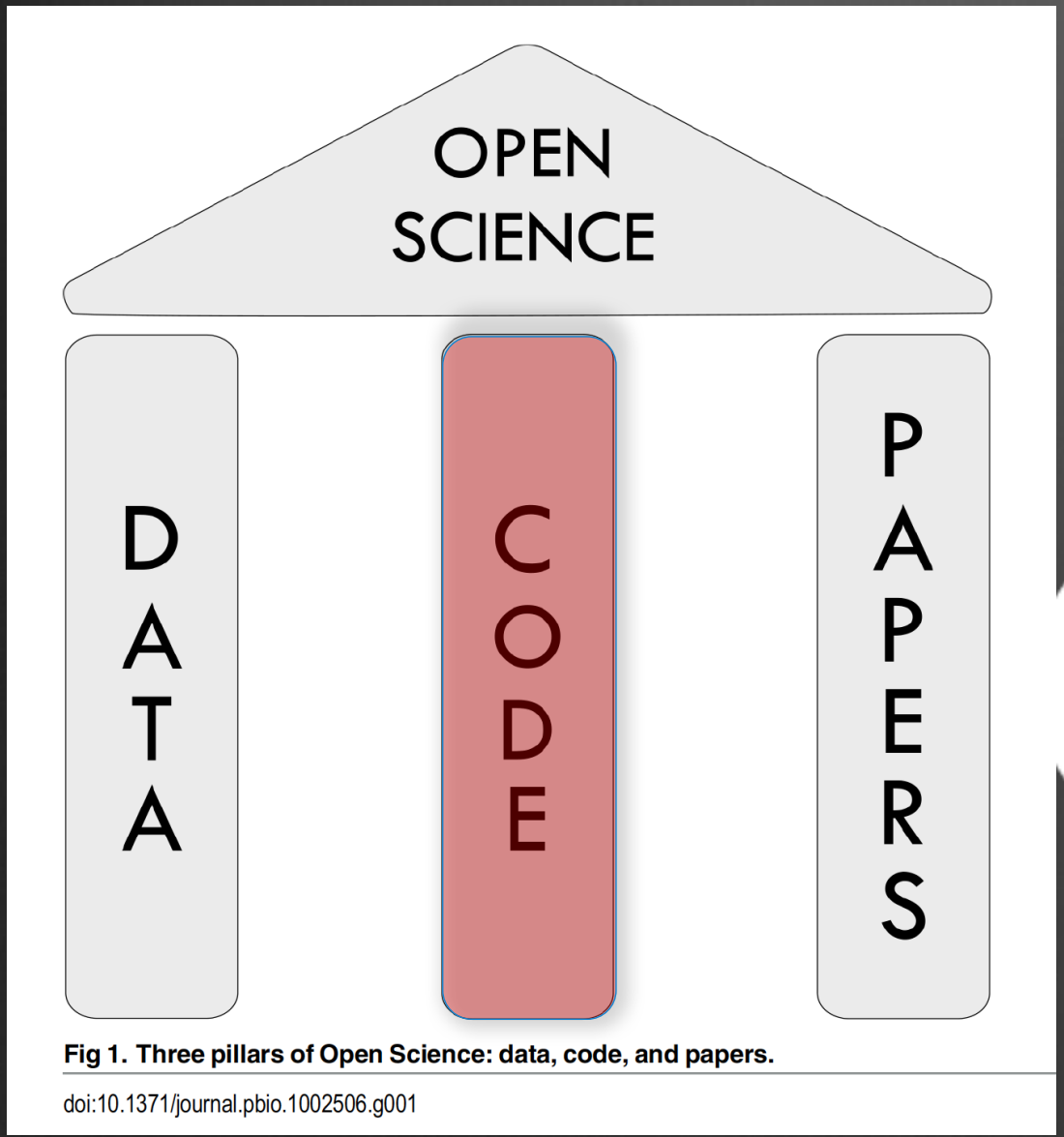


Fig 1. Three pillars of Open Science: data, code, and papers.

doi:10.1371/journal.pbio.1002506.g001

Open code enables greater reproducibility (includes non-code methods)

GitHub

What is Open Data?

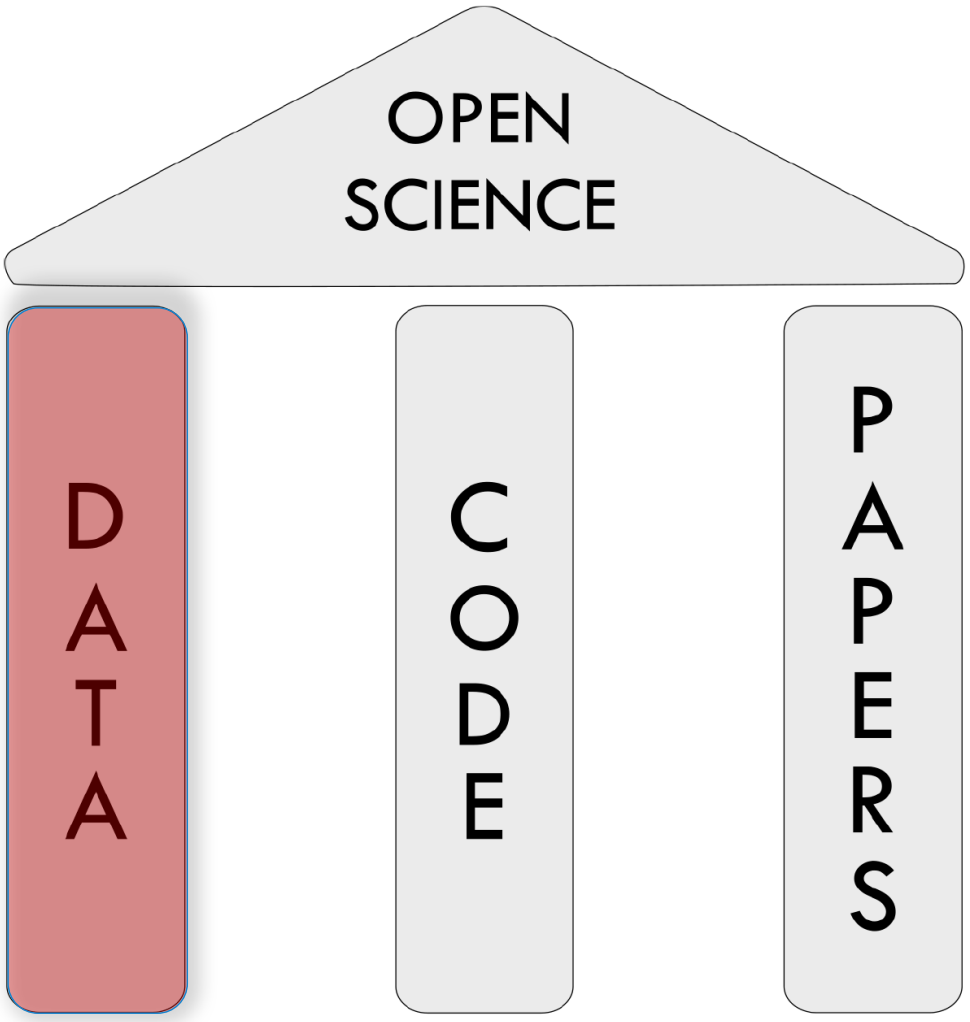


Fig 1. Three pillars of Open Science: data, code, and papers.

doi:10.1371/journal.pbio.1002506.g001

Data deposited in a public, community-recognized repository with a stable DOI

Follows FAIR Principle

- Findable
- Accessible
- Intra-operable
- Reusable

Should be deposited *before* publication

FAIR data

SCIENTIFIC DATA

OPEN

SUBJECT CATEGORIES

» Research data

» Publication characteristics

Comment: The FAIR Guiding Principles for scientific data management and stewardship

Mark D. Wilkinson *et al.*[#]

Received: 10 December 2015
Accepted: 12 February 2016
Published: 15 March 2016

There is an urgent need to improve the infrastructure supporting the reuse of scholarly data. A diverse set of stakeholders—representing academia, industry, funding agencies, and scholarly publishers—have come together to design and jointly endorse a concise and measureable set of principles that we refer to as the FAIR Data Principles. The intent is that these may act as a guideline for those wishing to enhance the reusability of their data holdings. Distinct from peer initiatives that focus on the human scholar, the FAIR Principles put specific emphasis on enhancing the ability of machines to automatically find and use the data, in addition to supporting its reuse by individuals. This Comment is the first formal publication of the FAIR Principles, and includes the rationale behind them, and some exemplar implementations in the community.

FAIR data

Box 2 | The FAIR Guiding Principles

To be Findable:
F1. (meta)data are assigned a globally unique and persistent identifier
F2. data are described with rich metadata (defined by R1 below)
F3. metadata clearly and explicitly include the identifier of the data it describes
F4. (meta)data are registered or indexed in a searchable resource

To be Accessible:
A1. (meta)data are retrievable by their identifier using a standardized communications protocol
A1.1 the protocol is open, free, and universally implementable
A1.2 the protocol allows for an authentication and authorization procedure, where necessary
A2. metadata are accessible, even when the data are no longer available

To be Interoperable:
I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
I2. (meta)data use vocabularies that follow FAIR principles
I3. (meta)data include qualified references to other (meta)data

To be Reusable:
R1. meta(data) are richly described with a plurality of accurate and relevant attributes
R1.1. (meta)data are released with a clear and accessible data usage license
R1.2. (meta)data are associated with detailed provenance
R1.3. (meta)data meet domain-relevant community standards

Outline

- Why are we here?
- Who are we?
- How will this work?

Who are we?

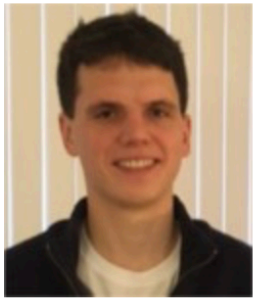
Course Leads and Guests Speakers

Satra Ghosh,
MIT

Yarik Halchenko,
Dartmouth

Wolfgang Resch,
NIH HPC Team

Adam Thomas



John Lee

Dylan Nielson

Outline

- Why are we here?
- Who are we?
- How will this work?

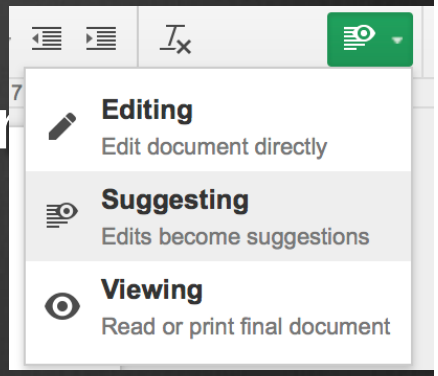
How: Course Methods & Tools

- Methods based on:

- Minimize lecturing. Mostly interactive, live coding with lots of peer teaching
- Red & blue sticky notes
- Google Doc
- Your neighbors

How: Course Tools

- Exercise #1: Introduce yourself to your two neighbors
- Exercise #2:
  - Open this google doc link in your browser http://bit.ly/NIH-Repro
  - Change to Suggesting Mode
  - Type your name in the document
  - Put a green sticky note on the back of your laptop



How: Course Schedule

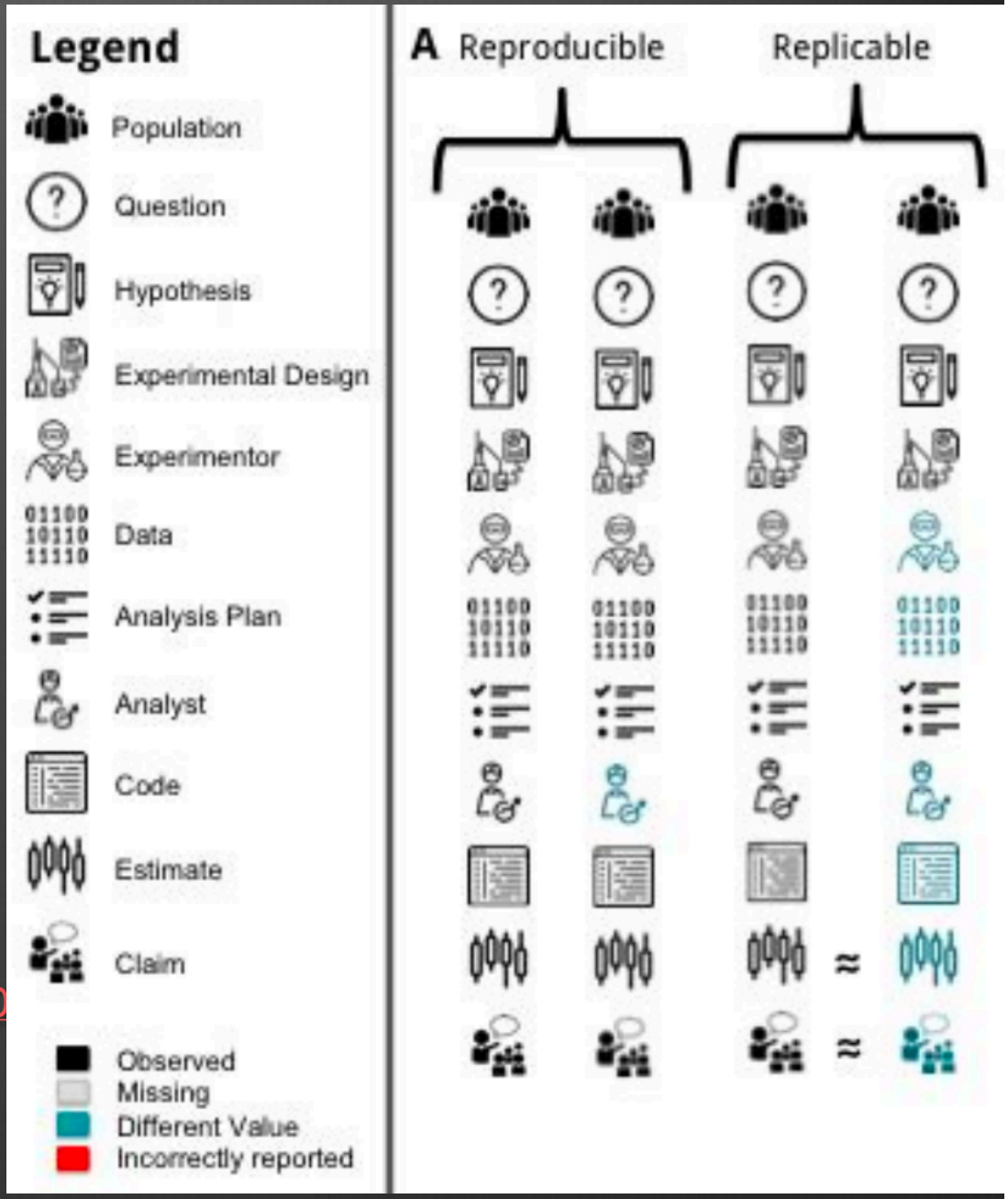
Time	Tuesday Aug 1	Instructor	Wed Aug 2nd	Instructor
9:00	Setup and Orientation	Adam Thomas	Nipype	Satra Ghosh
9:30	Setup and Orientation	John Lee	Nipype	Satra Ghosh
10:00	HPC & Containers	Wolfgang Resch	Nipype	Satra Ghosh
10:30	HPC & Containers	Wolfgang REsch	Nipype	Satra Ghosh
11:00	Python & Classes	Dylan Nielson	Nipype	Satra Ghosh
11:30	Python & Classes	Dylan Nielson	Nipype	Satra Ghosh
12:00	Python & Classes	Dylan Nielson	Nipype	Satra Ghosh
12:30	Lunch		Walk or Uber to Rock Bottom	
13:00	Lunch		Lunch & Wrap Up at Rock Bottom	Adam Thomas
13:30	git refresher	John Lee	Lunch at Rock Bottom	
14:00	git refresher	John Lee	Open Hacking	
14:30	Git-annex & Data Lad	Yarik Halchenko	Open Hacking	
15:00	Git-annex & Data Lad	Yarik Halchenko	Open Hacking	
15:30	Git-annex & Data Lad	Yarik Halchenko	Open Hacking	
16:00	Git-annex & Data Lad	Yarik Halchenko	Open Hacking	
16:30	Git-annex & Data Lad	Yarik Halchenko	Open Hacking	
17:00	Adjourn		Happy Hour!	

Questions?

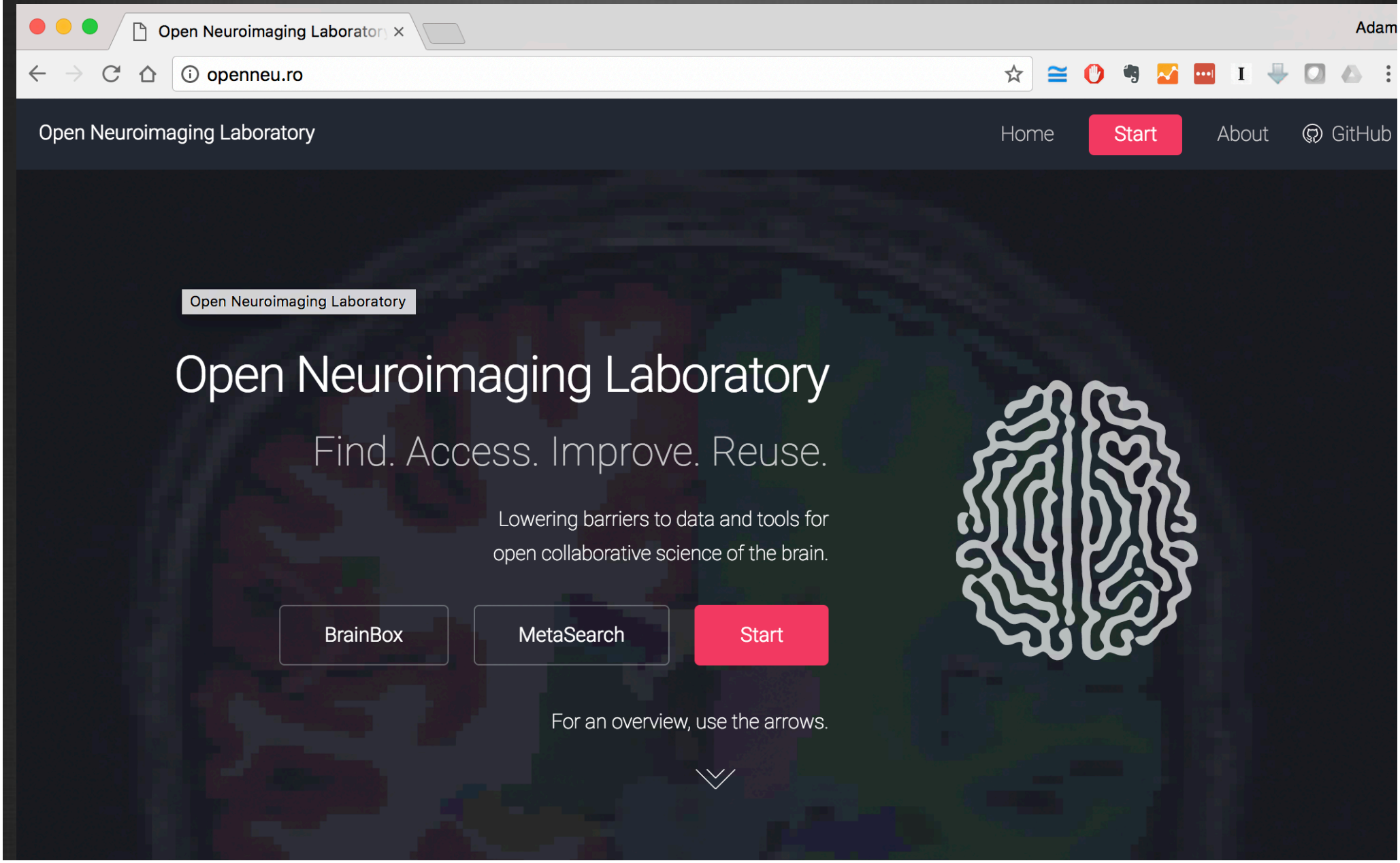
Extra Slides Below

Why: Replicable vs. Reproducible

- Replication: new data, different team
- Reproducible: Same data, different team
- Where replication is hard or impossible, reproducible is the next best thing
- http://biorxiv.org/content/biorxiv/early/2016/07/29/066803.full.pdf

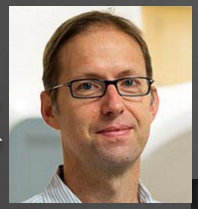
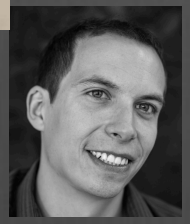
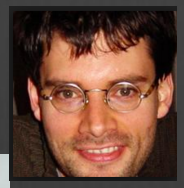
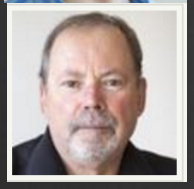


FAIR data
http://openneu.ro



Credits

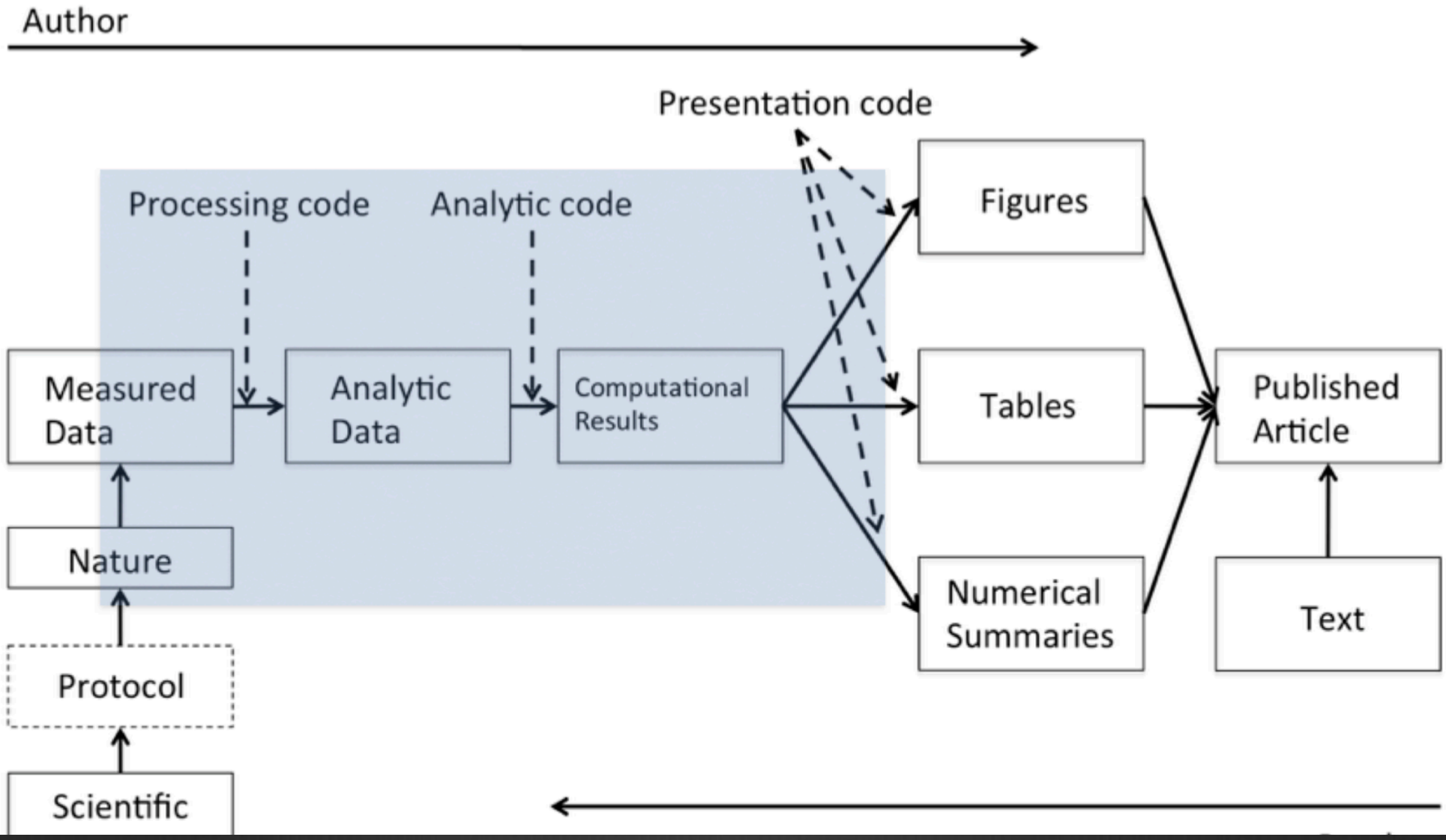
Material borrowed, adapted, and/or stolen from:

- Russ Poldrack 
- Chris Gorgolewski 
- Brian Nosek 
- Tal Yorkoni 
- Niko Kriegeskorte 
- Tom Nichols 
- Phil Bourne 

Outline

- Why do we need Open Science?
- What is Open Science?
- How do I do Open Science?

The Data Science Pipeline



Problems:
Wasted time & resources

"How much time do you spend handling, reorganizing, and managing your data as opposed to actually *doing* science?"

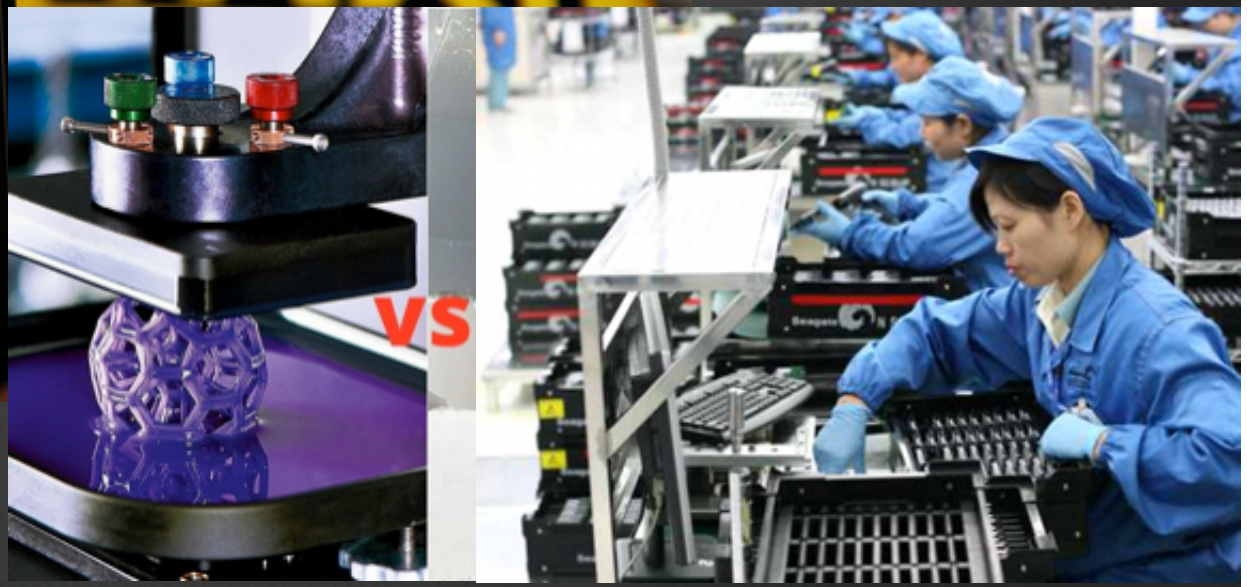
- Median answer is 80%

Why Open Science?
Wasted Time & resources

Unpublished Data

- File drawer problem
- Lost staff & lost metadata
- Underutilized data

Problems: The big-data revolution



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Open Data: Community recognized Repositories

MRI Specific Repos

- OpenfMRI
- COINS
- FCP/INDI
- LONI
- LORIS
- NITRC
- XNAT Central
- ANIMA*
- BALSA*
- Neuovault*

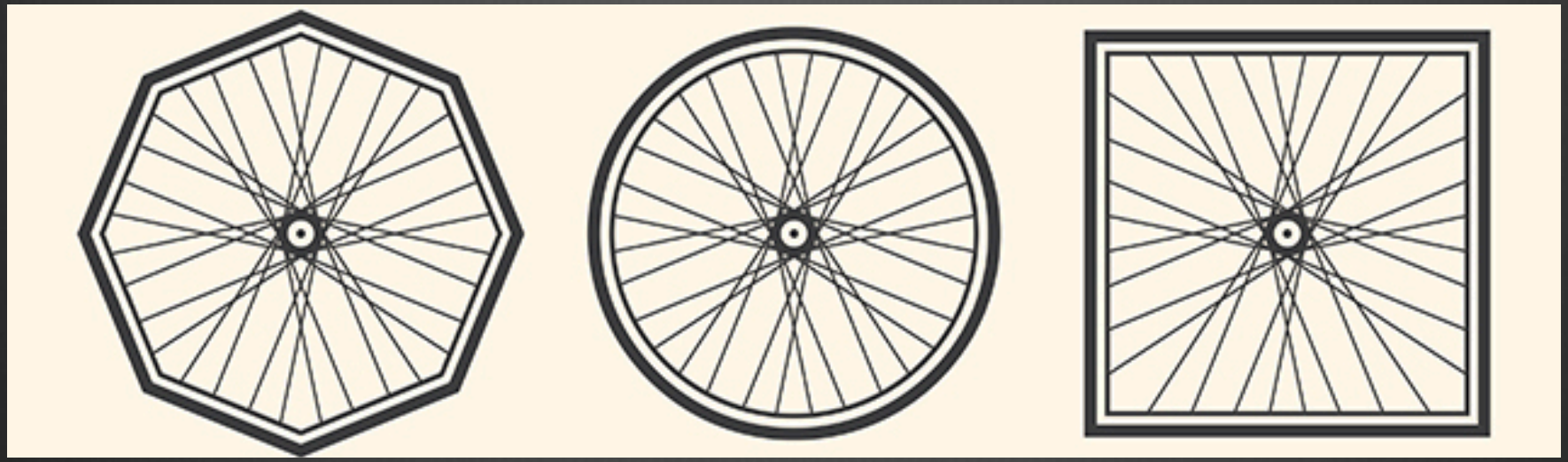
Data Agnostic Repos

- FigShare
- Dryad
- DataVerse
- Open Science Framework
- NIMH Data Archive

Coming soon: A dedicated MRI image repository for MRI studies conducted at intramural NIMH

* Statistical & derived data only

Open Code – Don't Reinvent



Reuse and improve

Open Code - Version Control

Version control systems allows you to:

- Store all of your analysis in a central repository
- Keep a history of "snapshots" of your evolving analysis
- Quickly switch between different versions of your analysis
- Adopt and modify code from other scientists
- Collaborate

What are Open Papers?

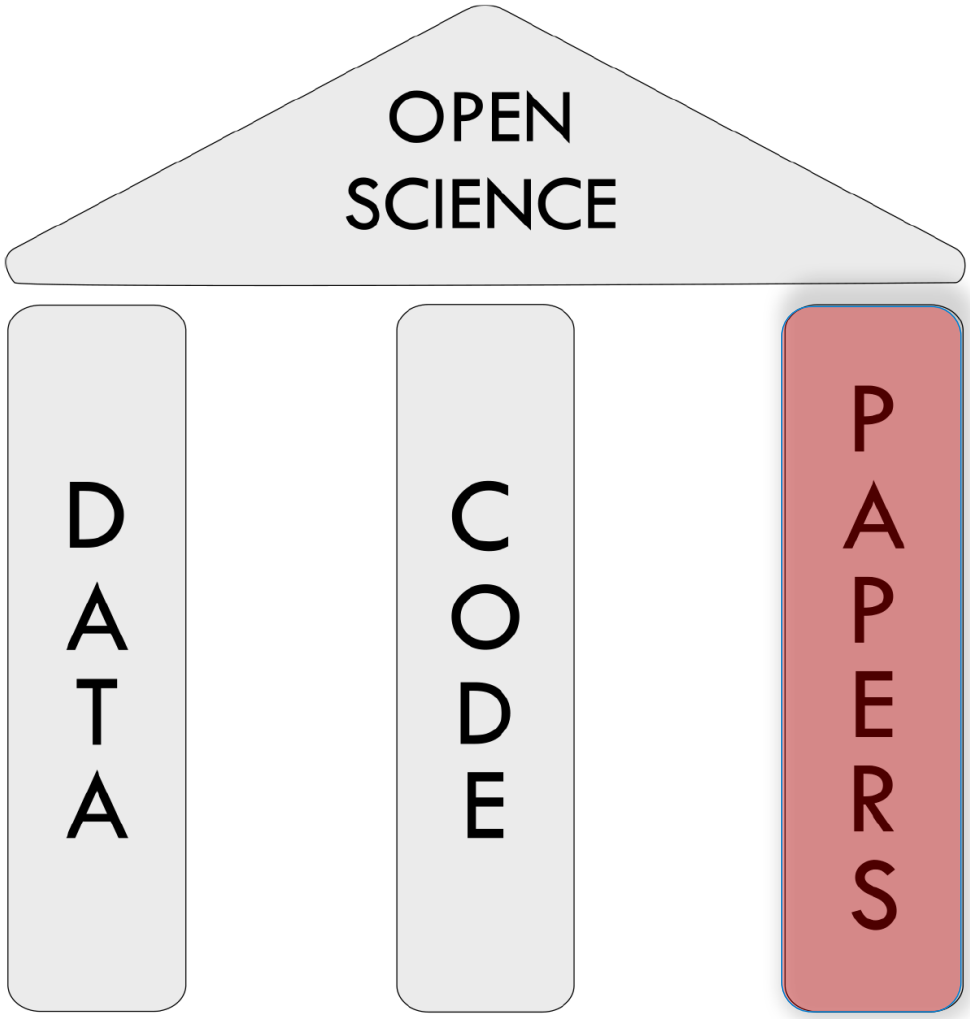


Fig 1. Three pillars of Open Science: data, code, and papers.

doi:10.1371/journal.pbio.1002506.g001

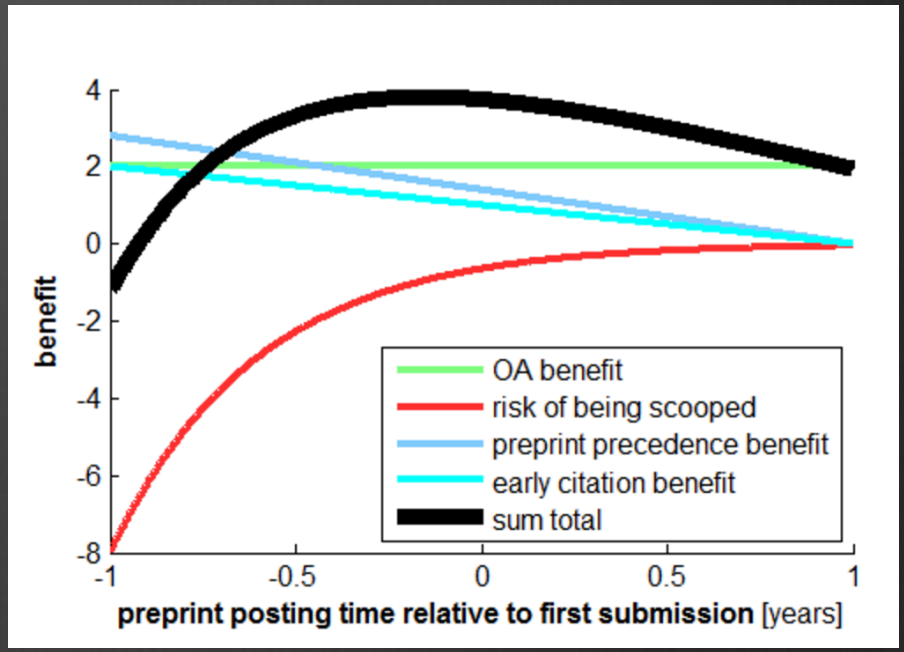
- Preprint posting
- Open access
- Open review

Open Papers: Preprint posting

arXiv.org

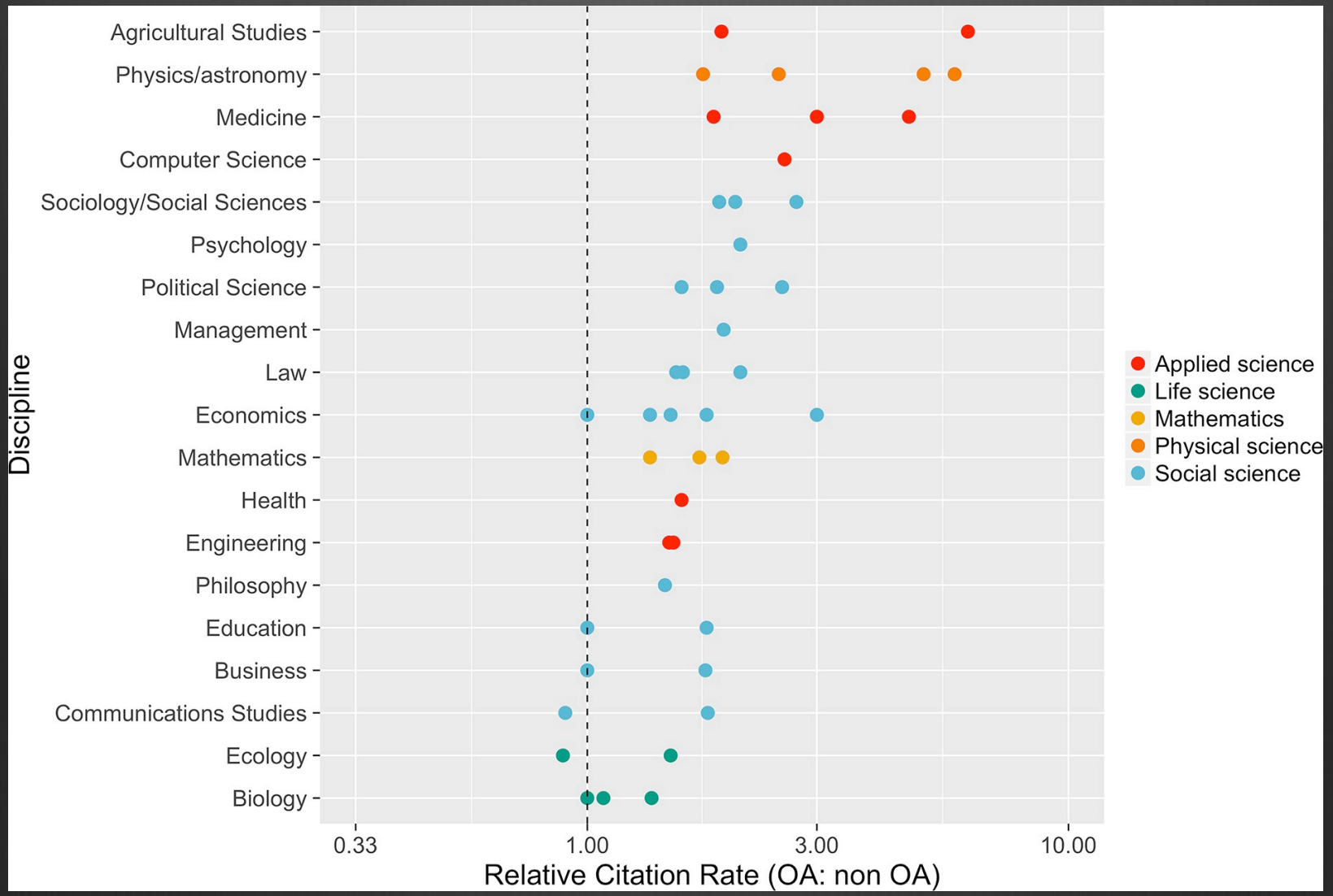
bioRxiv beta
THE PREPRINT SERVER FOR BIOLOGY

- Benefits:
  - Open access
  - Catch errors
  - Earlier citation
  - Earlier precedence, prevent scooping
  - Speed and improve final submission



Kriegeskorte (2016) DOI:10.15200/winn.145838.88372

Open Access
Open access publication are cited more



mean citation rate of OA articles divided by mean citation rate of non-OA articles

Open Review

The Winnower is founded on the principle that all ideas should be openly discussed, debated, and archived.

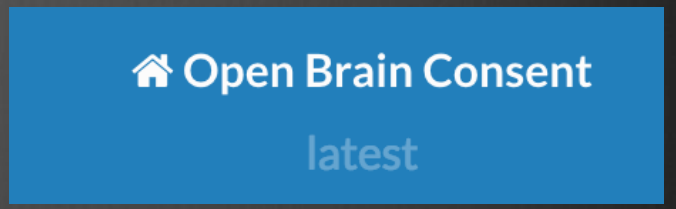
- Public discussion of pros and cons of submission
- Optional anonymity
- Prevent low-quality and or biased review

Outline

- Why do we need Open Science?
- What is Open Science?
- How do I do Open Science?

How – Plan Ahead

- Get data sharing in your protocol:
  - NIMH Data Sharing Commitee
  - https://open-brain-consent.readthedocs.io



- When designing, collecting, and analyzing consult with standards documents:
  - Enhancing Quality and Transparency of Health Research (EQUATOR) http://www.equator-network.org
  - Best Practices in Data Analysis and Sharing in Neuroimaging using MRI (COBIDAS) http://dx.doi.org/10.1101/054262

Standards – EQUATOR & COBIDAS

- EQUATOR: Different standards for different designs
  - RCT, crossover, observational, etc.
- COBIDAS Sections
  1. Experimental Design
  2. Image Acquisition
  3. Preprocessing
  4. Statistical Modeling
  5. Results
  6. Data Sharing
  7. Reproducibility
- Both EQUATOR and COBIDAS focus on reporting,
- Reviewing them in advance will help you plan and design your study
- Also useful reference when reviewing papers

Standards – EQUATOR & COBIDAS

Checklists

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	
	2b	Specific objectives or hypotheses	
Methods			
Trial design	3a	Description of trial design (such as p	
	3b	Important changes to methods after	
Participants	4a	Eligibility criteria for participants	
	4b	Settings and locations where the dat	
Interventions	5	The interventions for each group with actually administered	
Outcomes	6a	Completely defined pre-specified pri were assessed	
	6b	Any changes to trial outcomes after t	
Sample size	7a	How sample size was determined	
	7b	When applicable, explanation of any	
Randomisation:			

Table D.1. Experimental Design Reporting

Aspect	Notes	Mandatory
Number of subjects	*Elaborate each by group if have more than one group.*	
Subjects approached		N
Subjects consented		N
Subjects refused to participate	Provide reasons.	N
Subjects excluded	Subjects excluded after consenting but before data acquisition; provide reasons.	N
Subjects participated and analyzed	Provide the number of subjects scanned, number excluded after acquisition, and the number included in the data analysis. If they differ, note the number of subjects in each particular analysis.	Y
Inclusion criteria and descriptive statistics	*Elaborate each by group if have more than one group.*	
Age	Mean, standard deviation and range.	Y
Sex	Absolute counts or relative frequencies.	Y
Race & ethnicity	Per guidelines of NIH or other relevant agency.	N

COBIDAS – Highlights

- Report scan parameters by exporting exam cards
- Preprocessing include *all* steps applied to the data before and must be reported
- For maximal transparency, report all regions of interest (ROIs) and/or experimental conditions examined as part of the research, so that the reader can gauge the degree of any HARKing
  - Hypothesizing After The Results are Known
  - It's OK to explore your data, just be clear that that is what you're doing

COBIDAS – 4. Statistical Modeling

- Different reporting standards for different statistical approaches (univariate, multivariate, connectivity).
- Appendix C: Translates software used to statistical language

Appendix C. Short descriptions of fMRI models

While any analysis software consists of myriad modelling decisions, an author must be able to describe the key facets of an analysis in the methods section of their paper. To facilitate this, and to suggest a level of detail that is useful to readers unfamiliar with the software yet not distractingly long, we provide short descriptions for the most commonly used statistical models in widely used software packages.

C1. Task fMRI

Summaries for AFNI[44], Freesurfer[45], FSL[46], & SPM[47] are based on versions AFNI_2011_12_21_1014, FreeSurfer 5.3, FSL 5.0.8 and SPM 12 revision 6470, respectively.

AFNI 1st level – 3dDeconvolve: Linear regression at each voxel, using ordinary least squares, drift fit with polynomial.
AFNI 1st level – 3dREMLfit: Linear regression at each voxel, using generalised least squares with a voxel-wise ARMA(1,1) autocorrelation model, drift fit with polynomial.
AFNI 2nd level – 3dTtest: Linear regression at each voxel, using ordinary least squares.
AFNI 2nd level – 3dMEMA: Linear mixed effects regression at each voxel, using generalized least squares with a local estimate of random effects variance.
AFNI 2nd level – 3dMVM: Multivariate ANOVA or ANCOVA at each voxel.
AFNI 2nd level – 3dLME: General linear mixed-effects modeling at each voxel, with separate specification of fixed and random variables.
Freesurfer 1st Level – selxavg3-sess: Linear regression at each surface element, using generalized least squares with a element-wise AR(1) autocorrelation model, drift fit with polynomial.
Freesurfer 2st Level – mri_glmfit: Linear regression at each surface element, using ordinary least squares.

COBIDAS – 5. Results

- Mass univariate analyses should report:
  - All Effects tested
  - Tables of brain coordinates,
  - Thresholded maps
  - Extracted data
- Functional Connectivity
- Multivariate and Predictive Analysis
  - Evaluation : Quality of predicted fit
  - Interpretation: What does it mean

COBIDAS – 6. Data Sharing

- Planning: "Data sharing is most onerous when done as an afterthought"
- "a comprehensive data management plan—that involves all authors, collaborators, funding agencies, and publishing entities—is essential"

COBIDAS – 7. Reproducibility

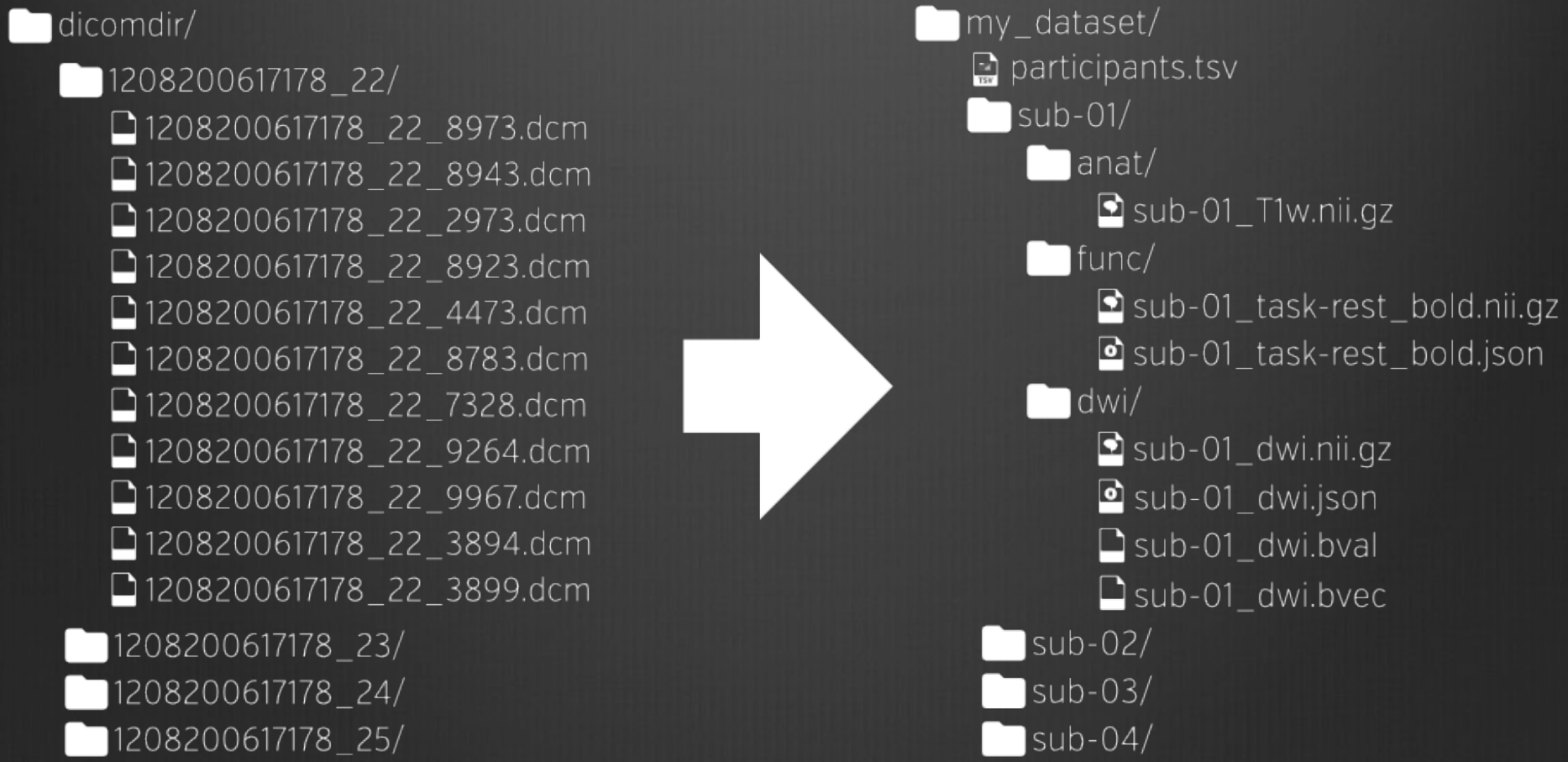
Archiving: Think long term

- Open-source software is more likely to be available long term
- URLs "decay" over time. Use Digital Object Identifiers (DOI) instead

Organizing your data - BIDS

A simple and intuitive way to organize and describe your neuroimaging and behavioral data.

http://bids.neuroimaging.io



How to be Open – Choose your battles

Be open when you can, as you can

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.
Research materials transparency	Journal encourages materials sharing—or says nothing	Article states whether materials are available and, if so, where to access them.	Materials must be posted to a trusted repository. Exceptions must be identified at article submission.	Materials must be posted to a trusted repository, and reported analyses will be reproduced independently before publication.
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.

Summary and Take Homes

- Science is changing (for the better) in both scope (big) and culture (open) to address future challenges
- Open science strives to maximize reproducibility and transparency of data, code, and papers
- Adopting Open Science practices yields benefits in productivity, impact, and reach
- You don't have to do it all at once, and you don't have to do it alone

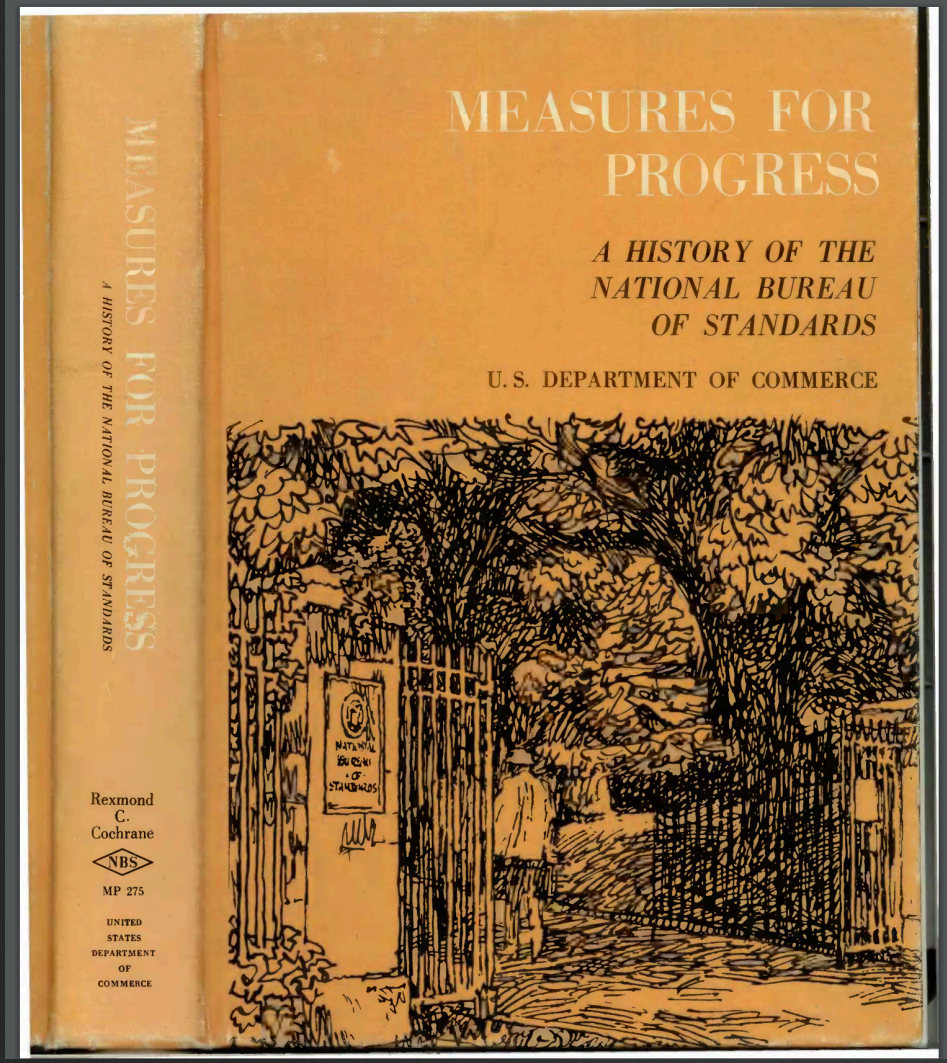
Thanks!

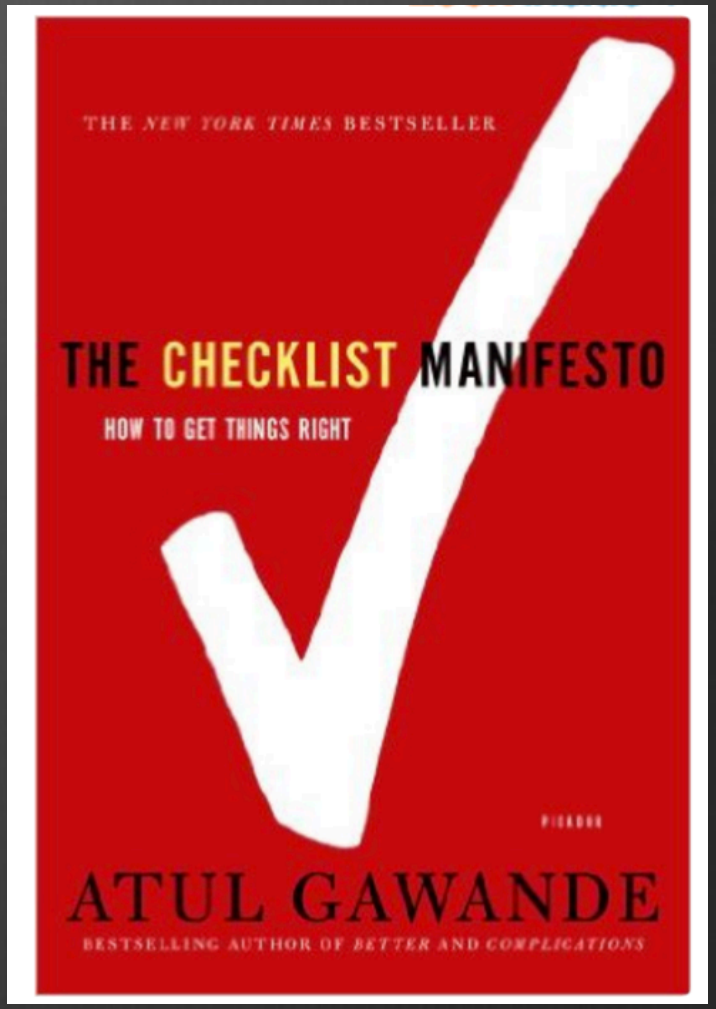
See online slides for more URLs and references:
https://fmrif.nimh.nih.gov/public/fmri-course/index_html

Questions?

The Problem

- Science vs. Art: The importance of standardization





Outline

- The Problem – Why do we need these?
- The Gist – TL;DR. What's in the specs?
- The Future – How and where are COBIDAS and BIDS going to effect me?

The Gist - COBIDAS

- The Seven Pillars of COBIDAS Reporting
  1. Experimental Design
  2. Image Acquisition
  3. Preprocessing
  4. Statistical Modeling
  5. Quiz Question #2

Outline

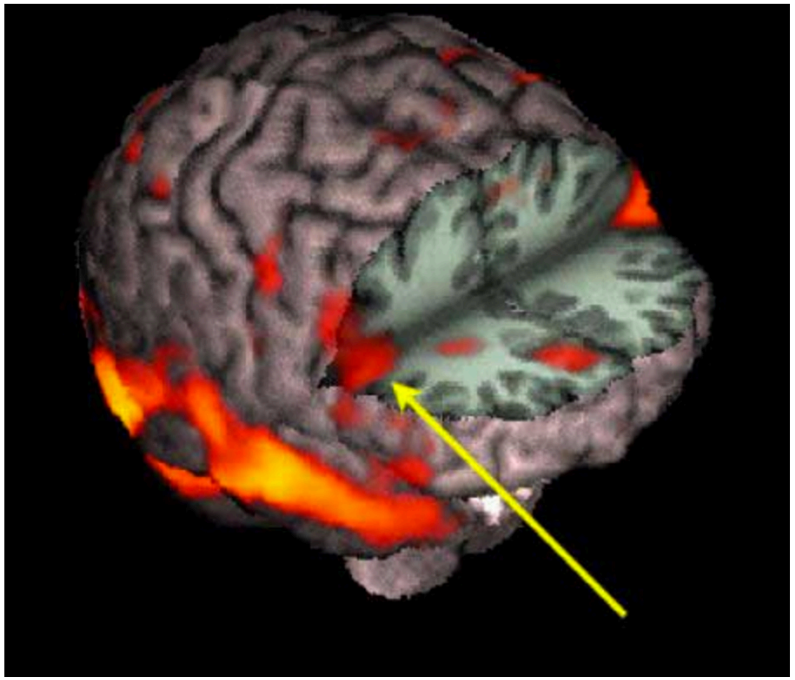
- The Problem – Why do we need these?
- The Gist – TL;DR. What's in the specs?
- The Future – How and where are COBIDAS and BIDS going to effect me?

Where will you encounter/use of COBIDAS & BIDS

- As a peer-reviewer and a peer-reviewee
- Uploading to and downloading from public repositories
- Training the next generation

The Problem

- Mistakes in Brain Imaging and Bridge Building
- Cocktail parties vs. Catastrophes



Mirror neuron activity in the right posterior inferior frontal gyrus – indicating identification and empathy - while watching the Disney/NFL ad.

Brain Imaging is maturing (finally)