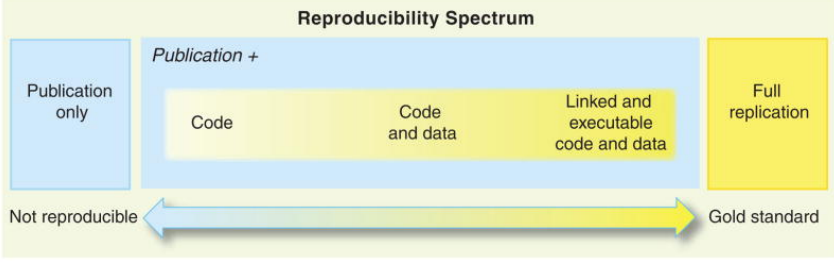
Reproducible research

An introduction for the R novice



Richard Layton

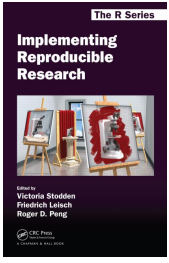
Rose-Hulman Institute of Technology
Fall 2018

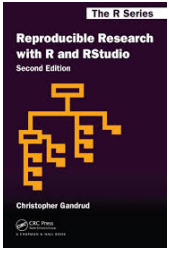
Image from Roger Peng (2011) Reproducible research in computational science. *Science* **334**(6060), 1226–1227.

Getting started

- Introductions
- Mystery question: *What is reproducible research?*

Practitioners tell us:





Research is reproducible when the data and the code used to obtain a finding are available and sufficient for an independent researcher to recreate the finding.

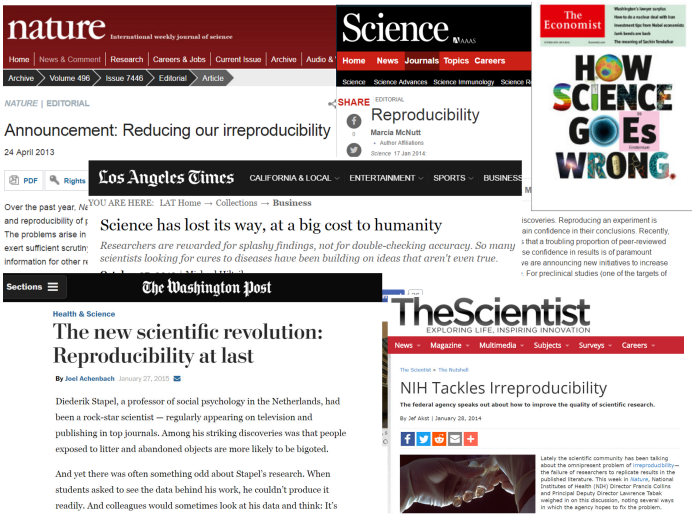
- computational, data-intensive
- spans the full data, analysis, & publication workflow
- most of us have received only perfunctory training (if any)

Victoria Stodden, F. Leisch, & R. Peng, ed., *Implementing Reproducible Research*, CRC Press, 2014.
Christopher Gandrud, *Reproducible Research with R and RStudio, 2/e*, CRC Press, 2015.

Events tell us:

More accountability is needed because of

- data falsification
- erroneous analysis
- misleading presentation of results



Karen EC Levy & David Merritt Johns, When open data is a Trojan Horse: The weaponization of transparency in science and governance, *Big Data and Society*, 2016.

Reproduction revealed that their primary findings were false

Results were used to justify austerity policies, but the major effect disappeared after correcting for

- coding errors
- selective exclusion of available data
- unconventional weighting of summary statistics

Kenneth Rogoff & Carmen Reinhart

Thomas Herdon, Michael Ash, & Robert Pollin, Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff, Political Economy Research Institute, U Mass Amherst, 2013.

Reproduction revealed that he falsified data

To obtain the results he wanted, he altered data in several ways. To date (2018) consequences include:

- clinical trials (real patients) terminated and 11 malpractice suits settled
- 18 research journal articles retracted
- Duke University must now obtain preapproval from NIH for funding changes

Anil Potti, formerly a cancer researcher at Duke University

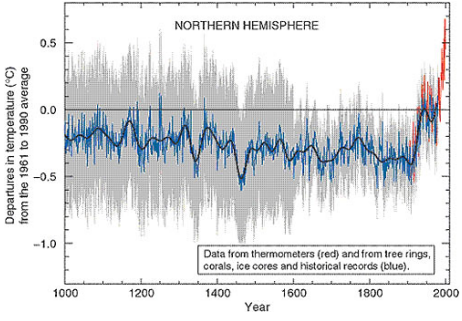
Jason deBruyn, Trial involving disgraced scientist and bunk Duke research, *Triangle Business Journal*, 2015-01-23.
Ivan Oransky, It's official: Anil Potti faked cancer research data, say Feds, *Retraction Watch*, 2015-11-07.

Reproduction, however, is also used to *discredit scientists*

Mann's work has withstood 15 years of scrutiny—and still holds up. But he refused to share.

Scientists and "skeptics" are in a knife fight, and you don't bring data to a knife fight. — Paul Erlich

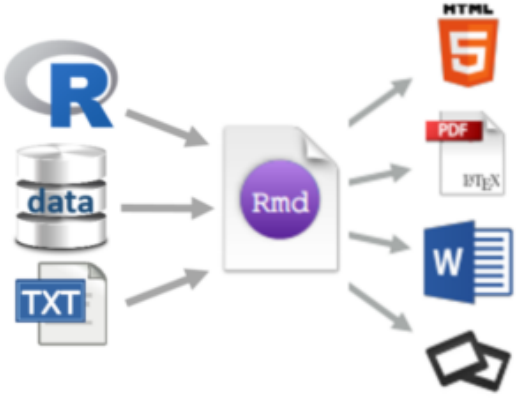
Why should I make the data available to you, when your aim is to try and find something wrong with it? — Phil Jones



1000 years of temperature variation with uncertainties, Michael Mann

Freed Pearce, Climate change debate overheated after skeptic grasped 'hockey stick', *The Guardian*, 2010-02-09.
Brad Keyes, Mann retirement: Analysis, reax, *Climate Sceptic*, 2016-05-08.
Jeff Leek, De-weaponizing reproducibility, 2015-03-13.

Our focus is on explicitly linking the report, paper, or talk to the data and scripts that generate the findings

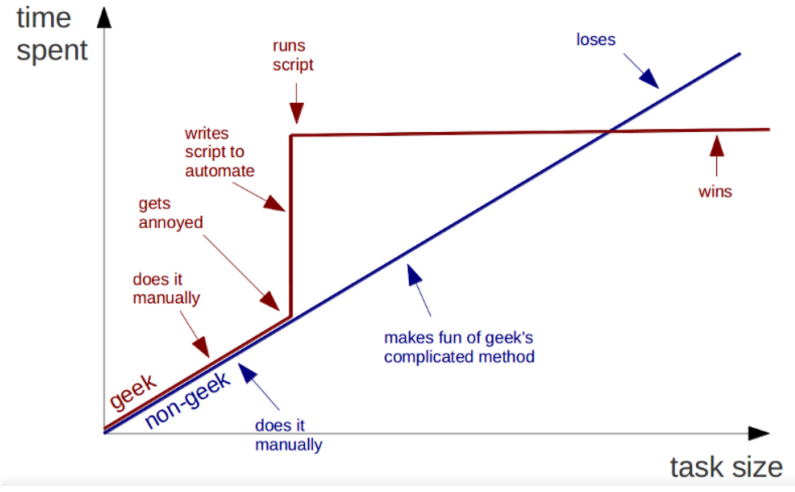


R Markdown (.Rmd) files are the central link

Changes are automatically updated and embedded in the output document.

Cut and paste no more!

The benefits first accrue to you



- reproducible for your future self
- faster updating of results
- faster resumption of work after hiatus

Steps towards reproducibility

- Write scripts (avoid manual copy, paste, mouse-clicks)
- Plan the organization and naming scheme for files
- Strive for simplicity & readability
- Write for reusability & testability
- Agree on a workflow for collaborating before starting a manuscript
- DRY (don't repeat yourself)
- Link files explicitly
- Use version control
- Plan data management
- License your software
- Manage package dependencies

Karl Broman, Initial steps toward reproducible research.
Jenny Bryan, Karen Cranston, Justin Kitzes, Lex Nederbragt, Tracy Teal, and Greg Wilson, Good enough practices for scientific computing, 2016-01.

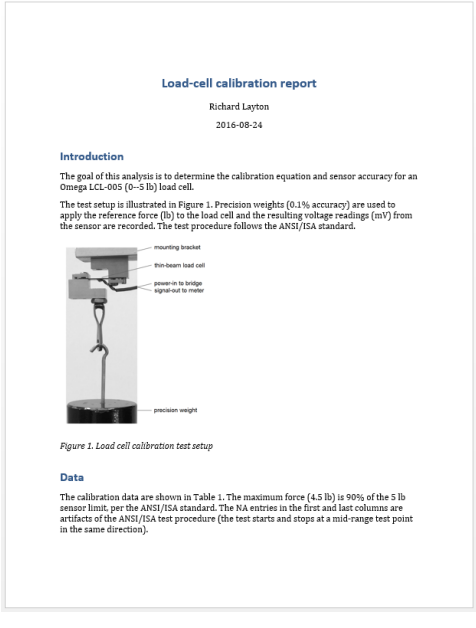
Steps towards reproducibility: in this course

- Write scripts (avoid manual copy, paste, mouse-clicks)
- Plan the organization and naming scheme for files
- Strive for simplicity & readability
- Write for reusability & testability
- Agree on a workflow for collaborating before starting a manuscript
- DRY (don't repeat yourself)
- Link files explicitly
- Use version control
- Plan data management
- License your software
- Manage package dependencies

Karl Broman, Initial steps toward reproducible research.
Jenny Bryan, Karen Cranston, Justin Kitzes, Lex Nederbragt, Tracy Teal, and Greg Wilson, Good enough practices for scientific computing, 2016-01.

Consider a sample report

- Imagine that you were the author of the “Load cell calibration report”
- Mystery question: Identify as many “manual operations” as possible.



Load-cell calibration report

Richard Layton

2016-08-24

Introduction

The goal of this analysis is to determine the calibration equation and sensor accuracy for an Omega LCL-005 (0–5 lb) load cell.

The test setup is illustrated in Figure 1. Precision weights (0.1% accuracy) are used to apply the reference force (lb) to the load cell and the resulting voltage readings (mV) from the sensor are recorded. The test procedure follows the ANSI/ISA standard.

Figure 1. Load cell calibration test setup

Data

The calibration data are shown in Table 1. The maximum force (4.5 lb) is 90% of the 5 lb sensor limit, per the ANSI/ISA standard. The NA entries in the first and last columns are artifacts of the ANSI/ISA test procedure (the test starts and stops at a mid-range test point in the same direction).

How the course is organized

- Course materials are reproducible.
  `https://github.com/DSR-RHIT/me497-reproducible-research`
- Syllabus
- Week 0 assignments