

# Digital badge

- Reproducible research

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Brendan Palmer,

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School of Public Health



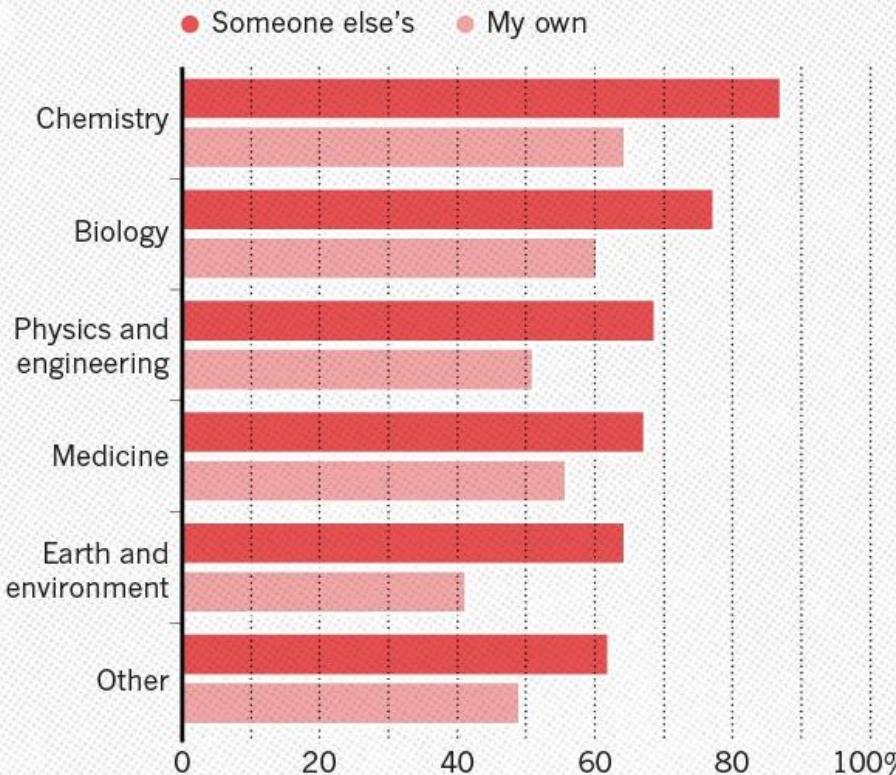
## 1,500 scientists lift the lid on reproducibility

Survey sheds light on the 'crisis' rocking research.

Monya Baker

### HAVE YOU FAILED TO REPRODUCE AN EXPERIMENT?

Most scientists have experienced failure to reproduce results.



## COMMENTARY

# Scientists behaving badly

To protect the integrity of science, we must look beyond falsification, fabrication and plagiarism, to a wider range of questionable research practices, argue **Brian C. Martinson, Melissa S. Anderson and Raymond de Vries**.

**Table 1 | Percentage of scientists who say that they engaged in the behaviour listed within the previous three years (*n* = 3,247)**

Top ten behaviours	All	Mid-career	Early-career
1. Falsifying or 'cooking' research data	0.3	0.2	0.5
2. Ignoring major aspects of human-subject requirements	0.3	0.3	0.4
3. Not properly disclosing involvement in firms whose products are based on one's own research	0.3	0.4	0.3
4. Relationships with students, research subjects or clients that may be interpreted as questionable	1.4	1.3	1.4
5. Using another's ideas without obtaining permission or giving due credit	1.4	1.7	1.0
6. Unauthorized use of confidential information in connection with one's own research	1.7	2.4	0.8 ***
7. Failing to present data that contradict one's own previous research	6.0	6.5	5.3
8. Circumventing certain minor aspects of human-subject requirements	7.6	9.0	6.0 **
9. Overlooking others' use of flawed data or questionable interpretation of data	12.5	12.2	12.8
10. Changing the design, methodology or results of a study in response to pressure from a funding source	15.5	20.6	9.5 ***
Other behaviours			
11. Publishing the same data or results in two or more publications	4.7	5.9	3.4 **
12. Inappropriately assigning authorship credit	10.0	12.3	7.4 ***
13. Withholding details of methodology or results in papers or proposals	10.8	12.4	8.9 **
14. Using inadequate or inappropriate research designs	13.5	14.6	12.2
15. Dropping observations or data points from analyses based on a gut feeling that they were inaccurate	15.3	14.3	16.5
16. Inadequate record keeping related to research projects	27.5	27.7	27.3

# Reproducible or replicable

		Data	
		Same	Different
Analysis	Same	Reproducible	Replicable
	Different	Robust	Generalisable

# Reproducible or replicable

		Data	
		Same	Different
Analysis	Same	Reproducible	Replicable
	Different	Robust	Generalisable

# Reproducible or replicable

		Data	
		Same	Different
Analysis	Same	Replicable	Reproducible
	Different	Robust	Generalisable

# Some cautionary tales

The Atlantic

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SCIENCE

## A Waste of 1,000 Research Papers

Decades of early research on the genetics of depression were built on nonexistent foundations. How did that happen?

ED YONG MAY 17, 2019

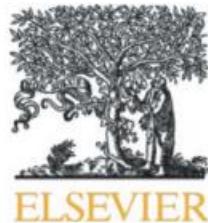


[Am J Psychiatry. 2019 May 1;176\(5\):376-387. doi: 10.1176/appi.ajp.2018.18070881. Epub 2019 Mar 8.](#)

**No Support for Historical Candidate Gene or Candidate Gene-by-Interaction Hypotheses for Major Depression Across Multiple Large Samples.**

[Border R<sup>1</sup>, Johnson EC<sup>1</sup>, Evans LM<sup>1</sup>, Smolen A<sup>1</sup>, Berley N<sup>1</sup>, Sullivan PF<sup>1</sup>, Keller MC<sup>1</sup>.](#)

# 241 shades of grey



Contents lists available at SciVerse ScienceDirect

NeuroImage

journal homepage: [www.elsevier.com/locate/ynim](http://www.elsevier.com/locate/ynim)



## Full Length Articles

### The secret lives of experiments: Methods reporting in the fMRI literature

Joshua Carp

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#### ARTICLE INFO

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Available online 10 July 2012

*Keywords:*  
fMRI  
Methods reporting  
Reproducibility  
Experimental design  
Analysis methods  
Statistical power

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#### ABSTRACT

Replication of research findings is critical to the progress of scientific understanding. Accordingly, most scientific journals require authors to report experimental procedures in sufficient detail for independent researchers to replicate their work. To what extent do research reports in the functional neuroimaging literature live up to this standard? The present study evaluated methods reporting and methodological choices across 241 recent fMRI articles. Many studies did not report critical methodological details with regard to experimental design, data acquisition, and analysis. Further, many studies were underpowered to detect any but the largest statistical effects. Finally, data collection and analysis methods were highly flexible across studies, with nearly as many unique analysis pipelines as there were studies in the sample. Because the rate of false positive results is thought to increase with the flexibility of experimental designs, the field of functional neuroimaging may be particularly vulnerable to false positives. In sum, the present study documented significant gaps in methods reporting among fMRI studies. Improved methodological descriptions in research reports would yield significant benefits for the field.

# Who benefits most from reproducibility?



**Casey Greene**  
@GreeneScientist

Follow

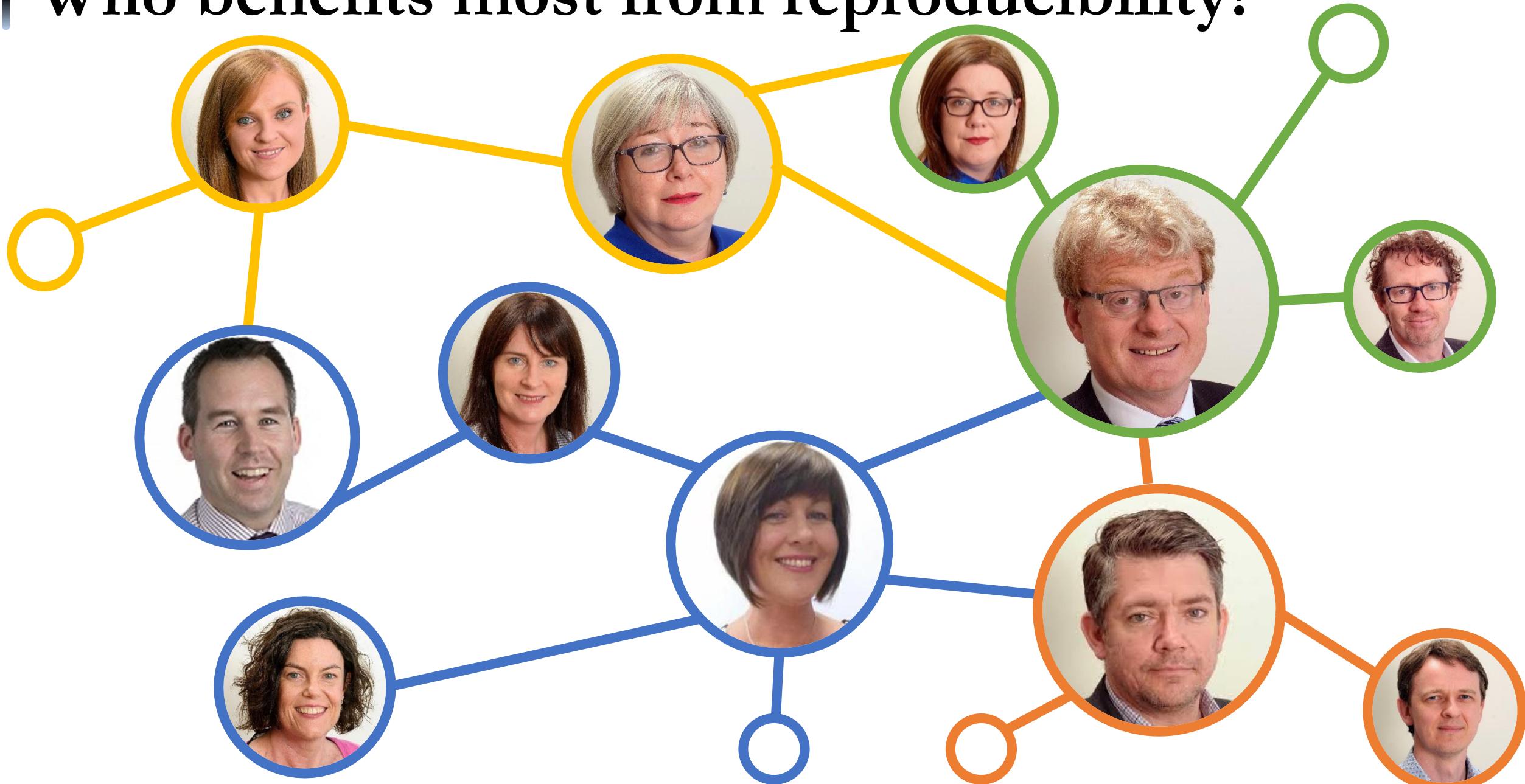


Reproducibility is important because the you  
of 3 months ago is terrible at answering  
email! - [@tracykteal](#) at [#2016dssummit](#)

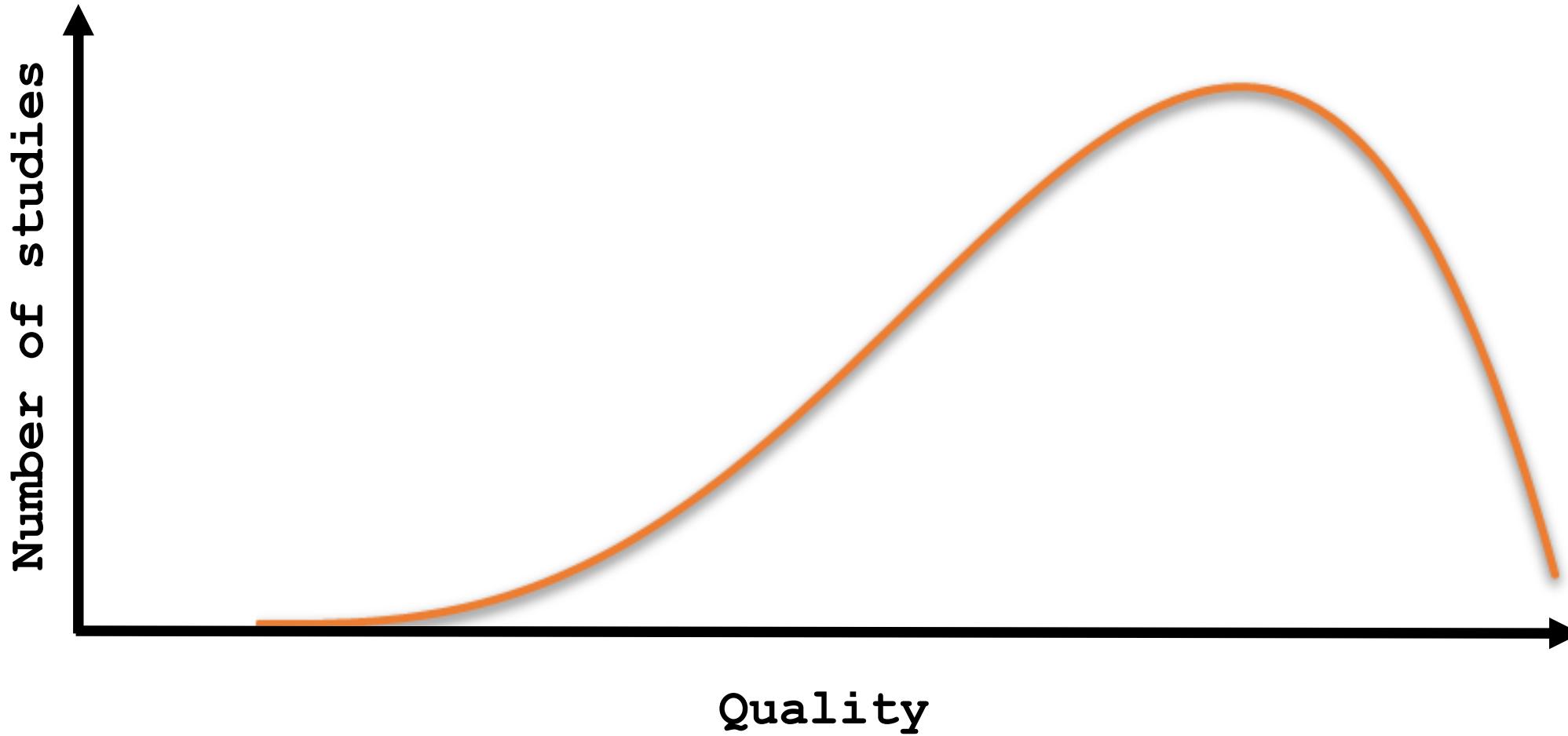
1:17 PM - 26 Oct 2016 from [Manhattan, NY](#)



# Who benefits most from reproducibility?



# Today



# Past failings



"In short, peer review misses all the hard stuff, and a worrying amount of the easy stuff"

James Heathers,  
Northwestern University

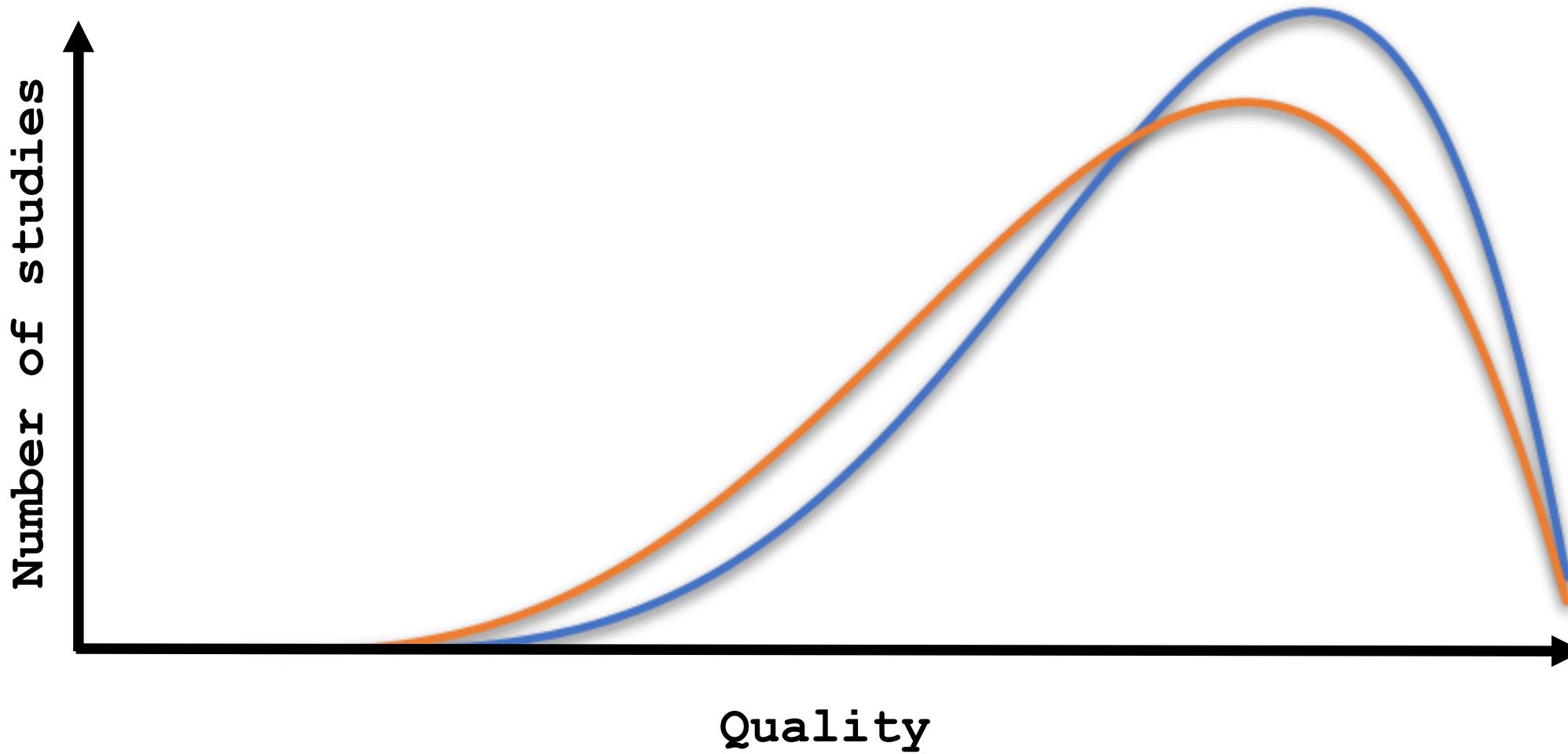
#datathugs



## **Brian Wansink: The grad student who never said no**

"Every day we would scratch our heads, ask "Why," and come up with another way to reanalyze the data with yet another set of plausible hypotheses. Eventually we started discovering solutions"

# Tomorrow



# Where to begin...



# Mistakes can happen



Rasmus Nielsen  
@ras\_nielsen

The one thing that all scientists fear the most is to find out that a major result they have published was based on erroneous data. This is an event that will affect you for the rest of your scientific career. 1/3

6:24 PM · Sep 27, 2019 · Twitter Web App

181 Retweets 1.4K Likes



Rasmus Nielsen @ras\_nielsen · Sep 27

Replying to @ras\_nielsen

David Reich (inspired by the work of Sean Harrison) has found an error in the UK Biobank data that likely explains most or all of our results regarding CCR5 delta-32. We will work with the Nature Medicine editors to get the publication record corrected. 2/3

34 95 861



Daniel MacArthur  
@dgmacarthur

It's also a good reminder for everyone: never blindly trust any genomic data set. They all contain hidden errors that evade bulk QC, even when very carefully done, but emerge when doing very specific analyses. Be suspicious, and tailor your QC to the question you're asking.

5:31 PM · Oct 2, 2019 · Twitter Web App



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Genetics  
Genomics  
Immunology  
Microbiology

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Abstract

A recent study reported that a 32-base-pair deletion in the CCR5 gene (CCR5-Δ32) is deleterious in the homozygous state in humans. Evidence for this came from a survival analysis in the UK Biobank cohort, and from deviations from Hardy-Weinberg equilibrium at a polymorphism tagging the deletion (rs62625034). Here, we carry out a joint analysis of whole-genome genotyping data and whole-exome sequencing data from the UK Biobank, which reveals that technical artifacts are a more plausible cause for deviations from Hardy-Weinberg equilibrium at this polymorphism. Specifically, we find that individuals homozygous for the deletion in the sequencing data are underrepresented in the genotyping data due to an elevated rate of missing data at rs62625034, possibly because the probe for this SNP overlaps with the Δ32 deletion. Another variant which has a higher concordance with the deletion in the sequencing data shows no associations with mortality. A genome-wide scan for effects of variants tagging this deletion shows an overall inflation of association p-values, but identifies only one trait at  $p < 5 \times 10^{-8}$ , and no mediators for an effect on mortality. These analyses show that the original reports of a recessive deleterious effect of CCR5-Δ32 are affected by a technical artifact, and that a closer investigation of the same data provides no positive evidence for an effect on lifespan.

# This is a big problem

# Our real life experiment



- UV light has potential to change the secondary metabolite composition (colour) of bronze/red lettuce
- Experimental setup:
  - 3 lettuce varieties
  - 3 UV filter conditions
  - 3 week duration

# Real data comes with real problems

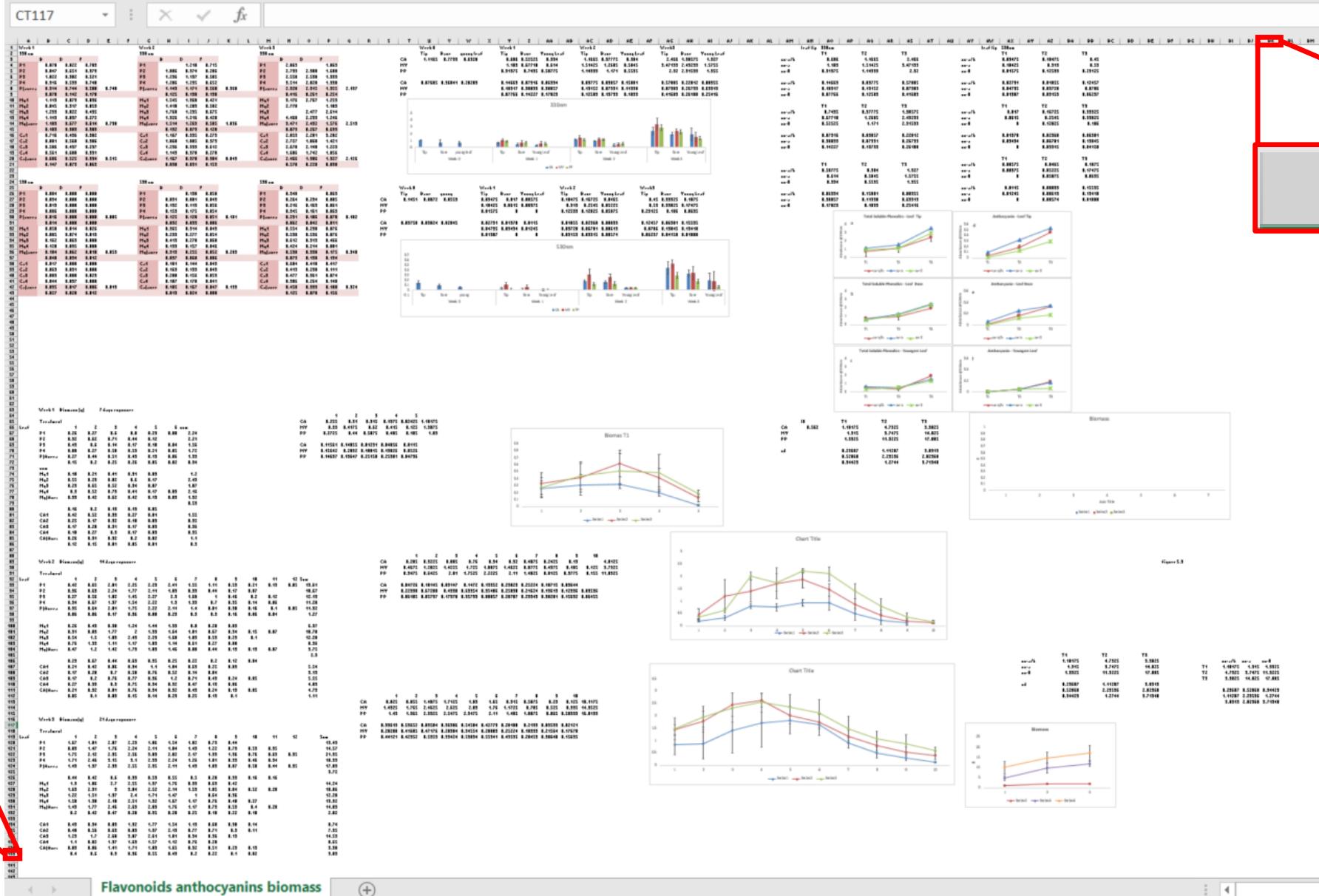
Raw Data wk 1-3 Lettuce Exp 1 - Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Week 1						Week 2						Week 3					
2	330 nm						330 nm						330 nm					
3		B	D	F				B	D	F				B	D	F		
4	P1	0.870	0.822	0.703			P1						1	2.869		1.069		
5	P2	0.847	0.651	0.379			P2						2	2.739	2.380	1.688		
6	P3	1.022	0.902	0.521			P3	1.236	1.197	0.585			P3	2.558	2.538	1.333		
7	P4	0.916	0.599	0.748			P4	1.206	1.295	0.652			P4	3.514	2.028	1.330		
8	P(average)	0.914	0.744	0.588	0.748		P(average)	1.149	1.171	0.560	0.960		P(average)	2.920	2.315	1.355	2.197	
9		0.078	0.142	0.170				0.125	0.138	0.190				0.416	0.261	0.254		
10	My1	1.119	0.873	0.896			My1	1.545	1.360	0.421			My1	3.176	2.767	1.259		
11	My2	0.845	0.917	0.853			My2	1.418	1.203	0.502			My2	2.778		1.183		
12	My3	1.299	0.822	0.435			My3	1.768	1.295	0.675			My3		2.477	2.614		
13	My4	1.149	0.097	0.272			My4	1.326	1.216	0.420			My4	4.460	2.233	1.246		
14	My(average)	1.103	0.677	0.614	0.798		My(average)	1.514	1.269	0.505	1.096		My(average)	3.471	2.492	1.576	2.513	
15		0.189	0.389	0.309				0.192	0.073	0.120				0.879	0.267	0.693		
16	Ca1	0.716	0.496	0.382			Ca1	1.167	0.935	0.273			Ca1	2.853	2.201	3.202		
17	Ca2	0.881	0.568	0.386			Ca2	1.060	1.005	0.373			Ca2	2.727	1.860	1.421		
18	Ca3	0.586	0.437	0.237			Ca3	1.296	0.993	0.612			Ca3	2.678	2.140	1.229		
19	Ca4	0.561	0.600	0.331			Ca4	1.143	0.978	0.278			Ca4	1.606	1.742	1.856		
20	Ca(average)	0.686	0.525	0.334	0.515		Ca(average)	1.167	0.978	0.384	0.843		Ca(average)	2.466	1.986	1.927	2.126	
21		0.147	0.073	0.069				0.098	0.031	0.159				0.578	0.220	0.890		
22																		
23																		
24	530 nm						530 nm						530 nm					
25		B	D	F				B	D	F				B	D	F		
26	P1	0.004	0.000	0.000			P1		0.138	0.050				P1	0.340		0.069	
27	P2	0.034	0.000	0.000			P2		0.091	0.081	0.043			P2	0.264	0.234	0.085	CA
28	P3	0.019	0.000	0.000			P3		0.132	0.119	0.056			P3	0.216	0.163	0.061	MY

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Normal Page Break Preview Custom Layout Views Workbook Views Show

Ruler Formula Bar Gridlines Headings Zoom 100% Zoom to Selection Window New Arrange Freeze All Panes Hide Synchronous Scrolling Reset Window Position Window Switch Windows Macros Macros

**Flavonoids anthocyanins biomass**

**Figure 5.8**

Figure 5.8 displays a Microsoft Excel spreadsheet titled "Flavonoids anthocyanins biomass" containing experimental data for three treatments (T1, T2, T3) across four weeks (Week 1, Week 2, Week 3, Week 4). The data includes biomass measurements and various flavonoid and anthocyanin concentrations.

**Data Summary:**

- Week 1 Biomass:** Biomass values range from 0.00 to 0.10 g/m². Biomass generally increases over time for all treatments.
- Treatment Biomass:** Biomass values for T1, T2, and T3 treatments are consistently higher than the control (C) across all weeks.
- Flavonoids and Anthocyanins:** Concentrations of various flavonoids (e.g., Quercetin, Catechins, Chlorophyll a, Chlorophyll b) and anthocyanins (e.g., Cyanidin, Delphinidin, Pelargonidin) are measured in mg/g. These values also show an upward trend over time.
- Statistical Significance:** P-values are provided for each measurement, indicating statistical significance between treatments and weeks.

**Charts:**

The spreadsheet contains several charts illustrating the data trends:

- Line Charts:** Four line graphs show the total biomass and total flavonoids (mg/m²) for each treatment (T1, T2, T3) over the four weeks.
- Bar Charts:** Three bar charts show the total anthocyanins (mg/m²) for each treatment (T1, T2, T3) over the four weeks.
- Scatter Plots:** Three scatter plots show the relationship between biomass and total flavonoids, total anthocyanins, and total phenolics for each treatment.

# Take small steps to big changes

THE AMERICAN STATISTICIAN  
2018, VOL. 72, NO. 1, 2–10  
<https://doi.org/10.1080/00031305.2017.1375989>



OPEN ACCESS



## Data Organization in Spreadsheets

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### ABSTRACT

Spreadsheets are widely used software tools for data entry, storage, analysis, and visualization. Focusing on the data entry and storage aspects, this article offers practical recommendations for organizing spreadsheet data to reduce errors and ease later analyses. The basic principles are: be consistent, write dates like YYYY-MM-DD, do not leave any cells empty, put just one thing in a cell, organize the data as a single rectangle (with subjects as rows and variables as columns, and with a single header row), create a data dictionary, do not include calculations in the raw data files, do not use font color or highlighting as data, choose good names for things, make backups, use data validation to avoid data entry errors, and save the data in plain text files.

### ARTICLE HISTORY

Received June 2017  
Revised August 2017

### KEYWORDS

Data management; Data organization; Microsoft Excel; Spreadsheets

# Less stress, more success

	A	B	C	D	E	F	G	H	I	J	K	L
1	id	week_no	filter_nam	treatment	replicate_no	flavonoids	biomass	variety	date	investigator		
2	1	0	ptp	nofilter	1	1.061	0.39	cos	2019/04/01	Darren Dahly		
3	2	0	ptp	nofilter	2	1.1805	0.42	cos	2019/04/01	Darren Dahly		
4	3	0	ptp	nofilter	3	1.0345	0.62	cos	2019/04/01	Darren Dahly		
5	4	0	ptp	nofilter	4	1.094	0.63	cos	2019/04/01	Brendan Palmer		
6	1	0	my	nofilter	1	1.061	0.39	cos	2019/04/01	Brendan Palmer		
7	2	0	my	nofilter	2	1.1805	0.42	cos	2019/04/01	Brendan Palmer		
8	3	0	my	nofilter	3	1.0345	0.62	cos	2019/04/01	Brendan Palmer		
9	4	0	my	nofilter	4	1.094	0.63	cos	2019/04/01	Brendan Palmer		
10	1	0	ca	nofilter	1	1.061	0.39	cos	2019/04/01	Brendan Palmer		
11	2	0	ca	nofilter	2	1.1805	0.42	cos	2019/04/01	Brendan Palmer		
12	3	0	ca	nofilter	3	1.0345	0.62	cos	2019/04/01	Brendan Palmer		
13	4	0	ca	nofilter	4	1.094	0.63	cos	2019/04/01	Darren Dahly		
14	5	1	ptp	filter	1	0.87	0.76	cos	2019/04/08	Darren Dahly		
15	6	1	ptp	filter	2	0.847	0.95	cos	2019/04/08	Darren Dahly		
16	7	1	ptp	filter	3	1.022	0.95	cos	2019/04/08	Darren Dahly		
17	8	1	ptp	filter	4	0.916	0.95	cos	2019/04/08	Darren Dahly		
18	9	1	my	filter	1	1.119	1.55	cos	2019/04/08	Darren Dahly		
19	10	1	my	filter	2	0.845	3.16	cos	2019/04/08	Darren Dahly		
20	11	1	my	filter	3	1.299	4.9	cos	2019/04/08	Brendan Palmer		
21	12	1	my	filter	4	1.149	5.5	cos	2019/04/08	Brendan Palmer		
22	13	1	ca	filter	1	0.716	5.5	cos	2019/04/08	Brendan Palmer		
23	14	1	ca	filter	2	0.881	7.94	cos	2019/04/08	Brendan Palmer		
24	15	1	ca	filter	3	0.586	8.71	cos	2019/04/08	Brendan Palmer		
25	16	1	ca	filter	4	0.561	8.71	cos	2019/04/08	Brendan Palmer		
26	17	2	ptp	filter	1	0	14.45	cos	2019/04/15	Brendan Palmer		
27	18	2	ptp	filter	2	1.006	2.14	cos	2019/04/15	Brendan Palmer		
28	19	2	ptp	filter	3	1.236	1.86	cos	2019/04/15	Brendan Palmer		
29	20	2	ptp	filter	4	1.206	1.2	cos	2019/04/15	Brendan Palmer		
30	21	2	mv	filter	1	1.545	2.45	cos	2019/04/15	Brendan Palmer		

data

dictionary

values



# Less stress, more success

# Less stress, more success

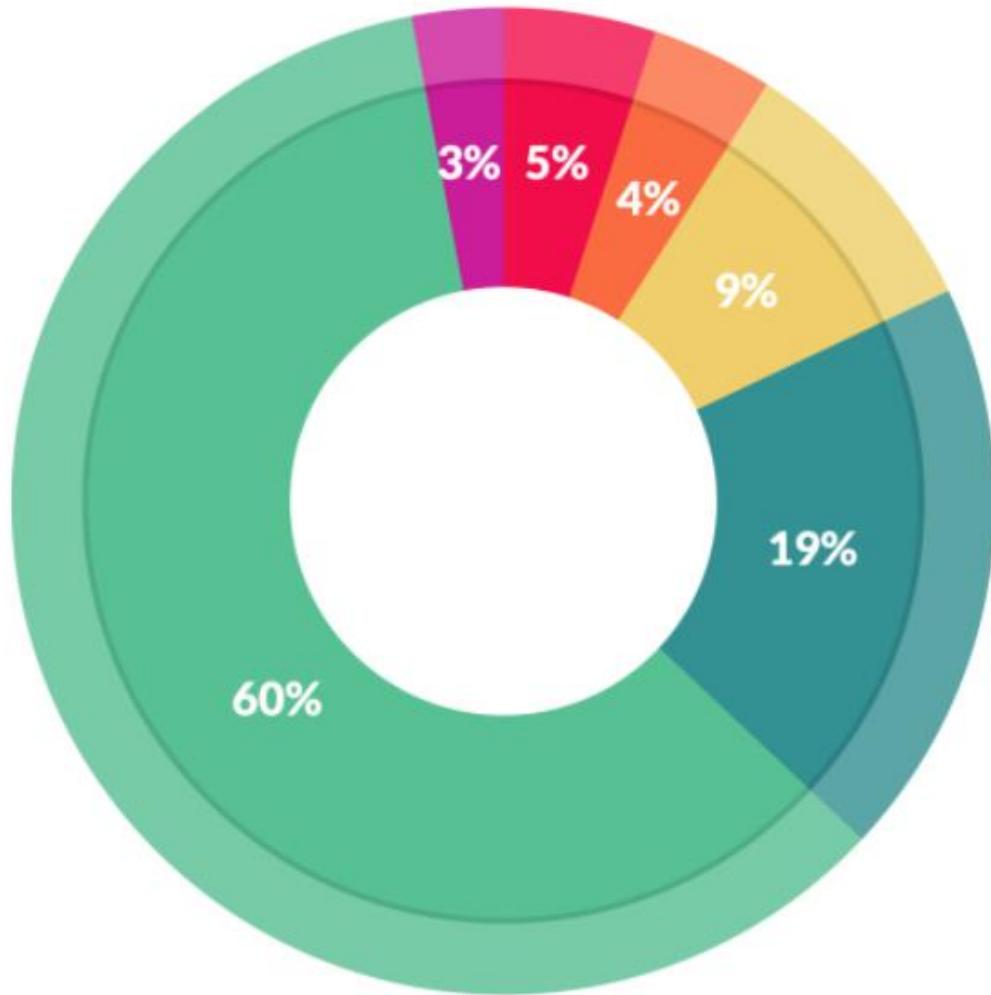
1	A	B	C	D	E	F	G	H	I	J	K	L
2	1	0	ptp	nofilter	1	1.061	0.39	cos	2019/04/01	Darren Dahly		
3	2	0	ptp	A	B	C	D	E				
4	3	0	ptp	1	field_name	data_type	data_format	example	standard_units	description		
5	4	0	ptp	2	id	numeric	integer	23	NA	Unique identifier applied to each observation		
6	1	0	my	3	week_no	numeric	integer					
7	2	0	my	4	filter_name	character	NA					
8	3	0	my	5	treatment	character	NA					
9	4	0	my	6	replicate_no	numeric	integer					
10	1	0	ca	7	flavonoids	numeric	double					
11	2	0	ca	8	biomass	numeric	double					
12	3	0	ca	9	variety	character	NA					
13	4	0	ca	10	date	date	YYYY/MM/DD					
14	5	1	ptp	11	investigator	character	Firstname Lastname					
15	6	1	ptp	12								
16	7	1	ptp	13								
17	8	1	ptp	14								
18	9	1	my	15								
19	10	1	my	16								
20	11	1	my	17								
21	12	1	my	18								
22	13	1	ca	19								
23	14	1	ca	20								
24	15	1	ca	21								
25	16	1	ca	22								
26	17	2	ptp	23								
27	18	2	ptp	24								
28	19	2	ptp	25								
29	20	2	ptp	26								
30	21	2	mv	27								
		data	dictionary	28								
				29								
				30								

The screenshot shows a data entry interface with two tabs: 'data' and 'dictionary'. The 'data' tab displays a grid of experimental data. The 'dictionary' tab provides a detailed schema for each column, including field\_name, data\_type, data\_format, example, standard\_units, and description. A tooltip for 'id' indicates it is a unique identifier applied to each observation.

Below the tabs, there are navigation buttons for the data grid: back, forward, data, dictionary, values, and a plus sign.

# Less stress, more success

# Resources are being wasted by not doing this



What data scientists spend the most time doing

- *Building training sets: 3%*
- *Cleaning and organizing data: 60%*
- *Collecting data sets; 19%*
- *Mining data for patterns: 9%*
- *Refining algorithms: 4%*
- *Other: 5%*

# Putting the pieces together

A: Define a project structure

B: Set a naming convention

C: Use scripted workflows

D: Digital notebooks

E: Version control

F: Data packaging

Reproducible  
research

# Still haven't found what I'm looking for

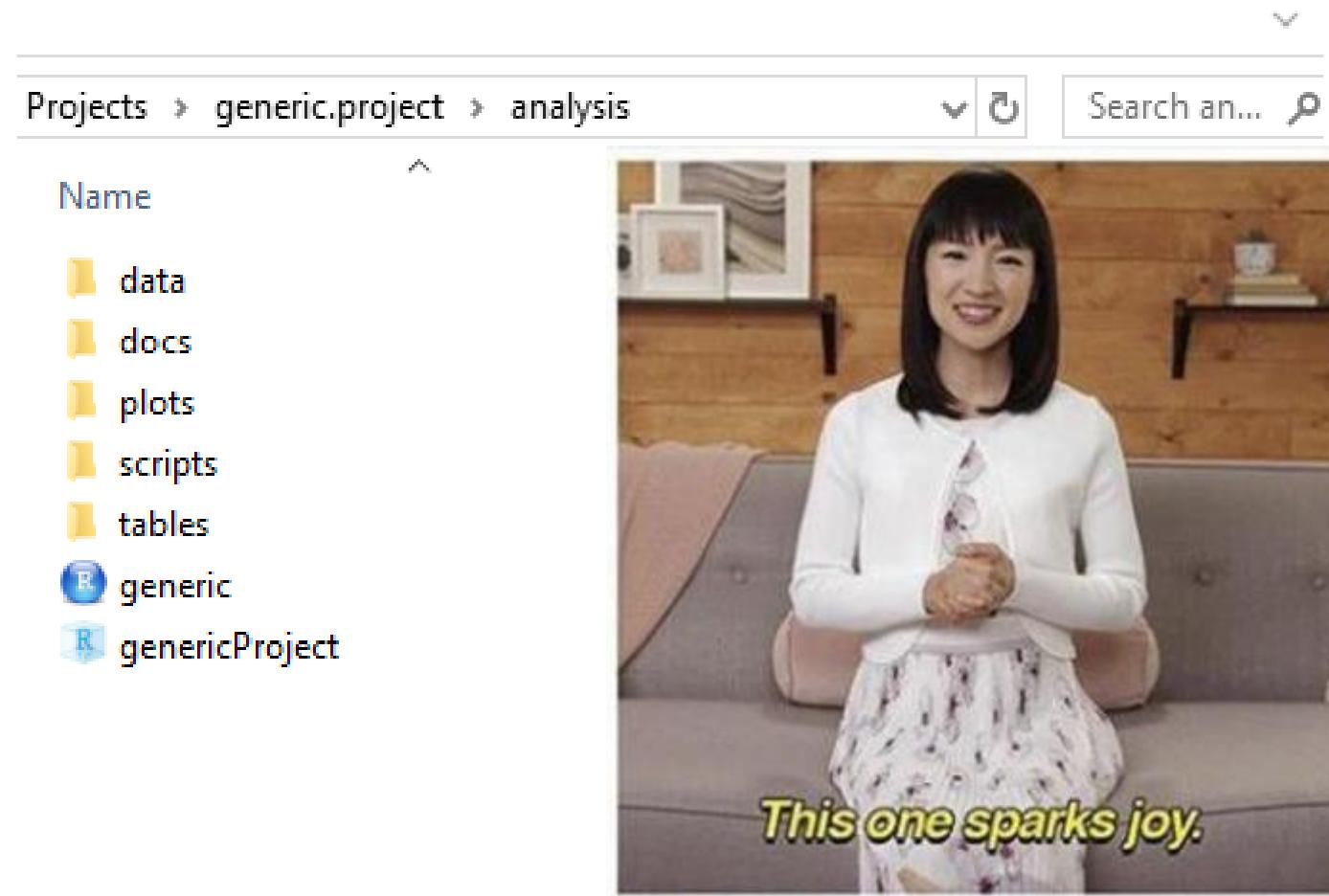
- Help your future-self

B\_Palmer\_Medicine\_Files > 4a Project > Pyrosequencing\_analysis > Pyrosequencing\_Paper > Draft\_Paper\_incl\_Figs > Submission > JVI\_Resubmission > JVI\_resubmission\_files > Final Final version

Name	Date modified
Cover_letter_B_A_Palmer_Sept_2014	10/09/2014 17:05
Fig_1_Sept_14	11/09/2014 10:31
Fig_1_Sept_14	10/09/2014 23:07
Fig_2_Sept_14	11/09/2014 10:31
Fig_2_Sept_14	10/09/2014 23:07
Fig_3_Sept_14	11/09/2014 10:31
Fig_3_Sept_14	10/09/2014 23:07
Fig_4_Sept_14	11/09/2014 10:31
Fig_4_Sept_14	10/09/2014 23:07
Fig_5_Sept_14	11/09/2014 10:33
Fig_5_Sept_14	10/09/2014 23:07
HCV_UDPS_B_A_Palmer_Sept_14	17/09/2014 12:21
Response_to_Reviewer_Sept_14	10/09/2014 22:42
Supplementary_Figure_B_A_Palmer_Sept_14	29/08/2014 13:21
Supplementary_Figure_B_A_Palmer_Sept_14	10/09/2014 22:31
Tables_B_A_Palmer_Sept_2014	10/09/2014 22:09



# A: Define a generic project structure



# B: Give your files and folders informative names

This PC > Documents > Projects > **2016-08-08\_RespPCT** > analysis > data

Name	Date modified
raw_data	21/01/2019 21:06
2018-11-06_abx	06/11/2018 13:10
2018-11-06_monitoring	06/11/2018 13:09
2018-11-06_pct	06/11/2018 13:08
2018-11-06_pt_info	06/11/2018 13:07

# Everything in its right place

- Make your file names:
  1. Machine readable
  2. Human readable
  3. Work with default ordering

**NO**

Name
All unique 4a amino acid Sequences (B-N).fas
All unique 4a amino acid Sequences (B-N).meg
All_AA_haplotypes.meg
All_AA_haplotypes_with_clonal_sequences.meg
BS100_AA_with_clones
BS100_AA_with_clones.nwk
BS1000_AA_pyro&clones
BS1000_AA_pyro&clones.nwk
BS1000_AA_pyro_only
BS1000_AA_pyro_only.nwk
BS1000_Uncle_Clonal_AA

**Yes**

Projects > 2016-08-08\_RespPCT > analysis > scripts

Name
R 01_clean_data
R 02_plots
R 03_tables
R 04_stats_analysis
R 05_post_hoc_stats
R functions
R randomization
R tables

# C: Joined up thinking

- The R scripts should also be human readable
  - Annotate the code
  - Break up the scripts into dedicated tasks
  - Interlink to other project scripts

```
1 # Data ----
2 # Eight tibbles returned from the 01_data_import_and_tidying_master_file.R
3 # 1. fgf23_data => FGF23 readings from study centres 01-03
4 # 2. food_level_data => Food diary entries
5 # 3. grouped_data => Dialysis and nondialysis diary entries by component
6 # 4. k_data => Serum potassium
7 # 5. master_data_clean => all the clean master file data if required
8 # 6. p_data => Serum phosphate
9 # 7. pth_data => Parathyroid hormone readings
10 # 8. pulses_nuts_data
11
12 source("scripts/01_data_import_and_tidying_master_file.R")
```

# Work from the raw data ALWAYS!!



**Tom Webb** @tomjwebb · 16 Jan 2015

If you could tell a new PhD student one thing to help make their data more useful/shareable, what would it be?

27

11

7



**Dr Gavin Simpson**

@ucfagls

Follow

Replying to @tomjwebb

@tomjwebb don't, not even with a barge pole, not for one second, touch or otherwise edit the raw data files. Do any manipulations in script

7:15 AM - 16 Jan 2015

# D: R Markdown

- R Markdown combines the code you wrote, the output produced and your own comments
- It can be viewed as an electronic laboratory notebook (ELN)
- You can view it as a digital lab notebook, where you are both recording what you're doing, and what you were thinking while you were doing it!
- R Markdown outputs can take many forms
  - Word documents, PDFs, slideshows etc.

# D: R Markdown

R ~/Open\_Science/Digital\_Badge/RCR - master - RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

lettuce\_report.Rmd\* Go to file/function Addins

```
1 ---  
2 title: "This is a reproducible document"  
3 author: "Dr. Brendan Palmer"  
4 date: "18th June 2019"  
5 output:  
6   word_document:  
7     fig_height: 4  
8     fig_width: 6  
9 ---  
10 # This is the beginning of the project  
11  
12 our initial reports might be restricted to lab meetings etc. We can use `R  
13 Markdown` to show the code we are using, so that the meetings are not just a  
14 demonstration of the results, but also an examination of the `code` used to obtain  
15 them.  
16  
17 knitr::opts_chunk$set(echo = FALSE, message = FALSE, warning = FALSE)  
18  
19 # Load your packages here  
20 library(tidyverse)  
21 library(knitr)  
22  
23  
24 The plot below is call from the ggplot object entitled `report_plot` created in  
25 the script `03_final_analysis.R`.  
26  
27 {r Plots from script, echo = FALSE}  
28 source("scripts/03_final_analysis.R")  
29  
30 # The location of the Rmd file dictates whether the path to other files is intact
```

## This is a reproducible document

Dr. Brendan Palmer

18th June 2019

### This is the beginning of the project

Our initial reports might be restricted to lab meetings etc. We can use R Markdown to show the code we are using, so that the meetings are not just a demonstration of the results, but also an examination of the code used to obtain them.

### Data overview

The plot below is call from the ggplot object entitled report\_plot created in the script 03\_final\_analysis.R.

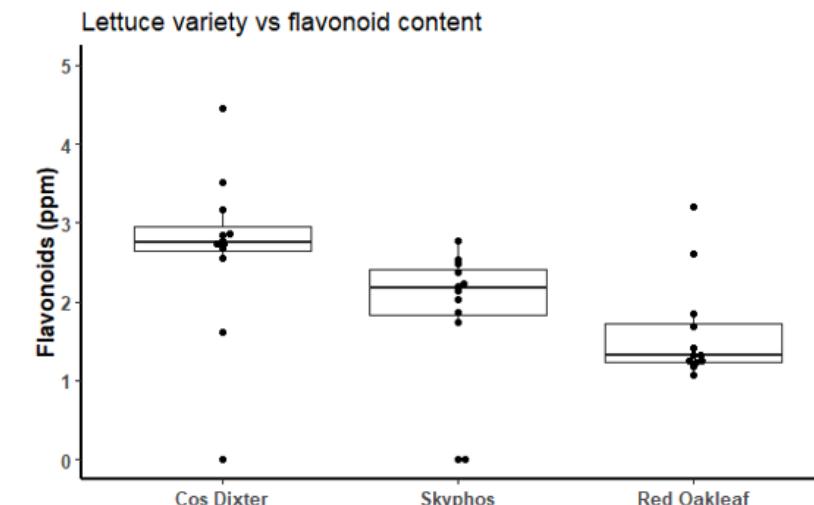
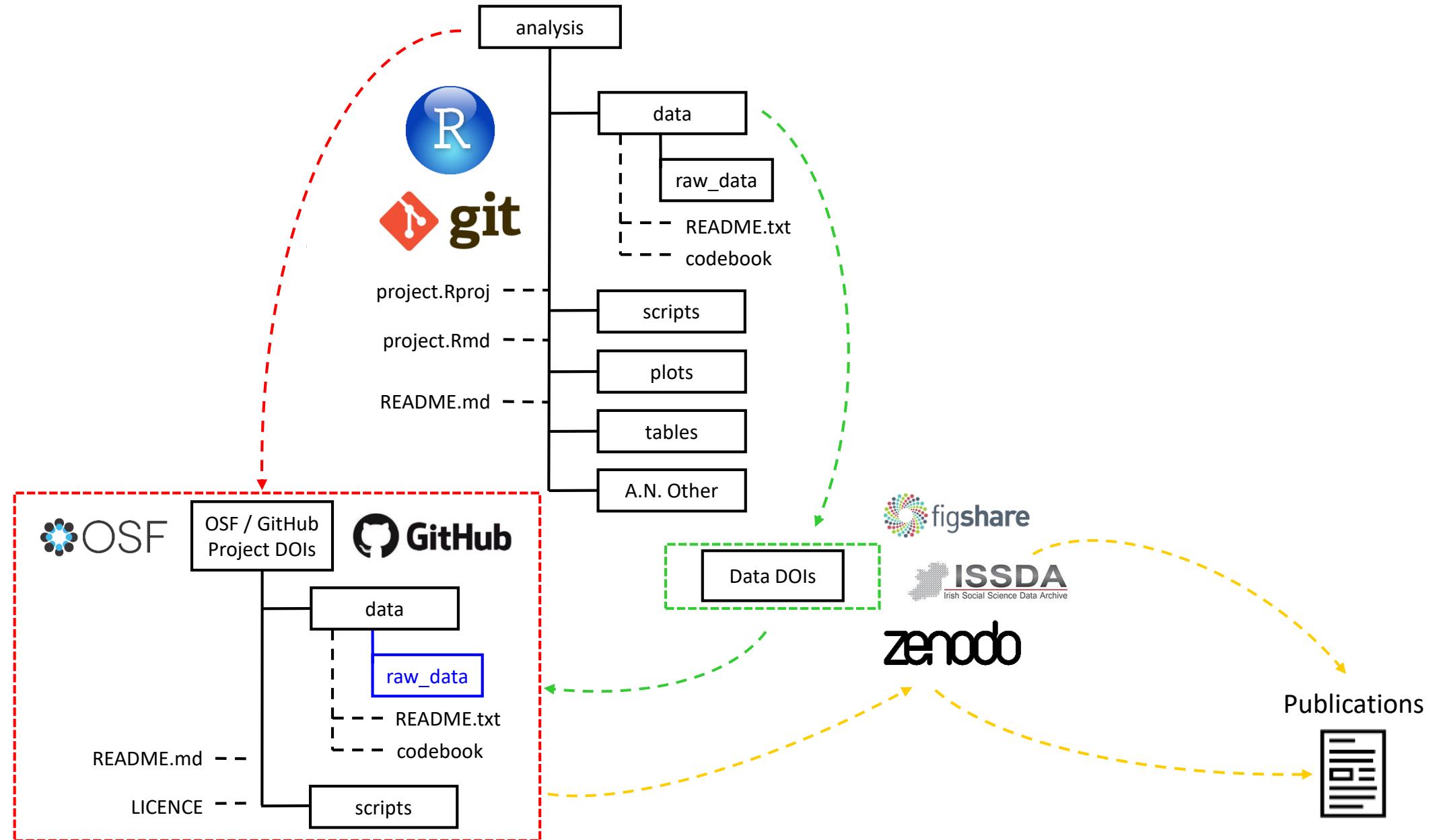


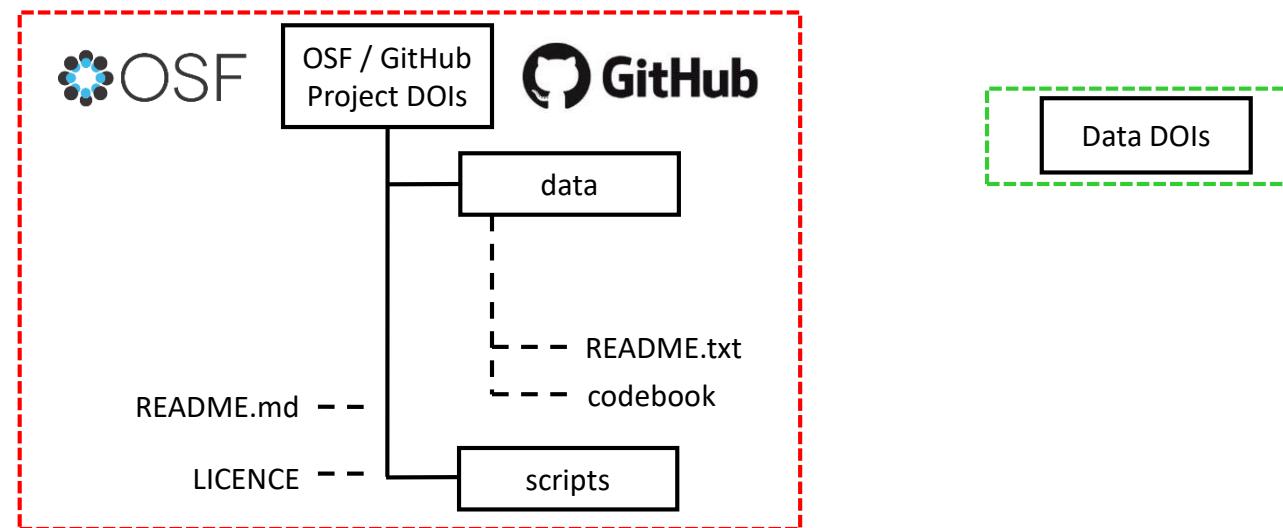
Fig. 1. Flavonoid content of three lettuce varieties under three experimental conditions.

Or we can also recreate the code within the R Markdown document as seen below.

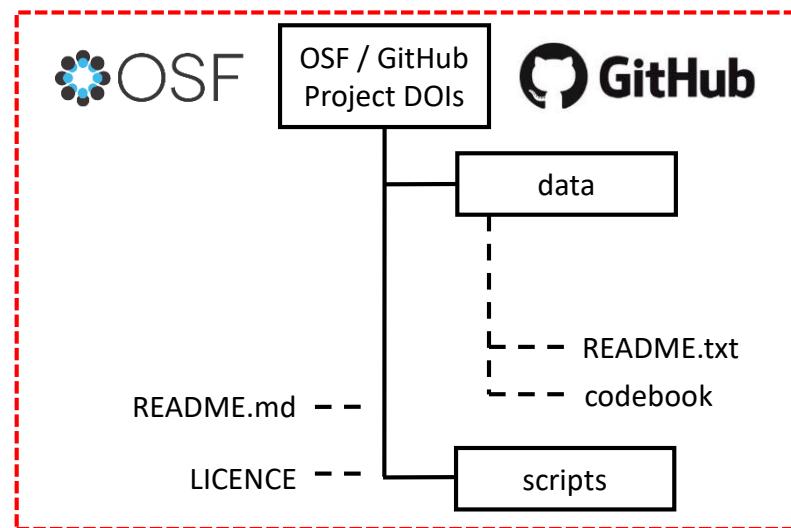
# What does this allow us to do?



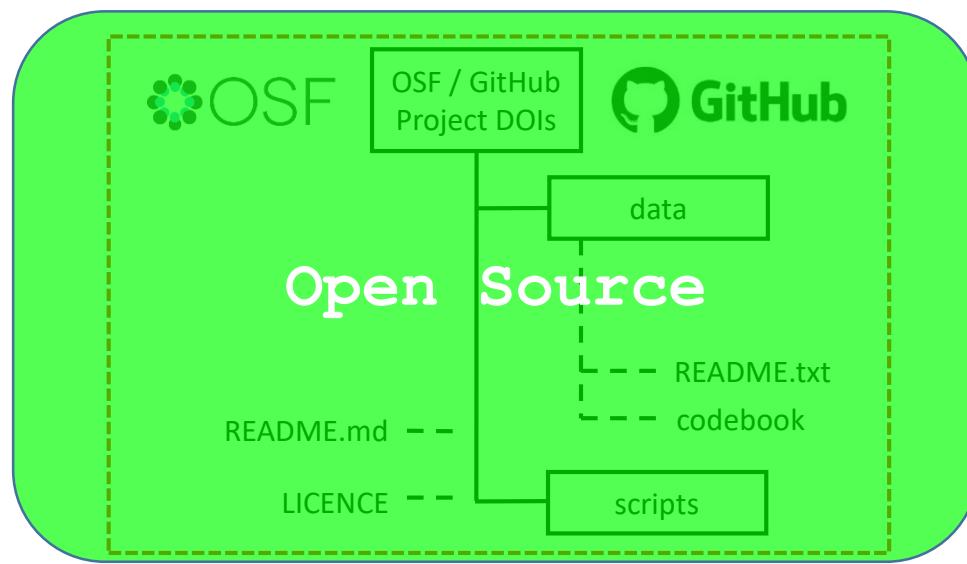
# What does this allow us to do?



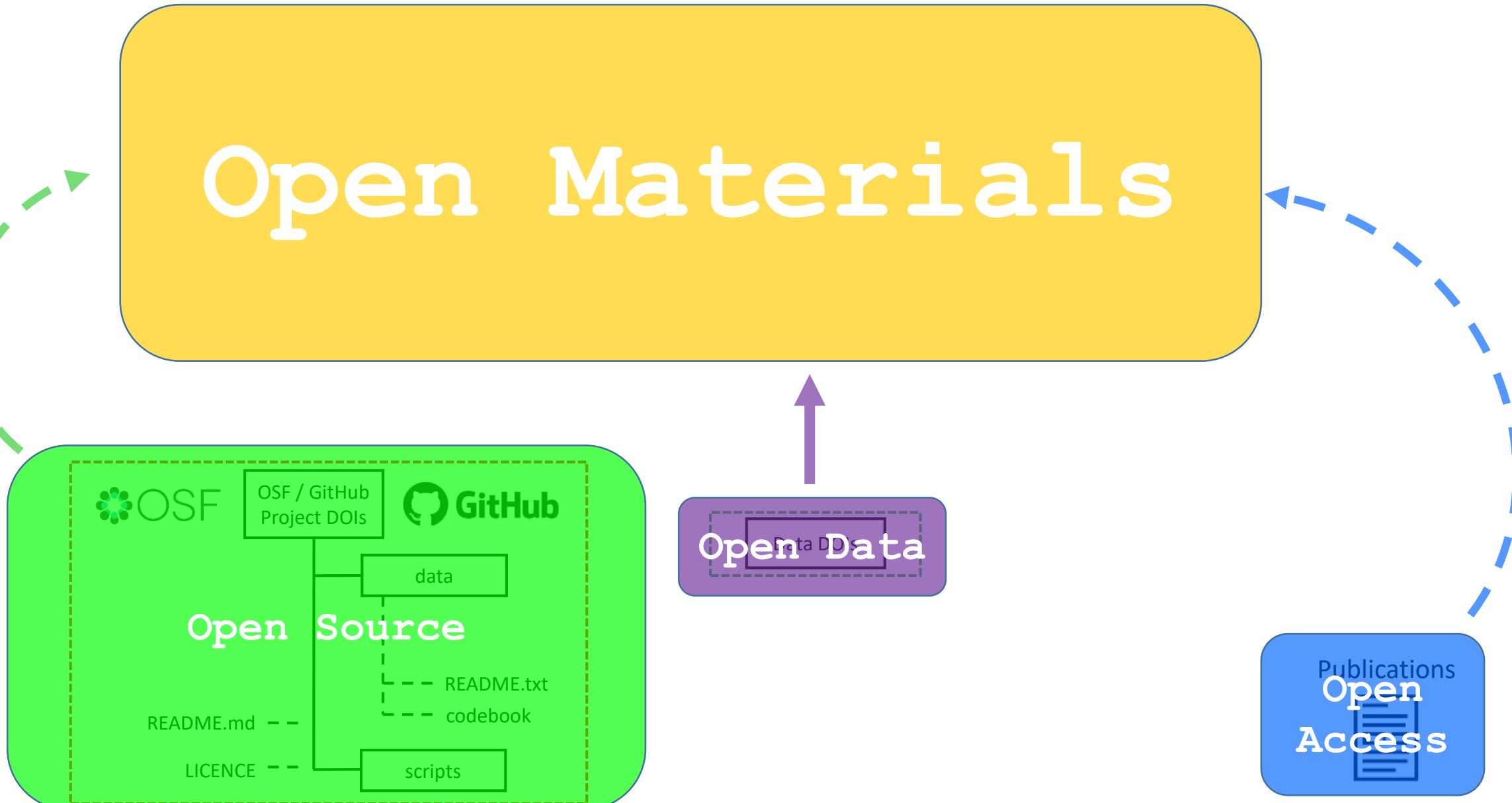
# What does this allow us to do?



# What does this allow us to do?



# What does this allow us to do?



# The butterfly has started flapping its wings



Why Plan S **10 Principles** Funders & support Implementation About Contact

"After 1 January 2020 scientific publications on the results from research funded by public grants provided by national and European research councils and funding bodies, must be published in compliant Open Access Journals or on compliant Open Access Platforms."



EUROPEAN COMMISSION  
Directorate-General for Research & Innovation  
H2020 Programme

Guidelines on  
FAIR Data Management in Horizon 2020



f) Data Management Plan – 2 pages max.

- Applicants should address the following issues:

- What standards will be applied?
- How will data be exploited and/or shared/made accessible for verification and reuse? If data cannot be made available, why?
- How data will be curated & preserved?
- If applicable, how does the applicant plan to make the research data FAIR (findable, accessible, interoperable and reusable).

**HRB Health Research Board**

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## Open Research

The HRB is committed to ensuring that its funded research is open, accessible and usable, so it can have the greatest possible impact.

There is a fundamental shift across Europe towards making research more transparent, collaborative, accessible and efficient. This Open Science movement is a strategic priority for the European Commission in research and innovation policy and an EU high-level Expert Group, the [Open Science Policy Platform](#) (OSPP 2016–2018) has been established to consider key implementation areas.

Funding Engagement Events Research News SFI Research Centres

Science Foundation Ireland joins DORA

14th February 2019, Dublin – Science Foundation Ireland has become a signatory to the San Francisco Declaration of Research Assessment (DORA), making a formal commitment to assessing the quality and impact of research through means other than journal impact factors.

# Install the Chrome plugin PubPeer

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J Surg Res. 2019 Apr 26;241:235-239. doi: 10.1016/j.jss.2019.03.062. [Epub ahead of print]

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**Is the Power Threshold of 0.8 Applicable to Surgical Science?-Empowering the Underpowered Study.**

Bababekov YJ<sup>1</sup>, Hung YC<sup>2</sup>, Hsu YT<sup>2</sup>, Udelsman BV<sup>2</sup>, Mueller JL<sup>2</sup>, Lin HY<sup>2</sup>, Stapleton SM<sup>2</sup>, Chang DC<sup>2</sup>.

Author information

Abstract

**BACKGROUND:** Many articles in the surgical literature were faulted for committing type 2 error, or concluding no difference when the study was "underpowered". However, it is unknown if the current power standard of 0.8 is reasonable in surgical science.

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Review Low-Dose Aspirin for the Prevention of Morbidity anc Agency for Healthcare Research...]

# Further reading



Sam Westwood

@westwoodsam1

Following



I am embarking on my own  
[#PaperPerDayChallenge](#) where I read at least one paper, well, per day for a whole year. To kick start,  
[nature.com/articles/43573...](http://nature.com/articles/43573...) inspired by  
[@ukrepro](#) Reproducibility Workshop  
[@CumberlandLodge](#) and a talk by  
[@MarcusMunafo](#)



## Scientists behaving badly

In a questionnaire-based survey of US biomedical researchers, respondents admitted to a range of dubious practices. Transgressions included failing to present data  
[nature.com](http://nature.com)

# Twitter



**UK Reproducibility Network**

@ukrepro

UK Reproducibility Network: a peer-led consortium to investigate factors which contribute to robust research, provide training, and disseminate best practice.



**Malcolm Macleod #FBPE**

@Macломaclee Follows you

clinical neurologist, stroke trialist, and interested in improving the quality of laboratory research



**Open Science MOOC**

@OpenScienceMOOC Follows you

A community designed for students and researchers to help make 'Open' the default setting for the future of research. Slack: [osmooc.herokuapp.com](https://osmooc.herokuapp.com)

⌚ Everywhere



**Brian Nosek**

@BrianNosek

Executive Director @ Center for Open Science, Professor @ University of Virginia, and co-Founder of Project Implicit



**Kate Button**

@ButtonKate Follows you

Academic. Psychologist. Cognitive mechanisms of depression & anxiety. Meta-science & scientific rigour. Sporadic Twitterer.



**Darren L Dahly**

@statsep1 Follows you

Principal Statistician, Epidemiologist, Sr Lecturer | @HRBIreland Clinical Research Facility @CRF\_CORK | Cork #Rstats Users Group [meetup.com/Cork-Ireland-R...](https://meetup.com/Cork-Ireland-R-/)



**Dorothy Bishop**

@deevybee

Professor of developmental neuropsychology. Blog on [deevybee.blogspot.com](http://deevybee.blogspot.com) Main focus #devlangdis, see: [youtube.com/radld](https://youtube.com/radld)



**Elisabeth Bik**

@MicrobiomDigest

Science consultant, PhD. Harbers-Bik LLC. Microbiome, research integrity & misconduct. Ex @Stanford. MicrobiomeDigest/Bik's Picks. Dutch/USA. My views.



**Retraction Watch**

@RetractionWatch

Tracking retractions as a window into the scientific process. Sign up for our daily newsletter: [eepurl.com/bNR1Un](http://eepurl.com/bNR1Un) Tips? team@retractionwatch.com



**Jenny Bryan**

@JennyBryan

Software engineer @rstudio, humane #rstats, adjunct prof @UBC where I created @STAT545, part of @ropensci