

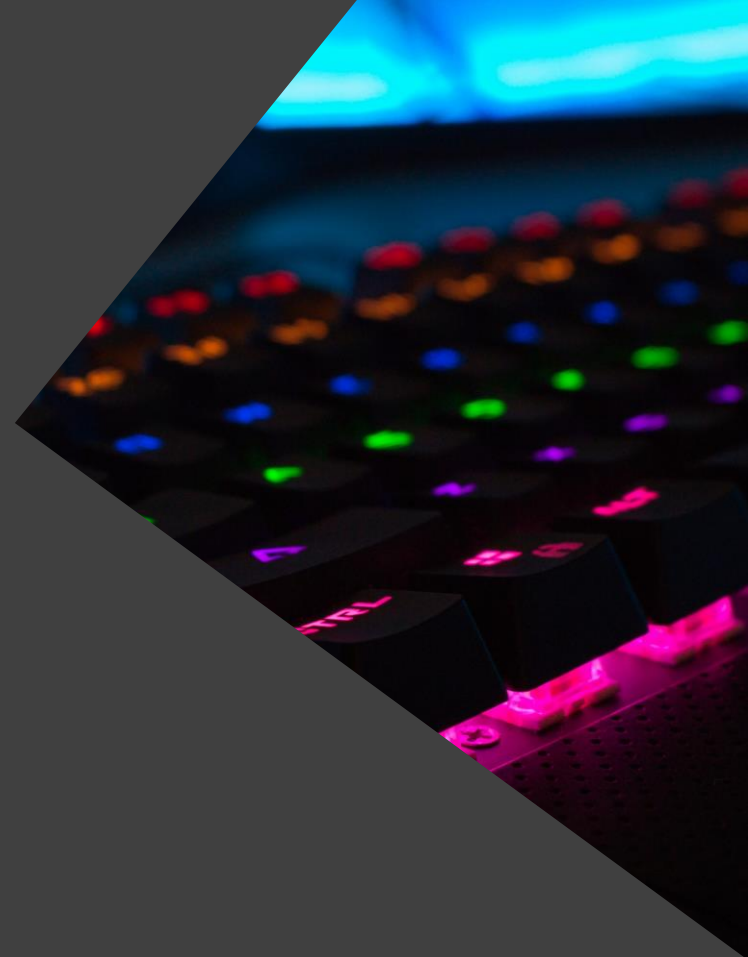
**The
Alan Turing
Institute**

The Turing Way
**A how to guide for
reproducible research**

Kirstie Whitaker

#MQDataScience #TuringWay @kirstie_j

Slides available, CC-BY, at <https://doi.org/10.5281/zenodo.3402510>



The Turing Way is:

- a book
- a community
- a global collaboration
- a whole tonne of work



Rachael Ainsworth



Becky Arnold



Louise Bowler



Sarah Gibson



Patricia Herterich



James Hetherington



Rosie Higman



Anna Krystalli



Catherine Lawrence



Alex Morley



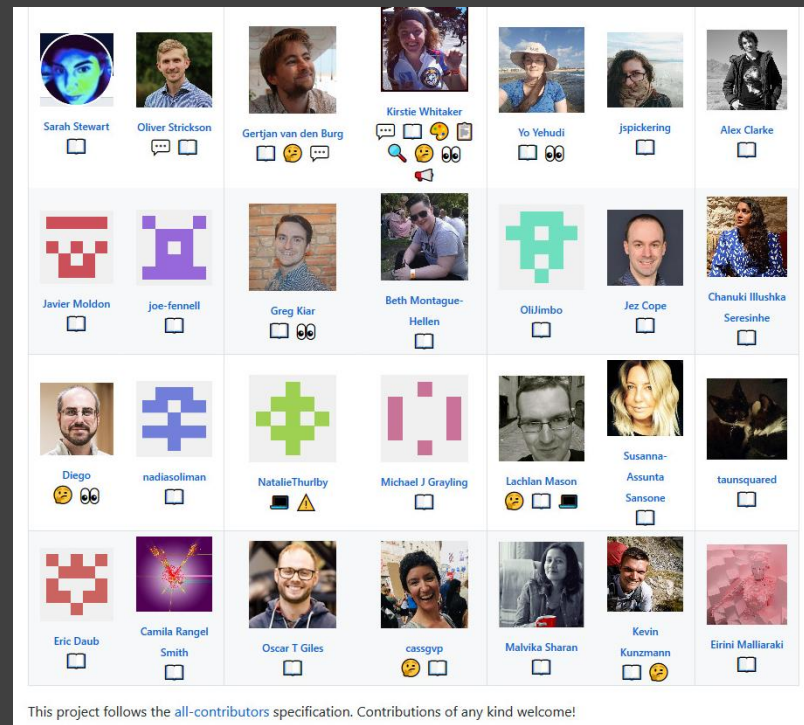
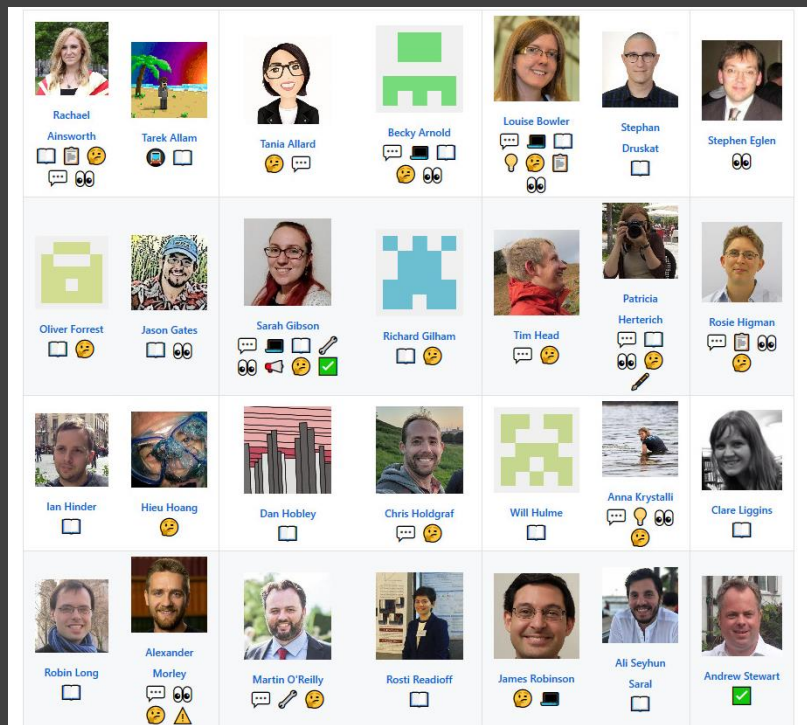
Martin O'Reilly



Binder Team

#MQDataScience #TuringWay @kirstie_j
<https://doi.org/10.5281/zenodo.3402510>

Thank you to all our contributors



This project follows the [all-contributors](#) specification. Contributions of any kind welcome!

<https://github.com/alan-turing-institute/the-turing-way#contributors>
<https://allcontributors.org/docs/en/emoji-key>

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<https://doi.org/10.5281/zenodo.3402510>



Picture credit: Chris Gorgolewski
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Academic errors have real world effects

	B	C	I	J	K	L	M
2			Real GDP growth				
3			Debt/GDP				
4	Country	Coverage	30 or less	30 to 60	60 to 90	90 or above	30 or less
26			3.7	3.0	3.5	1.7	5.5
27	Minimum		1.6	0.3	1.3	-1.8	0.8
28	Maximum		5.4	4.9	10.2	3.6	13.3
29							
30	US	1946-2009	n.a.	3.4	3.3	-2.0	n.a.
31	UK	1946-2009	n.a.	2.4	2.5	2.4	n.a.
32	Sweden	1946-2009	3.6	2.9	2.7	n.a.	6.3
33	Spain	1946-2009	1.5	3.4	4.2	n.a.	9.9
34	Portugal	1952-2009	4.8	2.5	0.3	n.a.	7.9
35	New Zealand	1948-2009	2.5	2.9	3.9	-7.9	2.6
36	Netherlands	1956-2009	4.1	2.7	1.1	n.a.	6.4
37	Norway	1947-2009	3.4	5.1	n.a.	n.a.	5.4
38	Japan	1946-2009	7.0	4.0	1.0	0.7	7.0
39	Italy	1951-2009	5.4	2.1	1.8	1.0	5.6
40	Ireland	1948-2009	4.4	4.5	4.0	2.4	2.9
41	Greece	1970-2009	4.0	0.3	2.7	2.9	13.3
42	Germany	1946-2009	3.9	0.9	n.a.	n.a.	3.2
43	France	1949-2009	4.9	2.7	3.0	n.a.	5.2
44	Finland	1946-2009	3.8	2.4	5.5	n.a.	7.0
45	Denmark	1950-2009	3.5	1.7	2.4	n.a.	5.6
46	Canada	1951-2009	1.9	3.6	4.1	n.a.	2.2
47	Belgium	1947-2009	n.a.	4.2	3.1	2.6	n.a.
48	Austria	1948-2009	5.2	3.3	-3.8	n.a.	5.7
49	Australia	1951-2009	3.2	4.9	4.0	n.a.	5.9
50							
51			4.1	2.8	2.8	=AVERAGE(L30:L44)	

<https://statmodeling.stat.columbia.edu/2013/04/16/memo-to-reinhart-and-rogo-off-i-think-its-best-to-admit-your-errors-and-go-on-from-there>
<https://www.bbc.co.uk/news/magazine-22223190>

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Magazine

Reinhart, Rogoff... and Herndon: The student who caught out the profs

By Ruth Alexander
BBC News

© 20 April 2013

f t Share

This week, economists have been astonished to find that a famous academic paper often used to make the case for austerity cuts contains major errors. Another surprise is that the mistakes, by two eminent Harvard professors, were spotted by a student doing his homework.



It's 4 January 2010, the Marriott Hotel in Atlanta. At the annual meeting of the American Economic Association, Professor Carmen Reinhart and the former chief economist of the International Monetary Fund, Ken Rogoff, are presenting a research paper called Growth in a Time of Debt.

<https://statmodeling.stat.columbia.edu/2013/04/16/memo-to-reinhart-and-rogoff-i-think-its-best-to-admit-your-errors-and-go-on-from-there>
<https://www.bbc.co.uk/news/magazine-22223190>

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Explicitly replicating research is really hard

eLIFE ABOUT COMMUNITY SUBMIT MY RESEARCH LOG IN/REGISTER

HOME MAGAZINE INNOVATION

CURATED BY Roger Davis et al.

Reproducibility Project: Cancer Biology

Investigating reproducibility in preclinical cancer research.

COLLECTION Dec 10, 2014

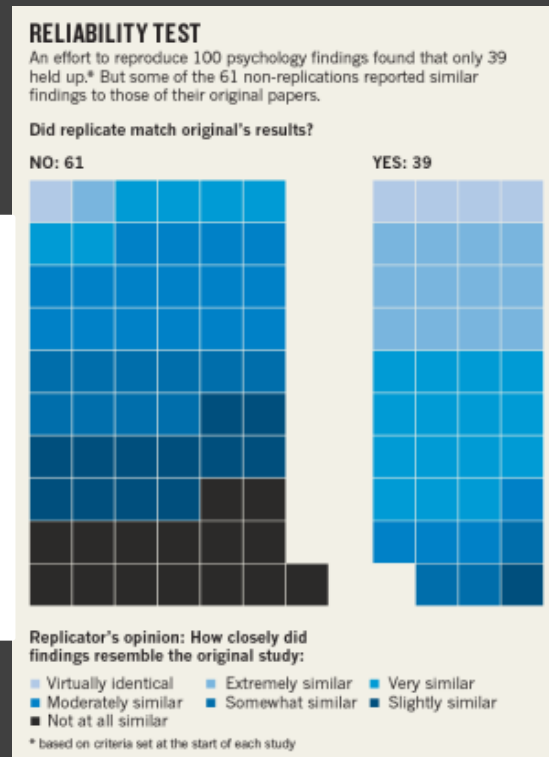
VIEWES 23,286

The Reproducibility Project: Cancer Biology is an initiative to independently replicate selected results from a number of high-profile papers in the field of cancer biology. For each paper a Registered Report detailing the proposed experimental designs and protocols for the replications is peer reviewed and published prior to data collection; the results of these experiments are then published as a Replication Study. The project is a collaboration between the Center for Open Science and Science Exchange.

The aim of the project is two-fold: to provide evidence about reproducibility in preclinical cancer research, and to identify the factors that influence reproducibility more generally. Interpreting the results reported in the Replication Studies requires a nuanced approach, as

DAVIDE BONAZZI

Plan to replicate 50 high-impact cancer papers
shrinks to just 18



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<https://doi.org/10.5281/zenodo.3402510>

<https://elifesciences.org/collections/9b1e83d1/reproducibility-project-cancer-biology>
<https://www.sciencemag.org/news/2018/07/plan-replicate-50-high-impact-cancer-papers-shrinks-just-18>
<https://www.nature.com/news/over-half-of-psychology-studies-fail-reproducibility-test-1.18248>

Fraud is not our
biggest problem



		Data	
		Same	Different
Analysis	Same	Reproducible	Replicable
	Different	Robust	Generalisable

<https://the-turing-way.netlify.com/reproducibility/03/definitions.html>

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<https://doi.org/10.5281/zenodo.3402510>

Is not considered
for promotion

Held to higher
standards than
others

Publication bias
towards novel
findings

Barriers to reproducible research

Requires
additional
skills

Plead the 5th

Support additional
users

Takes time

<https://doi.org/10.6084/m9.figshare.5537101>
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<https://doi.org/10.5281/zenodo.3402510>

The Turing Way



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<https://doi.org/10.5281/zenodo.3402510>

1. Introduction

2. Reproducibility

3. Open Research

4. Version Control

5. Collaborating on GitHub/GitLab

6. Research Data Management

7. Reproducible Environments

8. Testing

9. Reviewing

10. Continuous Integration

11. Reproducible Research with Make

12. Risk Assessment

Welcome to the Turing Way

The Turing Way is a lightly opinionated guide to reproducible data science.

Our goal is to provide all the information that researchers need at the start of their projects to ensure that they are easy to reproduce at the end.

This also means making sure PhD students, postdocs, PIs and funding teams know which parts of the “responsibility of reproducibility” they can affect, and what they should do to nudge data science to being more efficient, effective and understandable.

A bit more background

Reproducible research is necessary to ensure that scientific work can be trusted. Funders and publishers are beginning to require that publications include access to the underlying data and the analysis code. The goal is to ensure that all results can be independently verified and built upon in future work. This is sometimes easier said than done. Sharing these research outputs means understanding data management, library sciences, software development, and continuous integration techniques: skills that are not widely taught or expected of academic researchers and data scientists.

The Turing Way is a handbook to support students, their supervisors, funders and journal editors

<https://the-turing-way.netlify.com/introduction/introduction>

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FAIR....but not open



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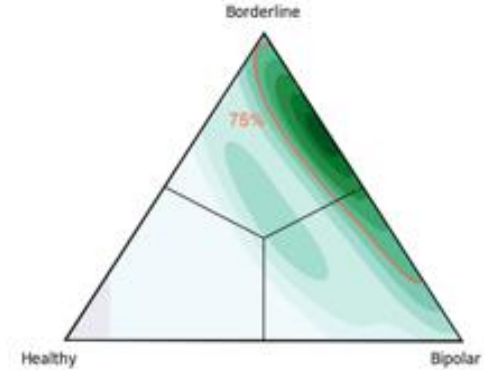
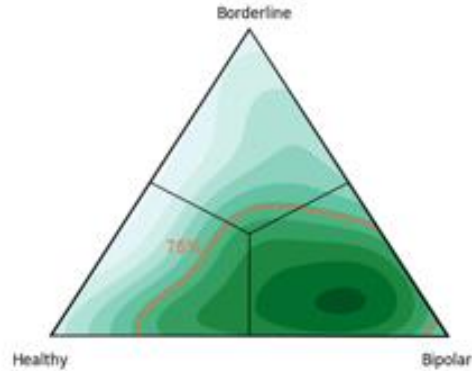
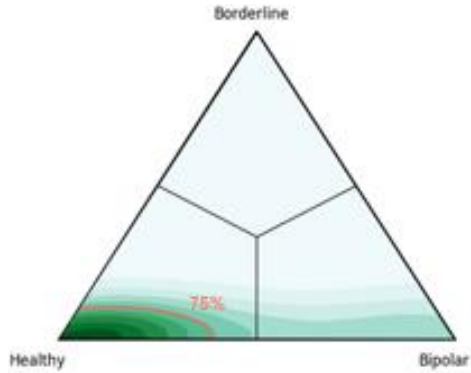
Champion: Terry Lyons



A signature-based machine learning model for bipolar disorder and borderline personality disorder

Imanol Perez Arribas, Guy Goodwin, John Geddes, Terry Lyons, Kate Saunders





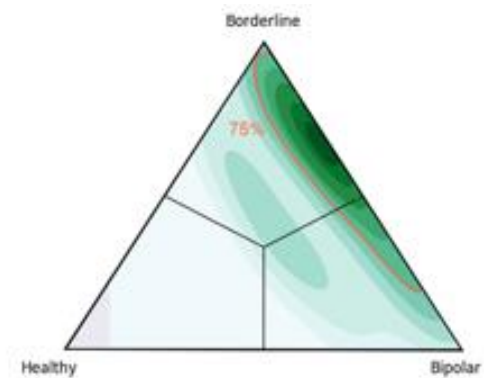
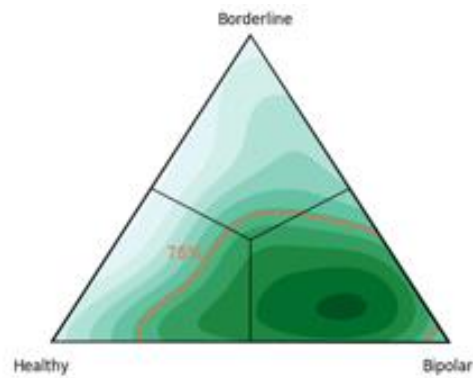
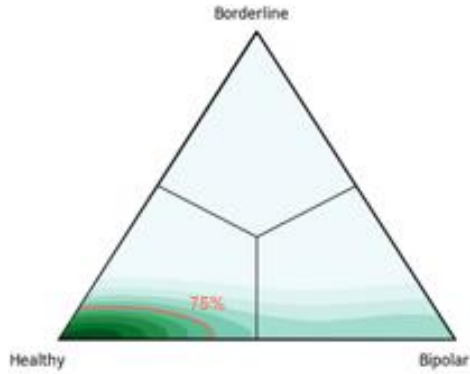
Imanol Pérez Arribas

“We can’t share the data.
The original researchers did
not ask for consent to do so.
We can share simulated and
synthetic data so that
researchers can feel
confident in applying our
method to their own data.”

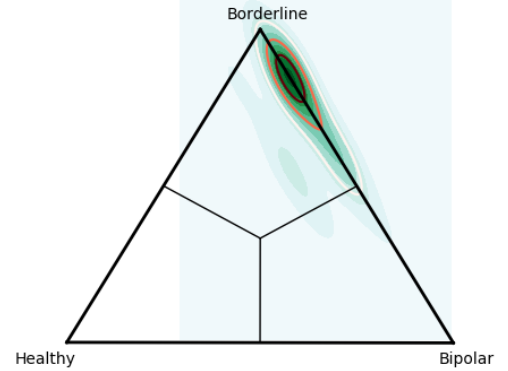
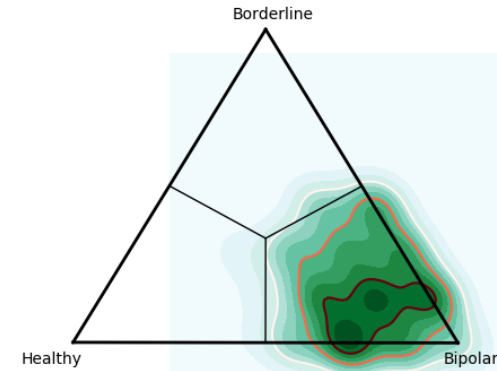
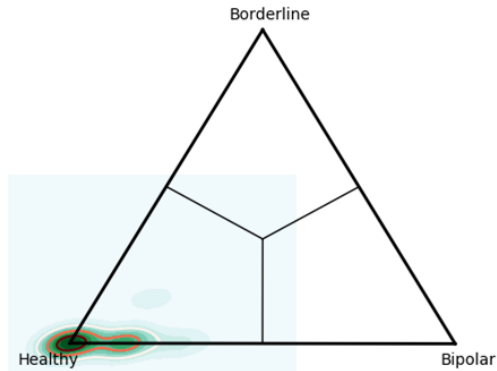


<https://www.maths.ox.ac.uk/people/imanol.perez>
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<https://doi.org/10.5281/zenodo.3402510>

Publication



Synthetic Data



AS OPEN AS POSSIBLE, AS CLOSED AS NECESSARY

Grantees have the right to opt-out, but need to say **why**



Top three reasons for opt-out:

privacy



intellectual property rights



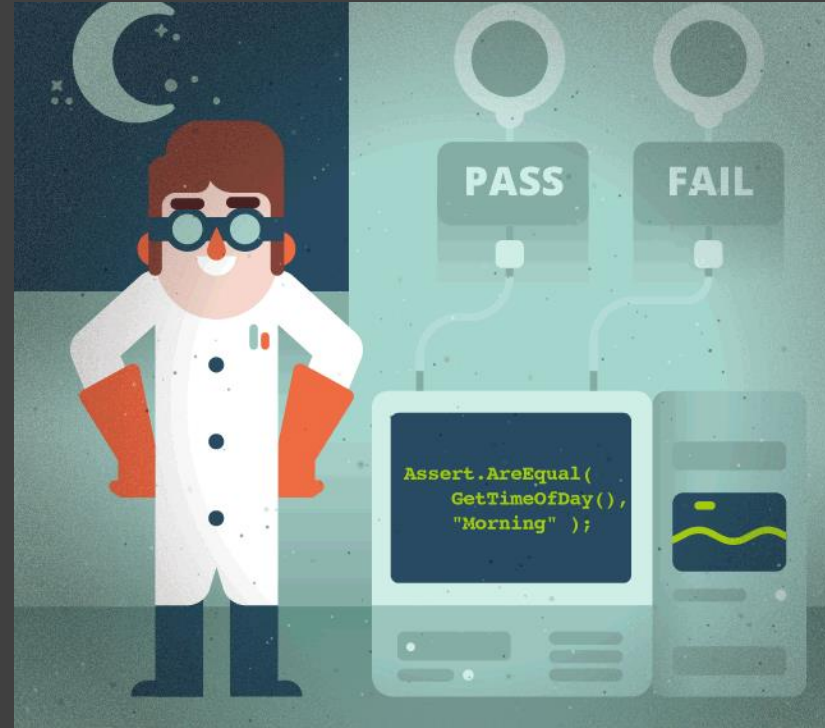
might jeopardise project's main objective

Testing for research

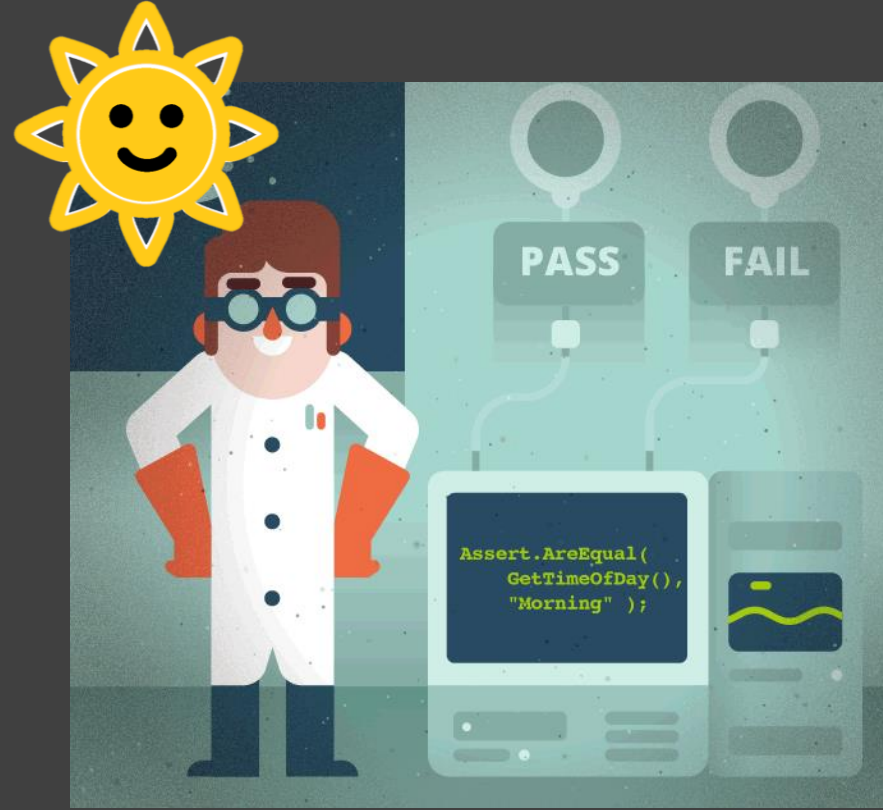


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<https://doi.org/10.5281/zenodo.3402510>

Is your code doing what
you think its doing?

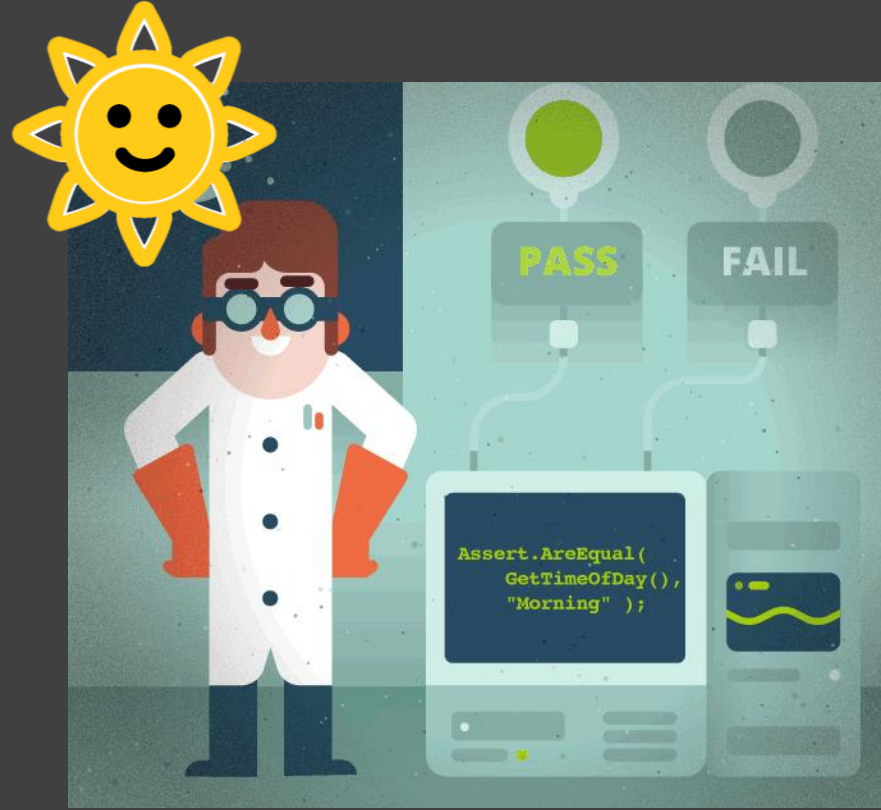


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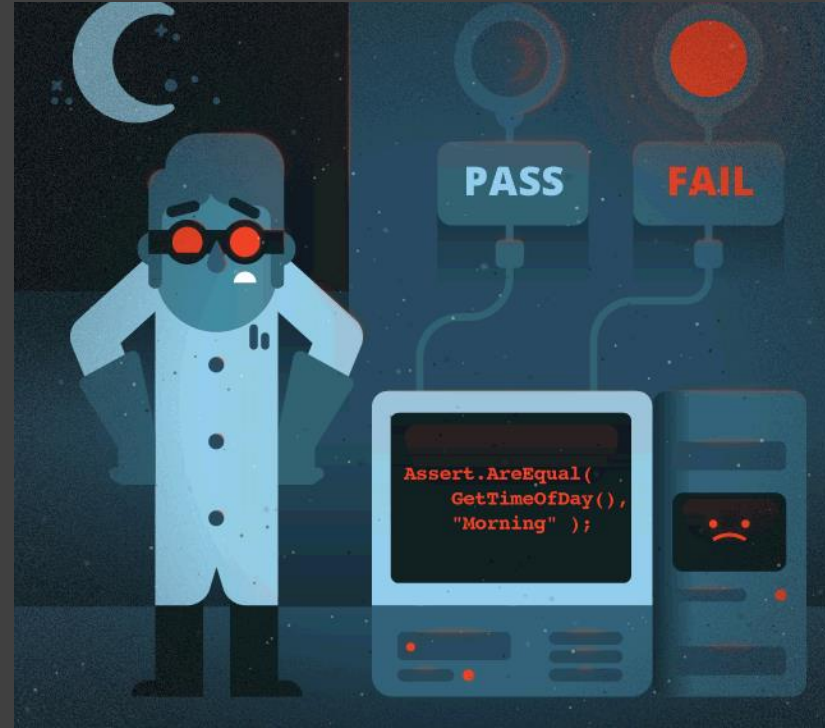
Is your code doing what
you think its doing?

```
Assert.AreEqual(  
    GetTimeOfDay(),  
    "Morning" )
```



Is your code doing what
you think its doing?

```
Assert.AreEqual(  
    GetTimeOfDay(),  
    "Morning" )
```



Louise Bowler

“Add a test before you change anything.”



<https://www.turing.ac.uk/people/researchers/louise-bowler>

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<https://doi.org/10.5281/zenodo.3402510>

Louise Bowler

“Add a test before you change anything.

Particularly if you’re just going to tidy up your code before sharing it.”

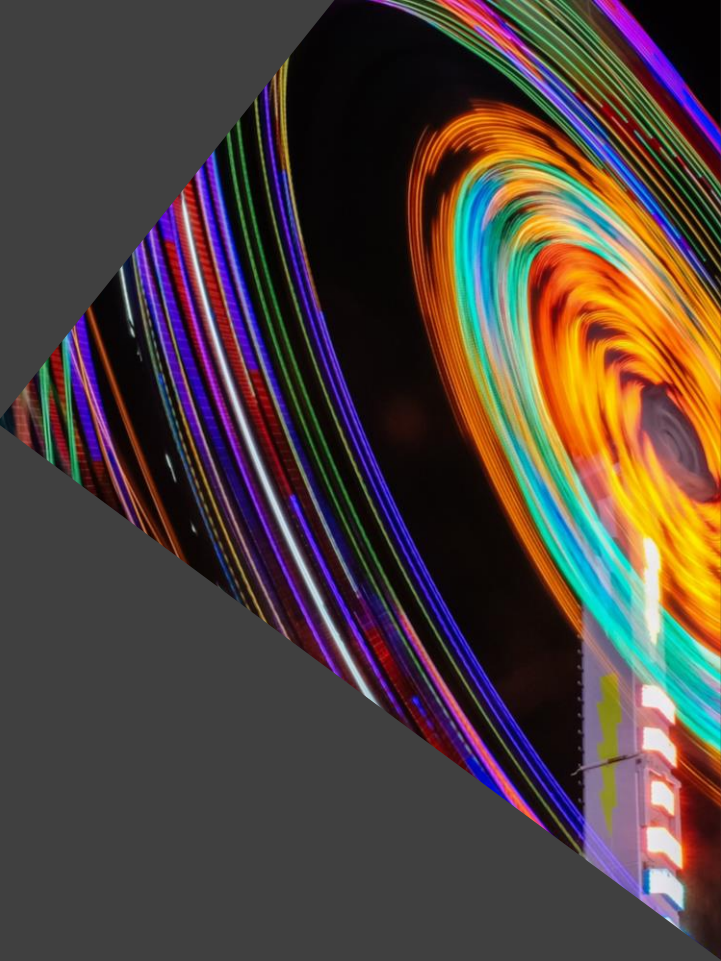


<https://www.turing.ac.uk/people/researchers/louise-bowler>

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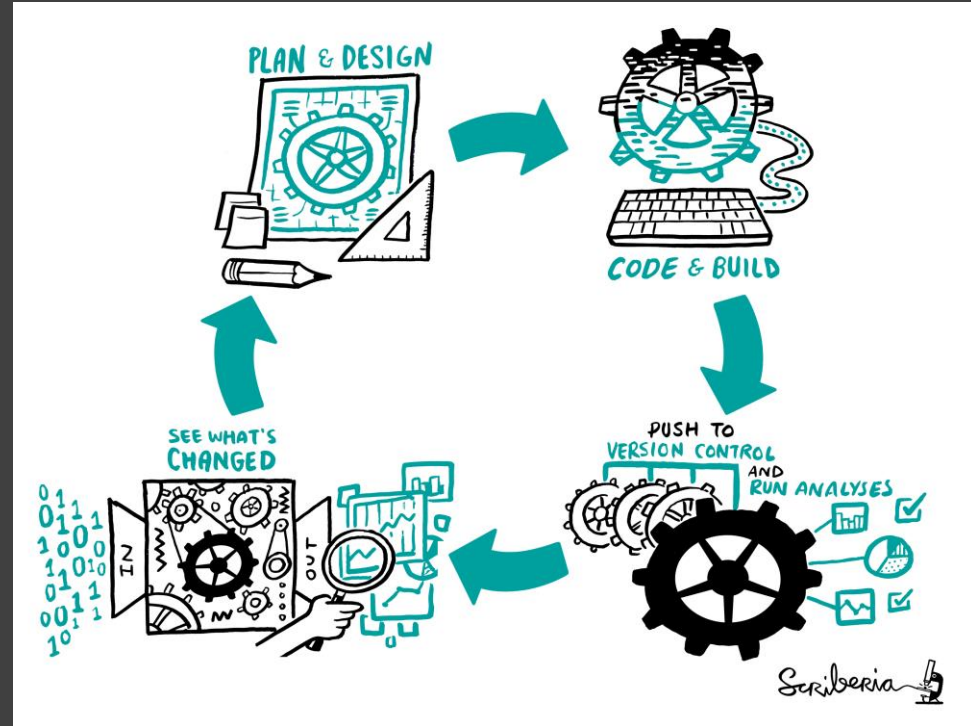
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Continuous Analysis



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- Plan and design your experiment
- Write down those steps in code
- Push to version control and run the analyses
 - Traditionally done on the cloud, but the important part is that all steps are run every time
- Test to see what's changed



Dashboard Changelog Documentation Help

Search all repositories

alan-turing-institute / signatures-psychiatry build unknown

My Repositories Running (0/0) +

Current Branches Build History Pull Requests More options

✗ alan-turing-institute/PosteriorB # 98

Duration: 2 hrs 11 min 35 sec
Finished: about 9 hours ago

✓ alan-turing-institute/signatures # 1

Duration: 1 min 41 sec
Finished: about 12 hours ago

✓ bids-standard/bids-specification # 506

Duration: 32 sec
Finished: a day ago

✓ lab-add-synth-data Add travis config - #1 passed Restart build

Commit 023d957
Compare e63a607...023d957
Branch lab-add-synth-data

Louise Bowler

</> Python: 2.7

Job log View config

<https://github.com/alan-turing-institute/signatures-psychiatry>

#MQDataScience #TuringWay @kirstie_j

<https://doi.org/10.5281/zenodo.3402510>

[https://the-turing-way.netlify.com/
continuous_integration/continuous_integration.html](https://the-turing-way.netlify.com/continuous_integration/continuous_integration.html)

Dashboard

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Duration: 1 min 41 sec
Finished: about 12 hours ago

✓ bids-standard/bids-specification # 50

Duration: 32 sec
Finished: a day ago

Job log View config

Remove log Raw log

```

1 Worker information
6 Build system information
413
414 docker stop/waiting
416
417 $ git clone --depth=50 --branch=lab-add-synth-data https://github.com/alan-turing-institute
427
428 $ source ~/virtualenv/python2.7/bin/activate
429 $ python --version
430 Python 2.7.14
431 $ pip --version
432 pip 9.0.1 from /home/travis/virtualenv/python2.7.14/lib/python2.7/site-packages (python 2.7)
433 $ pip install -r requirements.txt
518 $ pytest -v
519 ===== test session starts =====
520 platform linux2 -- Python 2.7.14, pytest-4.4.1, py-1.5.2, pluggy-0.11.0 -- /home/travis/virtualenv/python2.7.14
/bin/python
521 cachedir: .pytest_cache
522 rootdir: /home/travis/build/alan-turing-institute/signatures-psychiatry
523 collected 4 items
524
525 test_synthetic.py::test_pairwise_group_classification_synth[239673-expected_values0] PASSED [ 25%]
526 test_synthetic.py::test_pairwise_group_classification_synth[425769-expected_values1] PASSED [ 50%]
527 test_synthetic.py::test_pairwise_group_classification_synth[772192-expected_values2] PASSED [ 75%]
528 test_synthetic.py::test_pairwise_group_classification_synth_defaults PASSED [100%]
529
530 ===== 4 passed in 33.00 seconds =====
531 The command "pytest -v" exited with 0.
532
533
534
535 Done. Your build exited with 0.

```

build unknown

More options

Restart build

<https://github.com/alan-turing-institute/signatures-psychiatry>
 #MQDataScience #TuringWay @kirstie_j
<https://doi.org/10.5281/zenodo.3402510>

https://the-turing-way.netlify.com/continuous_integration/continuous_integration.html

Dashboard

Search all repositories

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alan-turing-institute/Posterior # 98

Duration: 2 hrs 11 min 35 sec

Finished: about 9 hours ago

Job log View config

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519 ===== test session starts =====
520 platform linux2 -- Python 2.7.14, pytest-4.4.1, py-1.5.2, pluggy-0.11.0 -- /home/travis/virtualenv/python2.7.14/bin/python

```

4 passed in 33.00 seconds

The command "pytest -v" exited with 0.

Done. Your build exited with 0.

build unknown

More options

Restart build

529

530 ===== 4 passed in 33.00 seconds =====

531 The command "pytest -v" exited with 0.

532

Duration: 32 sec

Finished: a day ago

```

529 test_synthetic.py::test_pairwise_group_classification_synth_defaults PASSED [100%]
530 ===== 4 passed in 33.00 seconds =====
531 The command "pytest -v" exited with 0.
532
533
534
535 Done. Your build exited with 0.

```

Top

<https://github.com/alan-turing-institute/signatures-psychiatry>

#MQDataScience #TuringWay @kirstie_j

<https://doi.org/10.5281/zenodo.3402510>

https://the-turing-way.netlify.com/continuous_integration/continuous_integration.html

- Run the analysis from start to finish as you work
- Many times tests will fail as expected: you're developing the analysis!
- Sometimes tests will fail unexpectedly
- CI makes you be explicit about what has changed



1. Introduction

2. Reproducibility

3. Open Research

4. Version Control

5. Collaborating on GitHub/GitLab

6. Research Data Management

7. Reproducible Environments

8. Testing

9. Reviewing

10. Continuous Integration

11. Reproducible Research with

Make

12. Risk Assessment



Welcome to the Turing Way

The Turing Way is a lightly opinionated guide to reproducible data science.

Our goal is to provide all the information that researchers need at the start of their projects to ensure that they are easy to reproduce at the end.

This also means making sure PhD students, postdocs, PIs and funding teams know which parts of the “responsibility of reproducibility” they can affect, and what they should do to nudge data science to being more efficient, effective and understandable.

A bit more background

Reproducible research is necessary to ensure that scientific work can be trusted. Funders and publishers are beginning to require that publications include access to the underlying data and the analysis code. The goal is to ensure that all results can be independently verified and built upon in future work. This is sometimes easier said than done. Sharing these research outputs means understanding data management, library sciences, software development, and continuous integration techniques: skills that are not widely taught or expected of academic researchers and data scientists.

The Turing Way is a handbook to support students, their supervisors, funders and journal editors

<https://the-turing-way.netlify.com/introduction/introduction>

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<https://doi.org/10.5281/zenodo.3402510>

Becky Arnold

“There are a lot of things you need to know before you can jump into continuous integration.

Version control is a prerequisite for pretty much everything.”



<https://software.ac.uk/about/fellows/becky-arnold>

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1. Introduction
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10. Continuous Integration
11. Reproducible Research with Make
12. Risk Assessment

Continuous integration

Prerequisite	Importance	Notes
Experience with the command line	Necessary	A tutorial on working via the command line can be found here
Version control	Necessary	See the chapter on this for more information
Testing	Very helpful	See the chapter on this for more information
Reproducible computational environments	Necessary	See the chapter on this for more information, particularly the sections on YAML files and containers

Table of contents

- [Summary](#)
- [How this will help you/ why this is useful](#)
 - [What are continuous delivery and continuous deployment?](#)
- [What is Travis and how does it work?](#)
- [Setting up continuous integration with Travis](#)
 - [Basic steps](#)

https://the-turing-way.netlify.com/continuous_integration/continuous_integration.html

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Version control



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"FINAL".doc



FINAL.doc!



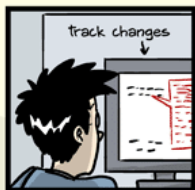
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FINAL_rev.6.COMMENTS.doc



FINAL_rev.8.comments.
CORRECTIONS.doc



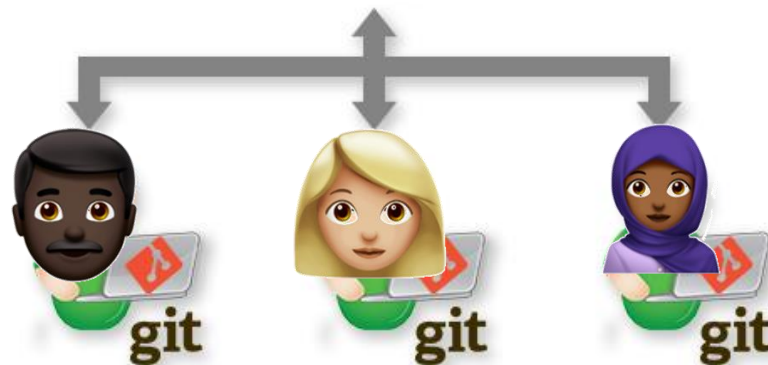
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corrections9.MORE.30.doc



FINAL_rev.22.comments49.
corrections.10.#@\$%WHYDID
ICOMETOGRADSCHOOL????.doc



JORGE CHAM © 2012



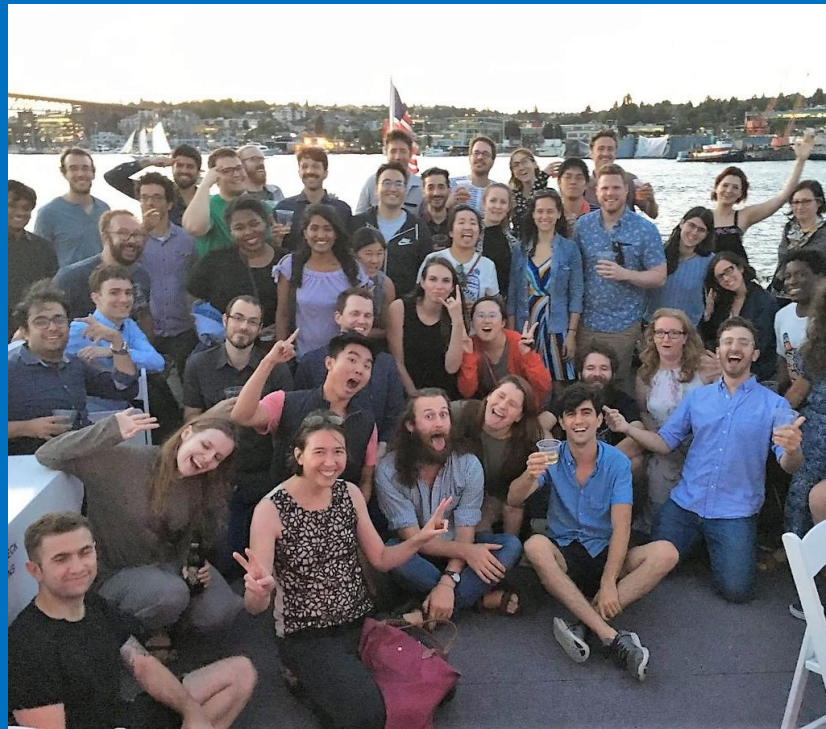
<http://phdcomics.com/comics/archive.php?comid=1531>

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<https://doi.org/10.5281/zenodo.3402510>

Neurohackademy

“Every hackathon should have a gong that you can ring when you complete your first pull request.”

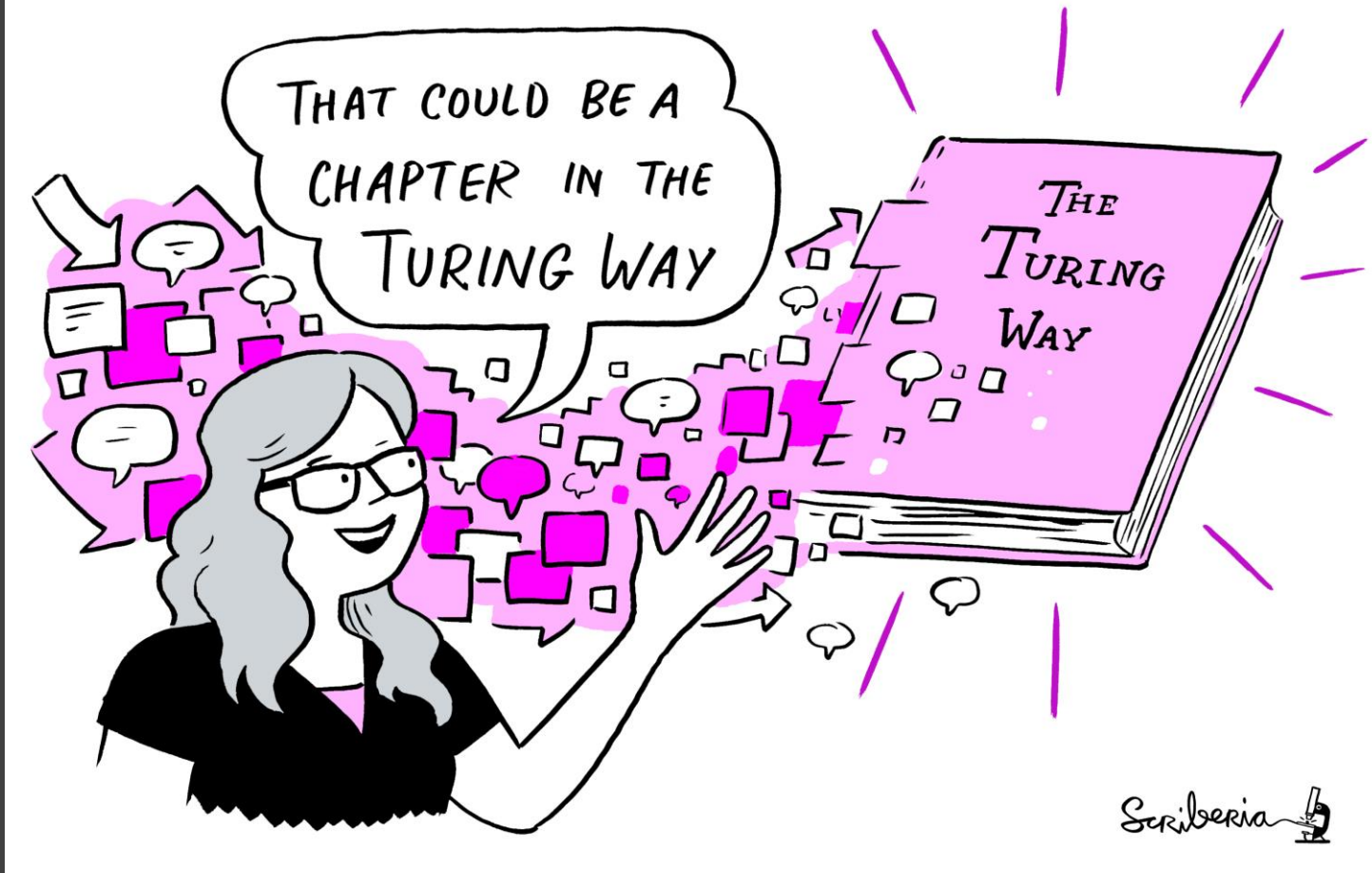


<https://neurohackademy.org>
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A global collaboration

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Patricia Herterich

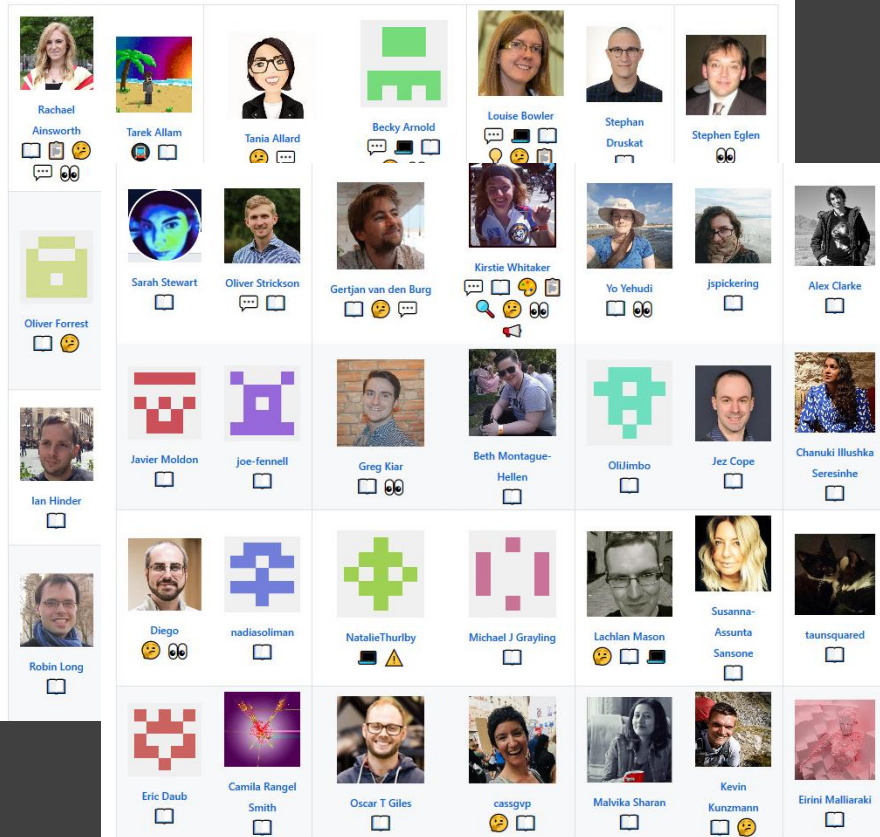
“What really sets The Turing Way apart is HOW we’re writing the book. The focus on community, the commitment to transparency and working open right from the beginning is an exciting (and terrifying) new way of working.”



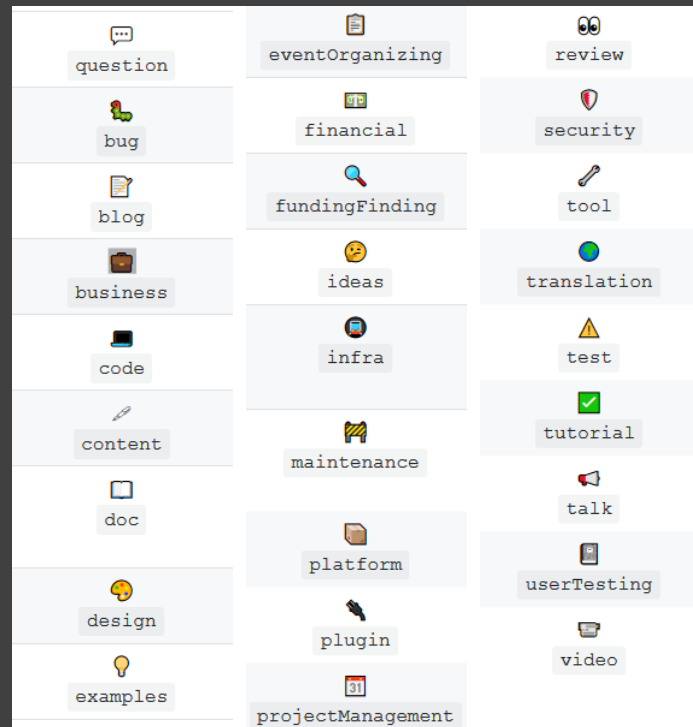
<https://rd-alliance.org/users/patricia-herterich>
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<https://doi.org/10.5281/zenodo.3402510>

Contributors

Thanks goes to these wonderful people (emoji key):



This project follows the [all-contributors](#) specification. Contributions of any kind welcome!



<https://github.com/alan-turing-institute/the-turing-way>

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<https://github.com/alan-turing-institute/the-turing-way#contributors>

<https://allcontributors.org/docs/en/emoji-key>

Open Leadership Principles



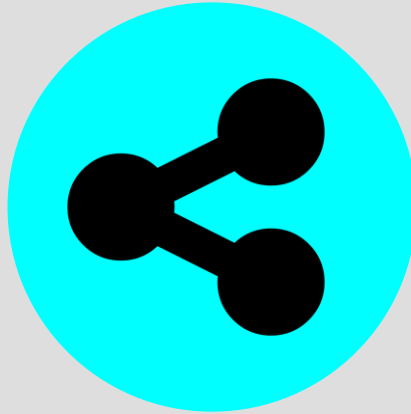
Understanding

You make the work accessible and clear

Read more

<https://mozilla.github.io/olm-whitepaper>

moz://a



Sharing

You make the work easy to adapt, reproduce, and spread



Participation & Inclusion

You build shared ownership and agency to make the work inviting and sustainable for all.

#MQDataScience #TuringWay @kirstie_j

<https://doi.org/10.5281/zenodo.3402510>

Join us at an online “Collaboration Café”

- 2 hours every week
- Zoom call, connect from anywhere
- “Shut up and write” or discuss and plan in breakout rooms



Time	Activity
Start	Welcome, code of conduct review
5 mins	Introductions and personal goal setting
15 mins	1st pomodoro session
35 mins	Break
40 mins	2nd pomodoro session
1hr 0 mins	Break
1hr 5 mins	3rd pomodoro session
1hr 25 mins	Break
1hr 30 mins	Open discussion: celebrations, reflections and future directions
2hr 0 mins	Close

<https://www.youtube.com/watch?v=l0z7OEBzEs>

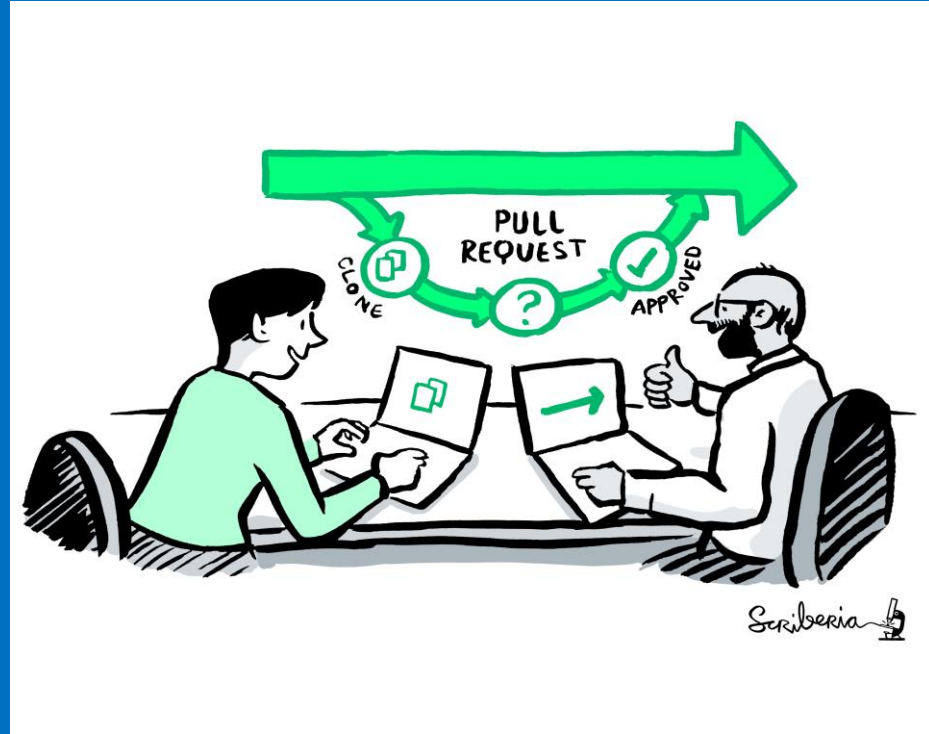
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<https://doi.org/10.5281/zenodo.3402510>

[https://github.com/alan-turing-institute/the-turing-way/blob/master/
project_management/online-collaboration-cafe.md](https://github.com/alan-turing-institute/the-turing-way/blob/master/project_management/online-collaboration-cafe.md)

Metrics for success

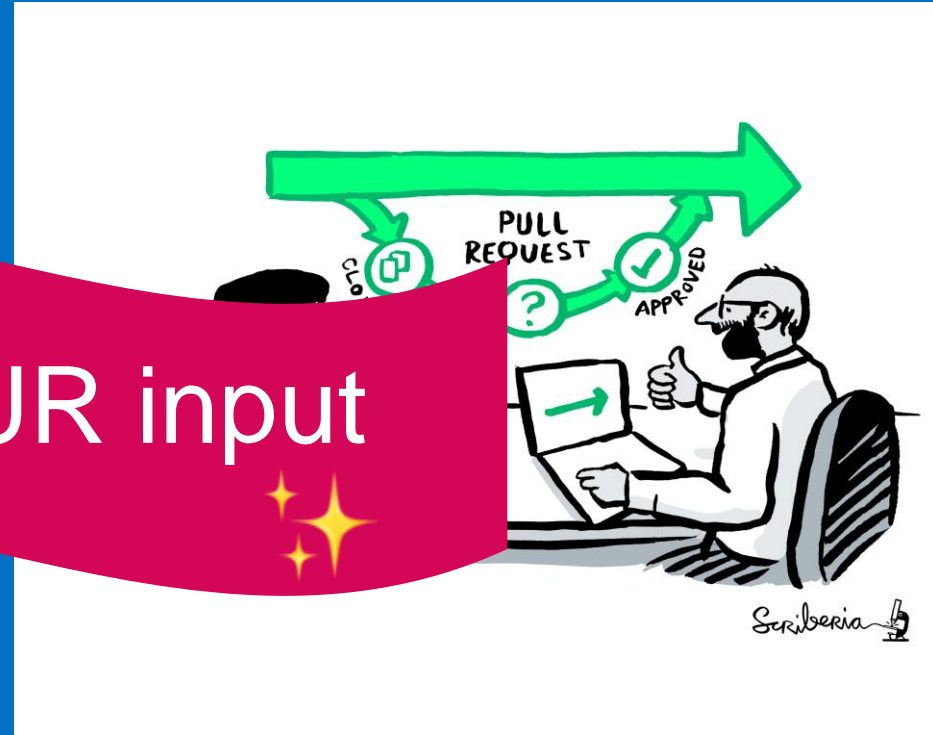
- 20 new chapters
- 100 authors
- 200 contributors
- 1000 mailing list subscribers
- 50 first pull requests
- 20 new contributors to other open source projects



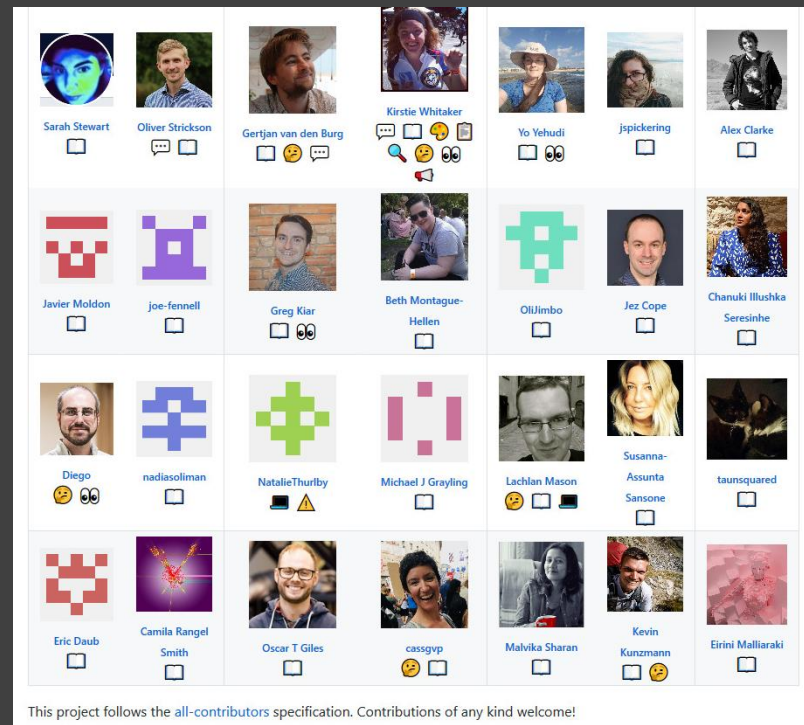
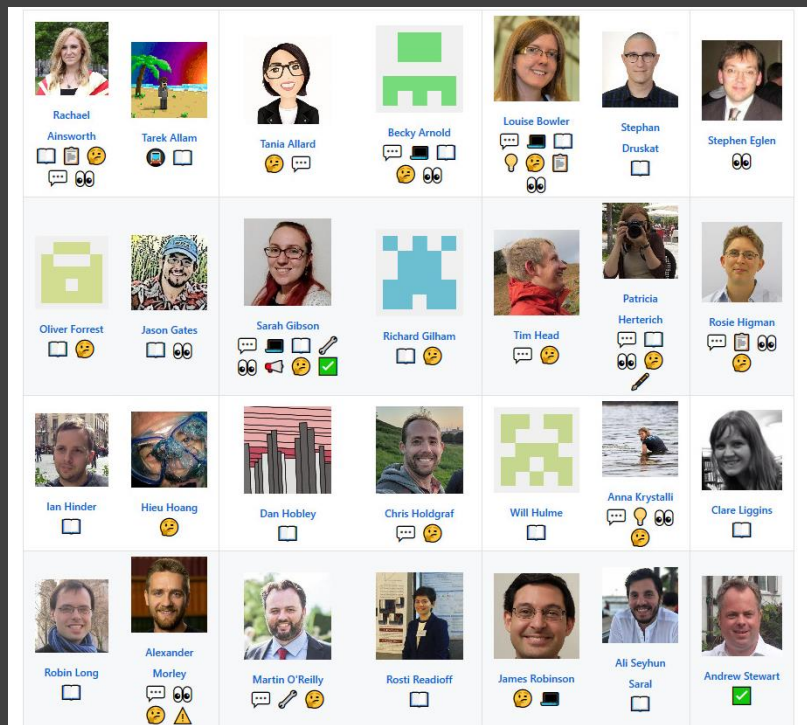
Metrics for success

- 20 new chapters
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and YOUR input



Thank you to current (& future) contributors



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<https://allcontributors.org/docs/en/emoji-key>

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<https://doi.org/10.5281/zenodo.3402510>

Thank you

The
Alan Turing
Institute



- Book: <https://the-turing-way.netlify.com>
- Newsletter: <https://tinyletter.com/TuringWay>
- GitHub: <https://github.com/alan-turing-institute/the-turing-way>
- Chat: <https://gitter.im/alan-turing-institute/the-turing-way>
- Next Collaboration Café: 18 September at 7pm UK time
- This work was supported by The UKRI Strategic Priorities Fund under the EPSRC Grant EP/T001569/1, particularly the "Tools, Practices and Systems" theme within that grant, and by The Alan Turing Institute under the EPSRC grant EP/N510129/1
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