

Putting the into Reproducible Research

Directors Cut

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UCL Tech Social



me: **Dr Anna Krystalli**

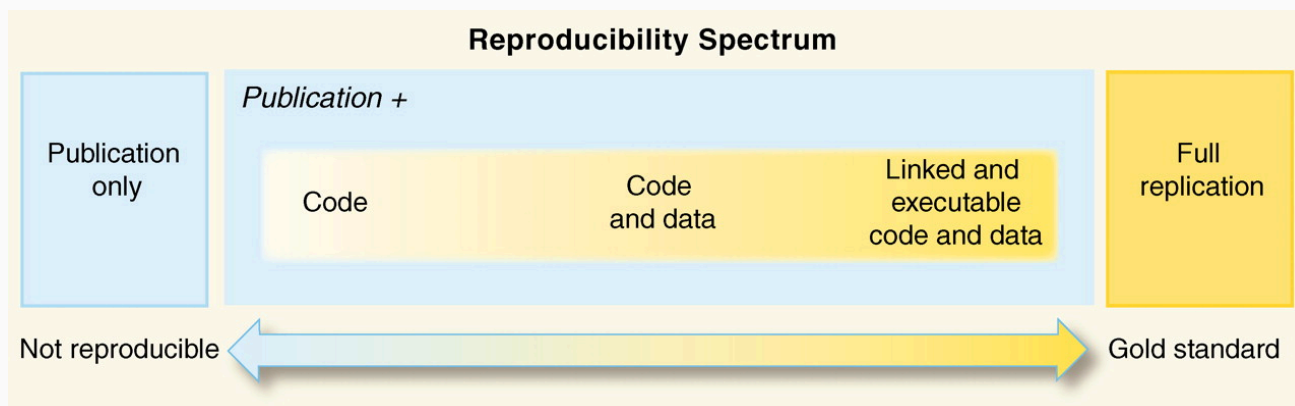
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 - twitter **@annakrystalli**
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- **Editor** **rOpenSci**
- **Core Team:** **ReproHack**

slides: **bit.ly/r-in-repro-research-dc-ucl**

Motivation

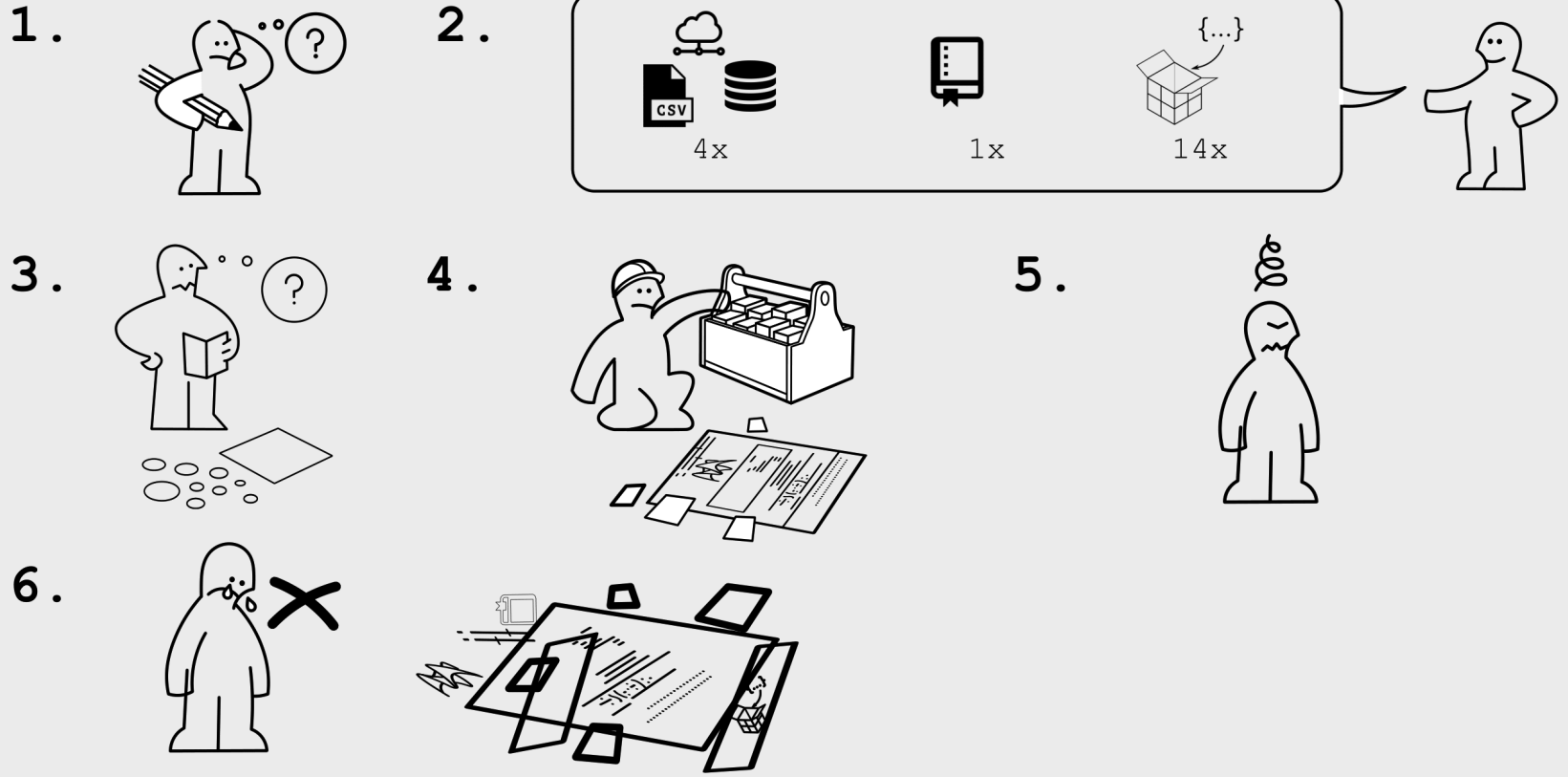
Calls for reproducibility

Reproducibility has the potential to serve as a **minimum standard for judging scientific claims** when full independent replication of a study is not possible.



Reproducible Research in Computational Science ROGER D. PENG, *SCIENCE* 02 DEC 2011 : 1226-1227

Is code and data enough?



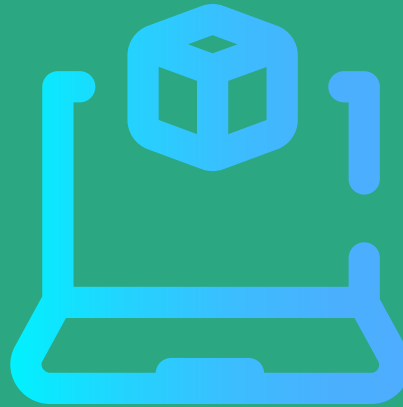
slide: **Karthik Ram: rstudio::conf 2019 talk**

R for Open Reproducible Research

A whistle-stop tour of tools, practices and conventions in R for more:

- **Reproducible**
- **Robust**
- **Transparent**
- **Reusable**
- **Shareable** research materials

Project management



Icon by **Freepik** from **flaticon.com**

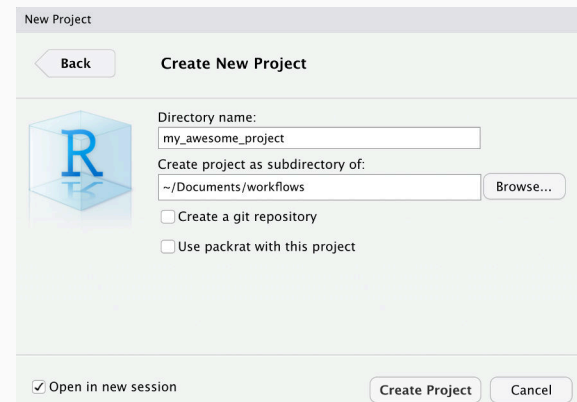
Rstudio Projects

Use Rstudio projects to keep materials associated with a particular analysis together

- **Self contained** and **portable**
- **Working directory set to root** of project on launch
- **Fresh session** everytime the project is launched

See Jenny Bryan's post on **project oriented workflows** for more details

File > New Project > New Directory



~/Documents/workflows/my_awesome_project - RStudio

my_awesome_project

Console Terminal x Jobs x

~/Documents/workflows/my_awesome_project/

```
R version 3.6.0 (2019-04-26) -- "Planting of a Tree"
Copyright (C) 2019 The R Foundation for Statistical Computing
Platform: x86_64-apple-darwin15.6.0 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

Hey Anna, welcome back, time to Rrrrrrrrock!
> |
```

Environment History Connections

Import Dataset

Global Environment

Environment is empty

Files Plots Packages Help Viewer

New Folder Delete Rename More

Documents > workflows > my_awesome_project

| | Name | Size | M |
|--|--------------------------|-------|---|
| | .. | | |
| | my_awesome_project.Rproj | 205 B | M |



here

Use  `here` to create robust relative paths

- **Robust paths relative to project root**

- portable
- independent of:
 - working directory
 - source code location



```
here::here()
```

```
## [1] "/Users/Anna/Documents/workflows/talks"
```

```
here::here("data", "summaries.csv")
```

```
## [1] "/Users/Anna/Documents/workflows/talks/data/summaries.csv"
```

Icon by **Freepik** from **flaticon.com**

Dependency management

Minimal approach

include an `install.R` script

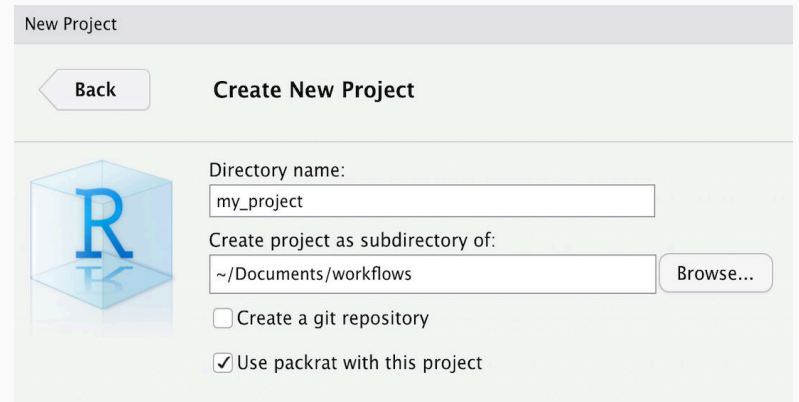
```
install.packages("dplyr")  
install.packages("purrr")
```

Most robust approach

use  `renv` (previously `packrat`)

- Create and manage a per project library of packages
- initialise during project set up

will revisit later on



New Project

Back Create New Project

Directory name:
my_project

Create project as subdirectory of:
~/Documents/workflows Browse...

Create a git repository

Use packrat with this project



drake

Use drake to orchestrate your workflows



Scale the work
you need.



Skip the work
you don't.



See evidence
of reproducibility.



make plan

```
plan ← drake::drake_plan(  
  raw_data = readr::read_csv(here::here("data", "iris.csv")),  
  data = raw_data %>%  
    dplyr::mutate(Species = forcats::fct_inorder(Species)),  
  fit = lm(Sepal.Width ~ Petal.Width + Species, data))
```

Plan

view plan

```
plan

## # A tibble: 3 x 2
##   target  command
##   <chr>   <expr_lst>
## 1 raw_data readr::read_csv(here::here("data", "iris.csv"))
## 2 data     raw_data %>% dplyr::mutate(Species = forcats::fct_inorder(Species))
## 3 fit     lm(Sepal.Width ~ Petal.Width + Species, data)
```

re-execute plan

```
drake::make(plan)
```

```
## All targets are already up to date.
```

inspect targets

```
drake::readd(fit)
```

```
##  
## Call:  
## lm(formula = Sepal.Width ~ Petal.Width + Species, data = data)  
##  
## Coefficients:  
##      (Intercept)      Petal.Width Speciesversicolor Speciesvirginica  
##           3.236           0.781           -1.501           -1.844
```

visualise workflow

```
drake::vis_drake_graph(drake::drake_config(plan))
```

Dependency graph



Version Control

Version Control

What is it? 🤔

The **management of changes** to documents, computer programs, large web sites, and other collections of information.

Git git

Open source (free to use) **Version control software.**

GitHub

A **website** (<https://github.com/>) that allows you to **store your Git repositories online** and makes it easy to collaborate with others.

Why use them in research?

Exhibit A

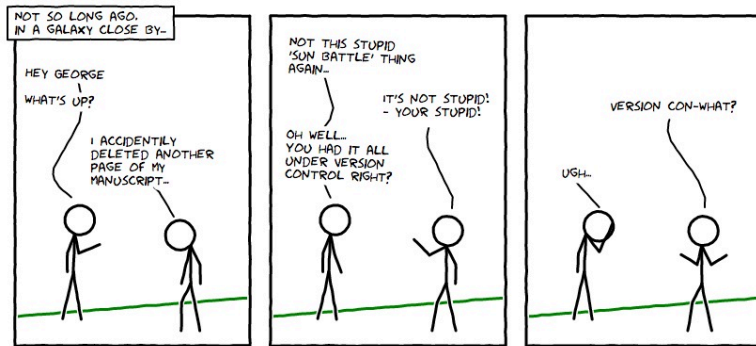


Image: xkcd CC BY-NC 2.5

Exhibit B

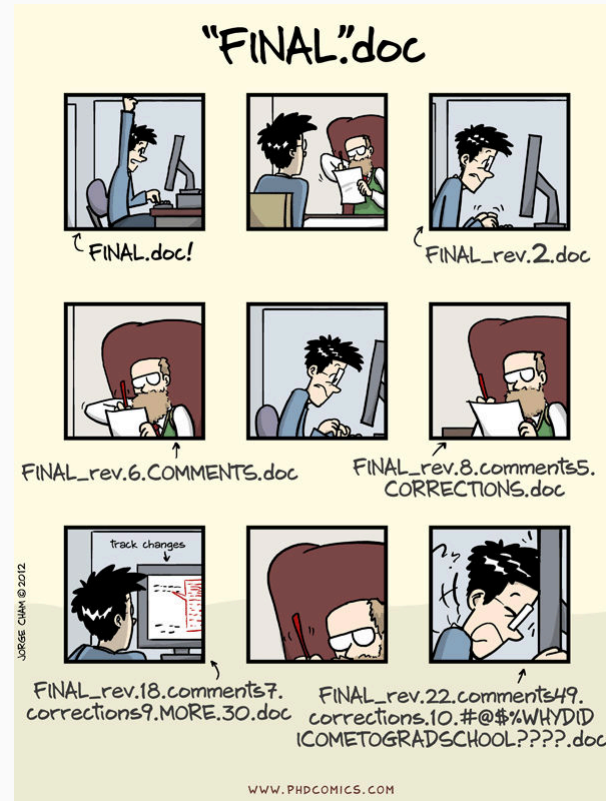


Image: Jorge Cham www.phdcomics.com

Git, Github & Rstudio

Before: git only through the terminal 🙄

Now: Rstudio + `usethis` 📁 == ❤️ `Git` & `GitHub` 😄



Configure git & GitHub

Configure git

Check your configuration

```
usethis::git_sitrep()
```

Set your configuration

Use your github username and and the email you used to sign-up on GitHub

```
usethis::use_git_config(  
  user.name = "Jane",  
  user.email = "jane@example.org")
```

Configure GitHub authentication

Get GITHUB Personal Authorisation Token

```
usethis :: browse_github_pat()
```

Settings / Developer settings

OAuth Apps

GitHub Apps

Personal access tokens

New personal access token

Personal access tokens function like ordinary OAuth access tokens. They can be used instead of a password for Git over HTTPS, or can be used to [authenticate to the API over Basic Authentication](#).

Token description

What's this token for?

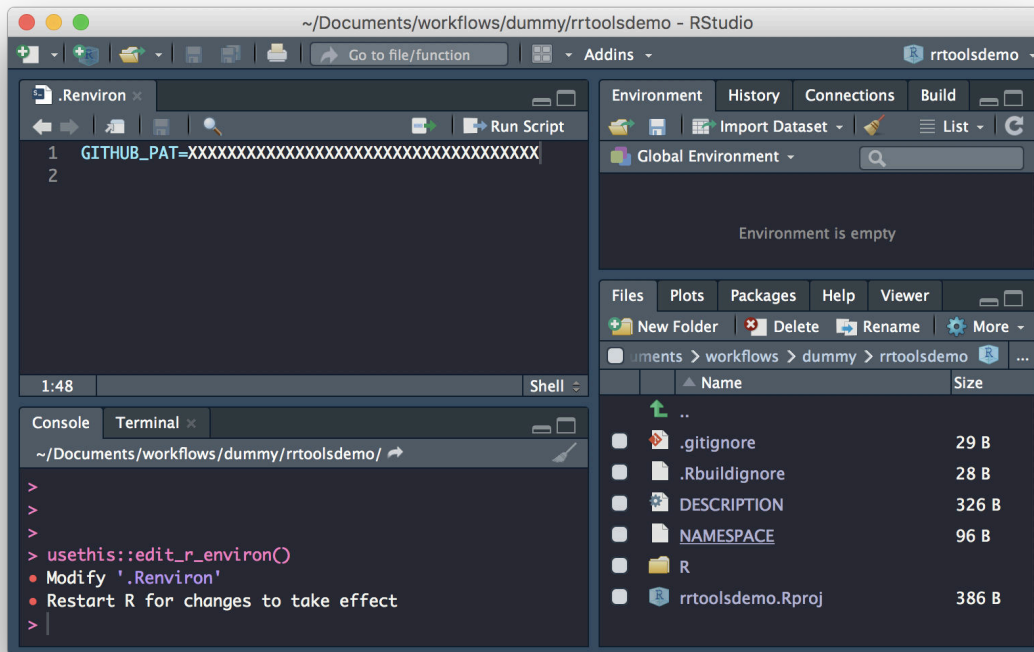
Select scopes

Scopes define the access for personal tokens. [Read more about OAuth scopes](#).

| | |
|---|--------------------------------------|
| <input checked="" type="checkbox"/> repo | Full control of private repositories |
| <input checked="" type="checkbox"/> repo:status | Access commit status |
| <input checked="" type="checkbox"/> repo_deployment | Access deployment status |
| <input checked="" type="checkbox"/> public_repo | Access public repositories |
| <input checked="" type="checkbox"/> repo:invite | Access repository invitations |

Store in `.Renvirom` file

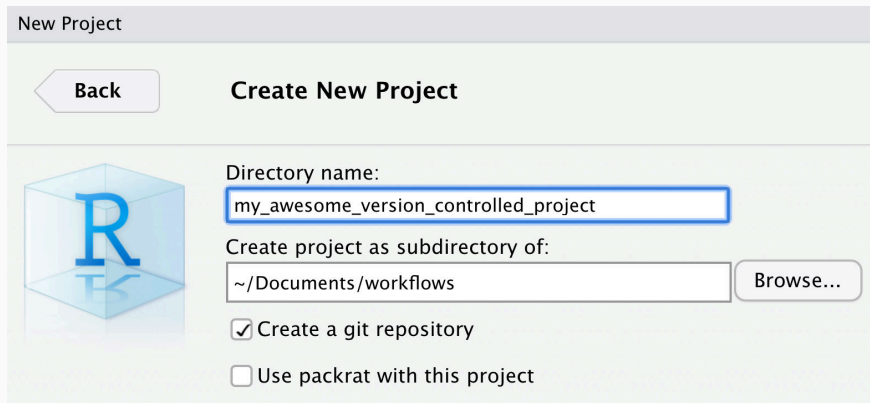
```
usethis::edit_r_envirom()
```



Initialise git

Initialise **Rstudio** project with Git by **just checking a box!**

It's now **a repository**



New Project

Back Create New Project

Directory name:
my_awesome_version_controlled_project

Create project as subdirectory of:
~/Documents/workflows Browse...

Create a git repository

Use packrat with this project


Forgot to? use `usethis::use_git()`

Git panel

Integrated graphical user interface

Version Control with Git or SVN

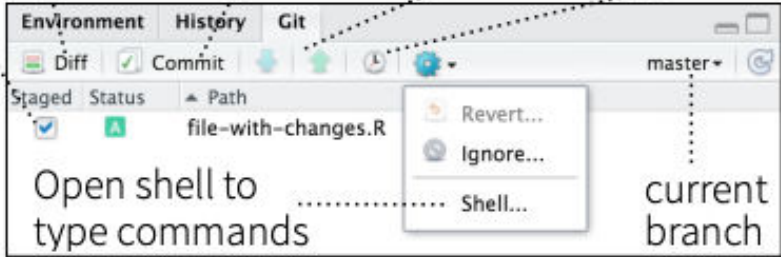
Turn on at **Tools > Project Options > Git/SVN**

 Stage files: Show file diff Commit staged files Push/Pull to remote View History

A Added
D Deleted
M Modified
R Renamed
? Untracked

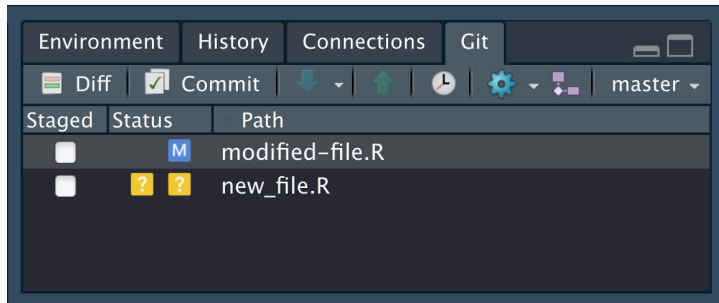
Open shell to type commands

current branch

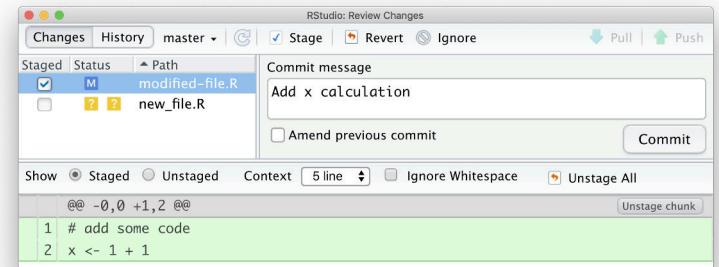


Git Rstudio workflow

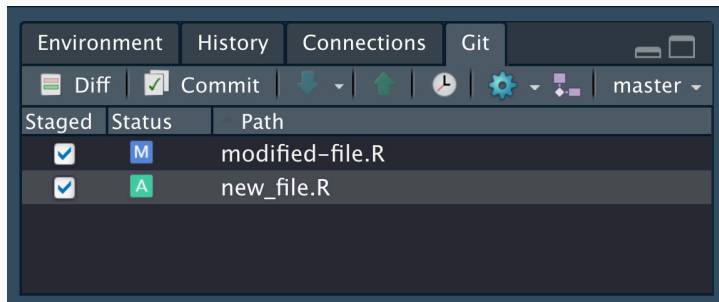
view file status



commit changes



stage files



Share on GitHub

Create repo

```
usethis :: use_github(protocol = "https")
```

The screenshot shows the GitHub interface for a repository named 'annakrystalli / my_awesome_project'. At the top, there are buttons for 'Unwatch' (1), 'Star' (0), and 'Fork' (0). Below this is a navigation bar with 'Code', 'Issues' (0), 'Pull requests' (0), 'Projects' (0), 'Wiki', 'Insights', and 'Settings'. A message states 'No description, website, or topics provided.' with an 'Edit' button. Below that, it says 'Manage topics'. A summary bar shows '4 commits', '1 branch', '0 releases', and '1 contributor'. There are buttons for 'Branch: master', 'New pull request', 'Create new file', 'Upload files', 'Find File', and 'Clone or download'. A commit history table is visible below.

| Commit | Message | Time |
|--------------------------|-------------------|------------------------------------|
| annakrystalli | Add x calculation | Latest commit 68c5dc9 18 hours ago |
| .gitignore | initial commit | 18 hours ago |
| modified-file.R | Add x calculation | 18 hours ago |
| my_awesome_project.Rproj | initial commit | 18 hours ago |
| new_name.txt | rename file | 18 hours ago |

Push further changes

The screenshot shows a dark-themed Git command palette with tabs for 'Environment', 'History', 'Connections', and 'Git'. The 'Git' tab is active, showing buttons for 'Diff', 'Commit', 'Push' (highlighted with a green box), 'Refresh', and 'Settings'.

Anatomy of a GitHub Repo

- **README**. Explain what your project is, and how to use it.
 - `usethis::use_readme_md()`
 - `usethis::use_readme_rmd()`
- **LICENSE**. Without a licence, the contents of the repository are technically closed.
 - Examples licence **MIT**: `usethis::use_mit_license(name = "Anna Krystalli")`
 - `?licenses`: details of functions available to generate licenses
 - <https://choosealicense.com/> help on choosing a licence.
- **CONTRIBUTING.md** - guidelines for contributors.
 - `usethis::use_tidy_contributing()` provides a relatively strict but instructive template
- **CODE_OF_CONDUCT.md** set the tone for discourse between contributors.
 - `use_code_of_conduct()`

GitHub issues

use GitHub issues to plan, record and discuss tasks.

issues

The screenshot shows the GitHub Issues page for the repository 'annakrystalli / gaitr'. The page is filtered to show 'is:issue is:open'. There are 15 open issues and 14 closed issues. The issues are listed in a table with columns for status, author, labels, projects, milestones, assignee, and sort. The issues are:

- #29: y axis radar plot (opened on 26 Mar by lore86)
- #28: P_adj value wilcox test (opened on 26 Mar by lore86)
- #24: Add documentation of get_ & set_group & vars functions (opened on 5 Feb by annakrystalli, labels: documentation, enhancement)
- #22: Publication strategy (opened on 5 Feb by annakrystalli, label: publication)
- #21: Anonymise variable names in examples (and tests?) (opened on 5 Feb by annakrystalli, labels: publication, testing)
- #18: Add significance asterisks to plots (opened on 29 Jan by lore86, labels: enhancement, plot)
- #17: Collate outputs into one file (opened on 29 Jan by lore86, labels: data-munging, stats, summaries)

projects

The screenshot shows the GitHub Projects page for the repository 'annakrystalli / gaitr'. The project is titled 'Complete group analysis code workflow' and was updated on 5 Mar. The project is divided into four columns: To do, In progress, and Done. The issues are:

- To do:**
 - #17: Collate outputs into one file (opened by lore86, labels: data-munging, stats, summaries)
 - #21: Anonymise variable names in examples (and tests?) (opened by annakrystalli, labels: publication, testing)
- In progress:**
 - #15: Parametric version of zscore, standard deviation in summary (opened by lore86, labels: enhancement, summaries)
 - #4: Ability to chose between parametric/non-parametric testing (opened by annakrystalli, labels: enhancement, stats, summaries)
 - #18: Add significance asterisks to plots (opened by lore86, labels: enhancement, plot)
- Done:**
 - #8: Bonferonni correction (opened by annakrystalli, labels: duplicate, stats)
 - #19: Pvalue no bonferonni correction (opened by lore86, label: stats)
 - #9: Determine which arguments of each statistics test should be available through map function (opened by annakrystalli, label: question)
 - #11: Add ability to choose metadata column with variable labels (opened by annakrystalli)

Literate programming with Rmarkdown

Literate programming


Programming paradigm first introduced by **Donald E. Knuth**.

Treat program as literature to be understandable to human beings



- focus on the logic and flow of human thought and understanding
- single document to integrate data analysis (executable code) with textual documentation, **linking data, code, and text**

Literate programming in R

Rmarkdown (`.Rmd`) integrates:

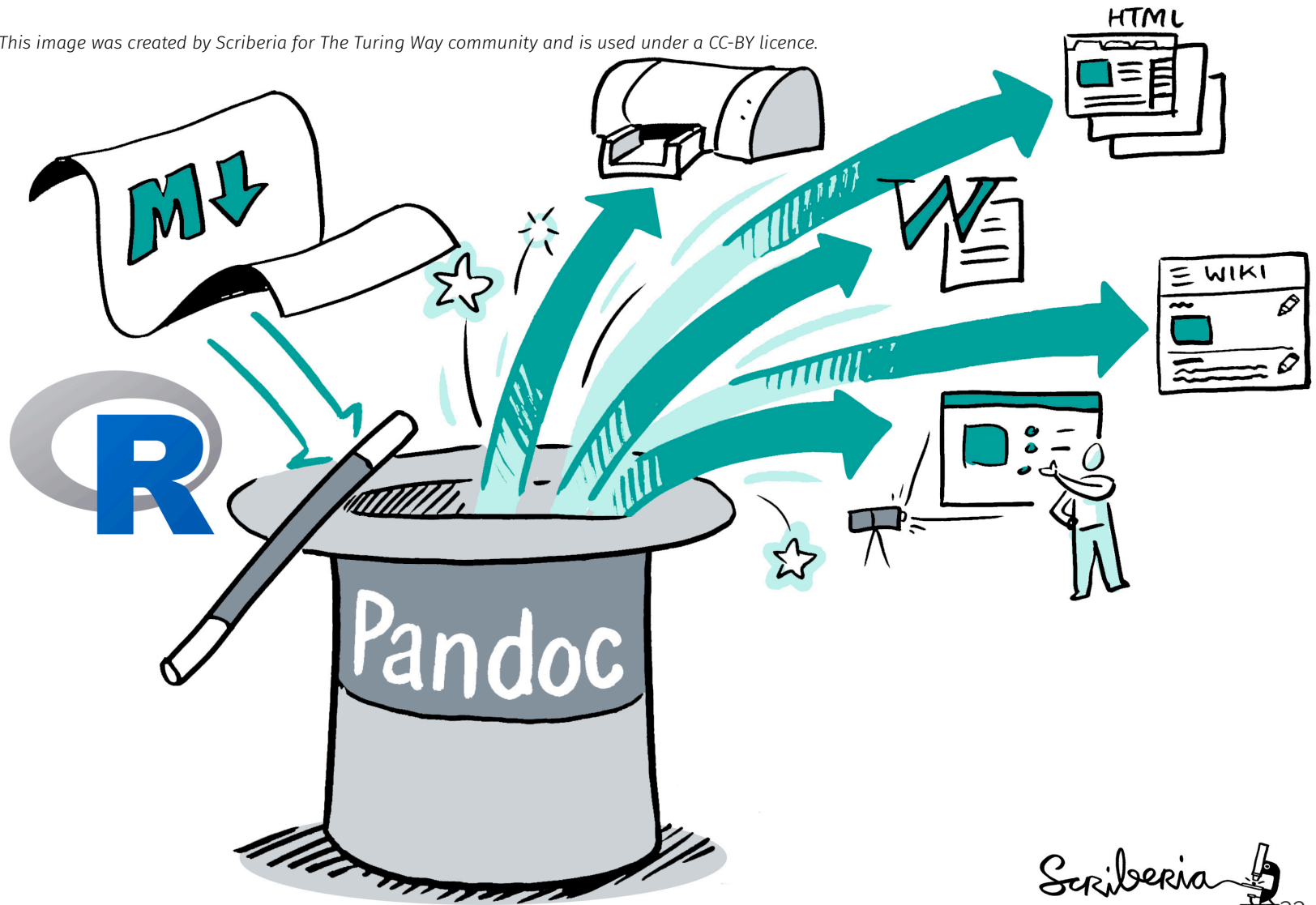
- a **documentantion** language (`.md`)
- a **programming** language (`R`)
- functionality to **"knit" them together** through  `knitr`

features

-  provides a framework for writing narratives around code and data
-  Code re-run in a clean environment every time the document is "knit"

Rmarkdown outputs

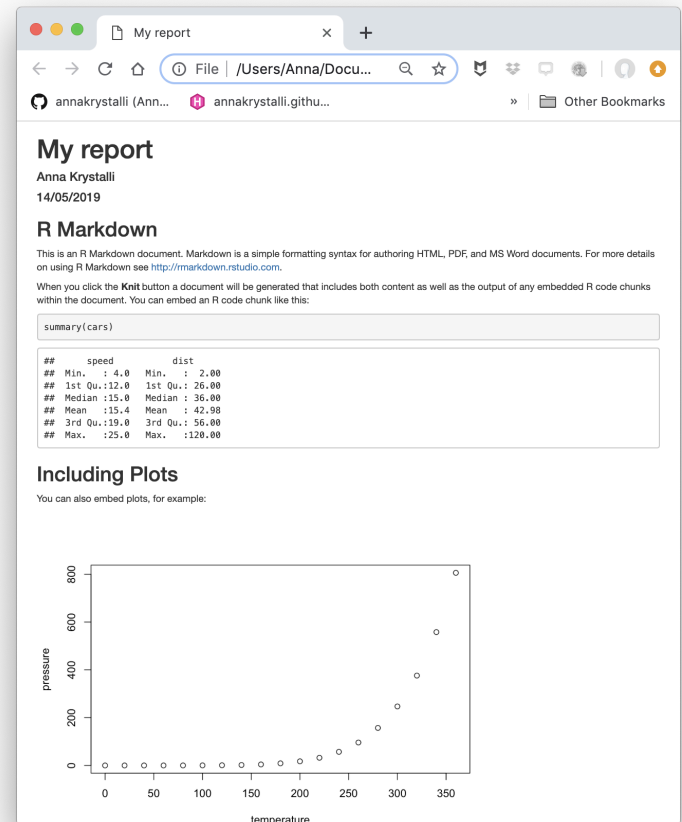
This image was created by Scriberia for The Turing Way community and is used under a CC-BY licence.



Rmarkdown to html


File > New File > RMarkdown... > Document

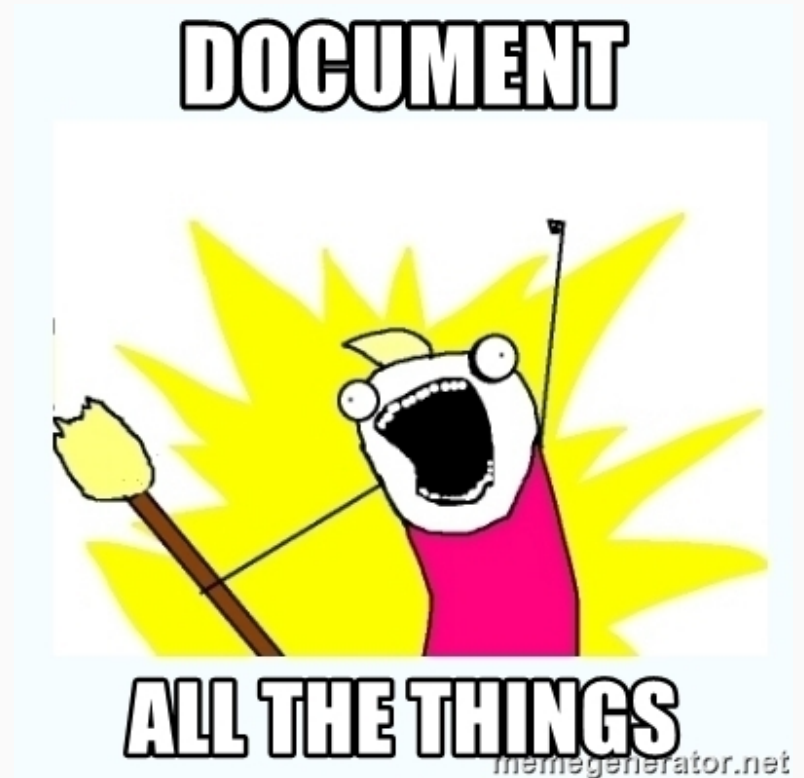
```
1 ---
2 title: "My report"
3 author: "Anna Krystalli"
4 date: "14/05/2019"
5 output: html_document
6 ---
7
8 ```{r setup, include=FALSE}
9 knitr::opts_chunk$set(echo = TRUE)
10 ```
11
12 ## R Markdown
13
14 This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML,
15 PDF, and MS Word documents. For more details on using R Markdown see
16 <http://rmarkdown.rstudio.com>.
17
18 When you click the Knit button a document will be generated that includes both content as
19 well as the output of any embedded R code chunks within the document. You can embed an R code
20 chunk like this:
21
22 ```{r cars}
23 summary(cars)
24 ```
25
26 ## Including Plots
27
28 You can also embed plots, for example:
29
30 ```{r pressure, echo=FALSE}
31 plot(pressure)
32 ```
33
34 Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the
35 R code that generated the plot.
```





Applications in research

Rmd documents can be useful for a number of research related **long form documentation** materials:

- Documentation of code & data (eg  **DataMaid**)
- Electronic Notebooks
- Supplementary materials
- Reports
- Papers



Publish to the web for free!

- **RPubs:** Publish rendered markdown documents on the web with the click of a button <http://rpubs.com/>
- **GitHub:** Host your site through  **pages** on GitHub. Enable in GitHub repo  **Settings**
- **Netlify:** Connect a repository, build your site, deploy and host for free. <https://www.netlify.com/>

GitHub Pages

GitHub Pages is designed to host your personal, organization, or project pages from a GitHub repository.

Your site is ready to be published at http://annakrystalli.me/my_awesome_project/.

Source

Your GitHub Pages site is currently being built from the master branch. [Learn more.](#)

master branch ▾

Theme Chooser

Select a theme to publish your site with a Jekyll theme. [Learn more.](#)

Choose a theme

Custom domain

Custom domains allow you to serve your site from a domain other than annakrystalli.me. [Learn more.](#)

Save

Enforce HTTPS ✓

HTTPS provides a layer of encryption that prevents others from snooping on or tampering with traffic to your site.

When HTTPS is enforced, your site will only be served over HTTPS. [Learn more.](#)

Rmarkdown extensions

Many great packages and applications build on rmarkdown.

All this makes it **incredibly versatile**.

bookdown

Create and maintain online books

Authoring with R Markdown. Offers:

- cross-references,
- citations,
- HTML widgets and Shiny apps,
- tables of content and section numbering

The publication can be exported to HTML, PDF, and e-books (e.g. EPUB)

Examples

- [rOpenSci Software Review policies](#)
- [Geocomputation in R](#)

Thesisdown

An updated R Markdown thesis template using the bookdown package

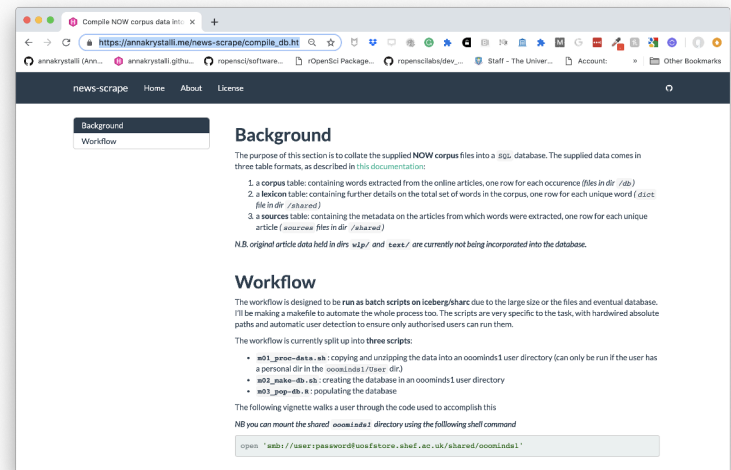
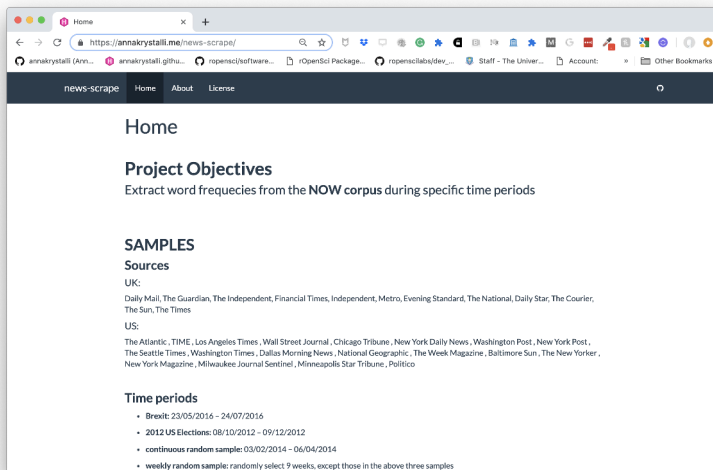
pkgdown

For building package documentation

Produce **function references** from `.Rd` files and **demonstrate function use** through long form documentation (vignettes).

Build analyses websites and organise your project

Makes it easier for researchers to organize projects and share results. Includes **checks to ensure rendered versions correspond to up to date versions of code.**



blogdown

For creating and maintaining blogs through R.

Check out <https://awesome-blogdown.com/>, a curated list of awesome #rstats blogs in **blogdown** for inspiration!

presentations

A number of existing frameworks

xaringan



Presentation Ninja 幻灯忍者 · 写轮眼

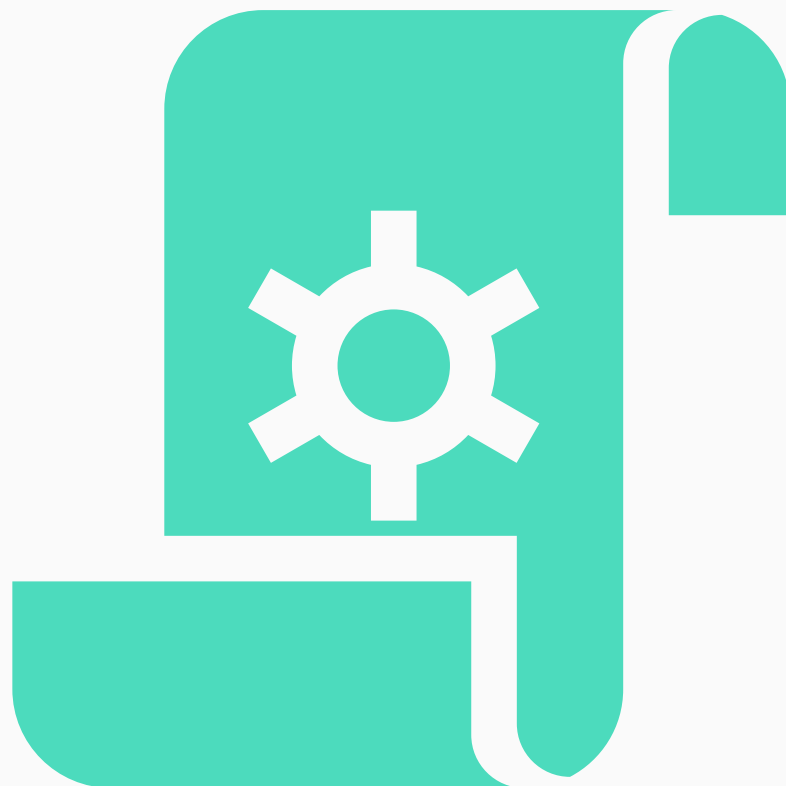


Managing code

Managing analysis code

Separate function definition and application

- When a project is new and shiny, an **analysis script usually contains many lines of directly executed code.**
- As it matures, **reusable chunks get pulled into their own functions.**
- The actual analysis scripts then become relatively short, and **functions defined in separate R scripts.**



R Package Structure

Used to share functionality with the R community

- Useful **conventions**
- Useful **software development tools**
- Easy **publishing** through GitHub



Build panel

Integrated graphical user interface

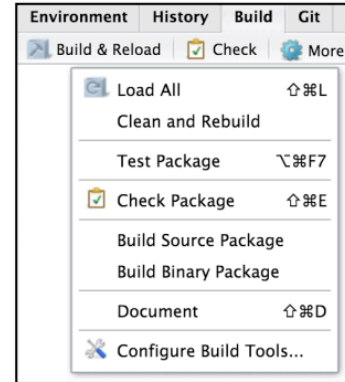
Package Writing



**File > New Project >
New Directory > R Package**

Turn project into package,
Enable roxygen documentation with
Tools > Project Options > Build Tools

Roxygen guide at
Help > Roxygen Quick Reference



R Package conventions:

- **metadata:** in the **DESCRIPTION** file
- **functions** in **.R scripts** in the **R/** folder
- **tests** in the **tests/** folder
- **Documentation:**
 - *functions* using **Roxygen notation**
 - *workflows* using **.Rmd documents** in the **vignettes/** folder

DESCRIPTION file

Package metadata

Package: gaitr

Type: Package

Title: Functions to support BMC gait analysis

Description: Helpers to analyse processed gait data.

Version: 0.0.9000

Authors@R:

```
c(person(given = "Anna",
         family = "Krystalli",
         role = c("aut", "cre"),
         email = "annakrystalli@googlemail.com"),
  person(given = "Lorenza",
         family = "Angelini",
         role = "aut",
         email = "l.angelini@sheffield.ac.uk"))
```

License: MIT + file LICENSE

citation

```
citation("gaitr")

##
## To cite package 'gaitr' in publications use:
##
##   Anna Krystalli and Lorenza Angelini (2019). gaitr: Functions to
##   support BMC gait analysis. R package version 0.1.1.
##   https://github.com/annakrystalli/gaitr
##
## A BibTeX entry for LaTeX users is
##
##   @Manual{,
##     title = {gaitr: Functions to support BMC gait analysis},
##     author = {Anna Krystalli and Lorenza Angelini},
##     year = {2019},
##     note = {R package version 0.1.1},
##     url = {https://github.com/annakrystalli/gaitr},
##   }
```


Dependency management

It's the job of the `DESCRIPTION` file to **list the packages that your code depends on**.

Imports:

```
dplyr,  
purrr,  
here,  
broom,  
tibble,  
magrittr,  
janitor,  
ggplot2
```

Suggests:

```
knitr,  
rmarkdown
```

add dependency

```
usethis::use_package("forcats", type = "Imports")
```

Functions in R/

example function script

Create a new function `.R` file in the `R/` folder

```
usethis::use_r("add")
```

```
R  
└─ add.R
```

```
0 directories, 1 files
```

Document functions with **Roxygen**

- Create help files on build (autogenerated `.Rd` files in `man/`)
- Specify which functions are exported (autogenerated `NAMESPACE`)

```
#' Add together two numbers.
#'
#' @param x A number.
#' @param y A number.
#' @return The sum of x and y.
#' @examples
#' add(1, 1)
#' add(10, 1)
add ← function(x, y) {
  x + y
}
```

tests

Tests provide confidence in what the code is doing.



Example test

```
usethis::use_test("add")
```

Creates a `tests/` folder with the following files

```
tests
├── testthat
│   └── test-add.R
└── testthat.R
```

test-add.R

```
context("test-add")

test_that("add works", {
  expect_equal(add(2, 2), 4)
})
```

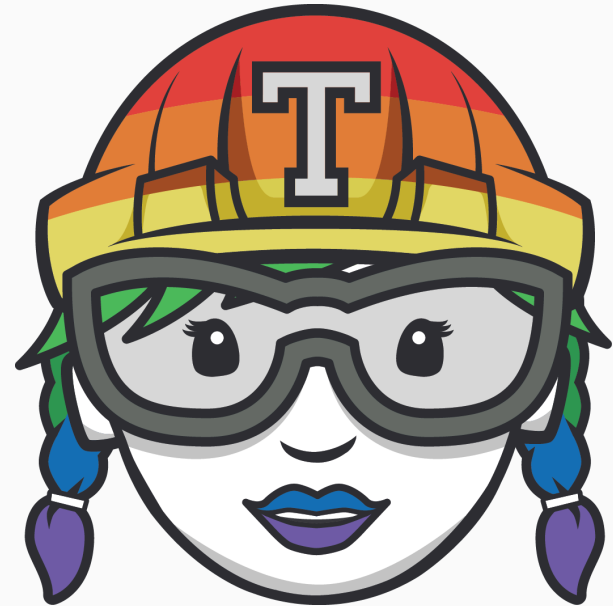
Continuous Integration w/ Travis

A cloud testing framework for automating your tests

- Monitor the effect of changes to the code
- Safe onboarding of contributions

Start with a `.travis.yml` file

```
usethis::use_travis()
```



.travis.yml

Resulting `.travis.yml` file template

```
language: R
sudo: false
cache: packages
```

instructions to enable TRAVIS CI

- ✓ Writing `'.travis.yml'`
- ✓ Adding `'^\\.travis\\.yml$'` to `'.Rbuildignore'`
- Turn on travis for your repo at <https://travis-ci.org/profile/annakrystalli>
- Copy and paste the following lines into `'/Users/Anna/Documents/workflows/talks/README.md'`

```
[![Travis build status](https://travis-ci.org/annakrystalli/talks.svg?branch=master)](ht
```

Continuous Integration w/ GitHub

You can now run Continuous Integration on GitHub! See Jim Hester's rstudio conf 2020 talk on [Azure Pipelines and GitHub Actions](#)

- `usethis::use_github_action_check_release()`: installs the **latest release R** version on **macOS** and runs `R CMD check` via the `rcmdcheck` package.
- `usethis::use_github_action_check_standard()`: runs `R CMD check` on the **three major OSs** (linux, macOS and Windows) on the **release version of R and R-devel**.
- `usethis::use_github_action_check_full()`: installs the **last 5 minor R versions** and runs `R CMD check` on the **three major OSs** (linux, macOS and Windows).

All github actions added to `.github/workflows` directory of a package.

Tips on Tests and CI

Use other R package tests & CI configurations as inspiration

- Look in `tests/` for ideas on suitable tests.
- Look at CI configuration files (eg `travis.yml` or files in `.github/workflows`) to set up testing environment.

Research compendia

A Research compendium

The paper is the advertisement

“an article about computational result is advertising, not scholarship. The **actual scholarship is the full software environment, code and data, that produced the result.**”

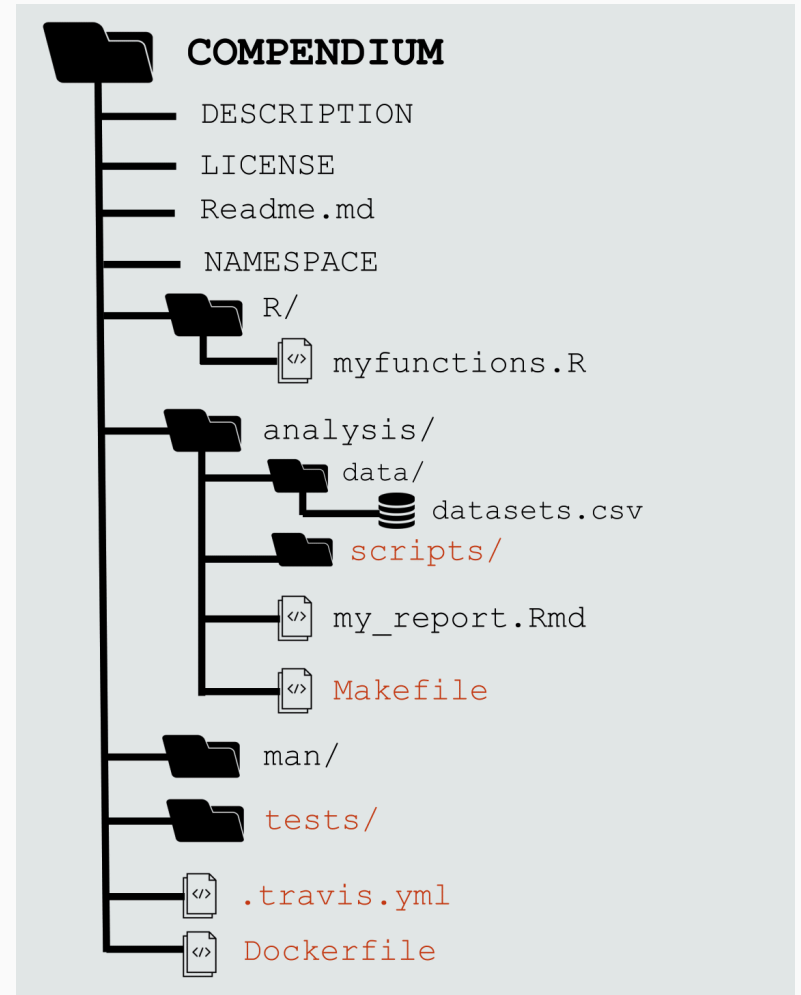
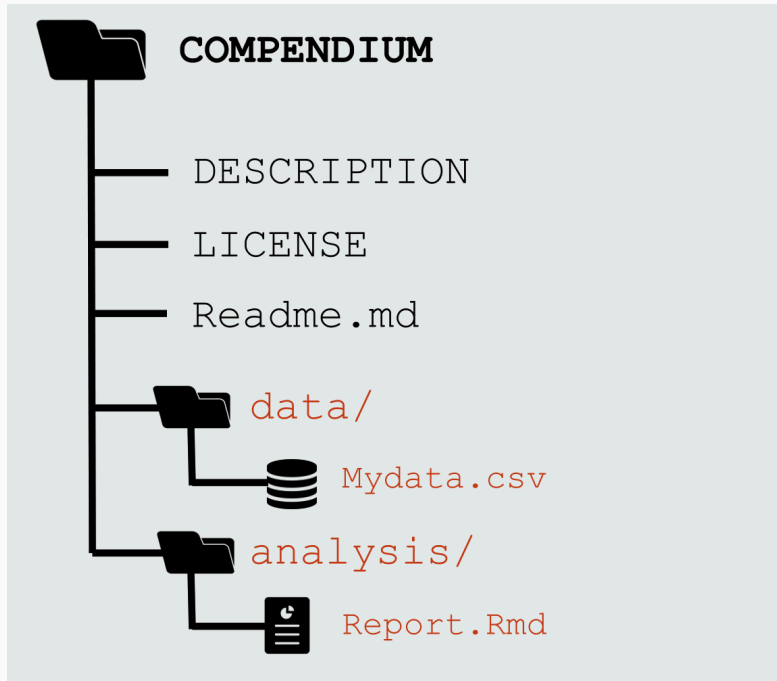
John Claerbout paraphrased in *Buckheit and Donoho (1995)*

The concept of a Research Compendium

“ ...We introduce the **concept of a compendium** as both a **container for the different elements** that make up the document and its computations (i.e. text, code, data, ...), and as a **means for distributing, managing and updating the collection.**”

Gentleman and Temple Lang, 2004

Research compendia in R



Example compendium

Paper:

Boettiger, C. (2018) *From noise to knowledge: how randomness generates novel phenomena and reveals information.*

<https://doi.org/10.1111/ele.13085>

Compendium

cboettig/noise-phenomena: Supplement to: "From noise to knowledge: how randomness generates novel phenomena and reveals information"

<http://doi.org/10.5281/zenodo.1219780>

The screenshot shows a GitHub repository page for 'cboettig/noise-phenomena'. The repository is titled 'Ecology Letters review paper: Noise-driven phenomena in population biology' and includes tags for 'research-compendium', 'reproducible-research', 'ecology', and 'stochasticity'. It has 119 commits, 2 branches, 4 releases, and 2 contributors. The repository is licensed under CC-BY-4.0. The file list includes:

| File | Description | Last Commit |
|-----------------------|---|-------------|
| appendixA | submitted revisions | a year ago |
| appendixB | submitted 2nd revisions | a year ago |
| paper | submitted 2nd revisions | a year ago |
| reviews | submitted 2nd revisions | a year ago |
| .Rbuildignore | Revisions in progress | a year ago |
| .drone.yml | remotes must still be listed in deps/import/suggests | 2 years ago |
| .gitignore | ignore list | a year ago |
| .travis.yml | install first | 2 years ago |
| DESCRIPTION | WIP: brief mentions of empirical work; a bit on tipping point / inform... | a year ago |
| Dockerfile | streamline travis | 2 years ago |
| README.md | fix FROM line, add badge | 2 years ago |
| noise-phenomena.Rproj | submitted revisions | a year ago |

rrtools: Creating Compendia in R

"The goal of rrttools is to provide **instructions, templates, and functions** for making a **basic compendium** suitable for writing **reproducible research with R.**"

Install **rrtools** from GitHub

```
# install.packages("devtools")  
devtools::install_github("benmarwick/rrtools")
```

Create compendium

```
rrtools::create_compendium("~/Documents/workflows/rrcompendium")
```

- ✓ Setting active project to '/Users/Anna/Documents/workflows/rrcompendium'
- ✓ Creating 'R/'
- ✓ Creating 'man/'
- ✓ Writing 'DESCRIPTION'
- ✓ Writing 'NAMESPACE'
- ✓ Writing 'rrcompendium.Rproj'
- ✓ Adding '.Rproj.user' to '.gitignore'
- ✓ Adding '^rrcompendium\\.Rproj\$', '^\\.Rproj\\.user\$' to '.Rbuildignore'
- ✓ Opening new project 'rrcompendium' in RStudio
- ✓ The package rrcompendium has been created
- ✓ Opening the new compendium in a new RStudio session...

Next, you need to: ↓ ↓ ↓

- Edit the DESCRIPTION file
- Use other 'rrtools' functions to add components to the compendium

Prepare for GitHub

```
rrtools::use_readme_rmd()
```

- ✓ Creating 'README.Rmd' from template.
- ✓ Adding 'README.Rmd' to ``.Rbuildignore``.
- Modify 'README.Rmd'
- ✓ Rendering README.Rmd to README.md for GitHub
- ✓ Adding code of conduct.
- ✓ Creating 'CONDUCT.md' from template.
- ✓ Adding 'CONDUCT.md' to ``.Rbuildignore``.
- ✓ Adding instructions to contributors.
- ✓ Creating 'CONTRIBUTING.md' from template.
- ✓ Adding 'CONTRIBUTING.md' to ``.Rbuildignore``.

rrcompendium

This repository contains the data and code for our reproduction paper:

Krystalli, A. (2018). *Partial Reproduction of Boettiger Ecology Letters 2018;21:1255–1267 with rrtools*.
<https://doi.org/DOI-to-paper>

Our reproduction pre-print is online here:

Krystalli, A. (2018). *Partial Reproduction of Boettiger Ecology Letters 2018;21:1255–1267 with rrtools*, Accessed 27 Nov 2018. Online at <https://doi.org/DOI-to-compendium>

How to cite

Please cite this compendium as:

Krystalli, A. (2018). *Compendium of R code and data for 'Partial Reproduction of Boettiger Ecology Letters 2018;21:1255–1267 with rrtools'*. Accessed 27 Nov 2018. Online at <https://doi.org/DOI-to-compendium>

How to download or install

You can download the compendium as a zip from from this URL:
<https://github.com/annkrystalli/rrcompendium/archive/master.zip>

Or you can install this compendium as an R package, `rrcompendium`, from GitHub with:

Licenses

Text and figures : [CC-BY-4.0](#) Copyright (c) 2018 Carl Boettiger.

Code : See the [DESCRIPTION](#) file

Data : [CC-BY-4.0](#), Copyright (c) 2018 Carl Boettiger.

Contributions

We welcome contributions from everyone. Before you get started, please see our [contributor guidelines](#). Please note that this project is released with a [Contributor Code of Conduct](#). By participating in this project you agree to abide by its terms.

Create analysis folder

```
rrtools::use_analysis()
```

- ✓ Adding bookdown to Imports
- ✓ Creating 'analysis' directory and contents
- ✓ Creating 'analysis'
- ✓ Creating 'analysis/paper'
- ✓ Creating 'analysis/figures'
- ✓ Creating 'analysis/templates'
- ✓ Creating 'analysis/data'
- ✓ Creating 'analysis/data/raw_data'
- ✓ Creating 'analysis/data/derived_data'
- ✓ Creating 'references.bib' from template.
- ✓ Creating 'paper.Rmd' from template.

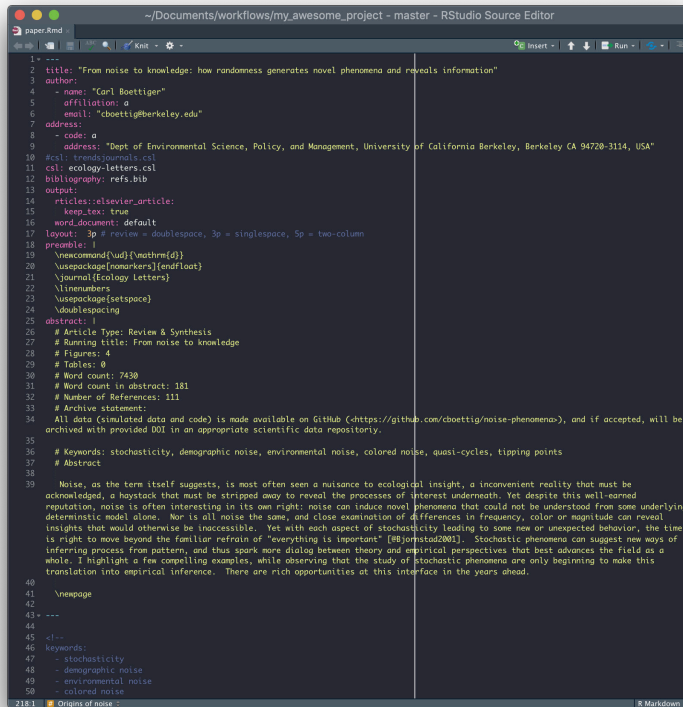
Next, you need to: ↓ ↓ ↓ ↓

- Write your article/report/thesis, start at the paper.Rmd file
- Add the citation style library file (csl) to replace the default provided here, see <https://bookdown.org/yihui/bookdown/csl.html>
- Add bibliographic details of cited items to the 'references.bib' file
- For adding captions & cross-referencing in an Rmd, see <https://bookdown.org/yihui/bookdown/cross-referencing.html>
- For adding citations & reference lists in an Rmd, see http://rmarkdown.rstudio.com/authoring_bibliographies.html

paper.Rmd to paper.pdf

Rmd

pdf



```
1 ---
2 title: "From noise to knowledge: how randomness generates novel phenomena and reveals information"
3 author:
4   - name: "Carl Boettiger"
5     affiliation: a
6     email: "cboettig@berkeley.edu"
7 address:
8   - codes: a
9     address: "Dept of Environmental Science, Policy, and Management, University of California Berkeley, Berkeley CA 94720-3114, USA"
10 #col: trends/journals.csl
11 csl: ecology-letters.csl
12 bibliography: refs.bib
13 output:
14   rticles: classier_article:
15     keep_tex: true
16 word_document: default
17 layout: Sp # review = doublespace, Sp = singlespace, Sp = two-column
18 preface: |
19   \vsecommand{\uad}{\mathrme{d}}
20 \usepackage[nomarkers]{endfloat}
21 \journal[Ecology Letters]
22 \linenumbers
23 \usepackage[setspace]
24 \doublespacing
25 abstract: |
26 # Article Type: Review & Synthesis
27 # Running title: From noise to knowledge
28 # Figures: 4
29 # Tables: 0
30 # Word count: 7430
31 # Word count in abstract: 181
32 # Number of References: 111
33 # Archive statement:
34 All data (simulated data and code) is made available on GitHub (<https://github.com/cboettig/noise-phenomena>), and if accepted, will be
35 archived with provided DOI in an appropriate scientific data repository.
36 # Keywords: stochasticity, demographic noise, environmental noise, colored noise, quasi-cycles, tipping points
37 # Abstract
38 Noise, as the term itself suggests, is most often seen a nuisance to ecological insight, a inconvenient reality that must be
39 acknowledged, a hoystack that must be stripped away to reveal the processes of interest underneath. Yet despite this well-earned
40 reputation, noise is often interesting in its own right: noise can induce novel phenomena that could not be understood from some underlying
41 deterministic model alone. Not is all noise the same, and close examination of differences in frequency, color or magnitude can reveal
42 insights that would otherwise be inaccessible. Yet with each aspect of stochasticity leading to some new or unexpected behavior, the time
43 is right to move beyond the familiar refrain of "everything is important" [EBJornstad2001]. Stochastic phenomena can suggest new ways of
44 inferring process from pattern, and thus spark more dialog between theory and empirical perspectives that best advances the field as a
45 whole. I highlight a few compelling examples, while observing that the study of stochastic phenomena are only beginning to make this
46 translation into empirical inference. There are rich opportunities at this interface in the years ahead.
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```

Capturing dependencies

```
rrtools::add_dependencies_to_description()
```

Imports:

```
bookdown,  
ggplot2 (≥ 3.0.0),  
ggthemes (≥ 3.5.0),  
here (≥ 0.1),  
knitr (≥ 1.20),  
rticles (≥ 0.6)
```

Further Helpers



rarticles

Contains a **suite of custom R Markdown templates for popular journals**, simplifying the creation of documents that conform to research paper submission standards.

Reproducible Computational Environments

Why isn't sharing code enough?

Case Study: Sharing a Geospatial Analysis in R

On a computer without System Library GDAL ✘

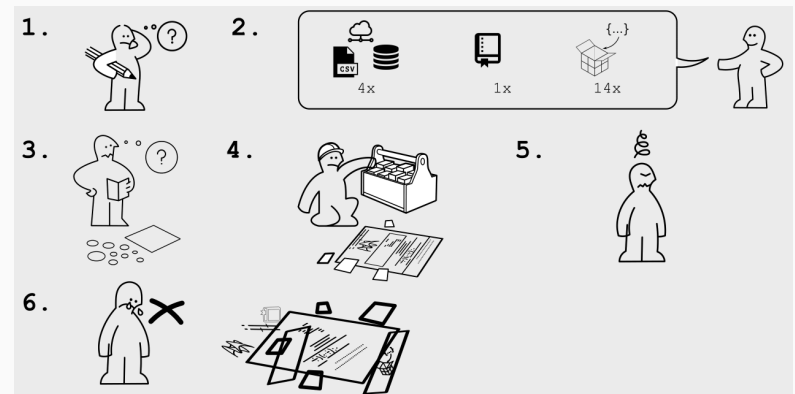
```
package 'rgdal' successfully unpacked  
and MD5 sums checked
```

```
configure: gdal-config: gdal-config  
checking gdal-config usability... ./conf  
line 1353: gdal-config: command not found  
no
```

```
Error: gdal-config not found
```

```
...
```

```
ERROR: configuration failed for  
package 'rgdal'
```



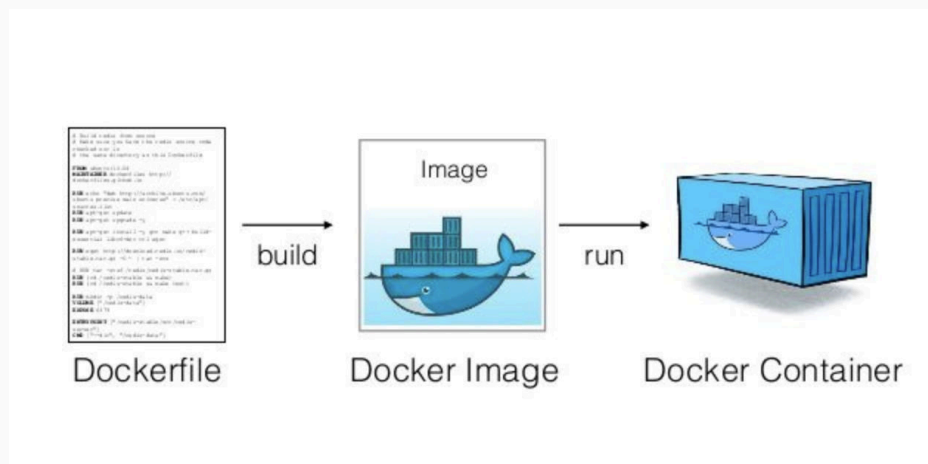
slide: **Karthik Ram: rstudio::conf 2019 talk**

What are Docker containers?

standardized units of software

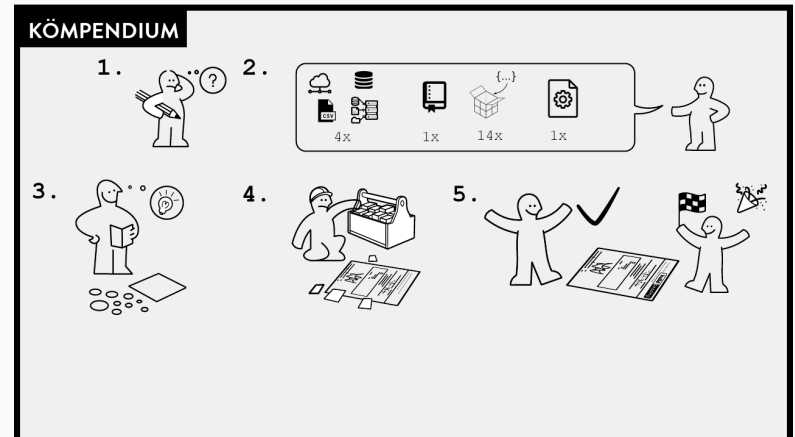
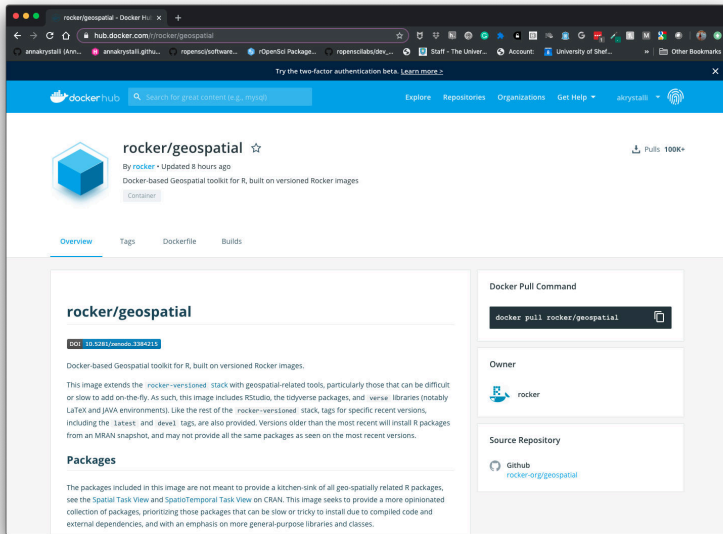
package up everything needed to run an application: *code, runtime, system tools, system libraries* and settings in a lightweight, standalone, executable package

- **Dockerfile:** Text file containing recipe for setting up computation environment.
- **Docker Image:** Executable **built** from the **Dockerfile** with all required dependencies installed. Can have many images from the same Dockerfile.
- **Docker Container:** **Docker Images** become containers at **runtime**



Rocker on DockerHub

using the `rocker/geospatial` Docker Image ✓



slide: **Karthik Ram: rstudio::conf 2019 talk**

Create Dockerfile w/ `rrtools`

```
rrtools::use_dockerfile()
```

- ✓ Creating 'Dockerfile' from template.
- ✓ Adding 'Dockerfile' to ``.Rbuildignore``.
- Modify

Next:

- * Edit the dockerfile with your name & email
- * Edit the dockerfile to include system dependencies, such as linux libraries that are needed for the R environment
- * Check the last line of the dockerfile to specify which Rmd should be rendered in the container

Dockerfile

```
# get the base image, the rocker/verse has R, RStudio and pandoc
FROM rocker/verse:3.6.0

# required
MAINTAINER Anna Krystalli <annakrystallil@googlemail.com>

COPY . /rrcompendiumDTB

# go into the repo directory
RUN . /etc/environment \
    # Install linux dependencies here
    # e.g. need this for ggforce::geom_sina
    && sudo apt-get update \
    && sudo apt-get install libudunits2-dev -y \
    # build this compendium package
    && R -e "devtools::install('/rrcompendiumDTB', dep=TRUE)" \
    # render the manuscript into a docx, you'll need to edit this if you've
    # customised the location and name of your main Rmd file
    && R -e "rmarkdown::render('/rrcompendiumDTB/analysis/paper/paper.Rmd')"
```

Docker + Travis

Create `.travis.yml`

```
rrtools::use_travis()
```

- ✓ Creating `'.travis.yml'` from template.
- ✓ Adding `'.travis.yml'` to ``.Rbuildignore``.

Next:

- * Add a travis shield to your README.Rmd:
[![Travis-CI Build Status](https://travis-ci.org/annakrystalli/rrcompendiumDTB.svg?branch=)]
- * Turn on travis **for** your repo at <https://travis-ci.org/annakrystalli/rrcompendiumDTB>
- * To connect Docker, go to <https://travis-ci.org/>, and add your environment variables: `DOCKER_EMAIL`, `DOCKER_USER`, `DOCKER_PASS` to enable pushing to the Docker Hub

.travis.yml

```
env:  
  global:  
    - REPO=$DOCKER_USER/rrcompendiumdtb  
  
sudo: required  
  
warnings_are_errors: false  
  
language: generic  
  
services:  
  - docker  
  
before_install:  
  - docker build -t $REPO .
```

Create & build image using dockerfile, i.e. compile pkg and render Rmd to Word doc

.travis.yml

Push our custom docker image to docker hub, env vars stored on travis-ci.org





after_success:

```
- docker login -u $DOCKER_USER -p $DOCKER_PASS
- export REPO=$DOCKER_USER/rrcompendiumdtb
- export TAG=`if [ "$TRAVIS_BRANCH" = "master" ]; then echo "latest"; else echo $TRAVIS_BRANCH; fi`
- docker build -f Dockerfile -t $REPO:$COMMIT .
- docker tag $REPO:$COMMIT $REPO:$TAG
- docker tag $REPO:$COMMIT $REPO:travis-$TRAVIS_BUILD_NUMBER
- docker push $REPO
```

Travis repository settings

Environment Variables

Customize your build using environment variables. For secure tips on generating private keys [read our documentation](#)

| | | | |
|-------------|---|---------------------------|---|
| DOCKER_PASS |  | Available to all branches |  |
| DOCKER_USER |  | Available to all branches |  |

Travis build passes!

 annakrystalli / rrcompendiumDTB  build passing

[Current](#) [Branches](#) [Build History](#) [Pull Requests](#)

More options 

✓ **master** correct compendium name on README

🔄 #12 passed

🔄 Restart build

🔄 Commit 90157b3 [↗](#)

🕒 Ran for 5 min 25 sec

🔄 Compare 3ea62f9..90157b3 [↗](#)

📅 about 2 hours ago

🔄 Branch master [↗](#)

 Anna Krystalli

 </> no language set

 AMD64

build passing

Image on Dockerhub



akrystalli [Edit profile](#)

Community User

Joined November 7, 2015

Repositories

Starred

Contributed

Displaying 3 of 3 repositories



akrystalli/rrcompendiumdtb

By **akrystalli** • Updated a few seconds ago

Container

1
Download

Docker Image: <https://hub.docker.com/repository/docker/akrystalli/rrcompendiumdtb>

Compendium Repository: <https://github.com/annakrystalli/rrcompendiumDTB>

Working with the Docker Image

Pull it from Dockerhub.

```
docker pull akrySTALLI/rrcompendiumdtb:latest
```

Run in Rstudio in your browser

More on [using the RStudio image](#)

```
docker container run -e PASSWORD=<password> -e USERID=$UID -p  
8787:8787 --detach --name rrcompendiumdtb  
akrySTALLI/rrcompendiumdtb:latest
```

Binder

What is binder? <https://mybinder.org/>

Thanks to [Google Cloud](#), [OVH](#) and [GESIS Notebooks](#) for supporting us 🙌!

Give it a repo url

→
SOON

Launch computational environment! 🤖

Turn a Git repo into a collection of interactive notebooks

Have a repository full of Jupyter notebooks? With Binder, open those notebooks in an executable environment, making your code immediately reproducible by anyone, anywhere.

Build and launch a repository

GitHub repository name or URL

 GitHub ▾

Git branch, tag, or commit

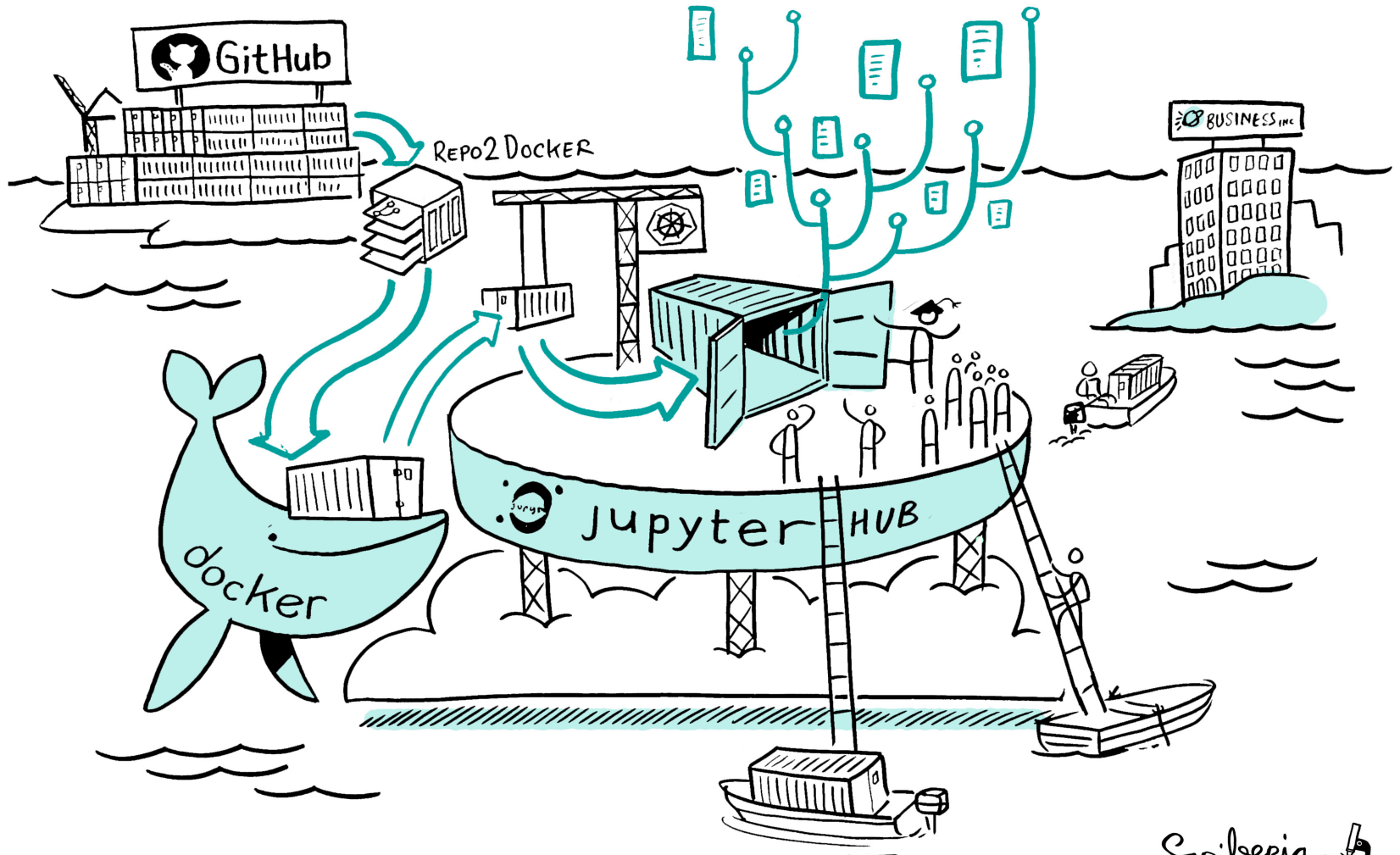
 📄

Path to a notebook file (optional)

 File ▾ launch 📄

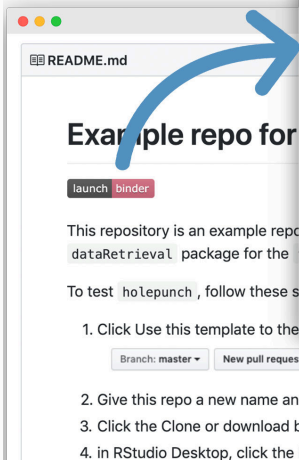
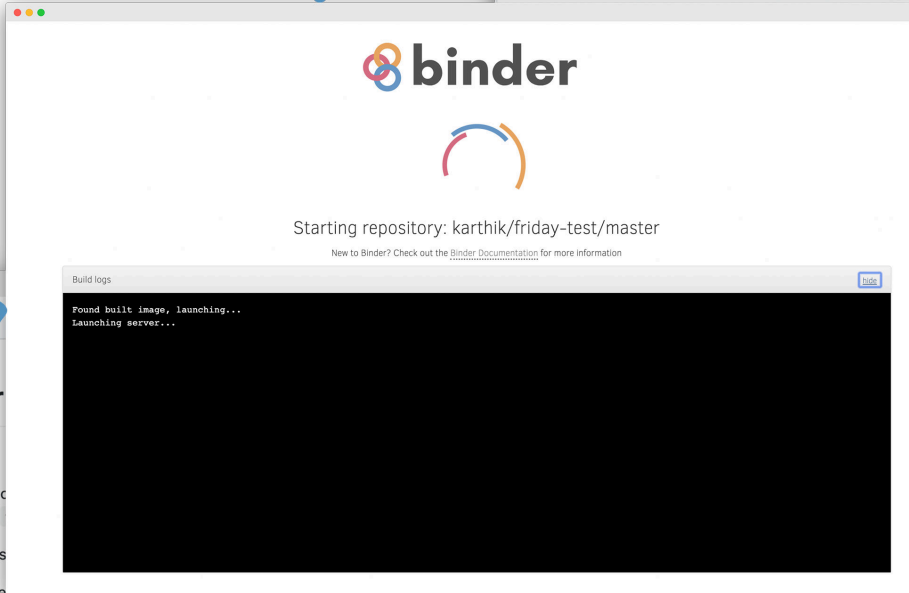
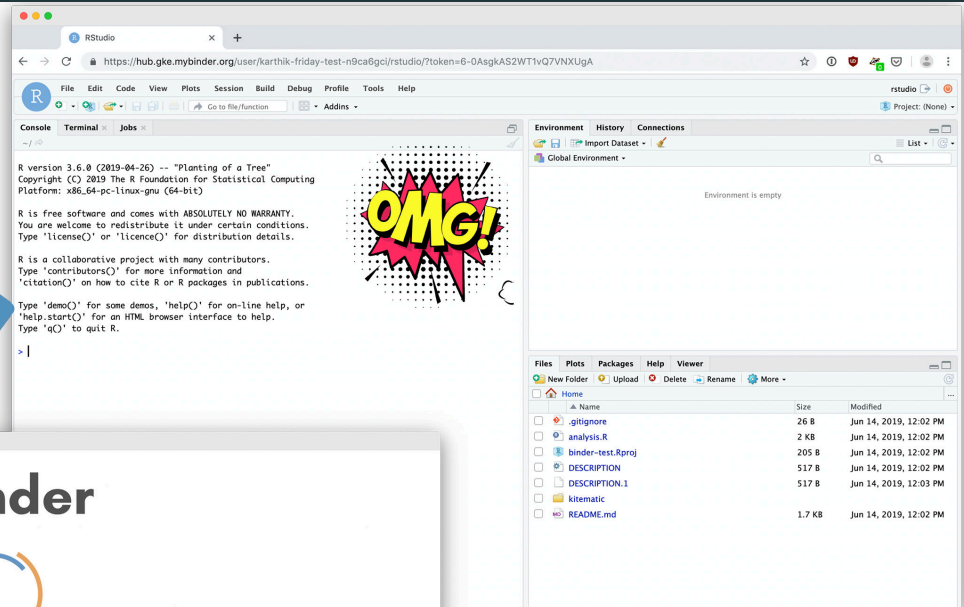
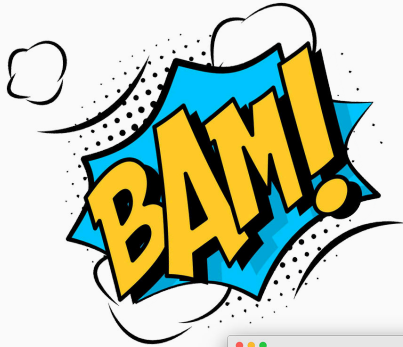
Binderhub Ecosystem

This image was created by Scriberia for The Turing Way community and is used under a CC-BY licence.



Scriberia 




Binder for R



1. Click Use this template to the left of Clone or download.
2. Give this repo a new name and create a new repo in your account
3. Click the Clone or download button, copy the URL.
4. in RStudio Desktop, click the Project drop down on the top right, Choose **New Project > Version Control > Git**, and

R repository options for Binder

slide: **Karthik Ram: rstudio::conf 2019 talk**

| Basic <i>free</i> | Premium <i>free</i> | Pro <i>free</i> |
|---|--|---|
| <i>install.r</i> <i>runtime.txt</i> <i>apt.txt</i> | <i>Dockerfile</i> <i>install.r</i> | <i>Dockerfile</i> DESCRIPTION |
| Slow but easy to setup. Recommended for beginners | Faster launch | Best for compendia |
|  |  |  |

Binderise your R projects w/ holepunch

<https://github.com/karthik/holepunch>

```
remotes::install_github("karthik/holepunch")
```

Create `.binder/Dockerfile`

```
holepunch::write_dockerfile(maintainer = "Anna Krystalli")
```

- Setting R version to 3.6.0
- Locking packages down at 2019-11-09
- ✓ Dockerfile generated at `./.binder/Dockerfile`

.binder/Dockerfile

```
FROM rocker/binder:3.6.0
LABEL maintainer='Anna Krystalli'
USER root
COPY . ${HOME}
RUN chown -R ${NB_USER} ${HOME}
USER ${NB_USER}

RUN wget https://github.com/annakrystalli/rrcompendiumDTB/raw/master/DESCRIPTION && R
devtools::install_deps(); devtools::install(); tinytex::install_tinytex()"

RUN rm DESCRIPTION.1; exit 0
```


Add binder **README** badge

```
holepunch::generate_badge()
```

- Copy and paste the following lines into `'/Users/Anna/Documents/workflows/compendia/1`
`[![Launch Rstudio Binder](http://mybinder.org/badge_logo.svg)](https://mybinder.org,`
`[Copied to clipboard]`



README.md

rrcompendiumDTB

build passing 

This repository contains the data and code for our reproduction paper:

Krystalli, A, (2018). *Partial Reproduction of Boettiger Ecology Letters 2018;21:1255–1267 with rrtools*.
<https://doi.org/{DOI-to-paper}>

Our reproduction pre-print is online here:

Krystalli, A, (2018). *Partial Reproduction of Boettiger Ecology Letters 2018;21:1255–1267 with rrtools*, Accessed 09 Nov 2019. Online at <https://doi.org/{DOI-to-compendium}>

Launched Binderised Compendium

The screenshot displays the RStudio interface within a web browser (hub.gke.mybinder.org). The left pane shows the R Markdown source code for 'paper.Rmd', with the 'Knit' button highlighted. The middle pane shows a PDF viewer displaying the rendered document, including the title 'From noise to knowledge: how randomness generates novel phenomena and reveals information', author 'Carl Boettiger', and an abstract. The right pane shows the RStudio environment with a file browser and a table of files.

```
1 ---
2 title: "From noise to knowledge: how randomness generates
3 author:
4   - name: "Carl Boettiger"
5     affiliation: a
6     email: "cboettig@berkeley.edu"
7 address:
8   - code: a
9     address: "Dept of Environmental Science, Policy, and
10 Berkeley CA 94720-3114, USA"
11 bibliography: refs.bib
12 layout: 3p # review = doublespace, 3p = singlespace, 5p
13 preamble: |
14   \usepackage[nomarkers]{float}
15   \linenumbers
16   \usepackage[setspace]
17   \doublespacing
18 abstract: |
19
20 # Abstract
21
22 Noise, as the term itself suggests, is most often seen
23 reality that must be acknowledged, a haystack that must
24 underneath. Yet despite this well-earned reputation, noise
25 induce novel phenomena that could not be understood from
26 all noise the same, and close examination of differences
```

From noise to knowledge: how randomness generates novel phenomena and reveals information

Carl Boettiger^a

^aDept of Environmental Science, Policy, and Management, University of California Berkeley, Berkeley CA 94720-3114, USA

Abstract

Noise, as the term itself suggests, is most often seen a nuisance to ecological insight, an inconvenient reality that must be acknowledged, a haystack that must be stripped away to reveal the processes of interest underneath. Yet despite this well-earned reputation, noise is often interesting in its own right: noise can induce novel phenomena that could not be understood from some underlying deterministic model alone. Nor is all noise the same, and close examination of differences in frequency, color or magnitude can reveal insights that would otherwise be inaccessible. Yet with each aspect of stochasticity leading to some new or unexpected behavior, the time is right to move beyond the familiar refrain of "everything is important" (Bjornstad and Grenfell 2001). Stochastic phenomena can suggest new ways of inferring process from pattern, and thus spark more dialog between theory and (Abbot 2011) perspectives that best advances the field as a whole. I highlight a few compelling examples, while observing that the study of stochastic phenomena are only beginning to make this translation into empirical inference. There are rich opportunities at this interface in the years ahead.

Email address: cboettig@berkeley.edu (Carl Boettiger)
Preprint submitted to Elsevier
November 9, 2019

| | Size | Modified |
|--|----------|----------------------|
| | 21.6 KB | Nov 9, 2019, 1:53 PM |
| | 603 B | Nov 9, 2019, 1:53 PM |
| | 6 KB | Nov 9, 2019, 1:53 PM |
| | 512 B | Nov 9, 2019, 2:00 PM |
| | 308.8 KB | Nov 9, 2019, 2:00 PM |
| | 13.4 KB | Nov 9, 2019, 1:53 PM |
| | 0 B | Nov 9, 2019, 2:00 PM |
| | 18.2 KB | Nov 9, 2019, 1:59 PM |
| | 53.8 KB | Nov 9, 2019, 1:53 PM |

Reproducibility in Practice

ReproHacks

one day reproducibility hackathons

Mission: Reproduce papers from code and data

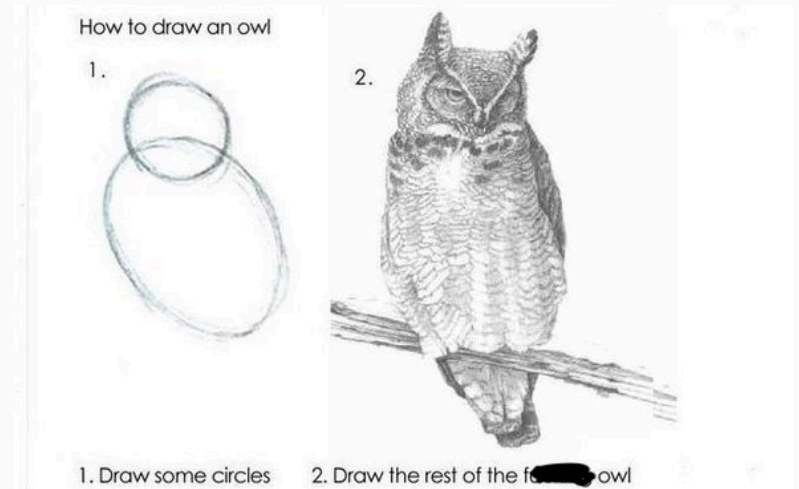
- Record experiences and feedback to authors
- Available soon: Publish Reproducibility Report in ReScience C



ReproHack Benefits

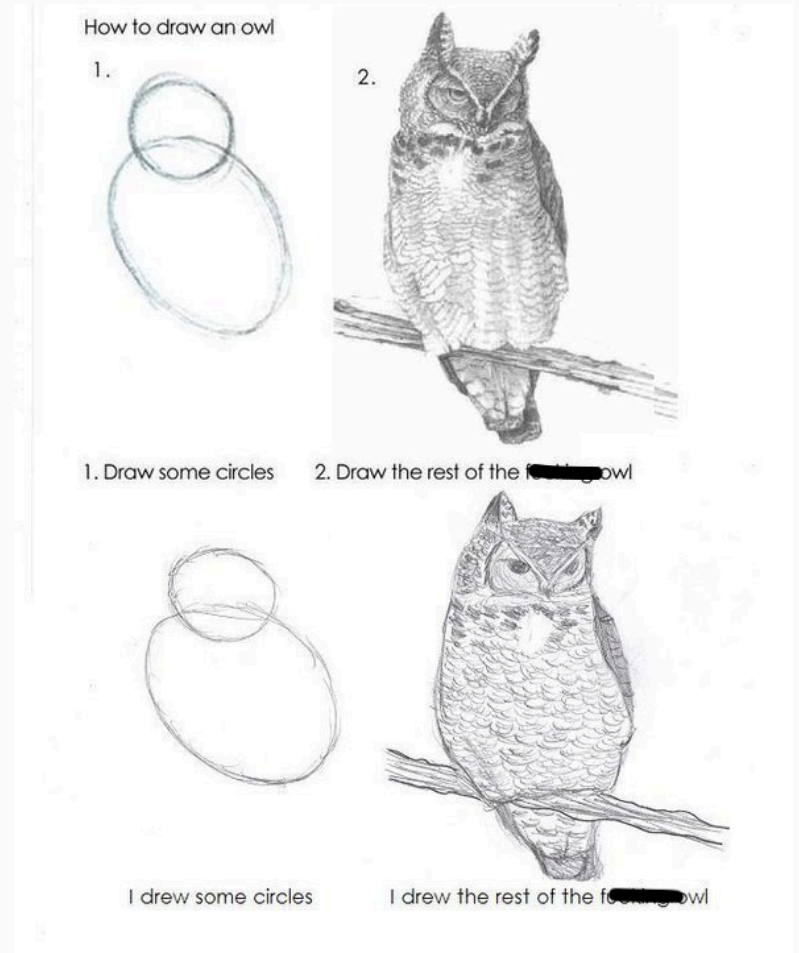
Participants

1. Practical reproducibility they can implement in their own work



Participants

1. Practical reproducibility they can implement in their own work



Participants

1. Practical reproducibility they can implement in their own work
2. Inspiration from working with other people's code and data.

CHIBIRD

Participants

1. Practical reproducibility they can implement in their own work
2. Inspiration from working with other people's code and data.
3. Reproduction as community value



Authors

1. Useful feedback on the reproducibility of their work

OpenCon ReproHack feedback form

Name of participant

Anna Krystalli, Marios Georgiou

Which paper did you attempt? *

Paper #3. The archaeology, chronology and stratigraphy of Madjedbebe (Malakunanja II): a site in northern Australia with early occupation

Team issue URL *

https://github.com/OpenCon-London/OpenCon_London-Doathon/issues/4

Did you manage to reproduce it? *

- Yes
 No
 Almost

On a scale of 1 to 10, how much of the paper did you manage to reproduce? *

1 2 3 4 5 6 7 8 9 10
None of it All of it

Authors

1. Useful feedback on the reproducibility of their work
2. Appreciation for their efforts in making their work reproducible



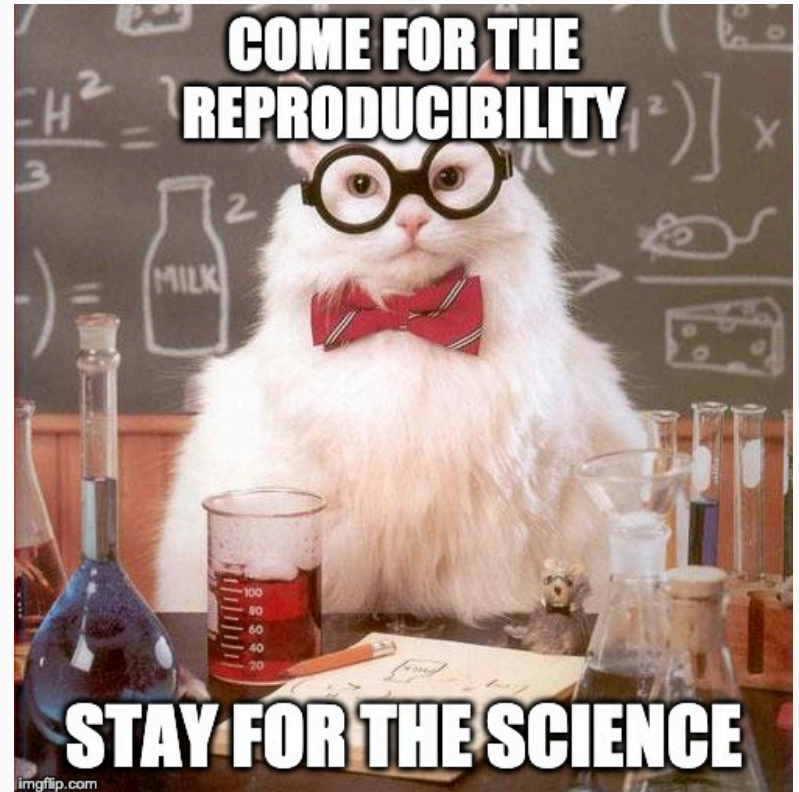
Authors

1. Useful feedback on the reproducibility of their work
2. Appreciation for their efforts in making their work reproducible

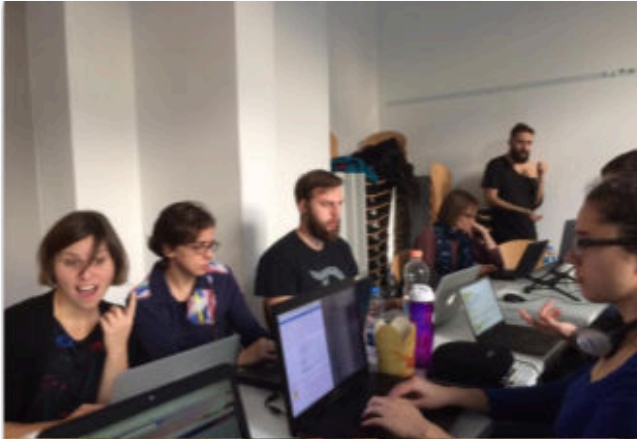


Authors

1. Useful feedback on the reproducibility of their work
2. Appreciation for their efforts in making their work reproducible
3. An opportunity to engage others with their research.



Reproducing papers is fun!!



Huge thanks to [@EnviroKaty](#) for submitting a fab 🦋 🦋 🦋 paper to the [#CCMcr19](#) [#ReproHack](#)! I had loads of fun reproducing the analysis for this really cool paper

<https://t.co/v1ww2D5xhg>
pic.twitter.com/r8rYMAMvPm


— Jessica Ward (@JKRWard)

[June 27, 2019](#)

Upcoming ReproHacks!

This thing is really happening!

pic.twitter.com/d2xnHNo9z2

— ReproHack NL 

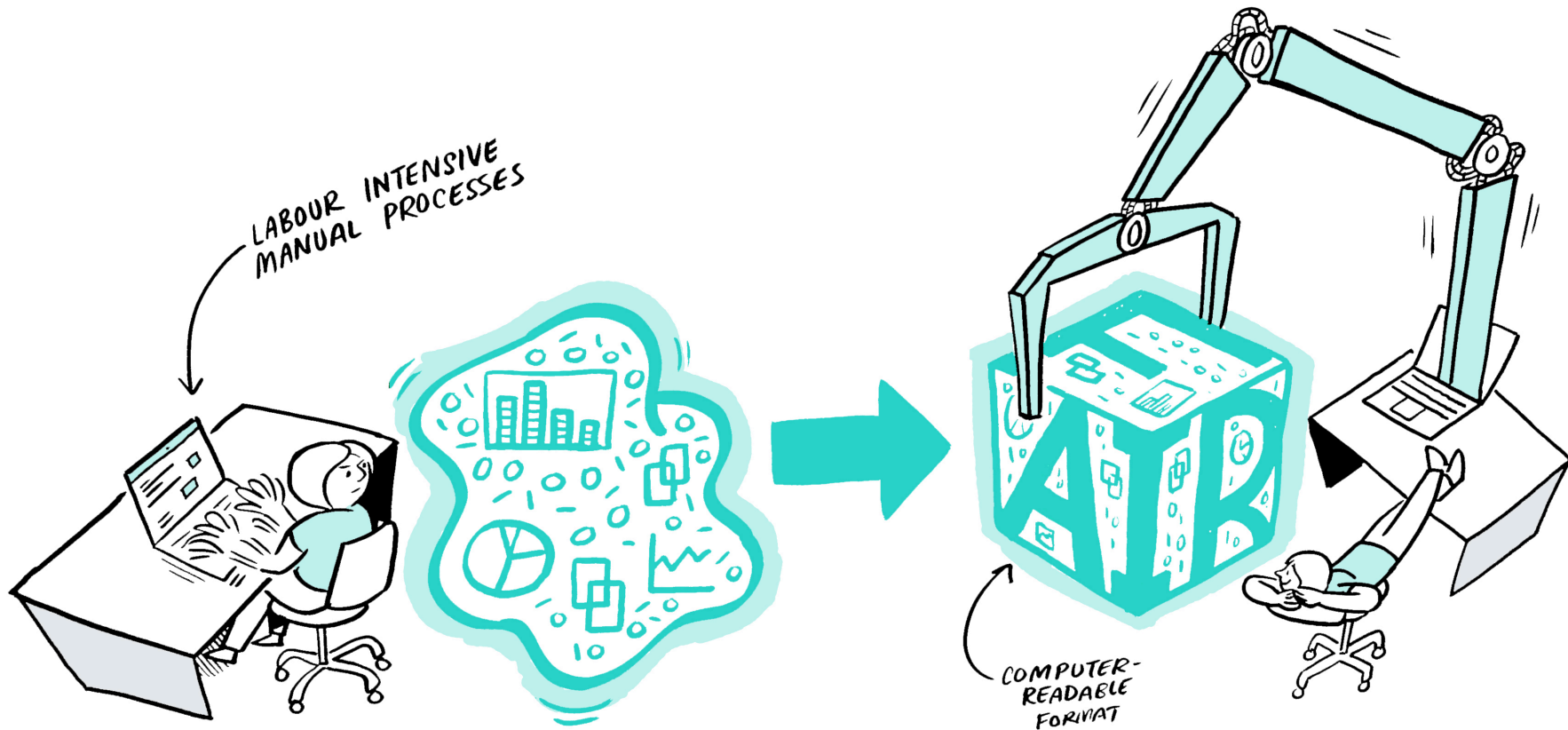
(@ReproHackNL) [September 20, 2019](#)



Take home

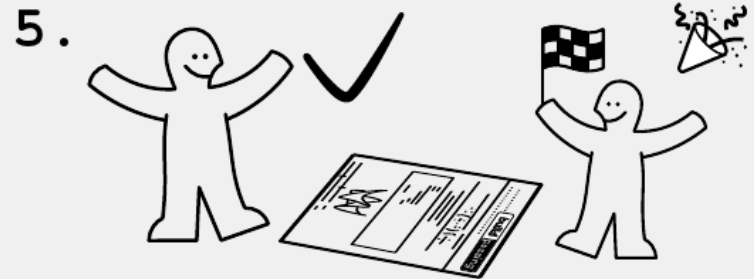
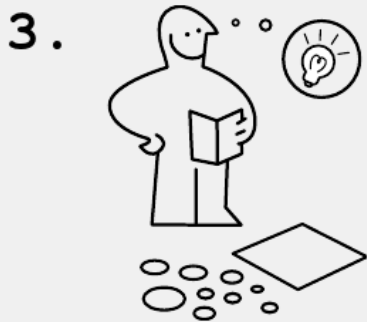
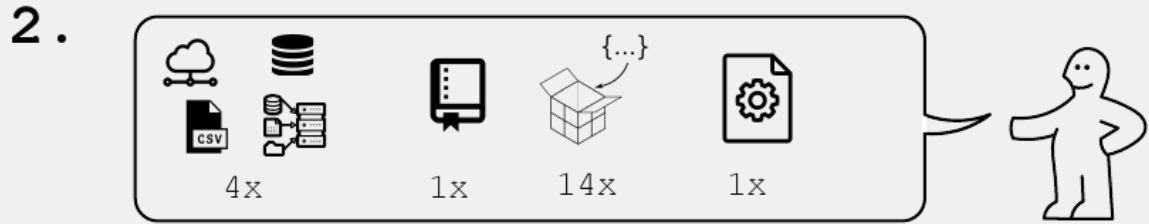
Following conventions

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Successful Reproducibility

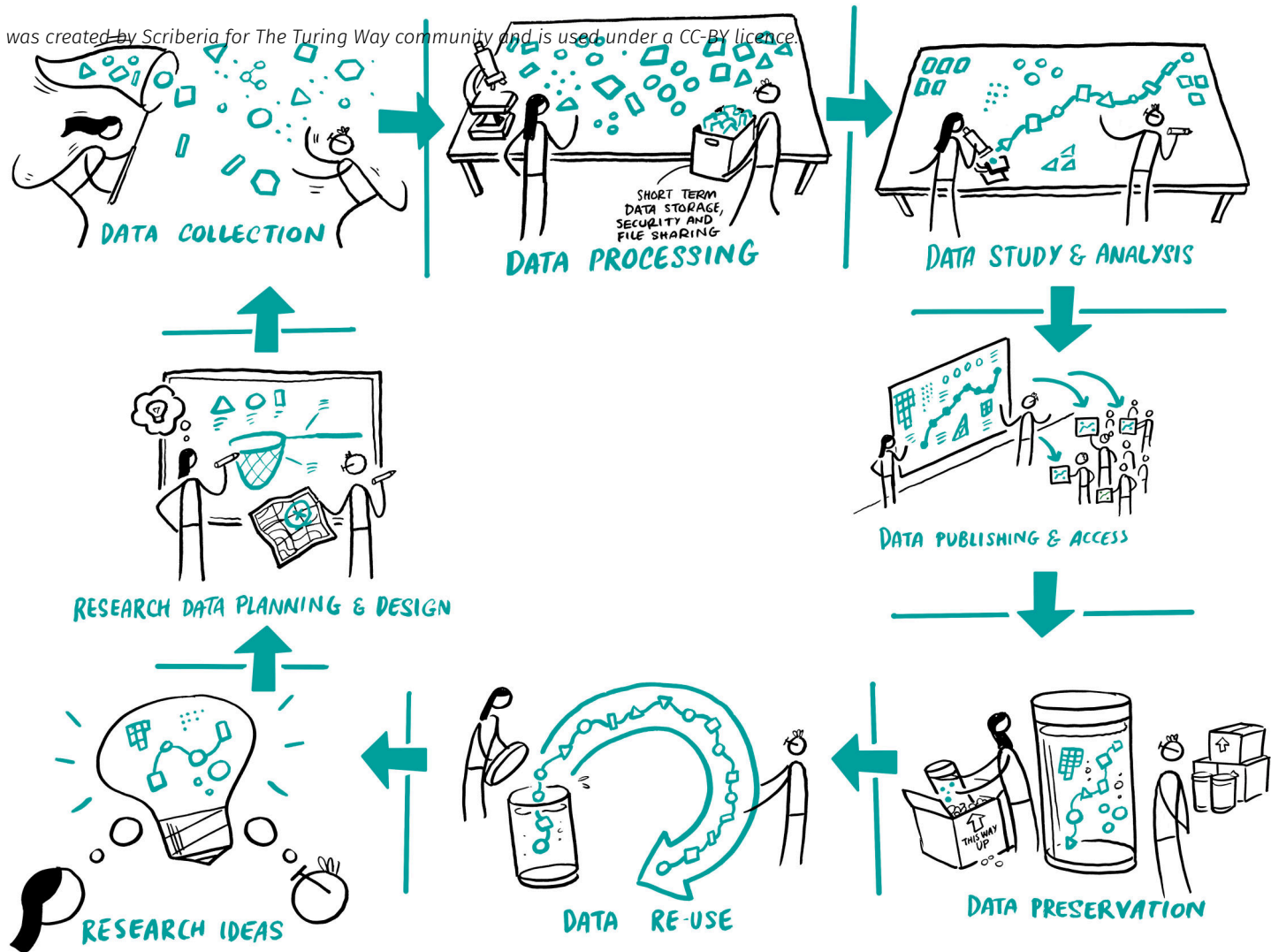
KÖMPENDIUM



slide: **Karthik Ram: rstudio::conf 2019 talk**

Enhanced Research Cycle

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Reproducibility as standard

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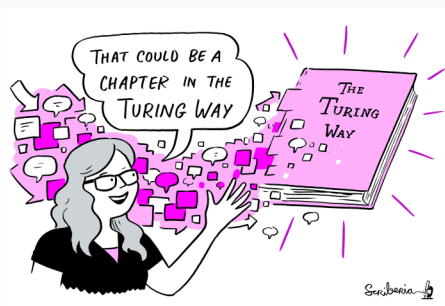
Resources

The Turing Way

Book

a lightly opinionated guide to reproducible data science

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



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

workshops

- **Boost Your Research Reproducibility with Binder** [materials](#)
- **Build a binderhub** [materials](#)

Reproducibility in R

Version Control

- [Happy Git and GitHub for the useR](#)

RMarkdown

- [R Markdown: The Definitive guide](#)
- [RMarkdown Driven Development \(RmdDD\)](#): Blog post by Emily Riederer

R Packages

- [R packages](#) by Hadley Wickham and Jenny Bryan

Research Compendia

- Karthik Ram: [rstudio::conf 2019 talk](#)

Docker & Binder

- Getting started with binder [docs](#)
- rOpenSci [Docker tutorial](#)

Tutorials

- [Rstudio Essentials](#) Webinar series
- [rrresearch](#): ACCE DTP course on Research Data & Project Management

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