Developing a Workflow to Maximize Reproducibility and Research Impact: Managing Data, Computer Code, and Projects for Success

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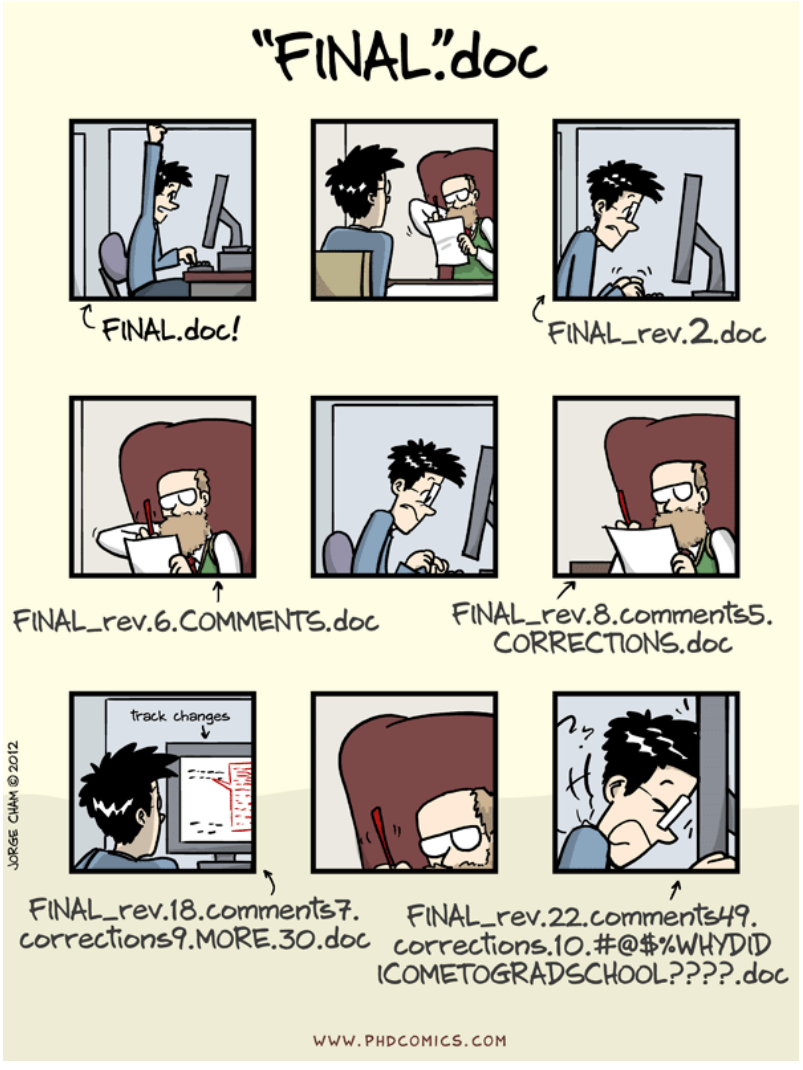
Why worry about reproducibility?

Working towards future reproducibility makes my code easier for my collaborators (and me) to read, run, and debug today,
and that's why I think reproducibility is a **win-win for all researchers**."
-Althea



Why worry about reproducibility?

"[Reproducibility] provides security, saves time, and forces me to be more thoughtful about my workflow." - Ethan Young

- make your life easier! Now, and in the future
- collaborations
- broader research impact
- increased citations
- transparency
- grant and journal requirements

Is my research reproducible?

- Are your research documents stored in these formats?
  - .csv
  - .txt
  - .pdf
  - .html
  - .R/.Rdata
    - YES!
  - .doc/.docx
  - .sas
  - .xls/.xlsx
  - any other proprietary file format
    - NO!

Is my research reproducible?

- Is your code linear?
  - Clear environment often and at beginning of script
  - Don't save .Rdata or history
  - Each program should focus on one main task or analysis
  - Don't rely on manual commenting/uncommenting

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So, what's wrong here?

```
# What variables are significant?
lm.out <- lm(weight ~ height, data = trial.data)
remove(lm.out) # clear previous lm.out for each
               #   new lm() definition above

# Is the relationship significant?
#     (If not, clear and try a new regressor)
summary(lm.out)
```

Is my research reproducible?

- Are your files easily shared with others?
  - Organized directory structure
  - Files relatively linked
  - Well-documented & commented
  - Consistency in coding practices

"The point of having style guidelines is to have a common vocabulary of coding so people can concentrate on *what* you are saying, rather than on *how* you are saying it." - Google's R Style Guide

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1. RStudio Projects for organizing data, code, and output
2. R-Markdown and R-Oxygen for documenting your code and creating reproducible reports
3. GitHub for version-control, collaborating and archiving

1. RStudio Projects

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- Raw data
- Processed data
- Analysis scripts
- Paper/Manuscript-related documents
- Sharing documents ("transmittals")
- Metadata
- Maps or other deliverables

RStudio Projects provide an opportunity for you to organize and manage all of these types of folders in **one place** in a way that **relatively links** everything together and **eases sharing**.

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Up next, Activity 1!

Activity 1: Data management and updating

Here, we will read in and process three weeks of experimental data and do some preliminary analysis. Then, we will get a final (4th) week of data, which we will merge with the original data.

The goals are to:

1. Be introduced to RStudio
2. Create a framework for keeping data organized and up-to-date
3. Automatically update our analyses based on the master dataset

Context: Abundance data from ~75 invertebrate species sampled on various beaches along the Dutch coast.

Zuur, A.F., E.N. Ieno, and G.M. Smith (2007) Analysing Ecological Data. Springer, New York.

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Before we begin today, we need sync your individual versions of the workshop documents with Althea's master branch:

1. Open RStudio and your reproducibility_workshop.rproj. (File > Open Project...)
2. Open shell (Tools > Shell...)
3. Type in exactly, then press enter:

```
$ git fetch upstream
```

4. Type in exactly, then press enter:

```
$ git checkout master
```

5. Type in exactly, then press enter:

```
$ git merge upstream/master
```

Activity 1: Data management and updating

Now create a new folder in student_folders/ for all of today's activities. Name the folder after yourself (or an alias).

Open a new R Script file and save it to that new folder as **"activity1a_data_processing.R"**

First, we will read in first three weeks of data and combine them, process the data a little bit, and save the merged/processed data for analysis.

Secondly, we will save another new R Script file as **"activity1b_data_analysis.R"** and do (preliminary) regression analysis.

Finally, we will pretend to have just gotten the final week's data in and update everything in a "reproducible" way.

1. RStudio Projects

Other links

`https://swcarpentry.github.io/r-novice-gapminder/02-project-intro/`

Data Mangement Tips

- Treat data as read-only
  - Don't use Excel, etc, to manipulate raw data
  - Use a single R program for all manipulation
  - Save "cleaned" or "processed" data in easily loadable formats
- Differentiate data types with folders *raw* versus *processed* versus *output* (e.g., linear regression objects, etc)
- Write dates in YYYYMMDD or equivalent format

Tips

- Don't use github with large files :-(
- Create new projects in GitHub first, then sync them with RStudio

Why R-Markdown for manuscripts?

"I can do reproducible work in R (making me happy) and format the output report in Word (making my collaborators happy)" - Richard Layton `http://rmarkdown.rstudio.com/articles_docx.html`