Reproducible Tools and Workflows

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Tools we'll see this week

- R, RStudio
  - https://cran.r-project.org/
  - https://www.rstudio.com/
- make (and other command line tools)
  - For Mac/Linus: pre-installed
  - For Windows:
    https://cran.r-project.org/bin/windows/Rtools/
- git
  - git (https://git-scm.com/)
  - github (https://github.com/)
  - gitkraken (https://www.gitkraken.com/)
- any text editor
- any command line terminal

Introductions

- Me:
  - Thomas
  - Political Scientist, Methodology Department
  - R

- You:
  - Name
  - Field/Department
  - Tools/Software

Learning Objectives

1. Understand how to organize a reproducible research project

2. Recognize different approaches to reproducibility and tools for implementing various reproducible workflows

3. Th: Apply various workflows to your own work

4. Th: Understand how to collaborate reproducibly

Activity!

How do you organize your files for a project?

Wait, but why do we care?

If we're going to be transparent *in the end* (e.g., at verification or data archiving stage), what do we need to provide?

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A well-organized, reproducible analysis!

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If we're going to be transparent *in the end* (e.g., at verification or data archiving stage), what do we need to provide?

A well-organized, reproducible analysis!

So rather than make that an annoying, post-hoc exercise related to publication, try to get organized and stay organized throughout your project from the very beginning.

Open Science
@openscience

"Reproducibility is collaboration with people you don't know, incl. yourself next week." – @philipbstark #openscience

The single most important part of reproducibility is naming things!

FINAL.doc!

FINAL_rev.2.doc

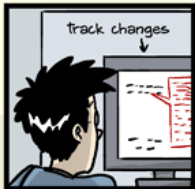FINAL_rev.6.COMMENTS.doc

FINAL_rev.8.comments5.CORRECTIONS.doc

FINAL_rev.18.comments7.
corrections9.MORE.30.doc

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

Name	Date modified	Type	Size
Dissertation - Prospectus 0.doc	2015-07-15 09:17	Microsoft Word 9...	18 KB
Dissertation - Prospectus 1.doc	2015-07-15 09:18	Microsoft Word 9...	142 KB
Dissertation - Prospectus 2.doc	2015-07-15 09:18	Microsoft Word 9...	246 KB
Dissertation - Prospectus 3.doc	2015-07-15 09:18	Microsoft Word 9...	250 KB
Dissertation - Prospectus 4.doc	2015-07-15 09:19	Microsoft Word 9...	250 KB
Dissertation - Prospectus 5.doc	2015-07-15 09:19	Microsoft Word 9...	263 KB
Dissertation - Prospectus 6.doc	2015-07-15 09:19	Microsoft Word 9...	287 KB
Dissertation - Prospectus 7.doc	2015-07-15 09:19	Microsoft Word 9...	291 KB
Dissertation - Prospectus 8.doc	2015-07-15 09:19	Microsoft Word 9...	300 KB
Dissertation - Prospectus 9 (For Jamie).pdf	2015-07-15 09:19	PDF File	328 KB
Dissertation - Prospectus 9.doc	2015-07-15 09:19	Microsoft Word 9...	340 KB
Dissertation - Prospectus 10 (Big Question).doc	2015-07-15 09:18	Microsoft Word 9...	19 KB
Dissertation - Prospectus 10 (New) hml.doc	2015-07-15 09:18	Microsoft Word 9...	179 KB
Dissertation - Prospectus 10 (New).doc	2015-07-15 09:18	Microsoft Word 9...	280 KB
Dissertation - Prospectus 10a (Big Question).doc	2015-07-15 09:18	Microsoft Word 9...	19 KB
Dissertation - Prospectus 10b (Big Question).doc	2015-07-15 09:18	Microsoft Word 9...	32 KB
Dissertation - Prospectus 10c (Big Question).doc	2015-07-15 09:18	Microsoft Word 9...	34 KB
Dissertation - Prospectus 11 (Outline).doc	2015-07-15 09:18	Microsoft Word 9...	25 KB
Dissertation - Prospectus 11.doc	2015-07-15 09:18	Microsoft Word 9...	287 KB
Dissertation - Prospectus 12.doc	2015-07-15 09:18	Microsoft Word 9...	175 KB
Dissertation - Prospectus 12a (Outline).doc	2015-07-15 09:18	Microsoft Word 9...	40 KB
Dissertation - Prospectus 12b (Outline).doc	2015-07-15 09:18	Microsoft Word 9...	50 KB
Dissertation - Prospectus 13 (Outline).doc	2015-07-15 09:18	Microsoft Word 9...	159 KB
Dissertation - Prospectus 13a (Outline).doc	2015-07-15 09:18	Microsoft Word 9...	228 KB
Dissertation - Prospectus 13b (Outline).doc	2015-07-15 09:18	Microsoft Word 9...	266 KB
Dissertation - Prospectus 13c.doc	2015-07-15 09:18	Microsoft Word 9...	320 KB
Dissertation - Prospectus 14 (Methods Draft for Jami...	2015-07-15 09:18	Microsoft Word 9...	44 KB

What makes up the ideal reproducible research product?

- Gandrud's template

- rOpenSci's "Research Compendium"

- Project TIER

- AJPS Replication/Verification Policy
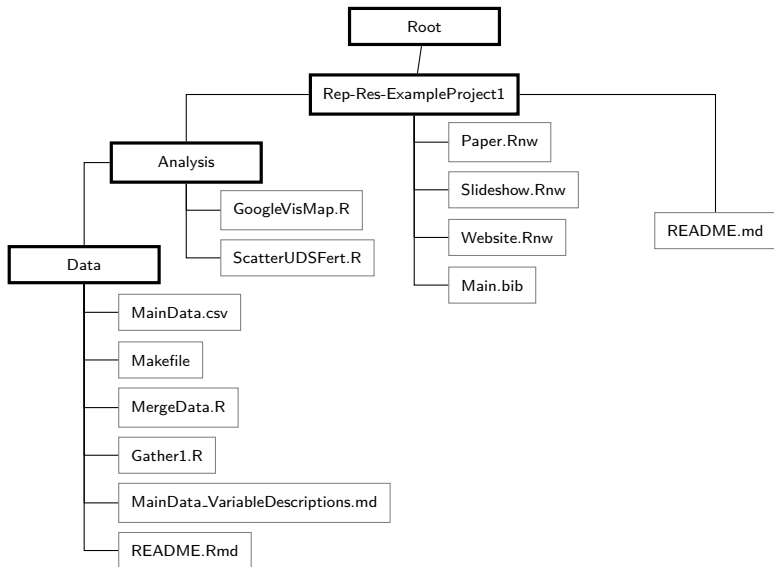
```
project
|- DESCRIPTION      # project metadata and dependencies
|- README.md        # top-level description of content
|
|- data/            # raw data, not changed once created
| +- my_data.csv    # data files in open formats
|
|- analysis/        # any programmatic code
| +- my_scripts.R   # R code used to analyse data
```

TIER Protocol Documentation

Original Data

Original data files

Importable data files (if necessary)

Metadata

The Metadata Guide

Supplementary metadata documents
(if necessary)

Documents

The final paper

The Data Appendix

The Read Me file

Analysis Data

Analysis data files

Command Files

Command files

Don't be this guy:
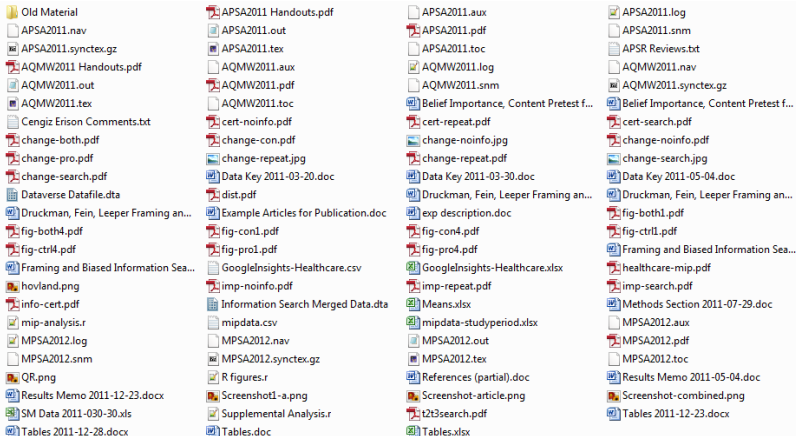
```
mkdir code

mkdir data

mkdir figures

echo # My Project > README.md
```

Everything you do should be plain text*

Everything you do should be plain text*

* Exceptions to this are images (sometimes)

- **Plain text is always compatible** Every single operating system has a plain text editor and they are all compatible up to the encoding of the text. This means that if you develop your lecture notes on a Mac and I develop them on a PC then we can still easily share - no worrying if you have the right software.
- **Plain text is easy to mix and match** If your lecture materials are in a simple plain text format like markdown you can copy and paste the materials from one lecture into another and when the document is compiled make all the formatting/colors/etc. match. No more looking at hodgepodges of borrowed slides some with one ppt format and some with another.
- **Plain text is easy to maintain** We mostly work on scalable education here at the JHU Data Science Lab. We often think of scalable education in terms of the number of students, but here we have also run into the problem of scaling the number of courses/instructor. I am currently the lead instructor on more than half a dozen classes running all the time. Every time I have to re-record a video it takes set up time, recording time, editing time. If I have an error in a markdown file it is a quick edit to a text file.
- **Plain text is lightweight** Images can be stored online and the lecture notes themselves are small. This might not matter where internet access is good, but in places with limited resources or wifi, this can be the difference from easily accessible lecture notes and bad ones.
- **Plain text is always forward compatible** Regardless of the next platform, if we have all of our knowledge/lecture notes stored in plain text it will be easy to extact them. When you switch platform, or compiling software, or style, there isn't a worry about the files not working appropriately.

https://simplystatistics.org/2017/06/13/

the-future-of-education-is-plain-text/

Additionally. . .

- Easy to use in version control

- Easy to dynamically update as part of an analysis "pipeline"

File	Good format(s)
Document	.md, .tex, .Rmd, .Rnw
Presentation	.tex, .Rmd, .Rnw
Code	.R, .Rmd, .py, .do, .ado
Data	.tsv, .csv
Codebook	.txt
Citations	.bib
Images	.svg, .pdf, .png
References	.bib

Is it possible to take the plain text ideology too far?

```
        1    25    11331112144243343311   11112122111211362 121412342343414343 13 1 1 13524   3422332322
        2    23    31321121244442443 1   111111222122112213613135141422444214414 1 1 13125   4243232221
        3    20    11121121132111111 11   11112121212143133141451114424543333341 2 1 1123   114113131
        4    20    11112121223123321 21   112211121211221222 12522234332442333411 1 1 3335   313333123
        5    20    42221111121111112   111113111111111112341141441111211414112221 1 1 32234   111113111
        6    19    22211111212212212 11   21111121111133244111311113134424442321 2 2 11412   131212131
        7    19    22121111222112111 11   3 11213 1221112422 13522122242442232324 4 4 1123   241222221
        8    20    31232212442244432   11211121121212123412 144324443444433444 1 3 112331   232213242
        9    21    42222111221222221   212111112122112 1242 13511242244432133232 1 1 13385   2333232223
       10    21    11222121233223331 22   12121222123112313 2 41122222413343441 2 1 11131   324222243
       11    21    31211111232333332   3 3 11123 1111331232 2 411222224133434412 2 1 1 1131   3332222432
       12    25    22211121322223232 12   2222221222212224614145114441244412444 1 1 1 1183   222254423
       13    21    42132222242244311   21112122112332432462 2 52224424442223244 2 2 13335   343233323
       14    18    22212111422144313211   11111112112114422 22 2 31223214333433423 1 1 11234   222222231
       15    17    42121112222233221   11211111112122123233122 12222424442243444 1 2 23155   323223232
       16    20    42221111212314221   11121121121121133452 124122224244442444 1 1 13183   244334243
       17    22    22121111321223321 22   3 11112131122231312511124244432333333 3 1 11232   344322243
       18    22    31122111224222441   11112221211111421242 2 2212212413424243 1 2 2 23135   413233222
       19    18    22331121441244413321   11212111131215246121352124442344222444 4 4 1135   414444134
       20    17    42121122323224431   4 2122111122113323313135414441444424444 2 2 13133   342223113
       21    18    11121121321142311 11   11112111132133234 211521224234442322441 1 2 3145   322223122
       22    19    31111112234244231   12211111211212542262 121322442443334444 2 2 21145   313234322
       23    22    11211222224442422 12   21111121122142235122 53244444442444443 1 4 1183   322321234
       24    24    22122111342332411 11   111112221211212312311112222424344122243 4 1 1 1133   441424422
       26    23    42121112121221411   11111221121121243431313441444144431433411 1 1 33155   441424142
       28    20    22111121321333311 12   21222222131134142122 5112441444414223313 3 1 3354   322312112
       29    24    31211111121341232   212111211211213121251421 511111114423442242 3 2 2114231 211112141
       30    18    11111221444244422 11   21122221212244111322 52144324443223421 1 1 1335   413441224
       31    20    11121111111114121111   11221211111111123132 4141521344334224212 1 3 113234 222213232
       33    20    22112222322243221 22   211212112113113214213251144314444324444 3 1 1143   213322124
```

```
//STEP2   EXEC PROC=SLINK,TESTPGM=BADK,ACCT=BADK
```

you describe your opinion of **(INSERT ITEM: ROTATE ITEMS a.-i. AND g.-i.)** as very favorable, mostly favorable, mostly UNfavorable, or very unfavorable? **(INTERVIEWERS: PROBE TO DISTINGUISH BETWEEN "NEVER HEARD OF" AND "CAN'T RATE")**

			Very Favor-able	Mostly Favor-able	Mostly Unfavor-able	Very Unfavor-able	Never Heard of	Can't Rate
(115)	a.	Network television news (1-96)	1	2	3	4	5	6
(116)	b.	Local TV news (1-96)	1	2	3	4	5	5
(117)	c.	The daily newspaper you are most familiar with (1-96)	1	2	3	4	5	6
(118)	d.	Congress (1-96)	1	2	3	4	5	6
(119)	e.	Tobacco companies (7-94)	1	2	3	4	5	6
(120)	f.	Labor unions (2-96)	1	2	3	4	5	6
(121)	g.	Bill Clinton (2-96)	1	2	3	4	5	6
(122)	h.	Hillary Clinton (2-96)	1	2	3	4	5	5
(123)	i.	Bob Dole (2-96)	1	2	3	4	5	6

Questions?

File names

Which of these do we like best?

- PhD Comics style

- Sequential version numbers

- Datestamps

File names

Which of these do we like best?

- PhD Comics style

- Sequential version numbers

- Datestamps

- None of the above (Git!)

Activity!

What's your analytic workflow? How do you get results into a paper, poster, or presentation?

My First Workflow

My First Workflow

1. Make figure/table/analysis in R

My First Workflow

1. Make figure/table/analysis in R
2. Copy/paste into Word document

My First Workflow

1. Make figure/table/analysis in R
2. Copy/paste into Word document
3. Adjust figure/table numbering

My First Workflow

1. Make figure/table/analysis in R
2. Copy/paste into Word document
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4. Double check references

My First Workflow

1. Make figure/table/analysis in R
2. Copy/paste into Word document
3. Adjust figure/table numbering
4. Double check references
5. Save as PDF
6. Change something in 1, repeat 2-5

My First Workflow

1. Make figure/table/analysis in R
2. Copy/paste into Word document
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6. Change something in 1, repeat 2-5
7. Get feedback (f*ck!!), repeat 1-5

My First Workflow

1. Make figure/table/analysis in R
2. Copy/paste into Word document
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6. Change something in 1, repeat 2-5
7. Get feedback (f*ck!!), repeat 1-5
8. Get reviews (f*ck!!!!!), repeat 1-5

My First Workflow

1. Make figure/table/analysis in R
2. Copy/paste into Word document
3. Adjust figure/table numbering
4. Double check references
5. Save as PDF
6. Change something in 1, repeat 2-5
7. Get feedback (f*ck!!), repeat 1-5
8. Get reviews (f*ck!!!!!), repeat 1-5
9. Repeat 7 (f*ck!!!!!!!!!!!!!!!), repeat 1-5

Workflows as DAGs

- Reproducibility means executing a DAG

- DAG
  - Directed
  - Acyclic
  - Graph

- Files are *nodes*; workflows are *arrows*

- Example: `https://github.com/leeper/make-example`
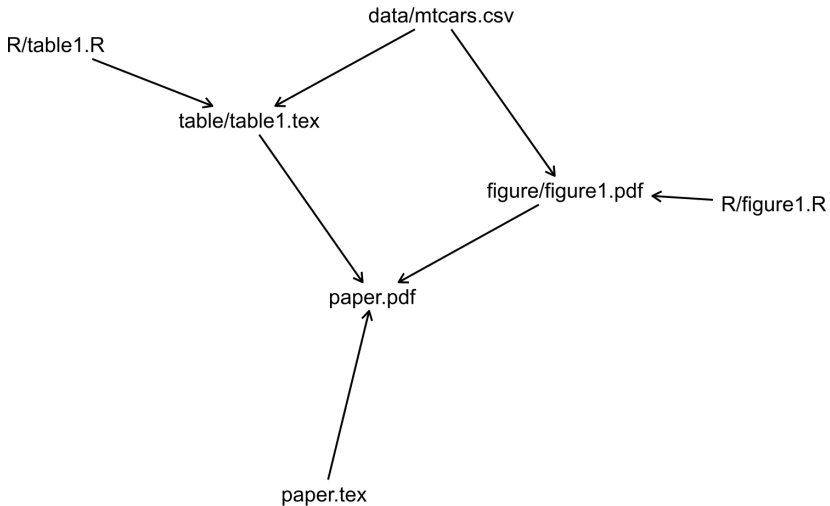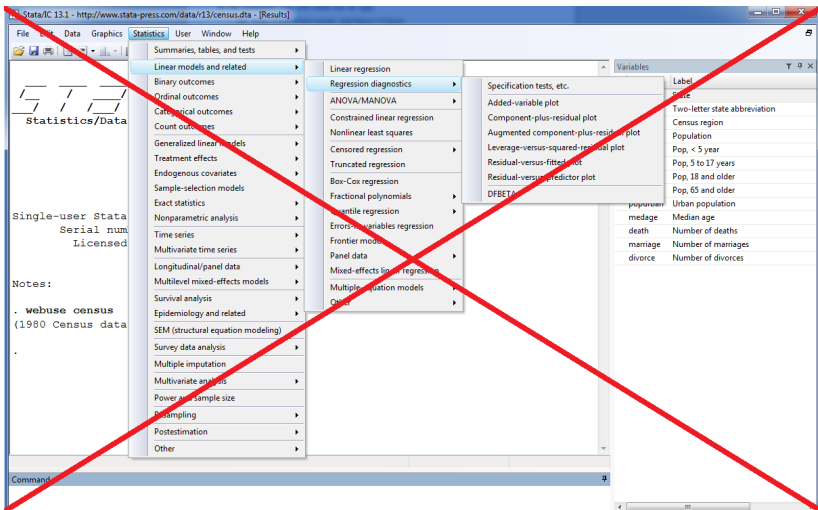
What's wrong with point-and-click?

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- Lose track of the DAG

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- Won't comply with DA-RT verification policies

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What's wrong with point-and-click?

- Lose track of the DAG
- Won't comply with DA-RT verification policies
- You will make mistakes!
- Eventually, you will have wasted your entire life manually fixing references, figure/table cross-references, and making sure that all of your numbers are correctly rounded and p-values have the correct number of stars next to them!

The prevalence of statistical reporting errors in psychology (1985–2013)

Michèle B. Nuijten[1] · Chris H. J. Hartgerink[1] · Marcel A. L. M. van Assen[1] ·
Sacha Epskamp[2] · Jelte M. Wicherts[1]

**Abstract** This study documents reporting errors in a sample
of over 250,000 p-values reported in eight major psychology
journals from 1985 until 2013, using the new R package
"statcheck." statcheck retrieved null-hypothesis significance
testing (NHST) results from over half of the articles from this
period. In line with earlier research, we found that half of all
published psychology papers that use NHST contained at least
one p-value that was inconsistent with its test statistic and
degrees of freedom. One in eight papers contained a grossly
inconsistent p-value that may have affected the statistical con-
clusion. In contrast to earlier findings, we found that the aver-
age prevalence of inconsistent p-values has been stable over
the years or has declined. The prevalence of gross inconsis-
tencies was higher in p-values reported as significant than in
p-values reported as nonsignificant. This could indicate a system-
atic bias in favor of significant results. Possible solutions for the
high prevalence of reporting inconsistencies could be to encour-
age sharing data, to let co-authors check results in a so-called

Most conclusions in psychology are based on the results of
null hypothesis significance testing (NHST; Cumming et al.,
2007; Hubbard & Ryan, 2000; Sterling, 1959; Sterling,
Rosenbaum, & Weinkam, 1995). Therefore, it is important
that NHST is performed correctly and that NHST results are
reported accurately. However, there is evidence that many
reported p-values do not match their accompanying test sta-
tistic and degrees of freedom (Bakker & Wicherts, 2011;
Bakker & Wicherts, 2014; Berle & Starcevic, 2007; Caperos
& Pardo, 2013; Garcia-Berthou & Alcaraz, 2004; Veldkamp,
Nuijten, Dominguez-Alvarez, Van Assen, & Wicherts,
2014; Wicherts, Bakker, & Molenaar, 2011). These
studies highlighted that roughly half of all published
empirical psychology articles using NHST contained at
least one inconsistent p-value and that around one in
seven articles contained a gross inconsistency, in which
the reported p-value was significant and the computed
p-value was not, or vice versa.
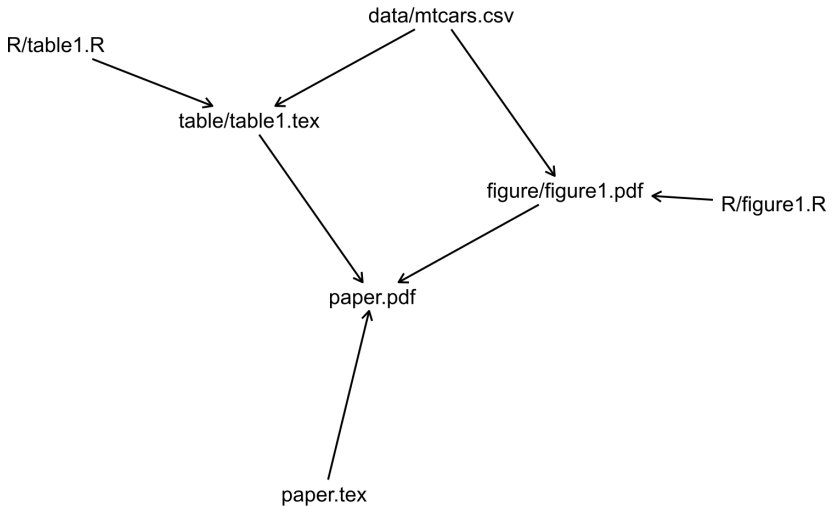
Four Basic Workflows

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3. make ("code within workflow")

4. knitr/rmarkdown ("workflow within code")

Everything in One File

```
# Brexit Deservingnes Experiment Analysis
# setwd("c:/users/thomas/dropbox/brexitdeservingness/")

# load data
dat <- rio::import("data/LSE_Hobolt_May18_Client.sav")
stopifnot(identical(dim(dat), c(3273L, 62L)))

# Regression analysis: perceived deservingness
stargazer::stargazer(
  # reduced model (only leavers and remainers) with interaction
  lm(opinion ~ identity * condition, data = subset(dat, identity %in% c("A Leav
  type = "tex",
  out = "figures/results-deservingness.tex",
  star.char = c("*"),
  star.cutoffs = c(0.05),
  notes = c("* $p<0.05$"),
  notes.append = FALSE,
  model.numbers = FALSE,
  float = FALSE,
  digits = 2,
  align = TRUE
)
```

One-File-Per-Output

```
# Preference Trial Experiment Analysis
# Thomas J. Leeper
# 2018-06-25
#setwd("C:/Users/Thomas/Dropbox/KnowledgeGaps")

# code
library("car")
library("xtable")
library("GK2011")
source("Analysis/functions.R")

# recoding
source("Analysis/experiment_cleaning.R")

# demographics
source("Analysis/experiment_demographics.R", echo = TRUE)

## Main analysis
source("Analysis/experiment_knowledge.R")

## Appendix
source("Analysis/experiment_appendix.R")
```

What's missing from these workflows?

R/table1.R

data/mtcars.csv

table/table1.tex

figure/figure1.pdf

R/figure1.R
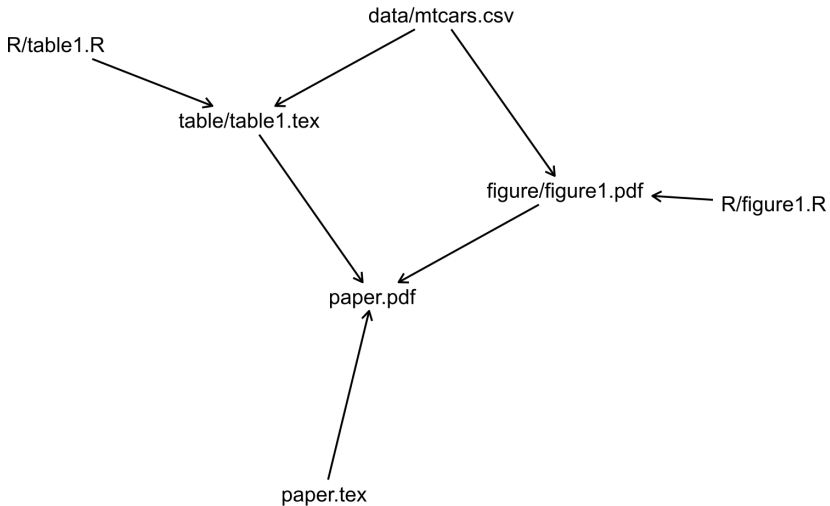
paper.pdf

paper.tex

make with a makefile

```
all: paper.pdf

figure/figure1.pdf: R/figure1.R data/mtcars.csv
    Rscript R/figure1.R

table/table1.tex: R/table1.R data/mtcars.csv
    Rscript R/table1.R

paper.pdf: paper.tex figure/figure1.pdf table/table1.tex
    pdflatex $<
    pdflatex $<
    bibtex $<
    pdflatex $<
```

Dynamic documents: rmarkdown

1. YAML metadata header
   ```
   ---
   title: My Manuscript
   author: Thomas J. Leeper
   ---
   ```

2. Document contents in **markdown**
   ```
   # A header
   ## A subhead
   This is my manuscript, **bold** and *italic*.
   ```

3. Code in "code chunks":
   ```
   ```{r chunk1}
   # R code
   hist(rnorm(1000))
   ```
   ```

```
---
- title: My Manuscript
- author: Thomas J. Leeper
- date: 2017-09-21
- output: pdf_document
---

This is my manuscript.

```{r chunk1}
# R code
hist(rnorm(1000))
```
```

This is my manuscript.

```
# R code
hist(rnorm(1000))
```

Histogram of rnorm(1000)

What about Stata?

1. ✓ Do everything in one file

2. ✓ Master file calls code for one-file-per-output

3. ✓ make ("code within workflow")

4. ? Nothing as powerful as rmarkdown/knitr

How do you pick a workflow?

- There is no one-size-fits-all workflow!

- Decide what works for you for a given project with particular collaborators

- I use multiple workflows on different projects

Questions?

Activity!

What tools do you use to store, share, and/or archive your research materials?

Keeping things

Three ways of thinking about how you keep and store your research materials:

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   - Going back in time for long-lived projects
   - Verification at publication stage

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   - Collaborating simultaneously
   - Collaborating asynchronously

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1. Collaborating with yourself or others in the future
   - Going back in time for long-lived projects
   - Verification at publication stage

2. Collaborating with others now
   - Collaborating simultaneously
   - Collaborating asynchronously

3. Collaborating with others after you die
   - Future reproducibility requests

Keeping things

Live Collaboration

Other Collaboration

Keeping things

Live Collaboration

- Google Docs

- Overleaf

- Dropbox/Box/etc.

- Email?

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Other Collaboration

- Active project:
  Version control (git)
- Backup: Dropbox,
  GDrive, S3, Github

Keeping things

Live Collaboration

- Google Docs

- Overleaf

- Dropbox/Box/etc.

- Email?

Other Collaboration

- Active project: Version control (git)
- Backup: Dropbox, GDrive, S3, Github

- Archiving: Dataverse, Zenodo, Figshare, OSF

Git

- Git is "an open-source distributed version control system"

- Developed in 2005 by Linus Torvalds

- Widely used in software development world

Why use Git for reproducibility?

Why use Git for reproducibility?

- Helps you keep and *annotate* snapshots of your project over time
    - Better than renaming your files all the time
    - Better than using within-file VCS (e.g., Word)
    - Better than single-stream sharing (e.g., Dropbox)

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- Facilitates collaboration (incl. with future you)

- It's FOSS with lots of clients, tools, and community support
    - Widely used in software development world

Version Control as Organization

- Version control helps you stay organized

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- Version control helps you stay organized
    1. What's important to keep around?

Version Control as Organization

- Version control helps you stay organized
    1. What's important to keep around?
    2. What's not important to keep around?

Version Control as Organization

- Version control helps you stay organized
  1. What's important to keep around?
  2. What's not important to keep around?
  3. What is all this crap?

Version Control as Organization

- Version control helps you stay organized
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- You're probably already version controlling informally!

Learning Objectives

1. Understand how to organize a reproducible research project

2. Recognize different approaches to reproducibility and tools for implementing various reproducible workflows

3. Th: Apply various workflows to your own work

4. Th: Understand how to collaborate reproducibly

Key Takeaways

- Once you work reproducibly, you'll never want to go back to your old workflow

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Key Takeaways

- Once you work reproducibly, you'll never want to go back to your old workflow

- "Advanced" workflows (e.g., make, git) get complicated — StackOverflow is your friend

- Collaborators probably don't know how to (or want to) use these tools

- Reproducibility is selfish first and for science second!

Questions?

5 Hands-On
- Introductory Git
- Git Branches & History
- Collaborating with Git
- Intermediate Git
- Rmarkdown/knitr
- make

Goal of Hands-On Practice

1. Work together on migrating a workflow

2. Dig through replication archives

3. Work individually or in pairs on making workflow more reproducible

Let's vote: What should we do?

Using Git

- Git create a "local repository" file that you can interact with using a number of tools
  - Command-line `git`
  - Git Bash
  - Git GUI
  - GitHub Desktop
  - RStudio (via "Projects")
  - GitHub/Bitbucket/GitLab web interfaces
  - Gitkraken
  - git2r (R package)
  - . . .

Initializing a Project Structure

- There's no single best way to organize a project

- But, some words of wisdom:
  - Put like with like
  - Avoid excessive hierarchy
  - Not everything needs to go into git
  - Steal others' structures!

```
git --version
git
git config --global user.name "My Name"
git config --global user.email "me@example.com"
git config --list
```

```
git init
git status
echo Hello world! > README.md
git add README.md
git status
git rm --cached README.md
git status
git add --all
git commit -m "my first commit!"
git status
git log
```

Git Essentials

1. stage

2. commit

3. branch

4. merge

5. push and pull

Git Essentials

1. stage
   - add/**stage**: select files to be recorded in a "snapshot" of the project
   - rm/**unstage**: remove files from the snapshot (but not from your computer)

2. `commit`

3. `branch`

4. `merge`

5. `push` and `pull`

Git Essentials

1. stage

2. commit
   - **commit**: record a permanent snapshot of the staged files, labelled with a "commit message"
   - **amend**: modify (typically the most recent) commit with new changes or commit message

3. branch

4. merge

5. push and pull

Git Essentials

1. `stage`

2. `commit`

3. `branch`
   - produce a complete *local* copy of the project where changes can be made independently of the "master" branch

4. `merge`

5. `push` and `pull`

Git Essentials

1 stage

2 commit

3 branch

4 merge
   - update a branch with changes from another local branch (or a remote); you can change multiple branches independently.

5 push and pull

Git Essentials

1. stage

2. commit

3. branch

4. merge

5. push and pull
   - **push**: send the project (any new commits) to a remote server (like GitHub)
   - **pull**: grab new commits from a remote server

Git Essentials

1. stage

2. commit

3. branch

4. merge

5. push and pull

90% of What You Need

- `git add` (stage) or `git rm` (unstage)
- `git commit`
- `git status`
- `git log`
- `git remote`
  - `git push`
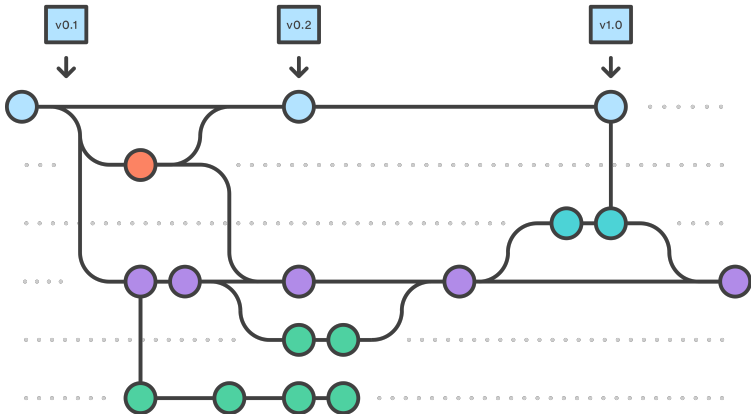 - `git pull`
- `git branch`
  - `git merge`

Branches

- Branches are local, parallel versions of your entire project

- Useful for multiple things:
  - Experimentation
  - Manuscript submissions
  - Collaboration

Source: https://www.atlassian.com/git/tutorials

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Simple branch and merge

```
git status
git checkout -b thomas
git status
# do something
git add --all
git commit -m "thomas's commit"
git checkout master
git branch
git log --graph --oneline
git merge thomas
```

GUIs

- You can do everything in Git on the command line

- GUIs can be helpful for:
  - Exploring history
  - Visualizing branches
  - Confirming what you're doing

Merge conflicts

```
git checkout -b thomas
git status
# do something to README.md
git add --all
git commit -m "change on thomas"
git checkout master
# do something to README.md
git add --all
git commit -m "change on master"
git merge thomas
git log
```

Navigating History

```
git status
git log
git checkout <commit hash>
git status
ls
cat README.md
git checkout master
```

```
git status
git log
git checkout <commit hash>
git status
ls
echo aaaaaah!>manuscript.txt
git checkout master
```

Remotes

- A server ("cloud") instance of the Git repository

- Useful for multiple things:
    - Collaboration
    - Transparency
    - Archiving/backups
    - Using web-based Git interfaces

Remotes

- Three major players in cloud Git
  - GitHub
  - Atlassian Bitbucket
  - GitLab

- Why choose one or the other?
  - Cost
  - Collaborators
  - Private repositories

```
git status
git remote add github
https://github.com/leeper/rt2
git remote
git remote set-url
git remote rename
git remote remove
```

```
git status
git push github master -u
git fetch github
git fetch github master
git checkout -b new-idea
git push github new-idea
git checkout master
git pull github master
git pull
```

```
git status
git tag -a v0.0.1 -m "v0.0.1"
git push --tags

git tag -d v0.0.1
```

Tags versus Branches

- *Branches* are for working versions of project
    - Collaborator-specific branches
    - Submission-specific branches
    - Experimental or "bug fix" branches

- *Tags* are for marking particular snapshots
    - Significant moments in project history
    - Journal submission or conference version
    - Formal "releases"

Collaboration

- Technical aspects
    - Give collaborators access on GitHub (or wherever)
    - Work on separate branches
    - Merge agreed changes into **master**

- Human factors aspects
    - Requires agreeing on workflow
    - Communication about what goes in "master"
    - Can feel awkward if moving from a Dropbox- or email-based collaboration style

Try it with a partner!

1. Partner A create a GitHub repo; give Partner B access

2. Partner B should git fetch/git pull the repo

3. Partner B should create a local branch and git push

4. Partner A should git fetch the branch

5. Partner A should git merge the branch to **master** and git push

6. Partner B should git pull from **master**

7. Both use git log to compare

```
git status
git diff README.md
git diff HEAD README.md
git diff HEAD~1 README.md
git diff HEAD~2 README.md
git diff HEAD~3 README.md
git diff HEAD~20 README.md
git diff <commit hash> README.md
git diff <commit hash>
```

!! DANGER: Amend Commit !!

```
git status
git log --oneline
# maybe add/rm files
git amend
# enter the hell of vim


git config --global core.editor
"<executable> <options>"
```

Safe reversion

```
git status
git log --oneline
git revert <commit hash>
# enter the hell of vim
# or something else terrible
git revert --abort
```

!! DANGER: Unsafe reversion !!

The StackOverflow Question

```
git status
echo "bad bad bad" > bad.txt
git status
echo bad.txt > .gitignore
git status
echo bad bad bad > bad1.txt
echo bad bad bad > bad2.txt
echo bad* > .gitignore
git status
git add bad1.txt -f
git status
```

Rmarkdown

1. YAML metadata header

```
---
title: My Manuscript
author: Thomas J. Leeper
---
```

2. Document contents in **markdown**

```
# A header
## A subhead
This is my manuscript, **bold** and *italic*.
```

3. Code in "code chunks":

```
```{r chunk1}
# R code
hist(rnorm(1000))
```
```

```
---
- title: My Manuscript
- author: Thomas J. Leeper
- date: 2017-09-21
- output: pdf_document
---

This is my manuscript.

```{r chunk1}
# R code
hist(rnorm(1000))
```
```

Markdown Basics

Markdown is a very simple markup language for
formatting simple texts:

```
*italics*                  italics
*bold*                     bold
'preformatted'             preformatted
# Heading                  Heading Level 1
## Heading                 Heading Level 2
### Heading                Heading Level 3
[link](https://google.com) link
```

Chunk Options

```
```{r chunk1, eval=TRUE, echo=TRUE}
2 + 2
```

```{r chunk2, eval=TRUE, echo=FALSE}
2 + 2
```

```{r chunk3, echo=FALSE, results="hide"}
2 + 2
```
```

Global Chunk Options

```
```{r options, eval = TRUE, echo = FALSE}
library("knitr")
opts_chunk$set(echo = FALSE,
               cache = TRUE,
               message = FALSE)
```
```

Basic Tables

```
```{r table1, results = "asis"}
xtable::xtable(table(mtcars$cyl, mtcars$gear))

knitr::kable(head(mtcars))
```
```

Regression Results Tables

```
```{r table2, results = "asis"}
library("stargazer")
stargazer(
  x1 <- lm(mpg ~ disp + wt,
           data = mtcars),
  x2 <- lm(mpg ~ disp + wt + vs,
           data = mtcars),
  header = FALSE
)
```
```

Figures

```r
```{r fig1,
    fig.cap = "Fuel Economy by Weight",
    fig.height = 4,
    fig.width = 6}
library("ggplot2")
ggplot(mtcars,
    aes(x = wt,
        y = mpg,
        colour = factor(cyl))) +
  geom_point()
```
```

You can work in LaTeX, too!

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```
\begin{document}

Here is a code chunk.

\begin{knitrout}
\definecolor{shadecolor}{rgb}{0.969, 0.969, 0.969}\color{fgcolor}\begin{kframe}
\begin{alltt}
\hlstd{a} \hlkwb{<-} \hlnum{1}\hlopt{+}\hlnum{1}
\hlstd{a}
\end{alltt}
\begin{verbatim}
## [1] 2
\end{verbatim}
\end{kframe}
\end{knitrout}

You can also write inline expressions, 2.

\end{document}
```

You can work in LaTeX, too!

Here is a code chunk.

```
a <- 1+1
a
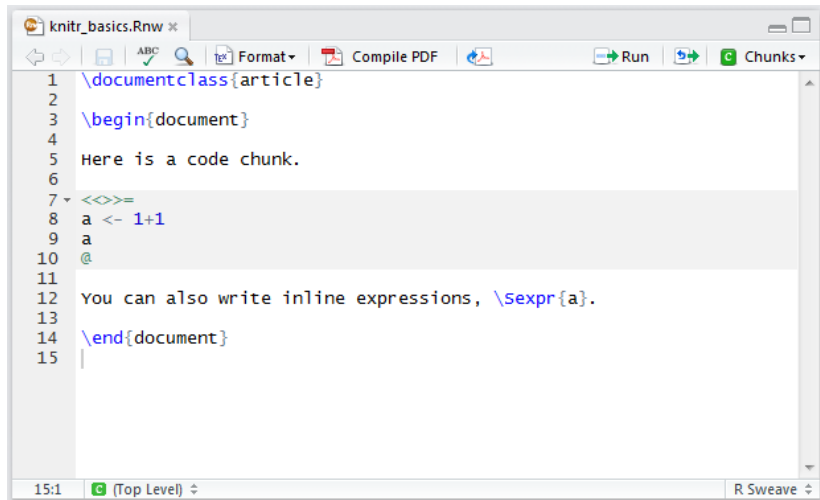
## [1] 2
```

You can also write inline expressions, 2.

makefiles

```
all: <final-target>

<target-1>: <source-file> <source-file>
    <script to produce target from source-file(s)>

<target-2>: <source-file> <target-1>
    <script to produce target from source-file(s)>
```