

Writing Reproducible Research Papers with R Markdown

Resul Umit

April 2020

Who am I?

Resul Umit

- post-doctoral researcher and lecturer at the Department of Political Science, University of Lucerne
- interested in representation, elections, and parliaments
 - **most recent publication**: When members of parliament disagree with their principals (country, constituency, party), how do they justify this to them?
 - more at resulmit.com

How did I use to write?

First, with **Stata + Word**, I was ...

- frustrated with Word
 - formatting tables, figures, citations, and equations
 - managing references
- tired of switching between programmes/screens
 - and, worried about making mistakes in between
- paying for programme licences

How did I use to write?

Then, with **Stata + R + LaTeX**, I was ...

- ~~frustrated with Word~~
 - ~~formatting tables, figures, citations, and equations~~
 - ~~managing references~~
- tired of switching between programmes/screens
 - and, worried about making mistakes in between
- paying for the Stata licence
- converting PDF documents to Word manually
 - coordinating work with co-authors who don't use LaTeX/PDF
 - submitting to journals which don't accept LaTeX/PDF

How do I write now?

Now, with R Markdown, I am ... happy!

- ~~frustrated with Word~~
 - ~~formatting tables, figures, citations, and equations~~
 - ~~managing references~~
- ~~tired of switching between programmes/screens~~
 - ~~and, worried about making mistakes in between~~
- ~~paying for the stata licence~~
- ~~converting PDF documents to Word, manually~~
 - ~~coordinating work with co-authors who don't use LaTeX/PDF~~
 - ~~submitting to journals which don't accept LaTeX/PDF~~

R Markdown

- Efficient
 - write text, cite sources, tidy data, analyse, table, and plot it in one programme/screen
 - re-do one, more, or all of these with ease
 - decrease the possibility of making mistakes in the process
- Flexible
 - output to various formats
 - e.g., HTML, LaTeX, PDF, Word
- Open access/source
 - use for free
 - create documents accessible to anyone with a computer and internet connection
 - benefit from the work of a great community of users/developers

Reproducibility — Before Publication

- Having written a complete draft
 - with data including re-coded variables, tables, figures, and text with references to specific results (e.g., numbers from summary and/or regression statistics)
- If you and/or your co-authors decide
 - to reverse a re-coded variable to its previous/original measure
 - and/or, to exclude a subgroup of observations from analysis
- How resource intensive would this revision be?
 - how long would this revision take?
 - how many programmes would be needed for this revision, and how much would they cost?
 - there is an inverse relationship between this resource intensity and reproducibility

Reproducibility — After Publication

- After your paper is published, if others, including your future self, would like to test how robust the results are
 - to reversing a re-coded variable to its previous/original measure
 - and/or, to excluding a subgroup of observations from analysis
- How resource intensive would this test be?
 - how accessible is the data, documentation (how was the variable re-coded in the first place?), and the code?
 - how long would the test take?
 - how many programmes would be needed for this revision, and how much would they cost?
 - there is an inverse relationship between this resource intensity and reproducibility

The Workshop — Overview

- Two half days, on how to write reproducible research papers with R Markdown
 - ideally, about ten hours
- Based on converting a mock manuscript written in Word to R Markdown
 - plus, improving its reproducibility and version-controlling it
 - with a PDF output in mind
- Designed for researchers with basic knowledge of R programming language
 - does not cover programming with R
 - e.g., writing functions
 - ability to regress, plot, and table in R will be very helpful
 - but not absolutely necessary — these skills can be developed after learning R Markdown as well

The Workshop — Contents

Part 1. Getting the Tools Ready

- e.g., downloading course material

Part 2. Introducing R Markdown

- e.g., creating a new document

Part 3. Setting Metadata

- e.g., defining output format

Part 4. Writing Text

- e.g., adding emphasis to text

Part 5. Managing References

- e.g., citing sources

Part 6. Adding Code, Figures, and Tables

- e.g., plotting data

Part 7. Addressing Functionality Gaps

- e.g., adjusting line spacing

Part 8. Using Version Control

- e.g., integrating Git and GitHub

Part 9. Working on a Real Project

- e.g., converting a work-in-progress of yours

The Workshop — Organisation

- Sit in groups of two
 - participants learn as much from their partner as from instructors
 - switch partners after every second part
- Type, rather than copy and paste, the code that you will find on these slides
 - typing is a part of the learning process
- When you have a question
 - ask your partner
 - google together
 - ask me

The Workshop — Organisation — Slides

Slides with this background colour indicate that your action is required, for

- setting the workshop up
 - e.g., downloading course material
- completing the exercises
 - e.g., managing references in R Markdown
 - there are 35 exercises
 - these slides have countdown timers

The Workshop — Organisation — Slides

- Codes and texts that go in R Markdown documents appear as such – in a different font, on gray background
 - long codes and texts will have their own line(s)
- Results that come out in output files appear as such — in the same font, on green background
 - except very obvious results, such as figures and tables
- Specific sections are highlighted yellow as such for emphasis
 - these could be for anything — codes and texts in input, results in output, and/or texts on slides

The Workshop — Aims

- To make you aware what is possible with R Markdown
 - we will cover a large breath of issues, not all of it is for long-term memory
 - awareness of what is possible, Google, and perseverance are all we need
- To encourage you to convert into R Markdown
 - practice with a mock manuscript (Parts 3–8)
 - start converting a real one (Part 9)

Part 1. Getting the Tools Ready

Course Materials — Download from the Internet

Materials, available at https://github.com/resulunit/rmd_workshop, have the following structure

```
rmd_workshop
|
|- manuscript
|   |- journals.Rmd
|   |- references.bib
|   |- apa_7th.csl
|   |- reproduce_this.pdf
|
|-data
|   |- journals.csv
|
|-image
|   |- google_scholar.png
|
|-presentation
|   |- rmd_workshop.pdf
```


Course Materials — Contents

- `reproduce_this.pdf`
 - the document, formatted in Word but saved as PDF, that we will re-create with R Markdown
 - randomly generated sentences, with figures and tables from randomly generated dataset^{*}
 - key sections in-need of attention are highlighted

[*] The text, *Lorem ipsum*, is generated with the `stringi` package (Gagolewski, 2020) while the dataset is created with the `fabricatr` package (Blair et al., 2019).

Course Materials — Contents

- `reproduce_this.pdf`
 - the document, formatted in Word but saved as PDF, that we will re-create with R Markdown
 - randomly generated sentences, with figures and tables from randomly generated dataset
 - key sections in-need of attention are highlighted
- `journals.Rmd`
 - the R Markdown document that we will work on
 - includes unformatted text from `reproduce_this.pdf` to save time
 - major components, such as paragraphs and tables, are numbered and marked in comments to facilitate navigation
- `references.bib`
 - a BibTeX document with three fabricated references
- `apa_7th.csl`
 - a Citation Style Language document, with APA (7th Edition) referencing style (Wiernik, 2020)

Course Materials — Contents

journals.csv

- a dataset created with the `fabricatr` package (Blair et al., 2019), imagined to explore the Google Scholar rankings of fictitious journals
- includes the following variables
 - **name**: journals (1090 random titles)
 - **origin**: geographic origins (five continents)
 - **branch**: major discipline of journals (four branches)
 - **since**: time of first publication (years)
 - **h5_index**: H5 Index (integers)
 - **h5_median**: H5 Median (integers)
 - **english**: English (1) vs. other-language (0) journals
 - **subfield**: subfield (1) vs. generalist (0) journals
 - **issues**: number of issues published per year (integers)

Course Materials — Contents

- `google_scholar.png`
 - a screenshot image of the [Google Scholar homepage](#)
- `rmd_workshop.pdf`
 - these slides in PDF format
 - HTML version is available at https://resulunit.com/teaching/rmd_workshop.html
 - offers, among others, the ability to scroll across long codes on some slides

Git — Download from the Internet and Install

- For Windows, install 'Git for Windows', downloading from <https://gitforwindows.org>
 - select 'Git from the command line and also from 3rd-party software'
- For Mac, install 'Git', downloading from <https://git-scm.com/downloads>

GitHub — Open an Account

Sign up for GitHub at <https://github.com>

- registering an account is free
- usernames are public
 - either choose an anonymous username (e.g., asdf029348)
 - or choose one carefully — it becomes a part of users online presence
- usernames can be changed later

R and RStudio — Download from the Internet and Install

- Download R from <https://cloud.r-project.org>
 - choose the version for your operating system
- Download RStudio from <https://rstudio.com/products/rstudio/download>
 - choose the free version

R Packages — Install from within RStudio

```
install.packages(c("rmarkdown", "tinytex",  
                  "dplyr", "ggplot2", "stargazer"))
```

- `rmarkdown` (Allaire et al., 2020), for automating the process of converting R Markdown documents into other formats
- `tinytex` (Xie, 2020), for PDF outputs
 - alternative: a TeX/LaTeX system installed on your computer
- `dplyr` (Wickham, 2020a), for data manipulation
 - alternatives: e.g., `base`, `data.table` (Dowle & Srinivasan, 2019)
- `ggplot2` (Wickham, 2020b), for figures
 - alternatives: e.g., `base`, `plotly` (Sievert et al., 2020)
- `stargazer` (Hlavac, 2018), for tables
 - alternatives: e.g., `knitr` (Xie, 2020b), `kableExtra` (Zhu, 2019)

R Project — Create from within RStudio

- RStudio allows for dividing your work with R into separate projects, each with own history etc.
 - [this page](#) has more information on why R projects are recommended
- Create a new R project for the existing directory `.../rmd_workshop/manuscript` from the RStudio menu:

```
File -> New Project -> Existing Directory -> Browse ->  
.../rmd_workshop/manuscript -> Open
```

- Rename the `.Rproj` file into something more meaningful
 - the default RStudio behaviour is to name the projects after the existing directory
 - but, we don't want all our projects to be named `manuscript.Rproj`

R Markdown Cheat Sheet — Download from the Internet

Downloading process can be imitated from within RStudio

- follow from the RStudio menu

Help -> Cheatsheets -> R Markdown Cheat Sheet

Other Resources*

- Pandoc User's Guide
 - available at <https://pandoc.org/MANUAL.html>
- R Markdown: The Definitive Guide (Xie et al., 2019)
 - open access at <https://bookdown.org/yihui/rmarkdown>
- R for Data Science (Wickham and Grolemund, 2019)
 - open access at <https://r4ds.had.co.nz>

[*] During the workshop, R Markdown Cheat Sheet is likely to be more helpful than these resources, which I recommend to be consulted after the workshop.

Part 3. Introducing R Markdown

R Markdown Document — Create from within RStudio

- Create a new R Markdown document from the RStudio menu:*

File -> New File -> R Markdown -> OK

- Save your new document:**

File -> Save

- Observe that
 - the document has been saved to your working directory, and
 - it has the .Rmd extension

[*] This is for demonstration purposes only. Otherwise, we will work with `journals.Rmd`, which you have already downloaded, to save time.

[**] Alternatively, use the Save button or the keyboard shortcut (e.g., `Ctrl + S` on Windows). For shortcuts, follow Tools -> Keyboard Shortcuts Help or Tools -> Modify Keyboard Shortcuts....

R Markdown Document — Components

Observe also that the document has three components

- **YAML**

```
1 ---  
2 title: "Untitled"  
3 output: html_document  
4 ---
```

R Markdown Document — Components

Observe also that the document has three components

- YAML
- **text**

```
1 ---
2 title: "Untitled"
3 output: html_document
4 ---
5
6
7
8
9
10
11
12 ## R Markdown
13
14 This is an R Markdown document. Markdown is a lightweight
15 and MS Word documents. For more details on using R Markdown see
16 When you click the Knit button a document will be generated,
17 well as the output of any embedded R code chunks like this:
```

R Markdown Document — Components

Observe also that the document has three components

- YAML
- text
- code chunks

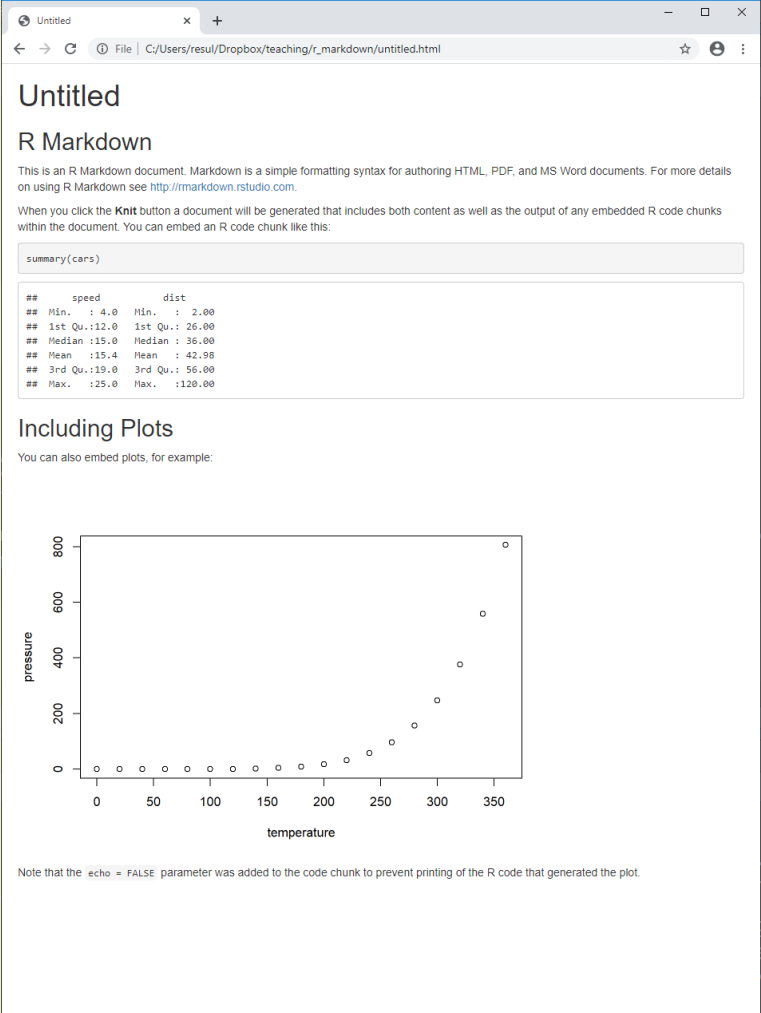
```
1 ---
2 title: "Untitled"
3 output: html_document
4 ---
```

```
12 ## R Markdown
13
14 This is an R Markdown document. Markdown is
15 and MS Word documents. For more details on u
16
17 When you click the Knit button a document
18 well as the output of any embedded R code ch
19 chunk like this:
```

```
7
8 ```{r setup, include=FALSE}
9 knitr::opts_chunk$set(echo = TRUE)
10
11
```


R Markdown Document — Compile

- Click the **Knit** button to compile it, and observe that
 - the output document has the same name as your `.Rmd` document
- You may want to delete these newly created files, as we will work with `journals.Rmd` instead to save time.



Untitled

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

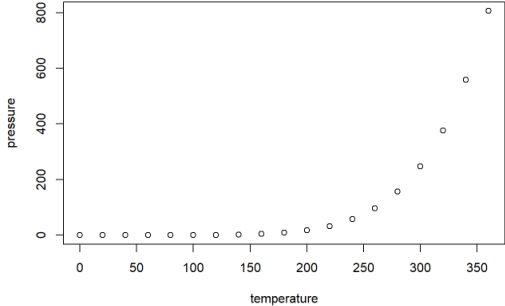
When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```
summary(cars)
```

```
##      speed      dist
## Min.   : 4.0    Min.   :  2.00
## 1st Qu.:12.0    1st Qu.: 26.00
## Median :15.0    Median : 36.00
## Mean   :15.4    Mean   : 42.98
## 3rd Qu.:19.0    3rd Qu.: 56.00
## Max.   :25.0    Max.   :120.00
```

Including Plots

You can also embed plots, for example:



Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.

R Markdown Document — Compilation Process

- When you Knit, the following happens:

```
.Rmd --knitr--> .md --pandoc--> output
```

- `knitr`^{*} executes the code if there is any, converts the resulting document from .Rmd (R Markdown) into .md (Markdown)
- `pandoc`^{**} transforms the .md document into your preferred output format(s)
 - e.g., HTML, LaTeX, PDF, Word
- This process is automated by the `rmarkdown` package

[*] If you had not already have the `knitr` package, it would have been installed together with the `rmarkdown` package.

[**] RStudio comes with a copy of `pandoc` (<http://pandoc.org>), which is not an R package, so that you do not have to install it separately.

R Markdown Document — Notes

- Behind the scenes, each .Rmd file is compiled in its own session, and therefore
 - the code needs to stand alone, for reproducibility reasons
 - you might have already loaded a package and/or imported data elsewhere (e.g., in a separate .R and/or .Rmd file), but even in the same session, these won't be available to a given .Rmd file
- R Markdown can produce more than documents,^{*} including
 - presentations, again with rmarkdown
 - books, with bookdown (Xie, 2020c)
 - websites, with blogdown (Xie, 2020d)

[*] Here we will focus on research papers only. In a separate workshop, I teach how to create professional websites with R Blogdown.

Part 3. Setting Metadata

YAML — Overview

.Rmd documents start* with YAML

- it includes the metadata variables
 - e.g., title, output format
- it is written between a pair of three hyphens -

```
---  
title:  
output:  
---
```

[*] Technically, we can place YAML anywhere in a .Rmd document. However, it is a good practice to start with YAML.

YAML — Variables

- `title` and `output` are the basic variables of YAML
 - variable names are typed in lower case, followed by a colon :
 - the list of available variables, as well as options and sub-options for these variables, depends on the output format
 - [Pandoc User's Guide](#) provides a comprehensive documentation
 - R Markdown Cheat Sheet provides a helpful list
- Typical YAML variables for an research paper:

```
---  
title:  
author:  
date:  
bibliography:  
csl:  
output:  
---
```

YAML — Variables

Variables can take strings

```
---  
title: "Journals: Random Words With Random Data"  
output:  
---
```

YAML — Variables

Variables can take strings, options

```
---  
title: "Journals: Random Words With Random Data"  
output: pdf_document  
---
```


YAML — Variables

Variables can take strings, options, **sub-options**

```
---  
title: "Journals: Random Words With Random Data"  
output:  
  pdf_document:  
    keep_tex: true  
---
```

YAML — Variables

Variables can take strings, options, sub-options, and `code`

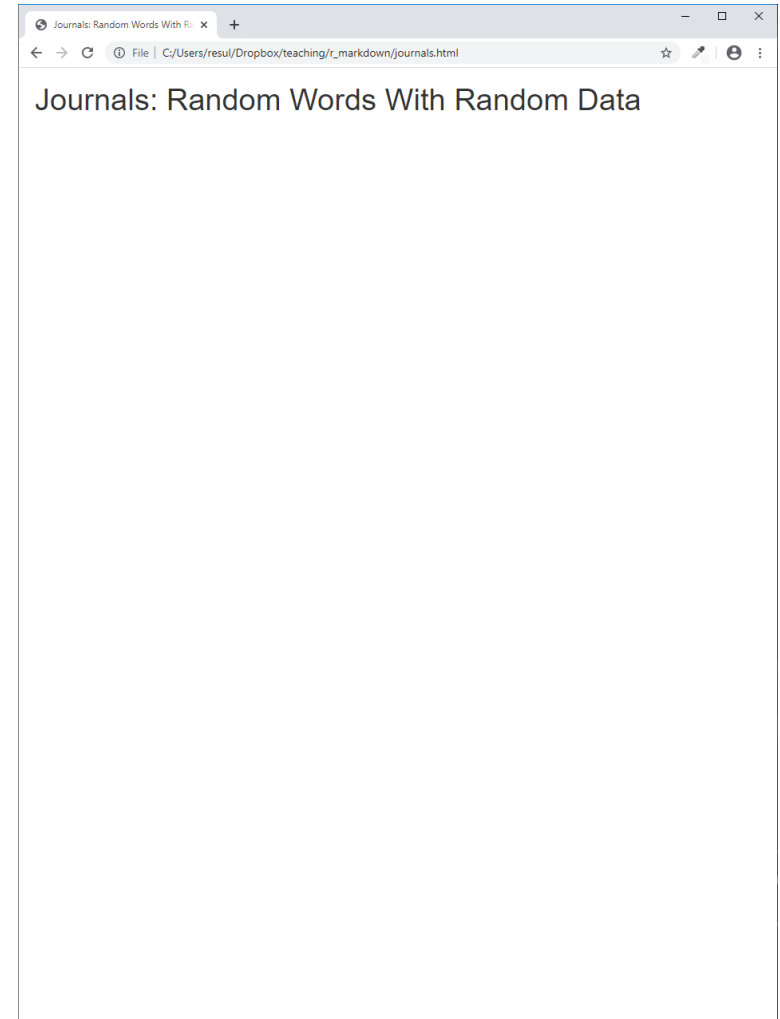
```
---  
title: "Journals: Random Words With Random Data"  
date: "r format(Sys.Date(), '%d %B %Y')"  
output:  
  pdf_document:  
    keep_tex: true  
---
```

YAML — Variables — Output Formats

Documents as output formats include

- **HTML**

```
---  
title: "Journals: Random Words With Random Data"  
output: html_document  
---
```

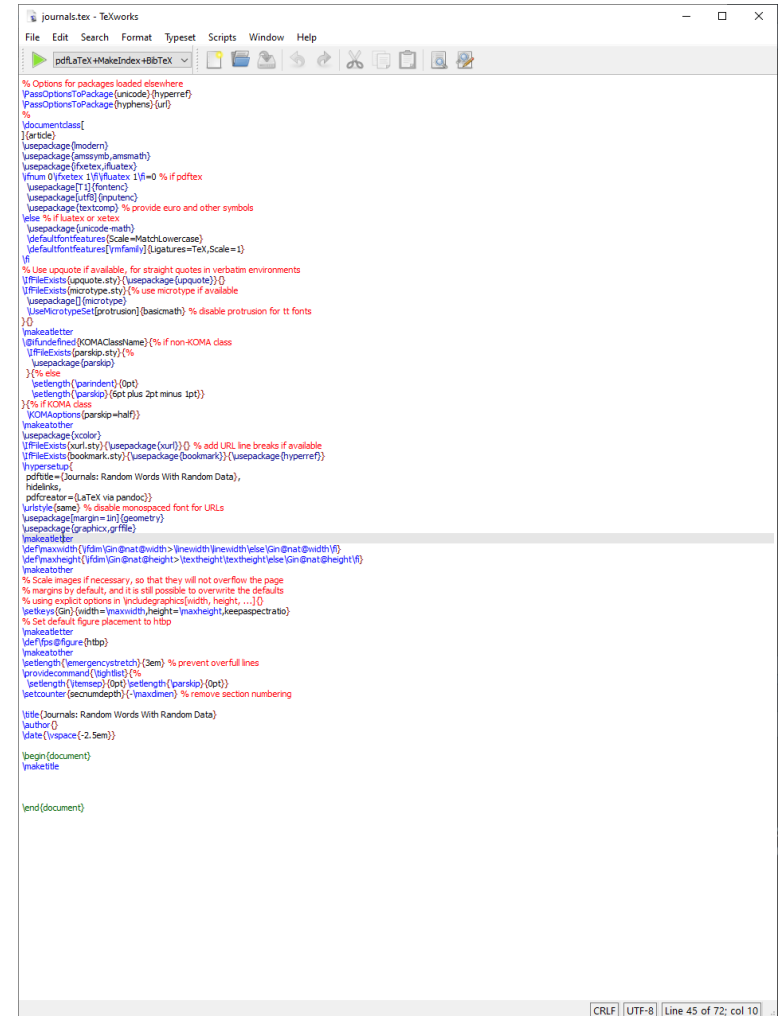


YAML — Variables — Output Formats

Documents as output formats include

- HTML
- LaTeX

```
---
title: "Journals: Random Words With Random Data"
output: latex_document
---
```

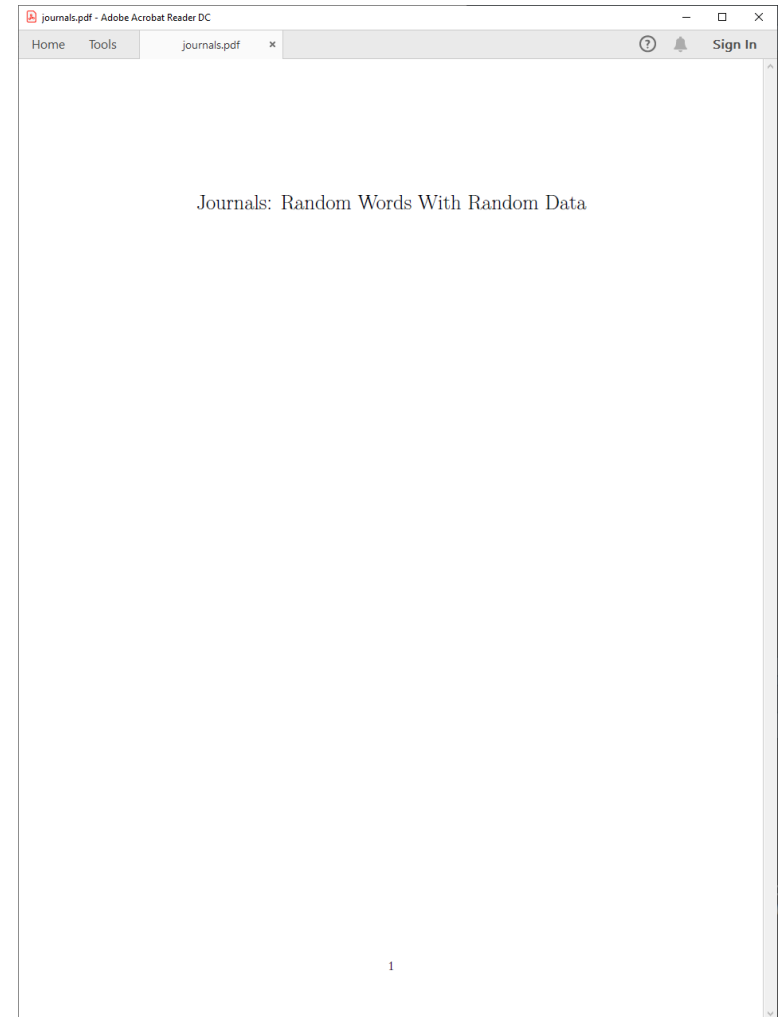


YAML — Variables — Output Formats

Documents as output formats include

- HTML
- LaTeX
- PDF

```
---  
title: "Journals: Random Words With Random Data"  
output: pdf_document  
---
```

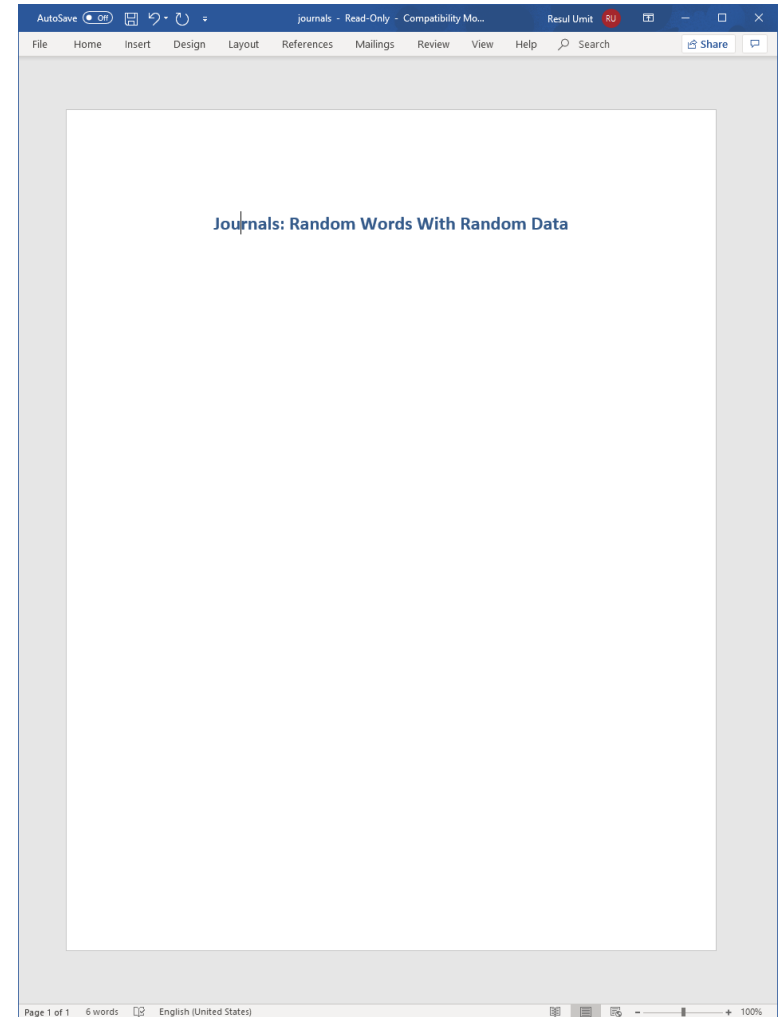


YAML — Variables — Output Formats

Documents as output formats include

- HTML
- LaTeX
- PDF
- Word

```
---  
title: "Journals: Random Words With Random Data"  
output: word_document  
---
```



YAML — Variables — Output Formats

- Documents as output formats

- `html_document`
- `latex_document`
- `pdf_document`*
- `word_document`
- `github_document`
- `md_document`
- `odt_document`
- `rtf_document`

- Presentations as output formats

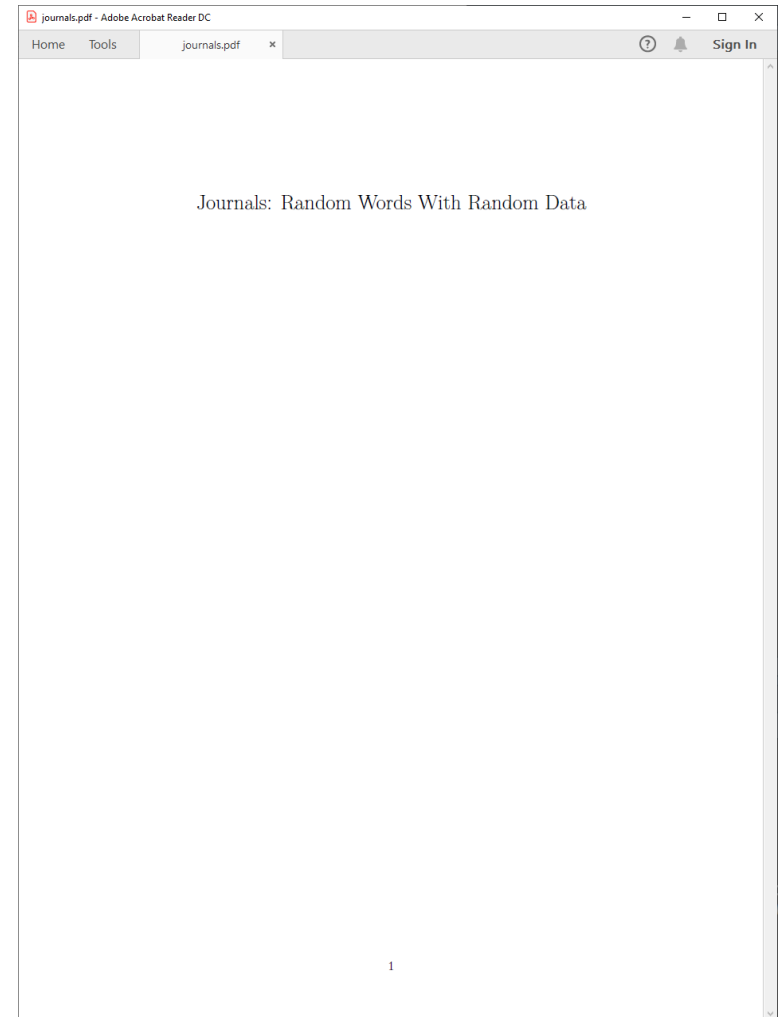
- `beamer_presentation`
- `ioslides_presentation`
- `powerpoint_presentation`
- `slidy_presentation`

[*] For reasons of simplicity, this workshop focuses on LaTeX and/or PDF outputs. Different output formats have slightly different customisations. see [Pandoc User's Guide](#) and/or R Markdown Cheat Sheet.

YAML — Strings

Strings with special characters, such as colon, require quotation marks " or '.

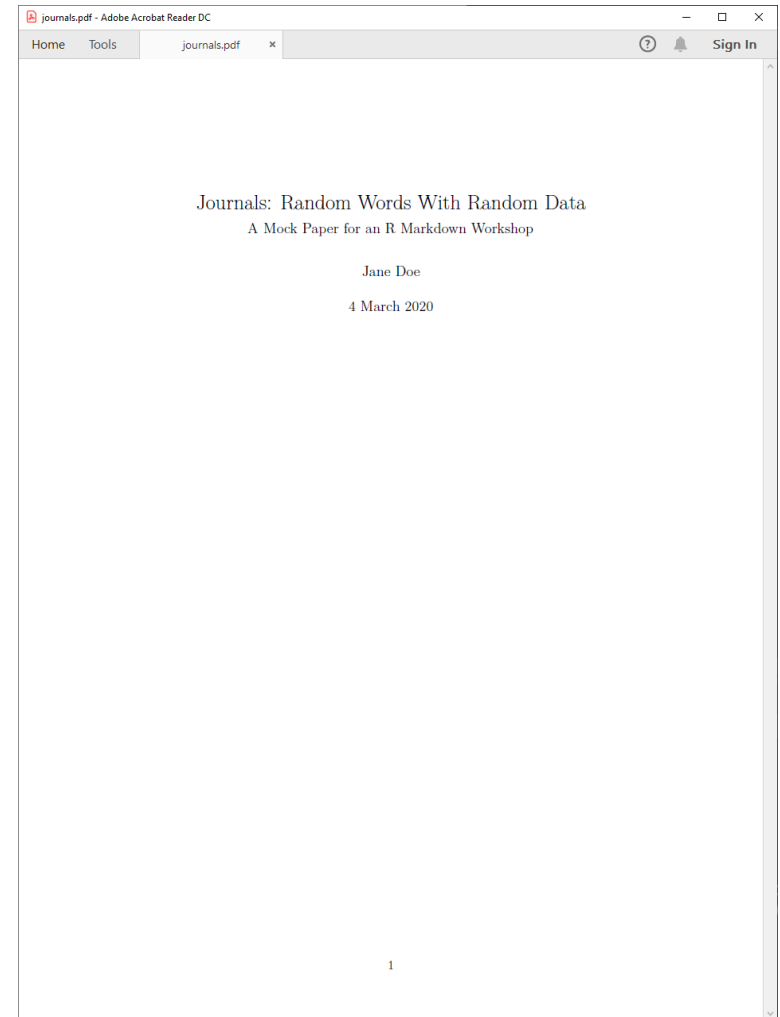
```
---  
title: "Journals: Random Words With Random Data"  
output: pdf_document  
---
```



YAML — Strings

Quotation marks are optional for strings without special characters

```
---  
title: "Journals: Random Words With Random Data"  
subtitle: A Mock Paper for an R Markdown Workshop  
author: Jane Doe  
date: 4 March 2020  
output: pdf_document  
---
```



YAML — Strings

The syntax `[^footnotes_go_here]` adds footnotes to strings

```
---  
title: "Journals: Random Words With Random Data^[Prelimi  
subtitle: A Mock Paper for an R Markdown Workshop  
author: "Jane Doe^[Department of Science, University of  
date: 4 March 2020  
output: pdf_document  
---
```

YAML — Strings

The bibliography and csl variables take strings as well

```
---  
title: "Journals: Random Words With Random Data^[Preliminary draft. Please do not cite or circulate  
subtitle: A Mock Paper for an R Markdown Workshop  
author: "Jane Doe^[Department of Science, University of Random. Email: jane.doe@random.edu. Website:  
date: 4 May 2020  
bibliography: references.bib  
csl: apa_7th.csl  
output: pdf_document  
---
```

YAML — Strings

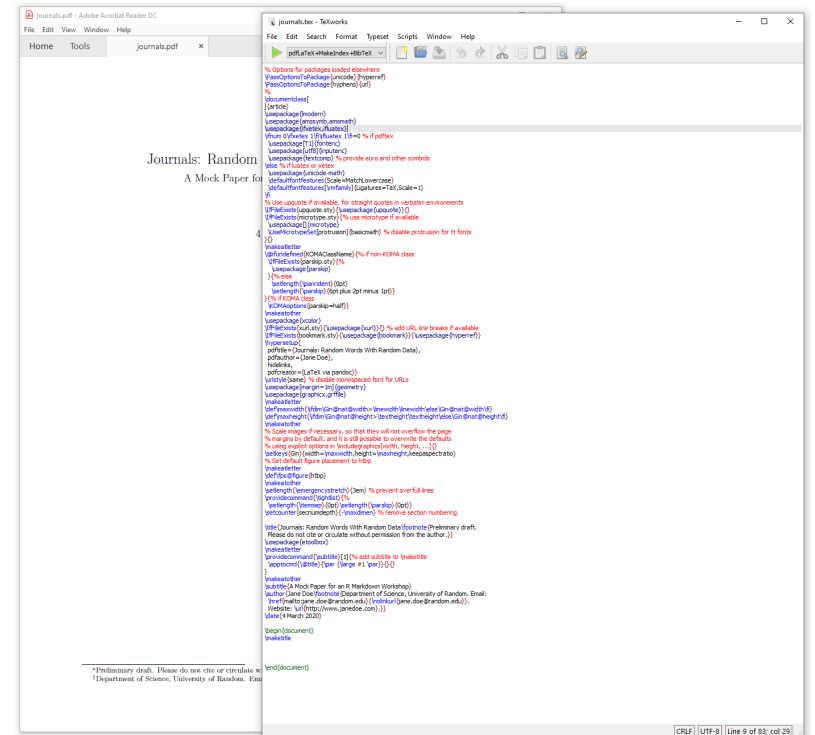
These strings depend on (a) where the files are located and (b) how they are named

```
---  
...  
bibliography: references/ref_library.bib  
csl: "C:/Users/resul/Dropbox/teaching/r_markdown/references/chicago_manual_17.csl"  
...  
---
```

YAML — Options and Sub-Options

Options can have sub-options

```
---
title: "Journals: Random Words With Random Data^[Preliminary draft]"
subtitle: A Mock Paper for an R Markdown Workshop
author: "Jane Doe^[Department of Science, University of Random]"
date: 4 March 2020
bibliography: references.bib
csl: apa_7th.csl
output:
  pdf_document:
    keep_tex: true
---
```



YAML — Options and Sub-Options

Options can have sub-options

```
---
title: "Journals: Random Words With Random Da
subtitle: A Mock Paper for an R Markdown Work
author: "Jane Doe^[Department of Science, Uni
date: 4 March 2020
bibliography: references.bib
csl: apa_7th.csl
output:
  pdf_document:
    keep_tex: true
---
```

Notice that

- this specific setting, highlighted, will create multiple outputs
 - a LaTeX and a PDF document
- all but the last option (i.e., `true`) takes a colon
- options and sub-options (except the last option, again) are stepwise indented
 - exactly with four spaces
 - the alignment between the colons for `pdf_document` and `keep_tex` is coincidental

YAML — R Code

Variables can take code as well

```
---  
title: "Journals: Random Words With Random Data^[Prelimi  
subtitle: A Mock Paper for an R Markdown Workshop  
author: "Jane Doe^[Department of Science, University of  
date: "r format(Sys.Date(), '%d %B %Y') "  
bibliography: references.bib  
csl: apa_7th.csl  
output: pdf_document  
---
```

YAML — R Code

Variables can take code as well

```
---
title: "Journals: Random Words With Random Da
subtitle: A Mock Paper for an R Markdown Work
author: "Jane Doe^[Department of Science, Uni
date: "r format(Sys.Date(), '%d %B %Y') "
bibliography: references.bib
csl: apa_7th.csl
output: pdf_document
---
```

Notice that

- such codes can be particularly useful for variables
 - that need frequent updates
 - and that can be automatically updated
 - e.g., date
- there are quotation marks around the code
- we'll cover codes in .Rmd documents later on in the workshop

YAML — R Code

Code and text can be combined in a string

```
---  
title: "Journals: Random Words With Random Data^[Prelimi  
subtitle: A Mock Paper for an R Markdown Workshop  
author: "Jane Doe^[Department of Science, University of  
date: "First version: 4 March 2020. This version: r for  
bibliography: references.bib  
csl: apa_7th.csl  
output: pdf_document  
---
```

YAML — Some Further Settings for PDF Outputs

- `fontsize`
 - the default is 10pt
 - the other options are 11pt and 12pt
- `linkcolor, urlcolor, citecolor`
 - the default is the colour of the text
 - the other options are white, red, green, blue, cyan, magenta, yellow
- `link-citations`
 - the default is no
 - the other option is yes — a click on an (part of) citation will take the screen to the relevant entry in the list of references

Exercises

10:00

- 1) Open `journals.Rmd` and fill in the YAML variables for the mock paper
 - take cues from `reproduce_this.pdf` and/or the slides
- 2) Add and set one of the variables mentioned among *Some Further Settings for PDF Outputs*
 - i.e., `fontsize`, `linkcolor`, `urlcolor`, `citecolor`, `link-citations`
- 3) Add and set a completely new variable not covered so far
 - see R Markdown Cheat Sheet
- 4) Knit your `journals.Rmd`
- 5) Consider tidying your working directory
 - you may wish to delete any trial files you have created so far
 - except, perhaps, `journals.pdf`, which we will keep re-creating
 - the original documents are `journals.Rmd`, `references.bib`, and `apa_tth.csl`

Part 4. Writing Text

Syntax — Overview

- R Markdown follows the syntax in Pandoc's Markdown
 - for the complete rules of the syntax, see [Pandoc User's Guide](#)
 - for a useful summary of the syntax, see the R Markdown Cheat Sheet

Syntax — Lines

Multiple spaces on a given line are reduced to one

```
This is a sentence followed by four spaces.    This is another sentence on the same line.
```

This is a sentence followed by four spaces. This is another sentence on the same line.

Line endings with fewer than two spaces are ignored

```
This is a sentence followed by one space.  
This is another sentence on a new line.
```

This is a sentence followed by one space. This is another sentence on a new line.

Syntax — Hard Brakes

Two or more spaces at the end of lines introduce hard brakes, forcing a new line

```
This is a sentence followed by two spaces.  
This is another sentence on a new line.
```

This is a sentence followed by two spaces.
This is another sentence on a new line.

Syntax — Line Blocks

Spaces in lines starting with a vertical line `|` are kept

```
| a one-space indent  
|   a five-space indent  
|     a ten-space indent
```

```
a one-space indent  
  a five-space indent  
    a ten-space indent
```


Syntax — Block Quotes

Lines starting with the grater-than sign `>` introduce block quotes

```
> In God, we trust. All others must bring data.  
>  
> --- Anonymous
```

In God, we trust. All others must bring data.

— Anonymous

Syntax — Paragraphs

One or more* blank lines introduce a new paragraph

This is the first sentence of a paragraph as it is preceded by a blank line. This is the second sentence of that paragraph, which is followed by a blank line.

This is the first sentence of a **new paragraph** as it is preceded by a blank line. This is the second sentence of that paragraph, which is followed by a blank line.

This is the first sentence of a paragraph as it is preceded by a blank line. This is the second sentence of that paragraph, which is followed by a blank line.

This is the first sentence of a *new paragraph* as it is preceded by a blank line. This is the second sentence of that paragraph, which is followed by a blank line.

[*] Multiple blank lines between paragraphs reduced to one

Syntax — Comments

Text with the syntax `<!-- comments -->` is omitted from output

```
<!-- This paragraph needs re-writing -->
```

This is the first sentence of a paragraph as it is preceded by a blank line. This is the second sentence of that paragraph, which is followed by a blank line.

This is the first sentence of a new paragraph `<!-- I've removed italics -->` as it is preceded by a blank line. This is the second sentence of that paragraph, which is followed by a blank line.

This is the first sentence of a paragraph as it is preceded by a blank line. This is the second sentence of that paragraph, which is followed by a blank line.

This is the first sentence of a new paragraph as it is preceded by a blank line. This is the second sentence of that paragraph, which is followed by a blank line.

Exercises

03:00

6) Hard Brakes

- see `reproduce_this.pdf`: page 1
- apply in `journals.Rmd`: paragraph 1

7) Line Blocks / Block Quotes

- see `reproduce_this.pdf`: page 1
- apply in `journals.Rmd`: block quote, between paragraphs 1 and 2

Syntax — Headers

The number sign `#` introduces headers; lower levels are created with additional signs — up to total five levels

`# Introduction` becomes

Introduction

`## 1. Introduction` becomes

1. Introduction

`### 3.1 Introduction` becomes

3.1 Introduction

`#### Introduction` becomes

Introduction

`##### Introduction` becomes

Introduction

Syntax — Emphases

A pair of single asterisk `*` or underscores `_` introduces italics

`*italics*` becomes *italics*

`_italics_` becomes *italics* as well

A pair of double asterisk or underscores introduces bold

`**bold**` becomes **bold**

`__bold__` becomes **bold** as well

These two rules can be combined

`**_bolditalics_**` becomes ***bolditalics***

`_**bolditalics**_` becomes ***bolditalics*** as well

Syntax — Strikethrough

A pair of double tildes ~ introduces strikethrough

~~strikethrough~~ becomes ~~strikethrough~~

Strikethrough can be combined with italics or bold

***~strikebold~~** or __~~strikebold~~__, they both become ~~**strikebold**~~

~~**strikebold**~~ or ~~__strikebold__~~, they both become ~~**strikebold**~~ as well

~~~strikeitalitcs~~~ or \_~~strikeitalitcs~~\_, they both become ~~*strikeitalitcs*~~

~~\*strikeitalitcs\*~~ or ~~\_strikeitalitcs\_~~, they both become ~~*strikeitalitcs*~~ as well

# Exercises

03:00

## 8) Headers

- see `reproduce_this.pdf`: pages 1 to 11
  - 11 headers, Abstract to References
- apply in `journals.Rmd`

## 9) Emphases

- see `reproduce_this.pdf`: pages 1 and 2
  - bold and italics
- apply in `journals.Rmd`: paragraph 2



# Syntax — Links — Internal\*

You can link text to section headers in the same document

[Conclusion] (#conclusion) becomes **Conclusion**, and a click takes the screen to that section

Multi-word headers need hyphenation

[Literature Review] (#literature-review) becomes **Literature Review**, and it works only if the second part is hyphenated

[\*] We will cover links to references, figures, and tables later on.

# Syntax — Links — External

You can link text to URLs

`[click here](https://resulunit.com/)` becomes [click here](https://resulunit.com/)

`<https://resulunit.com>` becomes <https://resulunit.com>

`[https://resulunit.com](https://resulunit.com/)` becomes <https://resulunit.com> as well

You can also link text to email addresses

`[email me](mailto:resul.umat@unilu.ch)` \* becomes [email me](mailto:resul.umat@unilu.ch)

`<resul.umat@unilu.ch>` becomes [resul.umat@unilu.ch](mailto:resul.umat@unilu.ch)

[\*] Notice the prefix **mailto:** in the second part of the construct

# Exercises

03:00

## 10) Links — Internal

- see `reproduce_this.pdf`: page 2
  - the link to the Literature Review section
- apply in `journals.Rmd`: paragraph 4

## 11) Links — External

- see `reproduce_this.pdf`: page 1
  - email and website links in one of the footnotes
- apply in `journals.Rmd`: title page items

# Syntax — Equations

Inline equations go between a pair of single dollar signs  $\$$  — with no space between the signs and the equation itself

`$E = mc^{2}$` becomes  $E = mc^2$

Block equations go in between a pair of double dollar signs — with or without spaces, it works

`$$ E = mc^{2} $$` becomes

$$E = mc^2$$

`$$E = mc_{2} $$` becomes

$$E = mc_2$$

# Syntax — Footnotes — Inline Notes

For inline footnotes, use the `^[footnote]` syntax

`Jane Doe^[Corresponding author.]` becomes `Jane Doe1`

Notice that

- the caret sign `^` comes **before** the left square bracket `[`
- this syntax works in YAML as well as in text
  - footnotes in YAML get symbols, in text they get numbers

`[1] Corresponding author.`

# Syntax — Footnotes — Notes with Identifiers

An alternative is to use the `[^identifier]` syntax, with identifiers defined elsewhere in the same document

```
Dr Doe holds a PhD in rock science.[^defence_date]  
[^defence_date]: She defended her thesis in 2017.
```

Dr Doe holds a PhD in rock science.<sup>1</sup>

Notice that

- the caret sign comes **after** the left square bracket
- this syntax works in text, but not in YAML

[1] She defended her thesis in 2017.

# Exercises

03:00

## 12) Equations

- see `reproduce_this.pdf`: page 7
- apply in `journals.Rmd`: paragraph 22; block equation, between paragraphs 22 and 23

## 13) Footnotes

- see `reproduce_this.pdf`: page 2
- apply in `journals.Rmd`: paragraph 3

# Syntax — Lists

Lines starting with asterisk `*` as well as plus `+` or minus `-` signs introduce lists

```
- books  
- articles  
- reports
```

- books
- articles
- reports



# Syntax — Lists — Nesting

Lists can be nested within each other, with indentation

```
+ books
+ articles
  - published
  - under review
    + revised and resubmitted
  - work in progress
```

- books
- articles
  - published
  - under review
    - revised and resubmitted
  - work in progress

# Syntax — Lists — Numbering

List items can be numbered

- ```
1. books
2. articles
  - published
  - under review
    + revised and resubmitted
  - work in progress
```

- ```
1. books
2. articles
  ◦ published
  ◦ under review
    ▪ revised and resubmitted
  ◦ work in progress
```

# Syntax — Dashes

Two hyphens grouped together introduce an en-dash

-- becomes —

Three hyphens grouped together introduce an em-dash

--- becomes —

# Syntax — Sub- and Super-scripts

A pair of tildes introduces subscript

`CO~2~` becomes `CO2`

A pair of carets introduces subscript

`R^2^` becomes `R2`

# Syntax — Sub- and Super-scripts

A pair of tildes introduces subscript

`CO~2~` becomes `CO2`

A pair of carets introduces subscript

`R^2^` becomes `R2`

Notice that

- the syntax here (Markdown-based) is different than the one for equations (LaTeX-based)
  - e.g., `R^2^` versus `mc^{2}`

# Exercises

03:00

## 14) Lists

- see `reproduce_this.pdf`: page 3
- apply in `journals.Rmd`: list, between paragraphs 10 and 11

## 15) Dashes

- see `reproduce_this.pdf`: page 2
- apply in `journals.Rmd`: paragraph 6

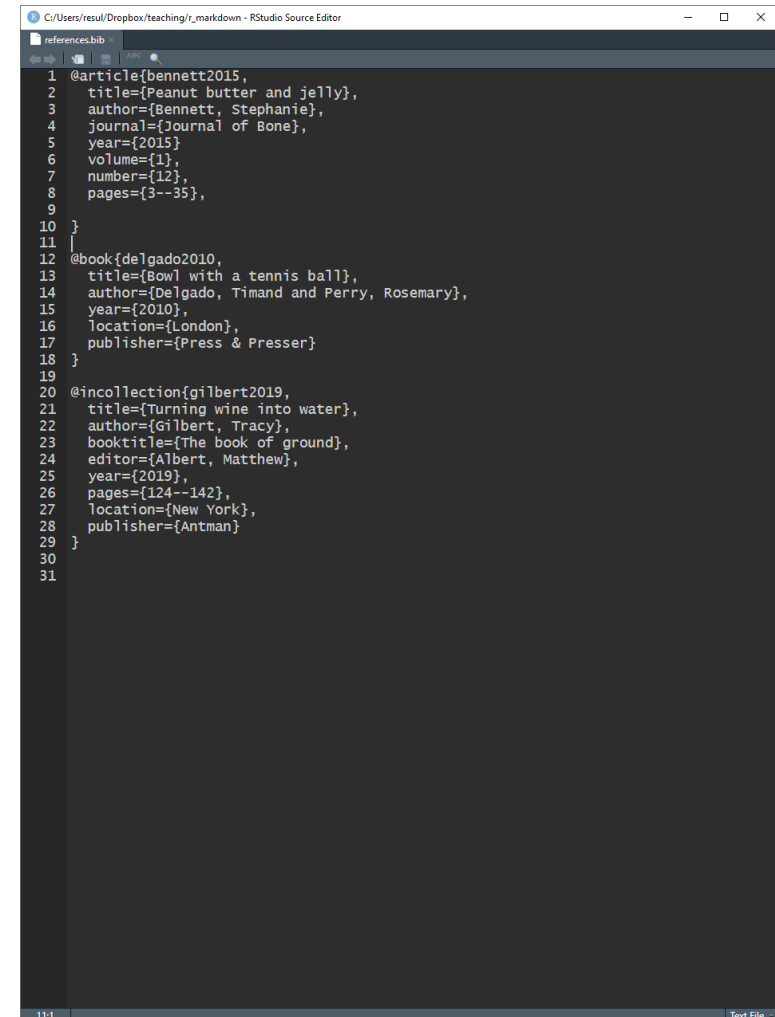
## 16) Sub- and Super-scripts

- see `reproduce_this.pdf`: page 2
- apply in `journals.Rmd`: paragraph 5

# Part 5. Managing References

# References — Bibliography Database

- References are defined in .bib files
  - they follow the BibTeX format
- pandoc looks for a .bib file, and for the definitions therein, to process citations
  - .bib files are specified with the bibliography variable in YAML
- pandoc can process a citation only if there is a linked entry in the .bib file
  - but not all entries have to be cited



```
1 @article{bennett2015,  
2   title={Peanut butter and jelly},  
3   author={Bennett, Stephanie},  
4   journal={Journal of Bone},  
5   year={2015},  
6   volume={1},  
7   number={12},  
8   pages={3--35},  
9 }  
10  
11  
12 @book{delgado2010,  
13   title={Bowl with a tennis ball},  
14   author={Delgado, Timand and Perry, Rosemary},  
15   year={2010},  
16   location={London},  
17   publisher={Press & Presser}  
18 }  
19  
20 @incollection{gilbert2019,  
21   title={Turning wine into water},  
22   author={Gilbert, Tracy},  
23   booktitle={The book of ground},  
24   editor={Albert, Matthew},  
25   year={2019},  
26   pages={124--142},  
27   location={New York},  
28   publisher={Antman}  
29 }  
30  
31
```



# References — Bibliography Database — Entries

- A BibTeX entry consists of three elements
  - a type
    - e.g., @article
  - a citation-key
    - e.g., bennett2015
  - a number of tags
    - e.g., title, author
- Different tags are available for different reference types
  - some tags are required, others are optional

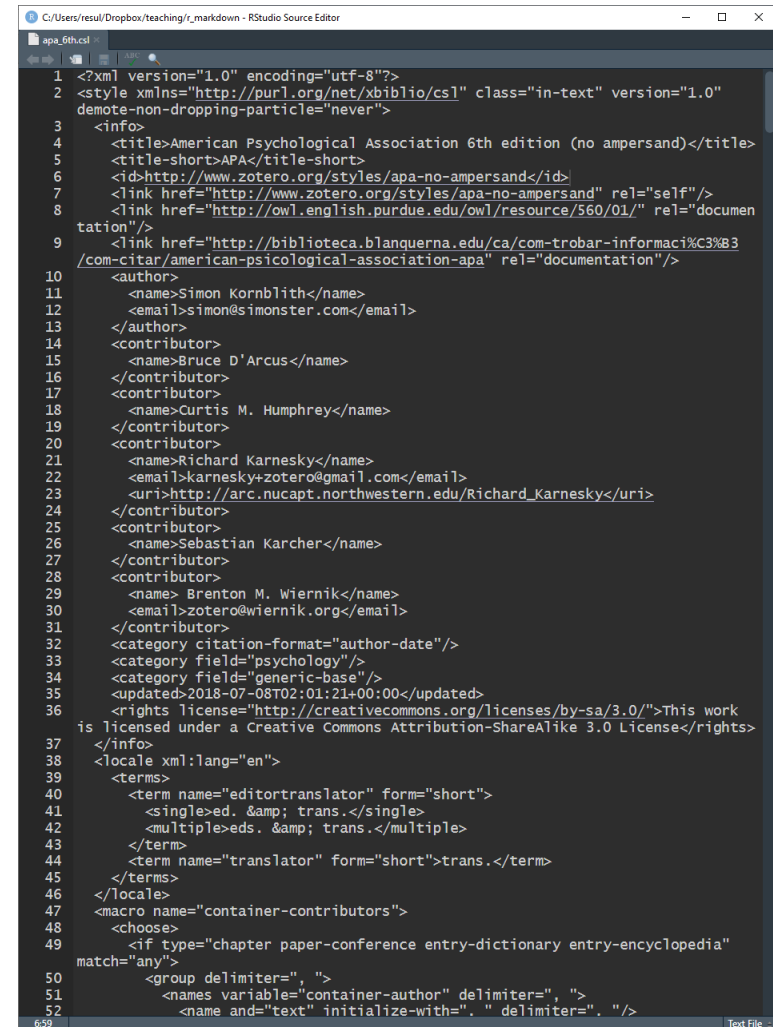
```
1 @article{bennett2015,  
2   title={Peanut butter and jelly},  
3   author={Bennett, Stephanie},  
4   journal={Journal of Bone},  
5   year={2015}  
6   volume={1},  
7   number={12},  
8   pages={3--35},  
9  
10  }  
11
```

# References — Bibliography Database — Entries

- One could create entries by hand
  - this requires knowing the BibTeX format, entry types, tags, and related information about references to be cited
    - this is not efficient
- A good alternative Google Scholar, which provides BibTeX entries
  - follow `cite` -> BibTeX and copy
  - paste into `.bib`, edit if necessary, and save
- Some publishers and journals provide BibTeX entries on their website as well

# References — Style

- Reference styles are defined in .csl files
  - files for different styles are available at <https://www.zotero.org/styles>
- pandoc looks for a .csl file, and for the styles therein, to style citations and references
  - .csl files are specified with the `csl` variable in YAML
  - if unspecified, it uses a Chicago author-date format
- .csl files affect the style only in outputs
  - no matter which the style is used, the citation syntax in .Rmd documents is the same



```
1 <?xml version="1.0" encoding="utf-8"?>
2 <style xmlns="http://purl.org/net/xbiblio/csl" class="in-text" version="1.0"
  demote-non-dropping-particle="never">
3   <info>
4     <title>American Psychological Association 6th edition (no ampersand)</title>
5     <title-short>APA</title-short>
6     <id>http://www.zotero.org/styles/apa-no-ampersand</id>
7     <link href="http://www.zotero.org/styles/apa-no-ampersand" rel="self"/>
8     <link href="http://owl.english.purdue.edu/owl/resource/560/01/" rel="documenta
  tion"/>
9     <link href="http://biblioteca.blauquerna.edu/ca/com-trobar-informaci%C3%B3
    /com-citar/american-psicological-association-apa" rel="documentation"/>
10    <author>
11      <name>Simon Kornblith</name>
12      <email>simon@simonster.com</email>
13    </author>
14    <contributor>
15      <name>Bruce D'Arcus</name>
16    </contributor>
17    <contributor>
18      <name>Curtis M. Humphrey</name>
19    </contributor>
20    <contributor>
21      <name>Richard Karnesky</name>
22      <email>karnesky@zotero@gmail.com</email>
23      <uri>http://arc.nucapt.northwestern.edu/Richard_Karnesky</uri>
24    </contributor>
25    <contributor>
26      <name>Sebastian Karcher</name>
27    </contributor>
28    <contributor>
29      <name>Brenton M. Wiernik</name>
30      <email>zotero@wiernik.org</email>
31    </contributor>
32    <category citation-format="author-date"/>
33    <category field="psychology"/>
34    <category field="generic-base"/>
35    <updated>2018-07-08T02:01:21+00:00</updated>
36    <rights license="http://creativecommons.org/licenses/by-sa/3.0/">This work
  is licensed under a Creative Commons Attribution-ShareAlike 3.0 License</rights>
37  </info>
38  <locale xml:lang="en">
39    <terms>
40      <term name="editortranslator" form="short">
41        <single>ed. & trans.</single>
42        <multiple>eds. & trans.</multiple>
43      </term>
44      <term name="translator" form="short">trans.</term>
45    </terms>
46  </locale>
47  <macro name="container-contributors">
48    <choose>
49      <if type="chapter paper-conference entry-dictionary entry-encyclopedia"
  match="any">
50        <group delimiter=" ">
51          <names variable="container-author" delimiter=" ">
52            <name and="text" initialize-with="." delimiter="." />
```

# References — In-text Citation Syntax

All citations keys take the 'at' sign @, square brackets and/or minus signs introduce variation

[@bennett2015] becomes (Bennett, 2015)

@bennett2015 becomes Bennett (2015)

[-@bennett2015] becomes (2015)

-@bennett2015 becomes 2015

[@bennett2015 35] becomes (Bennett, 2015, p. 35)

[@bennett2015 33–35] becomes (Bennett, 2015, pp. 33–35)

[@bennett2015, ch. 1] becomes (Bennett, 2015, ch. 1)

[@bennett2015; @gilbert2019] becomes (Bennett, 2015; Gilbert, 2019)

[see @bennett2015, for details] becomes (see Bennett, 2015, for details)

@bennett2015 [33–35] becomes Bennett (2015, pp. 33–35)

# Citations — Reference List

The list of references is inserted after the last line of the document, with no section header.

- ending your .Rmd documents with a header for the list of references

```
This is the last sentence of the manuscript.
```

```
## References
```

This is the last sentence of the manuscript.

## References

Bennett, S. (2015). Peanut butter and jelly. *Journal of Bone*, 1(12), 3–35.

Gilbert, T. (2019). Turning wine into water. In M. Albert (Ed.), *The book of ground* (pp. 124–142). New York: Antman.

# References — Internal Links

For internal links from in-text citations to the reference list, set `link-citations: yes` in YAML

- a click on these links take the screen to the relevant entry in the list
- the `linkcolor` variable make these links explicit
  - this is not necessary for the links to work

```
---  
...  
bibliography: references.bib  
csl: apa_7th.csl  
link-citations: yes  
linkcolor: blue  
...  
---
```

# Exercises

07:30

17) Add an entry to `references.bib` for the following book

- *R Markdown: The Definitive Guide* by Xie and co-authors

18) Reproduce the citations and reference list in the mock paper

- see `reproduce_this.pdf`: pages 3 and 11
- apply in `journals.Rmd`: paragraph 7 to 9

19) Change reference style

- download your `.csl` file for your favourite style from <https://www.zotero.org/styles>
- update the YAML variable

20) Link the citations to the reference list

## Part 6. Adding Code, Figures, and Tables



# Code, in and outside Chunks

# Code — Overview

Most codes go inside code chunks

- e.g., code that imports and cleans data, and/or produces tables and/or figures

```
```${r}

df <- read.csv("rmd_workshop_files/images_data/journals.csv") %>%
  mutate(age = 2020 - since,
         english = factor(english),
         subfield = factor(subfield))

```
```

Codes can also go in line with text

- .e.g., code that result in a single statistic

```
The average H5 Index for the journals in the dataset is `r mean(df$h5_index)`.
```

# Code Chunks — Overview

- Code chunks are delimited spaces between a pair of three backticks
  - below is an empty chunk for R code

```
```${r}  
```
```

- `r` is an option of the chunk, indicating that the code in the chunk above should be run by R
  - it could have been `python`, which we will not cover in this workshop
  - options go in a pair of curly brackets, on the same line with the first delimiter
- Chunks can be placed anywhere in `.Rmd` documents
  - their output, if there is any, might float around text to avoid breaking across pages

# Code Chunks — Labels

It is recommended to label the code chunks, which are otherwise automatically numbered

- informative labels can be helpful for navigating through error messages as well as filenames of plots and cache
  - in the example below, the chunk is labelled as `data_import`
- but note that duplicate labels lead to an error during compilation

```
```${r, data_import}  
df <- read_csv("data/journals.csv")  
```
```

# Code Chunks — Options

- Code chunks take options, listed on the same line with the first delimiter, in curly brackets
  - avoid spaces around the equal sign `=` between option tags and values
    - such spaces might lead to errors
  - in the example below, the chunk is labelled as `setup`, and the `include` option is set to `FALSE`
    - with this option and value, nothing from this chunk will be included in the output document

```
```${r, setup, include=FALSE}  
```
```

- The list of options is available at <https://yihui.org/knitr/options>
  - R Markdown Cheat Sheet provides a helpful list as well

# Code Chunks — Options — Defaults

Options have default values

- e.g., for `echo`, the default is `TRUE`
  - `echo`: should the source code printed in the output? — yes
- therefore the following two chunks have the same function

```
```${r}  
```
```

```
```${r, echo=TRUE}  
```
```

# Code Chunks — Options — Defaults

This chunk prints two things in the output document — (a) the code and (b) the head of the data frame

```
```${r}  
head(df)  
```
```

```
head(df)
```

```
##           name  origin  branch h5_index h5_median english subfield issues age  
## 1 Journal of Bears Americas Physical    73      97      1        1      7  61  
## 2 Journal of Moon   Asia   Social    72     106      1        0      6  64  
## 3 Journal of Lumber Americas Physical    72     100      1        1      8  30  
## 4 Journal of Houses Europe   Social    72     102      1        0      8  38  
## 5 Journal of Water Europe   Social    70     100      1        0      5  33  
## 6 Journal of Jeans Americas Physical    69     101      1        1      5  64
```

# Code Chunks — Options

Setting `echo=FALSE` prevents the code from being displayed in the output document

```
```{r, echo=FALSE}  
head(df)  
```
```

This chunk therefore prints one thing in the output document — the head of the data frame

```
##           name  origin  branch h5_index h5_median english subfield issues age  
## 1 Journal of Bears Americas Physical    73      97      1      1      7  61  
## 2 Journal of Moon   Asia   Social    72     106      1      0      6  64  
## 3 Journal of Lumber Americas Physical    72     100      1      1      8  30  
## 4 Journal of Houses Europe   Social    72     102      1      0      8  38  
## 5 Journal of Water Europe   Social    70     100      1      0      5  33  
## 6 Journal of Jeans Americas Physical    69     101      1      1      5  64
```



# Code Chunks — Other Useful Options

Prevent the result(s) of the source code from being displayed in the output document

```
```${r, results="hide"}  
head(df)  
```
```

This chunk therefore prints one thing in the output document — the source code

```
head(df)
```

Setting `results="asis"` passes the results as they are produced by the code. In creating tables for PDF output with the `stargazer` package,\* it is a must.

# Code Chunks — Other Useful Options

Cache results for future compilations

```
` `{r ... cache=TRUE}  
` `
```

Prevent R from running the code in the chunk altogether

```
` `{r ... eval=FALSE}  
` `
```

Prevent messages and/or warnings from being displayed in the output

```
` `{r ... error=FALSE, message=FALSE, warning=FALSE}  
` `
```

# Code Chunks — Other Useful Options

Define the **actual** dimensions of figures, in inches

```
```{r ... fig.height=6, fig.width=9}  
```
```

Define the size of figures **in the output document**, with `out.width` and/or `out.height`

```
```{r ... out.width="50%"}  
```
```

Define the alignment of figures — `left`, `right`, or `center`

```
```{r ... fig.align="center"}  
```
```

# Code Chunks — Other Useful Options

Define captions for figures

```
```{r ... fig.caption="A Scatter Plot"}  
```
```

Set the resolution for figures

```
```{r ... dpi=300}  
```
```

Set extra options, such as angle, that output format would accept for figures

```
```{r ... out.extra="angle=45"}  
```
```

# Code Chunks — The Setup Chunk

It is recommended to use the first code chunk for general setup, where you can

- define **your own defaults** for chunk options, with `knitr::opts_chunk$set()`
  - avoids repeating chunk options
- load the necessary packages
- import raw data

```
```${r, setup, include=FALSE}  
  
# chunk option defaults  
knitr::opts_chunk$set(echo=FALSE, message=FALSE)  
  
# packages  
library(dplyr)  
library(ggplot2)  
library(stargazer)  
  
# data  
df_raw <- read.csv("journals.csv")  
  
```
```

# Code Chunks — The Data Chunk

I recommend using the second chunk for the main operations\* on raw data

- e.g., for data cleaning and other transformations
- some minor transformations could be left to lower chunks
  - e.g., capitalizing variable names for figures

```
`r, data, echo=FALSE ...}  
  
df <- df_raw %>%  
  ...  
  
`r
```

[\*] I will be using the pipe operator `%>%` and other functions from the `dplyr` package for such operations in the following slides.

# Code Chunks — The Data Chunk

Transform `subfield` and `english` into factor variables

- despite being numeric — i.e., 0s and 1s — they are meant to be categorical variables

```
` `{r, data, echo=FALSE ...}  
  
df <- df_raw %>%  
  mutate(subfield = as.factor(subfield),  
         english = as.factor(english))  
  
` }
```

# Code Chunks — The Data Chunk

Create a new variable `age`, based on the existing variable `since`, to be used in regression models later on

```
`r, data, echo=FALSE ...}  
  
df <- df_raw %>%  
  mutate(subfield = as.factor(subfield),  
         english = as.factor(english),  
         age = 2020 - since)  
  
...
```

Drop the `since` variable, so that it won't appear in our summary statistics table later on

```
`r, data, echo=FALSE ...}  
  
df <- df_raw %>%  
  mutate(subfield = as.factor(subfield),  
         english = as.factor(english),  
         age = 2020 - since) %>%  
  select(-since)  
  
...
```



# Inline Code — Overview

Code can also be incorporated in text, with the ``r`` syntax

- unline chunks, these do not take options
- the output document will display the result of the code
  - in the exact place of the source code
- the result of the code will have the same formatting with the text

# Inline Code — Examples

If we multiply `_pi_` by `5`, we get ``r pi * 5``.

If we multiply *pi* by 5, we get 15.7079633.

The average H5 Index **for** the journals **in** the dataset is ``r mean(df$h5_index)``, which would round to ``r round(mean(df$h5_index), digits = 1)``.

The average H5 Index for the journals in the dataset is 26.3611366, which would round to 26.4.

`__Only `r nrow(subset(df, english == 0))` journals__` **in** the dataset are published **in** a language other than English.

**Only 113 journals** in the dataset are published in a language other than English.

# Exercises

07:30

## 21) Introduce a setup chunk

- define one or more defaults chunk options, with `knitr::opts_chunk$set()`
- load the packages that we will need — `dplyr`, `ggplot2`, and `stargazer`
- import raw data

## 22) Introduce a data chunk

- transform `subfield` and `english` into factors
- create a new variable `age`, based on `since`
- drop `since` from the data frame

## 23) Inline Code

- see `reproduce_this.pdf`: page 6
  - i.e., 1091 observations
- apply in `journals.Rmd`: paragraph 21
  - hint: use the `nrow` function

# Figures

# Figures — Images — Markdown Syntax

The syntax `![Figure Caption](figure.extension)` embeds images, and/or figures produced elsewhere,<sup>\*</sup> into .Rmd documents

- similar to the link syntax, only this time it is preceded by an exclamation mark **!**
- goes outside code chunks, on a new line
- simple, but not very customisable

[\*] Ideally, reproducible papers should produce their own images with data and code. However, there might be situations where this is not possible.

# Figures — Images — Markdown Syntax

```
![A screenshot of the Google Scholar homepage](../image/google_scholar.png)
```

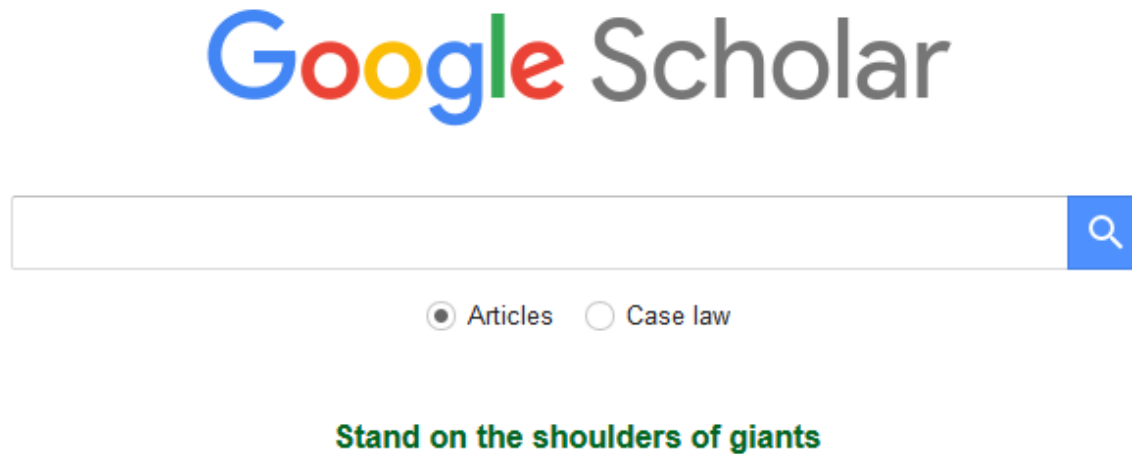
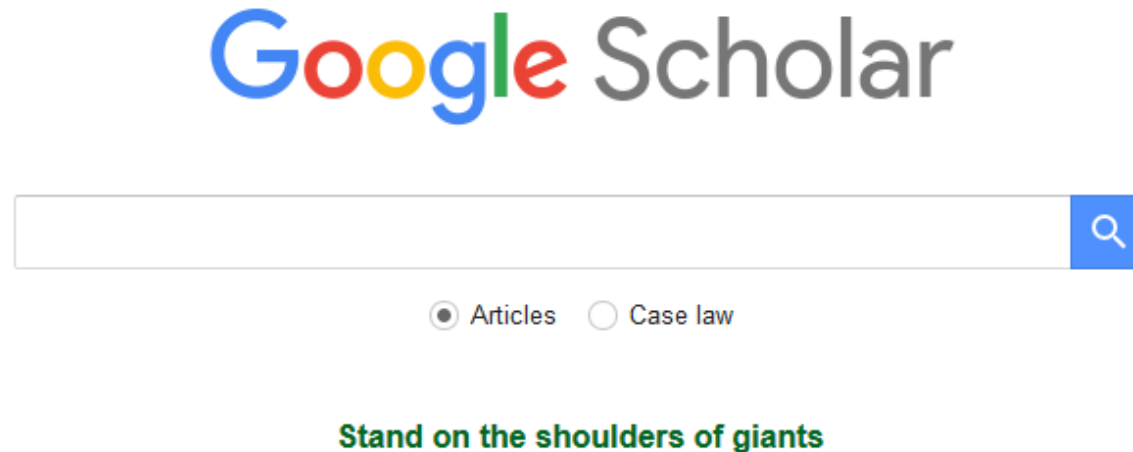


Figure 1: A screenshot of the Google Scholar homepage.

# Figures — Images — Markdown Syntax

Figures are numbered automatically

```
![A screenshot of the Google Scholar homepage](../image/google_scholar.png)
```



**Figure 1:** A screenshot of the Google Scholar homepage.

# Figures — Images — Markdown Syntax

The syntax can accept width or height attributes as follows

```
[A screenshot of the Google Scholar homepage](../image/google_scholar.png) { width=40% }
```

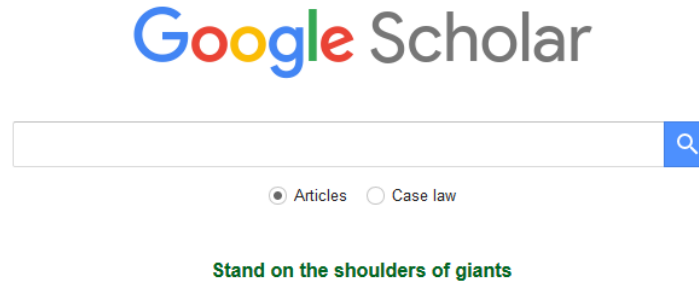


Figure 1: A screenshot of the Google Scholar homepage.



# Figures — Images — knitr

The knitr package offers a capable alternative with the `include_graphics()` function

- this goes inside code chunks
  - use the function with the double-colon operator `::`
    - e.g., `knitr::include_graphics("figure.extension")`
- this is more customisable, through the use of code chunks
  - size is defined with the `out.width` or `out.hight` options
    - rather than `fig.height` and/or `fig.width`

# Figures — Images — knitr

The knitr package offers a capable alternative with the `include_graphics()` function

```
```${r, screenshot, echo=FALSE, fig.cap="A screenshot of the Google Scholar homepage."}  
knitr::include_graphics("../figures/google_scholar.png")  
```
```

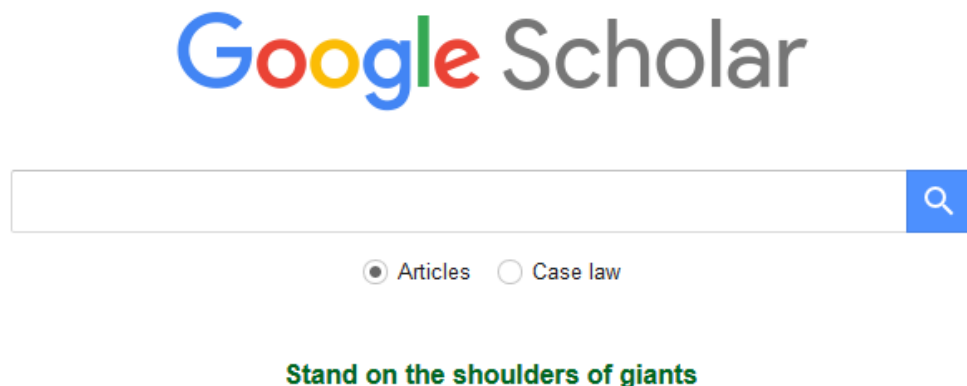


Figure 1: A screenshot of the Google Scholar homepage.

# Figures — Images — knitr

Size is defined with the chunk options `out.width` or `out.height`

```
```\{r ... out.width="40%" }  
knitr::include_graphics("../figures/google_scholar.png")  
```
```

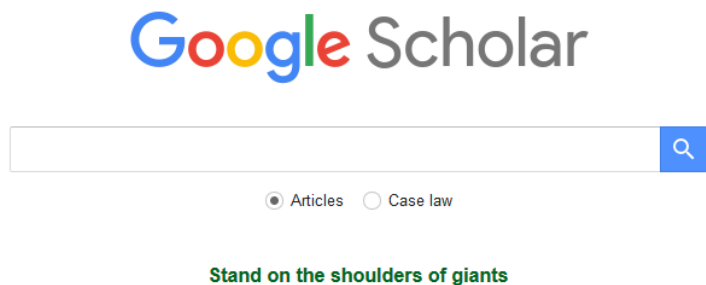


Figure 1: A screenshot of the Google Scholar homepage.

# Figures — Images — knitr

Most other chunk options are common with figures plotted within R Markdown, such as `fig.align`

```
```${r} ... fig.align="center"}```  
knitr::include_graphics("../figures/google_scholar.png")  
```
```

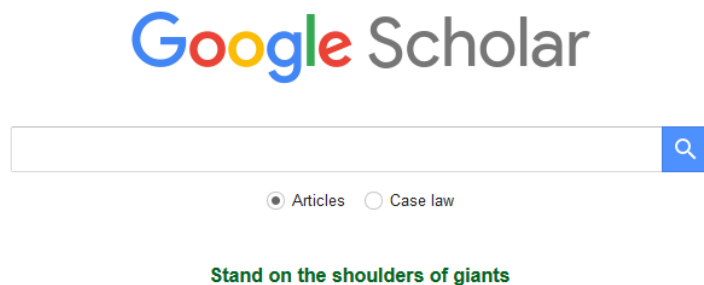


Figure 1: A screenshot of the Google Scholar homepage.

# Exercises

03:00

## 24) Images

- see `reproduce_this.pdf`: figure 1 on page 10
- apply in `journals.Rmd`: figure 1, between paragraphs 19 and 20

# Figures — ggplot2 — Overview

- A powerful package for visualising data
- Used widely, not only by academics, but also by large corporations such as the New York Times
- A huge amount is written on this package. See, for example,
  - the [package documentation](#)
  - this [book](#) by its creator Hadley Wickham
  - this [reference page](#)
  - this [webinar](#) by one of its authors, Thomas Lin Pedersen
  - these [further extensions](#), maintained by the ggplot2 community
- Among its alternatives are the base and plotly packages

# Figures — ggplot2 — Basics

## 1) The ggplot function and the data argument

- specify a data frame in the main ggplot function

```
ggplot(data = df)
```

## 2) The mapping aesthetics, or `aes`; most importantly, the variable(s) that we want to plot

- specify as an additional argument in the same ggplot function

```
ggplot(data = df, mapping = aes(x = h5_median, y = h5_index, color = subfield))
```

## 3) The geometric objects, or `geom`; the visual representations

- specify, after a plus sign `+`, as an additional function

```
ggplot(data = df, mapping = aes(x = h5_median, y = h5_index, color = subfield)) +  
  geom_point()
```

# Figures — ggplot2

Put the code in a chunk, and give it a caption

```
```{r, scatterplot, fig.cap = "A scatterplot of journal  
ggplot(data = df, mapping = aes(x = h5_median, y = h5_index  
  geom_point()  
```
```

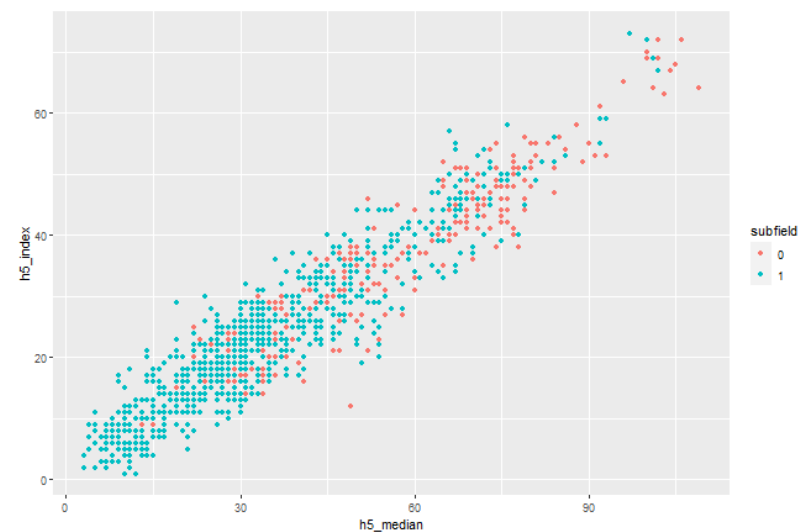


Figure 1. A scatterplot of journal metrics.



# Figures — ggplot2

Add facets for subgroups, e.g., branch

```
```{r, scatterplot, fig.cap = "A scatterplot of journal  
ggplot(data = df, mapping = aes(x = h5_median, y = h5_index)  
  geom_point() +  
  facet_wrap(. ~ branch)  
```\n```\n
```

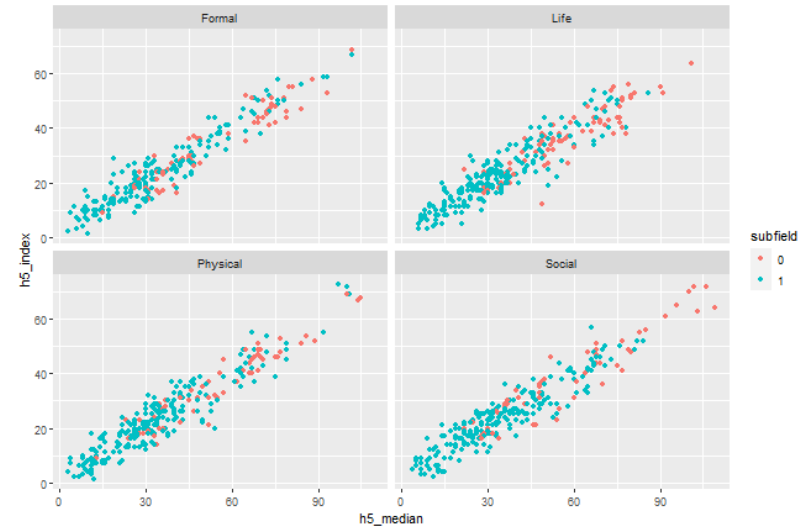


Figure 1. A scatterplot of journal metrics.

# Figures — ggplot2

Scale the colour to improve the legend

```
```{r, scatterplot, fig.cap = "A scatterplot of journal  
ggplot(data = df, mapping = aes(x = h5_median, y = h5_index)  
  geom_point() +  
  facet_wrap(. ~ branch) +  
  scale_colour_discrete(name = "Journal Type", break  
  ` ` `
```



Figure 1. A scatterplot of journal metrics.

# Figures — ggplot2

Change the theme

```
```{r, scatterplot, fig.cap = "A scatterplot of journal  
ggplot(data = df, mapping = aes(x = h5_median, y = h5_ir  
  geom_point() +  
  facet_wrap(. ~ branch) +  
  scale_colour_discrete(name = "Journal Type", brea  
  theme_bw()  
```\n```\n
```

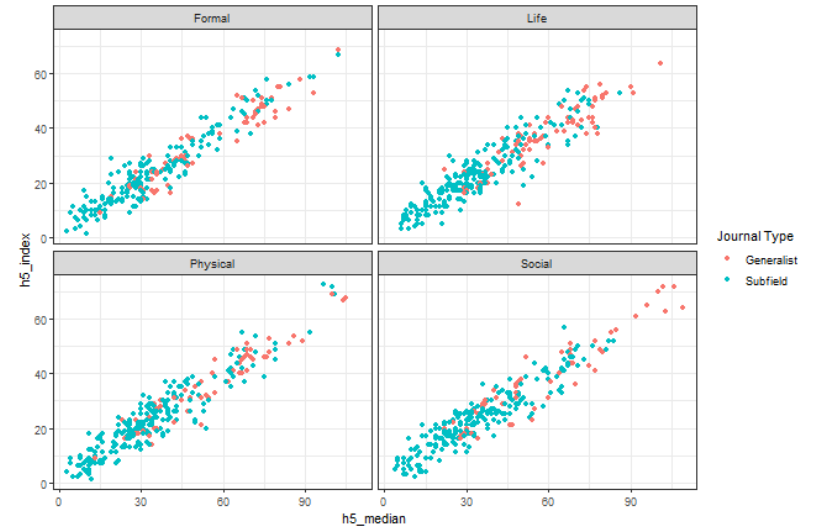


Figure 1. A scatterplot of journal metrics.

# Figures — ggplot2

Improve the axis labels, e.g., with capital first letters

```
```{r, scatterplot, fig.cap = "A scatterplot of journal  
ggplot(data = df, mapping = aes(x = h5_median, y = h5_ir  
  geom_point() +  
  facet_wrap(. ~ branch) +  
  scale_colour_discrete(name = "Journal Type", brea  
  theme_bw() +  
  labs(x = "H5 Median", y = "H5 Index")  
` ``
```

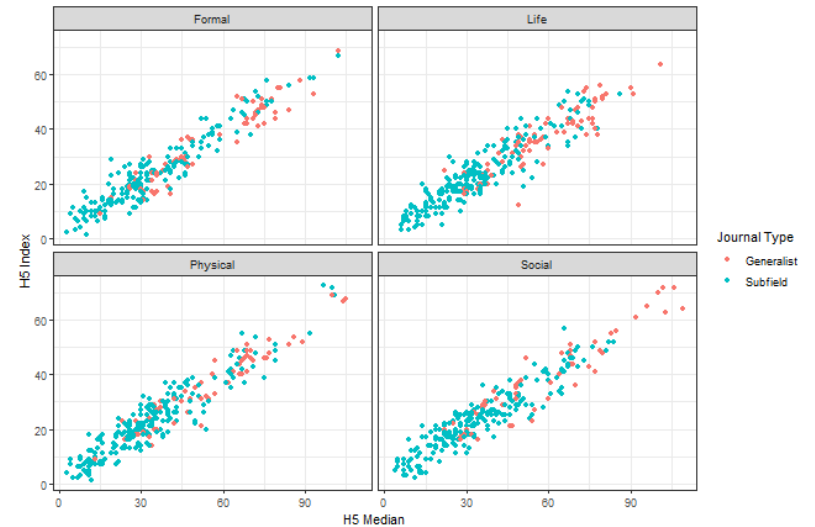


Figure 1. A scatterplot of journal metrics.

# Figures — ggplot2 — Notes

`geom_point` is one of many geoms available

- see this <https://ggplot2.tidyverse.org/reference> for other options, including
  - `geom_bar` for bar charts
  - `geom_boxplot` for box and whiskers plots

# Exercises

10:00

## 25) Barplot

- see `reproduce_this.pdf`: figure 2 on page 7
- apply in `journals.Rmd`: figure 2, between paragraphs 21 and 22

## 26) Scatterplot

- see `reproduce_this.pdf`: figure 3 on page 9
- apply in `journals.Rmd`: figure 3, between paragraphs 27 and 28

# Tables

# Tables — Markdown Syntax

The following syntax, outside code chunks, introduces tables that pandoc can recognise

| First Column | Second Column |
|--------------|---------------|
| First cell   | First cell    |
| Second cell  | Second cell   |
| Third cell   | Third cell    |

| First Column | Second Column |
|--------------|---------------|
| First cell   | First cell    |
| Second cell  | Second cell   |
| Third cell   | Third cell    |



# Tables — Markdown Syntax

The position of headers, relative to their line underneath, defines column alignments

| Left-Aligned | Centered    |
|--------------|-------------|
| -----        | -----       |
| First cell   | First cell  |
| Second cell  | Second cell |
| Third cell   | Third cell  |

| Left-Aligned | Centered    |
|--------------|-------------|
| First cell   | First cell  |
| Second cell  | Second cell |
| Third cell   | Third cell  |

# Tables — Markdown Syntax

A line starting with a colon, placed before or after tables, introduces captions

| Centered                            | Right-Aligned |
|-------------------------------------|---------------|
| -----                               | -----         |
| First cell                          | First cell    |
| Second cell                         | Second cell   |
| Third cell                          | Third cell    |
| : A hand-made table with R Markdown |               |

Table 1: A hand-made table with R Markdown

| Centered    | Right-Aligned |
|-------------|---------------|
| First cell  | First cell    |
| Second cell | Second cell   |
| Third cell  | Third cell    |

# Tables — Markdown Syntax

The caption line itself needs to be surrounded by empty lines

| Centered                            | Right-Aligned |
|-------------------------------------|---------------|
| -----                               | -----         |
| First cell                          | First cell    |
| Second cell                         | Second cell   |
| Third cell                          | Third cell    |
|                                     |               |
| : A hand-made table with R Markdown |               |
|                                     |               |

Table 1: A hand-made table with R Markdown

| Centered    | Right-Aligned |
|-------------|---------------|
| First cell  | First cell    |
| Second cell | Second cell   |
| Third cell  | Third cell    |

# Tables — Markdown Syntax

Tables are numbered automatically

```
: A hand-made table with R Markdown
```

```
    Centered
```

```
    Right-Aligned
```

```
-----  
First cell
```

```
-----  
First cell
```

```
Second cell
```

```
Second cell
```

```
Third cell
```

```
Third cell
```

**Table 1:** A hand-made table with R Markdown

| Centered    | Right-Aligned |
|-------------|---------------|
| First cell  | First cell    |
| Second cell | Second cell   |
| Third cell  | Third cell    |

# Tables — Markdown Syntax

Grid tables, with the following syntax, can handle complex cells with multiple lines and/or lists

```
+-----+-----+
| First Column | Second Column |
+=====+=====+
| - First item | First cell    |
| - Second item |               |
| - Third item  |               |
+-----+-----+
| Second cell   | Second cell with a |
|               | long text          |
+-----+-----+
| Third cell    | Third cell         |
|               |                     |
+-----+-----+
```

: A grid table with multi-line cells

Table 1: A grid table with multi-line cells

| First Column                                  | Second Column                   |
|-----------------------------------------------|---------------------------------|
| - First item<br>- Second item<br>- Third item | First cell                      |
| Second cell                                   | Second cell with a long<br>text |
| Third cell                                    | Third cell                      |

# Tables — Markdown Syntax

Grid tables can be aligned as well, with colons at the boundaries of the header separator\*

```
+-----+-----+
| Left-Aligned | Centered |
+:=====+:
| - First item | First cell |
| - Second item | |
| - Third item | |
+-----+-----+
| Second cell | Second cell with a |
| | | long text |
+-----+-----+
| Third cell | Third cell |
| | |
+-----+-----+

: A grid table with multi-line cells
```

Table 1: A grid table with multi-line cells

| Left-Aligned  | Centered                     |
|---------------|------------------------------|
| - First item  | First cell                   |
| - Second item |                              |
| - Third item  |                              |
| Second cell   | Second cell with a long text |
| Third cell    | Third cell                   |

[\*] Use `:=` for left-aligned, `::=` for centered, `:=` for right-aligned columns.

# Exercises

05:00

## 27) Markdown Tables

- see `reproduce_this.pdf`: table 1 on page 4
- apply in `journals.Rmd`: table 1, between paragraphs 11 and 12

# Tables — stargazer — Overview

- A capable package for creating tables to present
  - data in columns and rows
  - descriptive/summary statistics
  - regression models
- Used widely by academics
- Creates LaTeX code, HTML/CSS code, and ASCII text to be knitted
- A lot is written on this package. See, for example,
  - the [package documentation](#)
  - this [vignette](#) by its author Marek Hlavac
  - this [tutorial](#) by Jake Russ



# Tables — stargazer — Notes

- We must
  - set the chunk option `results="asis"` for chunks with stargazer tables
  - change the argument `type` in the `stargazer()` function for different output formats accordingly
    - e.g., the default `type = "latex"` is for LaTeX and PDF, `type = "html"` for HTML
- It is currently not quite possible to knit stargazer code into tables in Word documents
  - stargazer tables will not appear in Word documents automatically
  - workarounds available
    - knit to HTML as well as Word, copy the tables from HTML to Word
    - knit to PDF as well as Word, open PDF as Word, and copy the tables accross
- stargazer tables might look slightly different in different output formats
  - on the following slides, they will have the HTML look

# Tables — stargazer — Basics

- The `stargazer()` function
  - this is probably the only function you will ever use from this package
    - but it accepts many, many arguments to customise tables
- The data argument of that function, with two main options
  1. a data frame for data or summary statistics tables
    - e.g., `df`, here coming from `df <- read_csv(journals.csv)`
  2. one or more regression models for regression tables
    - e.g., `lm1`, here coming from `lm1 <- lm(h5_index ~ issues, data = df)`

# Tables — stargazer — Data Tables

Table the first four rows of the dataset

```
```{r data_table, echo=FALSE, results="asis"}  
stargazer(data = head(df, n = 4), type = "latex", summary = FALSE)  
```
```

Notice the options of the chunk and the arguments of the function

- with `echo=FALSE`, the code will not be displayed in the output document
- with `results="asis"`, knitr will pass through results without reformatting them
  - these results are produced in LaTeX, due to `type = "latex"`
  - they should remain LaTeX because our outcome document is PDF, converted from LaTeX
- with `summary = FALSE`, the table will present the data, not its descriptive statistics

# Tables — stargazer — Data Tables

Table the first four rows of the dataset

```
```{r data_table, echo=FALSE, results="asis"}  
  
stargazer(data = head(df, n = 4), type = "latex", summary = FALSE)  
  
```
```

% Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu  
% Date and time: Fri, Apr 10, 2020 - 12:31:21

Table 1:

|   | name              | origin   | branch   | h5_index | h5_median | english | subfield | issues | age |
|---|-------------------|----------|----------|----------|-----------|---------|----------|--------|-----|
| 1 | Journal of Bears  | Americas | Physical | 73       | 97        | 1       | 1        | 7      | 61  |
| 2 | Journal of Moon   | Asia     | Social   | 72       | 106       | 1       | 0        | 6      | 64  |
| 3 | Journal of Lumber | Americas | Physical | 72       | 100       | 1       | 1        | 8      | 30  |
| 4 | Journal of Houses | Europe   | Social   | 72       | 102       | 1       | 0        | 8      | 38  |

# Tables — stargazer — Data Tables

Set `header = FALSE` to remove the note preceding tables

```
```{r data_table, echo=FALSE, results="asis"}  
stargazer(data = head(df, n = 4), type = "latex", summary = FALSE, header = FALSE)  
```
```

Table 1:

|   | name              | origin   | branch   | h5_index | h5_median | english | subfield | issues | age |
|---|-------------------|----------|----------|----------|-----------|---------|----------|--------|-----|
| 1 | Journal of Bears  | Americas | Physical | 73       | 97        | 1       | 1        | 7      | 61  |
| 2 | Journal of Moon   | Asia     | Social   | 72       | 106       | 1       | 0        | 6      | 64  |
| 3 | Journal of Lumber | Americas | Physical | 72       | 100       | 1       | 1        | 8      | 30  |
| 4 | Journal of Houses | Europe   | Social   | 72       | 102       | 1       | 0        | 8      | 38  |

# Tables — stargazer — Data Tables

Define a caption with the title argument

```
```{r data_table, echo=FALSE, results="asis"}  
stargazer(data = head(df, n = 4), type = "latex", summary = FALSE, header = FALSE,  
          title = "First four rows of the dataset")  
```
```

Table 1: First four rows of the dataset

|   | name              | origin   | branch   | h5_index | h5_median | english | subfield | issues | age |
|---|-------------------|----------|----------|----------|-----------|---------|----------|--------|-----|
| 1 | Journal of Bears  | Americas | Physical | 73       | 97        | 1       | 1        | 7      | 61  |
| 2 | Journal of Moon   | Asia     | Social   | 72       | 106       | 1       | 0        | 6      | 64  |
| 3 | Journal of Lumber | Americas | Physical | 72       | 100       | 1       | 1        | 8      | 30  |
| 4 | Journal of Houses | Europe   | Social   | 72       | 102       | 1       | 0        | 8      | 38  |

# Tables — stargazer — Summary Statistics Tables

Create a table of summary statistics instead, for the complete dataset

```
```{r summary_table, echo=FALSE, results="asis"}  
stargazer(data = df, type = "latex", summary = TRUE, header = FALSE,  
          title = "Descriptive statistics")  
```
```

Table 1: Descriptive statistics

| Statistic | N     | Mean   | St. Dev. | Min | Pctl(25) | Pctl(75) | Max |
|-----------|-------|--------|----------|-----|----------|----------|-----|
| h5_index  | 1,091 | 26.361 | 13.814   | 1   | 17       | 35       | 73  |
| h5_median | 1,091 | 39.400 | 21.272   | 3   | 25       | 52       | 109 |
| issues    | 1,091 | 4.676  | 1.786    | 1   | 3        | 6        | 12  |
| age       | 1,091 | 42.902 | 26.370   | 1   | 23       | 56       | 158 |

# Tables — stargazer — Summary Statistics Tables

Keep only a selection of statistics

```
```{r summary_table, echo=FALSE, results="asis"}  
stargazer(data = df, type = "latex", summary = TRUE, header = FALSE,  
          title = "Descriptive statistics", summary.stat = c("n", "mean", "sd", "min", "max"))  
```
```

| Table 1: Descriptive statistics |       |        |          |     |     |
|---------------------------------|-------|--------|----------|-----|-----|
| Statistic                       | N     | Mean   | St. Dev. | Min | Max |
| h5_index                        | 1,091 | 26.361 | 13.814   | 1   | 73  |
| h5_median                       | 1,091 | 39.400 | 21.272   | 3   | 109 |
| issues                          | 1,091 | 4.676  | 1.786    | 1   | 12  |
| age                             | 1,091 | 42.902 | 26.370   | 1   | 158 |



# Tables — stargazer — Summary Statistics Tables

Omit a selection of statistics for the same effect

```
```{r summary_table, echo=FALSE, results="asis"}  
stargazer(data = df, type = "latex", summary = TRUE, header = FALSE,  
          title = "Descriptive statistics", omit.summary.stat = c("p25", "p75"))  
```
```

| Table 1: Descriptive statistics |       |        |          |     |     |
|---------------------------------|-------|--------|----------|-----|-----|
| Statistic                       | N     | Mean   | St. Dev. | Min | Max |
| h5_index                        | 1,091 | 26.361 | 13.814   | 1   | 73  |
| h5_median                       | 1,091 | 39.400 | 21.272   | 3   | 109 |
| issues                          | 1,091 | 4.676  | 1.786    | 1   | 12  |
| age                             | 1,091 | 42.902 | 26.370   | 1   | 158 |

# Tables — stargazer — Summary Statistics Tables

Flip the table

```
```{r summary_table, echo=FALSE, results="asis"}  
stargazer(data = df, type = "latex", summary = TRUE, header = FALSE, flip = TRUE,  
          title = "Descriptive statistics", omit.summary.stat = c("p25", "p75"))  
```
```

| Table 1: Descriptive statistics |          |           |        |        |
|---------------------------------|----------|-----------|--------|--------|
| Statistic                       | h5_index | h5_median | issues | age    |
| N                               | 1,091    | 1,091     | 1,091  | 1,091  |
| Mean                            | 26.361   | 39.400    | 4.676  | 42.902 |
| St. Dev.                        | 13.814   | 21.272    | 1.786  | 26.370 |
| Min                             | 1        | 3         | 1      | 1      |
| Max                             | 73       | 109       | 12     | 158    |

# Exercises

05:00

## 28) Summary Statistics Tables

- see `reproduce_this.pdf`: table 2 on page 8
- apply in `journals.Rmd`: table 2, between paragraphs 23 and 24

# Tables — stargazer — Regression Tables

Create a table of regression models instead

```
```{r regression_table, echo=FALSE, results="asis"}
stargazer(data = lm(h5_index ~ subfield, data = df),
           type = "latex", header = FALSE,
           title = "Regression Results")
```
```

Table 1: Regression Results

|                         | <i>Dependent variable:</i>     |
|-------------------------|--------------------------------|
|                         | h5_index                       |
| subfield1               | -12.926***<br>(0.896)          |
| Constant                | 36.171***<br>(0.781)           |
| Observations            | 1,091                          |
| R <sup>2</sup>          | 0.160                          |
| Adjusted R <sup>2</sup> | 0.160                          |
| Residual Std. Error     | 12.665 (df = 1089)             |
| F Statistic             | 207.926*** (df = 1; 1089)      |
| Note:                   | * p<0.1; ** p<0.05; *** p<0.01 |

# Tables — stargazer — Regression Tables

Models can also be estimated outside the function first

```
```{r regression_table, echo=FALSE, results="asis"}  
lm1 <- lm(h5_index ~ subfield, data = df)  
stargazer(data = lm1, type = "latex", header = FALSE,  
          title = "Regression Results")  
```
```

Table 1: Regression Results

|                         | <i>Dependent variable:</i>     |
|-------------------------|--------------------------------|
|                         | h5_index                       |
| issues                  | 1.913***<br>(0.227)            |
| Constant                | 17.415***<br>(1.137)           |
| Observations            | 1,091                          |
| R <sup>2</sup>          | 0.061                          |
| Adjusted R <sup>2</sup> | 0.060                          |
| Residual Std. Error     | 13.391 (df = 1089)             |
| F Statistic             | 70.959*** (df = 1; 1089)       |
| Note:                   | * p<0.1; ** p<0.05; *** p<0.01 |

# Tables — stargazer — Regression Tables

Keep only a selection of statistics

```
```{r regression_table, echo=FALSE, results="asis"}  
stargazer(data = lm1, type = "latex", header = FALSE,  
          title = "Regression Results",  
          keep.stat = c("n", "rsq"))  
```
```

Table 1: Regression Results

|                | <i>Dependent variable:</i>     |
|----------------|--------------------------------|
|                | h5_index                       |
| issues         | 1.913***<br>(0.227)            |
| Constant       | 17.415***<br>(1.137)           |
| Observations   | 1,091                          |
| R <sup>2</sup> | 0.061                          |
| Note:          | * p<0.1; ** p<0.05; *** p<0.01 |

# Tables — stargazer — Regression Tables

Display multiple models in the same table

```
```{r regression_table, echo=FALSE, results="asis"}
stargazer(data = list(lm1, lm2), type = "latex",
          header = FALSE, title = "Regression Results",
          keep.stat = c("n", "rsq"))
```
```

Table 1: Regression Results

|                | <i>Dependent variable:</i>  |           |
|----------------|-----------------------------|-----------|
|                | h5_index                    |           |
|                | (1)                         | (2)       |
| issues         | 1.913***                    | 1.424***  |
|                | (0.227)                     | (0.212)   |
| english1       |                             | 17.262*** |
|                |                             | (1.244)   |
| Constant       | 17.415***                   | 4.226***  |
|                | (1.137)                     | (1.415)   |
| Observations   | 1,091                       | 1,091     |
| R <sup>2</sup> | 0.061                       | 0.202     |
| Note:          | *p<0.1; **p<0.05; ***p<0.01 |           |

# Tables — stargazer — Regression Tables

Change variable labels

```
```{r regression_table, echo=FALSE, results="asis"}
stargazer(data = list(lm1, lm2), type = "latex",
  header = FALSE, title = "Regression Results",
  keep.stat = c("n", "rsq"),
  dep.var.labels = "H5 Index",
  covariate.labels = c("Issues", "English"))
```
```

Table 1: Regression Results

|                | <i>Dependent variable:</i>  |           |
|----------------|-----------------------------|-----------|
|                | H5 Index                    |           |
|                | (1)                         | (2)       |
| Issues         | 1.913***                    | 1.424***  |
|                | (0.227)                     | (0.212)   |
| English        |                             | 17.262*** |
|                |                             | (1.244)   |
| Constant       | 17.415***                   | 4.226***  |
|                | (1.137)                     | (1.415)   |
| Observations   | 1,091                       | 1,091     |
| R <sup>2</sup> | 0.061                       | 0.202     |
| Note:          | *p<0.1; **p<0.05; ***p<0.01 |           |



# Tables — stargazer — Regression Tables

Change significance levels

```
```{r regression_table, echo=FALSE, results="asis"}
stargazer(data = list(lm1, lm2), type = "latex",
  header = FALSE, title = "Regression Results",
  keep.stat = c("n", "rsq"),
  dep.var.labels = "H5 Index",
  covariate.labels = c("Issues", "English"),
  star.cutoffs = c(0.05, 0.01, 0.001))
```
```

Table 1: Regression Results

|                | <i>Dependent variable:</i>    |           |
|----------------|-------------------------------|-----------|
|                | H5 Index                      |           |
|                | (1)                           | (2)       |
| Issues         | 1.913***                      | 1.424***  |
|                | (0.227)                       | (0.212)   |
| English        |                               | 17.262*** |
|                |                               | (1.244)   |
| Constant       | 17.415***                     | 4.226**   |
|                | (1.137)                       | (1.415)   |
| Observations   | 1,091                         | 1,091     |
| R <sup>2</sup> | 0.061                         | 0.202     |
| Note:          | *p<0.05; **p<0.01; ***p<0.001 |           |

# Tables — stargazer — Regression Tables

Label the table for in-text reference

```
```{r regression_table, echo=FALSE, results="asis"}
stargazer(data = list(lm1, lm2), type = "latex",
  header = FALSE, title = "Regression Results",
  keep.stat = c("n", "rsq"),
  dep.var.labels = "H5 Index",
  covariate.labels = c("Issues", "English"),
  star.cutoffs = c(0.05, 0.01, 0.001),
  label = "regression_results")
```
```

Table 1: Regression Results

|                | <i>Dependent variable:</i>    |           |
|----------------|-------------------------------|-----------|
|                | H5 Index                      |           |
|                | (1)                           | (2)       |
| Issues         | 1.913***                      | 1.424***  |
|                | (0.227)                       | (0.212)   |
| English        |                               | 17.262*** |
|                |                               | (1.244)   |
| Constant       | 17.415***                     | 4.226**   |
|                | (1.137)                       | (1.415)   |
| Observations   | 1,091                         | 1,091     |
| R <sup>2</sup> | 0.061                         | 0.202     |
| Note:          | *p<0.05; **p<0.01; ***p<0.001 |           |

# Exercises

07:30

## 29) Regression Tables

- see `reproduce_this.pdf`: table 3 on page 10
- apply in `journals.Rmd`: table 3, between paragraphs 30 and 31

# Tables — stargazer — Referring to Tables

Refer to tables themselves with the `\autoref{table_label}` syntax

```
\autoref{regression_results} provides results from two OLS models.
```

**Table 1** provides results from two OLS models.

Refer to specific results within tables with inline code

```
In Model 1, the coefficient for _Issues_ is  
'r round(coef(summary(lm1))["issues", "Estimate"], digits = 2)'
```

In Model 1, the coefficient for *Issues* is 1.91.

# Exercises

05:00

## 30) Referring to Tables

- see `reproduce_this.pdf`: pages 7 and 9
- apply in `journals.Rmd`: paragraph 23 and 29

## Part 7. Addressing Functionality Gaps

# Functionality Gaps

- Not everything is possible to achieve with R Markdown syntax, code chunks, and/or code
  - e.g., centering text
- Workarounds available through inclusion of other languages and/or syntaxes in .Rmd documents
  - e.g., incorporating HTML or LaTeX code into R Markdown
  - workarounds might be output specific
    - e.g., LaTeX-based workarounds may work only for LaTeX and PDF outputs
- There are no exclusive list of gaps or workarounds
  - these are gap- or problem-specific
  - after writing a few manuscripts with R Markdown, you will have addressed most typical gaps in your workflow

# Functionality Gaps — Examples

## Problem:

There is no chunk option for figures labels. Without these, we cannot refer to figures with a link within text.

## Solution:

Insert a LaTeX label into the `fig.caption` option, and use the `\autoref{figure_caption}` syntax in text

```
\autoref{scatter_plot} visualises the relationship between the two journal metrics.
```

```
```{r ... fig.caption = "A Scatter Plot \\label{scatter_plot}"}  
ggplot(data = df) +  
  geom_point(...  
...`
```

**Figure 1** visualises the relationship between the two journal metrics.



# Functionality Gaps — Examples

## Problem:

Markdown tables do not have labels, which would otherwise allow us to refer to them in text

## Solution:

Insert a LaTeX label after the table caption, and use the `\autoref{table_caption}` syntax in text

See `\autoref{handmade_table}` for further details.

: A hand-made table with R Markdown `\label{handmade_table}`

| Left-Aligned | Centered |
|--------------|----------|
| ...          |          |

See **Table 1** for further details.

# Exercises

05:00

## 31) Referring to Figures

- see `reproduce_this.pdf`: pages 6 and 9
- apply in `journals.Rmd`: paragraphs 19, 21, and 27

## 32) Referring to Markdown Tables

- see `reproduce_this.pdf`: page 4
- apply in `journals.Rmd`: paragraph 11

# Functionality Gaps — Examples

## Problem:

R Markdown adds the list of references to the end of documents. This might be undesirable for some manuscripts, for example those with an appendix. Similarly, some journals require tables and figures to be added after references.

## Solution:

Define where exactly the list of references should appear with the HTML code `<div id = "refs">`

```
# References
<div id = "refs"></div>

# Appendix
```

# Functionality Gaps — Examples

## Problem:

R Markdown produces outputs with single-line-spaced text while we might prefer or be required (e.g., by journal submission rules) to double-space our manuscripts.

## Solution:

Use the `doublespacing` command from the LaTeX package `setspace` (Carlisle et al., 2011)

- because the command comes from a package, we need to add it to YAML with `header-includes`
- including commands in YAML ensures they are applied through the output<sup>\*</sup>

```
---  
...  
header-includes:  
  - \usepackage{setspace}\doublespacing  
---
```

[\*] This can be reversed anywhere in text, with the `singlespacing` command.

# Exercises

02:00

## 33) Line Spacing

- introduce 1.5 spacing to the manuscript
  - hint: the command is called `onehalfspacing`
- except for the Abstract, which should be single spaced

# Functionality Gaps — Examples

## Problem:

Pages, tables, figures etc. are numbered continuously across an output. We might prefer or be required (e.g., by journal submission rules) to change this behaviour, for example for appendices.

## Solution:

Use the `setcounter` in combination with the `renewcommand` command, outside code chunks

```
\setcounter{page}{1}  
\renewcommand*{\thepage}{A\arabic{page}}  
  
\setcounter{table}{0}  
\renewcommand*{\thetable}{A\arabic{table}}  
  
\setcounter{figure}{0}  
\renewcommand*{\thefigure}{A\arabic{figure}}
```

## Part 8. Using Version Control

# Version Control

- Research papers have many versions before publication
  - typically written over a long period of time, in numerous sittings
  - at the end of every sitting, essentially a different version of the same manuscript is created\*

[\*] They also often written by multiple authors, increasing the number of versions created. Here I assume projects are single-authored, leaving the topic of collaboration to the next section — Part 9.



# Version Control

- Research papers have many versions before publication
  - typically written over a long period of time, in numerous sittings
  - at the end of every sitting, essentially a different version of the same manuscript is created
- With many versions created over time, possibly on different computers, there emerges at least two challenges
  - keeping track of changes and versions
  - communicating these changes between computers
- We all version control, in different ways, such as
  - edit, rename, save
  - use applications or websites such as Dropbox, Google Docs, Overleaf
  - use distributed version control systems such as Git and GitHub

# Version Control — Manual Attempts

Typically, hand-made attempts to version control lead to cluttered folders

```
manuscript
|
|- journals_FINAL_19MAY.Rmd
|- journals_FINAL.Rmd
|- journals_26APRIL_newlit.Rmd
...
|- journals.Rproj
|- references.bib
|- apa_7th.csl
```

# Version Control — Git and GitHub — Definitions

- Git
  - a software that keeps track of versions of a set of files
  - it is local, the records are kept on your computer
- GitHub
  - a hosting service, or a website, that can keep the records
  - it is like Dropbox, but specifically structured to keep records with Git
- Repository, or repo
  - a set of files whose records are kept together, by Git and/or on GitHub
  - it is like a folder, which can keep files and other folders containing files

# Version Control — Git and GitHub — Definitions

- To commit
  - to take a snapshot of, to version a repository
  - it is like saving a new version of all changed files in your folder with a new name
  - it is local, the records are kept on your computer unless you push
- To push
  - to move the records from Git to GitHub, from your computer to online
  - it is like uploading (the new versions of) your files to a website,
  - it also involves merging, if this not the first push
- To pull
  - to move the updated records from GitHub to your computer
  - it is like downloading a zipped folder of files, and merging with the ones on your computer

# Version Control — Git and GitHub

Version control with Git and GitHub requires

1. **initial setup**, done once<sup>\*</sup>
  - unless for a new computer or, if ever, a new GitHub account
  - a bit technical, but worth the hassle
2. **project setup**, repeated for every paper
  - shorter, less complicated

[\*] We have started this process already, in Part 1 of the workshop, by downloading and installing Git and signing up for GitHub.

# Version Control — Git — Initial Setup

## 1) Enable version control with RStudio

- from the RStudio menu, follow:

Tools -> Global Options -> Git/SVN -> Enable version control interface for RStudio projects

- RStudio will likely find Git automatically. In case it cannot, Git is likely to be at
  - `c:/Program Files/Git/bin/git.exe` on Windows
  - `/usr/local/git/bin/git` on Mac

# Version Control — Git — Initial Setup

2) Set Git Bash as your shell (Windows-only step)

- from the RStudio menu, follow:

Tools -> Global Options -> Terminal -> New terminals open with: Git Bash

# Version Control — Git — Initial Setup

## 3) Introduce yourself to Git

- from the RStudio menu, follow:

Tools -> Terminal -> New Terminal

- Enter the following lines in the Terminal, with the email address that you have used to sign up for GitHub

```
git config --global user.name "YOUR NAME"  
git config --global user.email "YOUR EMAIL ADDRESS"  
git config --global --list
```



# Version Control — Git and Github — Project Setup

1) Initiate local version control with Git

- from the RStudio menu, follow:

Tools -> Version Control -> Project Setup... -> Version Control System -> Git

# Version Control — Git and Github — Project Setup

## 2) Create a new GitHub repository

- on GitHub, follow:

Repositories -> New -> Repository name (e.g., "rwd\_workshop") -> Public -> Create repository

- observe that
  - repository URLs have the following structure: [https://github.com/USER\\_NAME/REPOSITORY\\_NAME](https://github.com/USER_NAME/REPOSITORY_NAME)
    - this is the address to view the repository online
    - for use in the Terminal, the address gets the .git extension
      - e.g., [https://github.com/USER\\_NAME/REPOSITORY\\_NAME.git](https://github.com/USER_NAME/REPOSITORY_NAME.git)

# Version Control — Git and Github — Project Setup

## 3) Push an existing repository

- from the RStudio menu, follow:

Tools -> Terminal -> New Terminal

- enter the following lines in the Terminal, with your username and repository name

```
git remote add origin https://github.com/USER_NAME/REPOSITORY_NAME.git  
git push -u origin master
```

- observe that
  - now there is now a Git tab in RStudio, documenting the differences between you local repository and the one on GitHub. When you change a file, it will appear here.
  - your files now include a `.gitignore` file,
    - this is where you can list files and/or folders to be excluded from being tracked

# Version Control — Git and Github — Workflow

1) Edit and save one or more files under version control

- e.g., delete the first sentence of the abstract, and save

2) Commit and Push

- under the Git tab on RStudio, find the list of files edited
  - these will have M, for modified, as Status
- tick Staged\* for one or more files that you would like to commit
  - enter a Commit message that summarises the edits
  - click Commit to create a record of the new version locally to your computer
  - click Close -> Push to push the version to GitHub

[\*] To stage is to add files to be committed. It allows us to commit one or more files together or separately.

# Version Control — Git and Github — `.gitignore`

- `.gitignore` specifies which file(s) and/or folder(s) should be excluded from version control
  - a set of files and directories are ignored by default — see your `.gitignore` file
- There might be good reasons to ignore some files, including files
  - that contain information that we do not want others to see
    - e.g., personal API keys
  - that we do not have the right to share with others
    - e.g., secondary data with user agreements otherwise
  - that we (re-)create automatically as outputs
    - e.g., `journals.pdf`, as opposed to `journals.Rmd`
- See the documentation at <https://git-scm.com/docs/gitignore> for further details

# Version Control — Git and Github — .gitignore

Ignore a specific file in a specific folder, relative to the root directory

```
/manuscript/journals.pdf
```

Ignore a specific file in any folder

```
journals.pdf
```

Ignore all files with a specific extension

```
*.pdf
```

Ignore a specific folder

```
/literature/
```

# Version Control — Git and Github — .gitignore — Notes

- There are many other pattern formats
  - see the documentation at <https://git-scm.com/docs/gitignore>
- Starting to ignore a file or folder that is already being tracked requires clearing the cache
  - after changing and saving .gitignore, enter the following line in the Terminal
  - with your specific /path/to/file

```
git rm --cached /path/to/file
```

- Following command clears all cache
  - might be useful after changes to .gitignore that involves several files or folders
  - but should be used with care, on an otherwise up-to-date repository

```
git rm -r --cached .
```

# Exercises

05:00

## 34) Reproducibility and Version Control

- imagine that, after producing all these tables and figures, and writing up your results, you have decided to exclude journals from Oceania from analysis
  - hint: use the `filter` function in the data chunk
  - create a new version of the manuscript
  - comit and push to GitHub

## 35) Gitignore

- stop tracking `journals.pdf`
  - change `.gitignore`
  - remove `journals.pdf` from cache
  - comit and push to GitHub



## Part 9. Working on a Real Project

# Real Project

- Consider converting a real project to R Markdown
  - now, in the remainder of the workshop
- Choose an existing project, preferably
  - single-authored
  - at an early stage
  - but one that you will be working on in the very near future
- Ask me for help
  - with no more slides to go through, I will now focus on individual coaching

**Thank You!**

# References

# References

- Allaire, J. J., Xie, Y., McPherson, J., Luraschi, J., Ushey, K., Atkins, A., Wickham, H., Cheng, J., Chang, W. and Iannone, R. (2020). **rmarkdown: Dynamic documents for R**. R package, version 2.1.
- Blair, G., Cooper, J., Coppock, A., Humphreys, M., Rudkin, A. and Fultz, N. (2019). **fabricatr: Imagine your data before you collect it**. R package, version 0.10.0.
- Carlisle, D., Fairbairns, R., Harris, E. and Tobin, G. (2011). **setspace – Set space between lines**. LaTeX package, version 6.7a.
- Dowle, M. and Srinivasan, A. (2019). **data.table: Extension of 'data.frame'**. R package, version 1.12.8.
- Gagolewski, M. (2020). **stringi: Character String Processing Facilities**. R package, version 1.4.6.
- Hlavac, M. (2018). **stargazer: Well-formatted regression and summary statistics tables**. R package, version 5.2.2.
- Wickham, H. and Grolemund, G. (2019). R for data science. O'Reilly. Open access at <https://r4ds.had.co.nz>.
- Wickham, H., Chang, W., Henry, L., Pedersen, T. L., Takahashi, K., Wilke, C., Woo, K., Yutani, H. and Dunnington, D. (2020a). **dplyr: A grammar of data manipulation**. R package, version 0.8.5.

# References

- Wickham, H., François, W., Henry L. and Müller, K. (2020b). **ggplot2: Create elegant data visualisations using the grammar of graphics**. R package, version 0.8.5.
- Wiernik, B. M. (2020). **American Psychological Association 7th edition (no ampersand)**. Citation style language file, version 1.0.
- Xie, Y. (2020a). **tinytex: Helper functions to install and maintain TeX Live and compile LaTeX documents**. R package, version 0.21.
- Xie, Y. (2020b). **knitr: A general-purpose package for dynamic report generation in R**. R package, version 1.28.
- Xie, Y. (2020c). **bookdown: Authoring books and technical documents with R Markdown**. R package, version 0.18.
- Xie, Y. (2020d). **blogdown: Create blogs and websites with R Markdown**. R package, version 0.18.
- Xie, Y., Allaire, J. J., and Golemund, G. (2019). R markdown: The definitive guide. CRC Press. Open access at <https://bookdown.org/yihui/rmarkdown>.
- Zhu, H. (2019). **kableExtra: Construct Complex Table with 'kable' and Pipe Syntax**. R package, version 1.1.0.