



Writing dynamic and reproducible documents

An introduction to R Markdown

Julien Martin
12 January, 2024

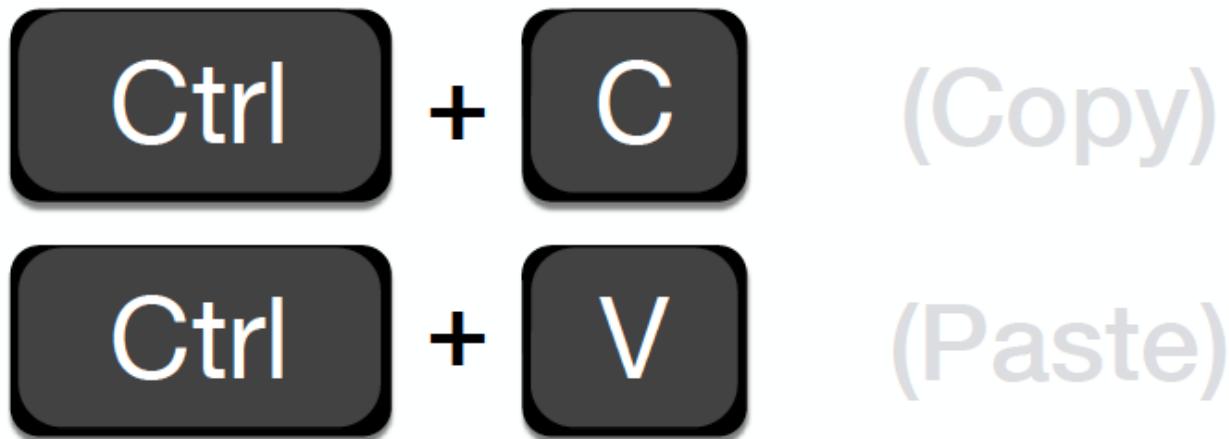
Motivation



#



How can you reproduce results?



What do we need to make research reproducible?

- Something to integrate text, figures and code
 - R, Python, etc
- Something that can be continuously edited and updated
 - Living or dynamic document
- Something that can be easily used in versioning tools
 - Git

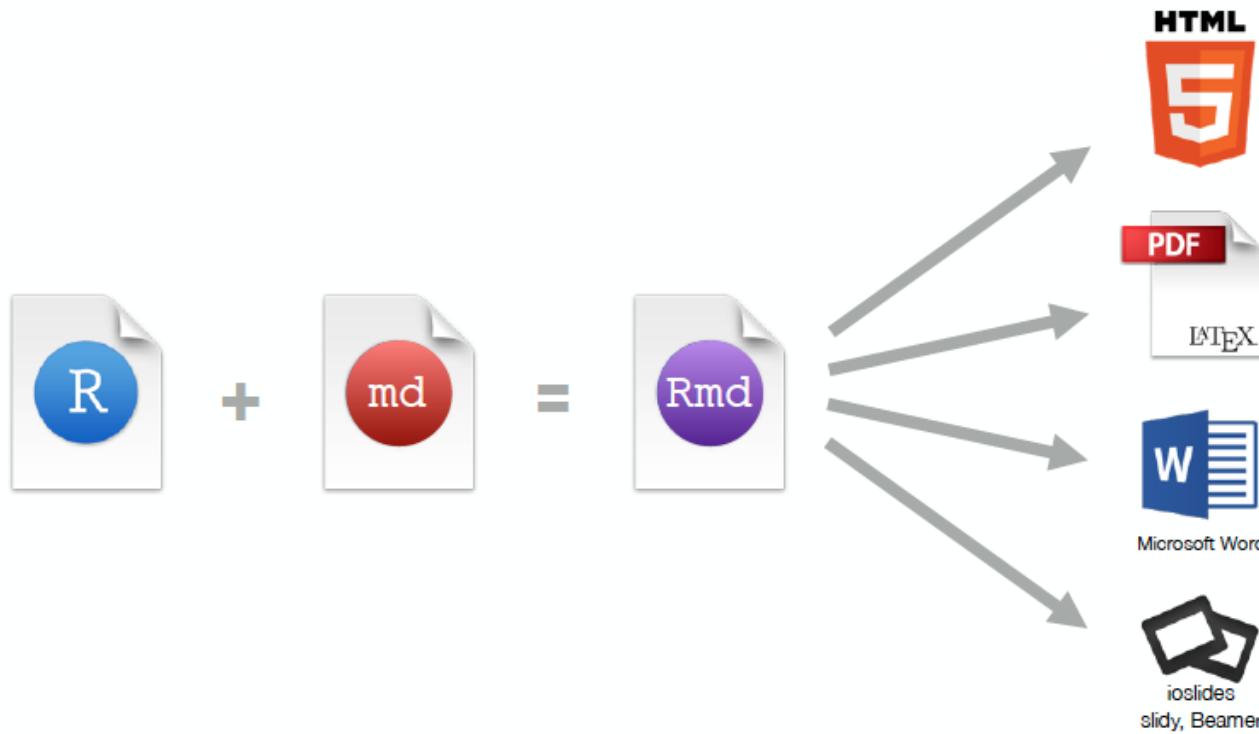
R MARKDOWN

We're getting the BAND BACK TOGETHER.

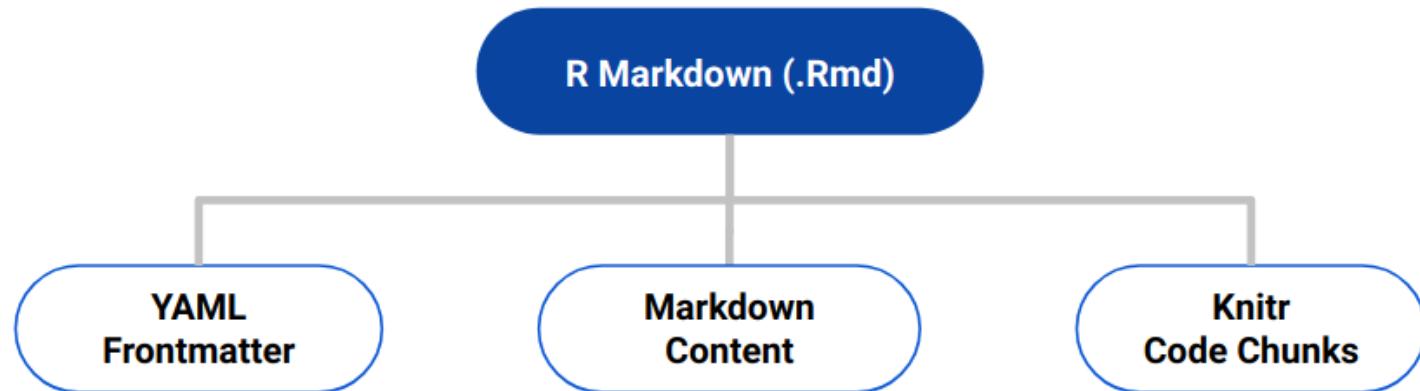


HORST '19

R Markdown workflow



Structure of a R Markdown document



<https://yongfu.name/2019-fju-rmd-talk/slides/#1>

Demonstration

```
1  ---
2  title: "Untitled"
3  author: "Julien Martin"
4  date: "15/01/2021"
5  output: html_document
6  ---
7
8  ```{r setup, include=FALSE}
9  knitr::opts_chunk$set(echo = TRUE)
10 ```

11
12 ## R Markdown
13
14 This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.
15
16 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:
17
18 ```{r cars}
19 summary(cars)
20 ```

21
22 ## Including Plots
23
24 You can also embed plots, for example:
25
26 ```{r pressure, echo=FALSE}
27 plot(pressure)
28 ```

29
30 Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.
31
```

```
1 ---  
2   title: "Untitled"  
3   author: "Julien Martin"  
4   date: "15/01/2021"  
5   output: html_document  
6 ---  
7  
8 ```{r setup, include=FALSE}  
9 knitr::opts_chunk$set(echo = TRUE)  
10 ...  
11  
12 ## R Markdown  
13  
14 This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.  
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24 You can also embed plots, for example:  
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26 ```{r pressure, echo=FALSE}  
27 plot(pressure)  
28 ...  
29  
30 Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.  
31
```

Front Matter: YAML

Chunk: R code

Text: markdown

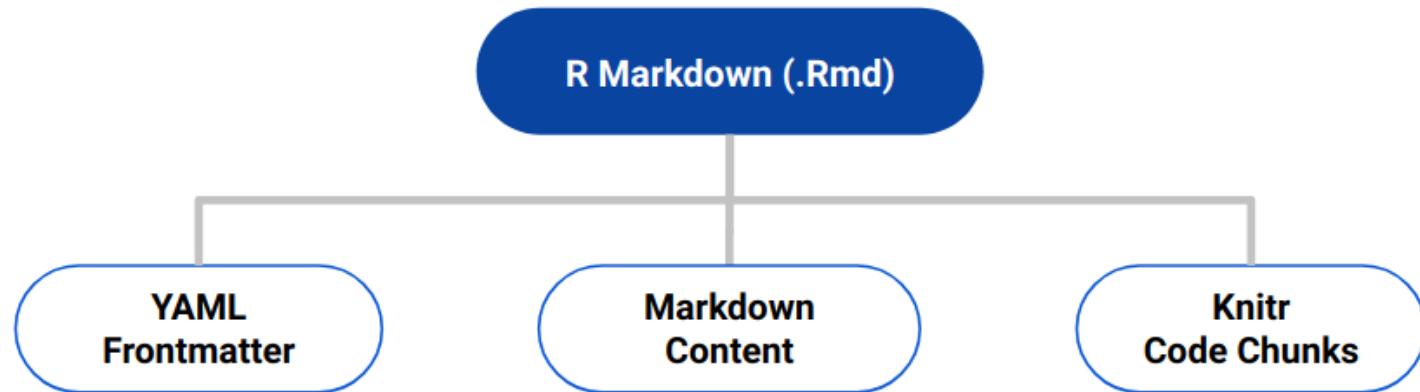
Content

Chunk: R code

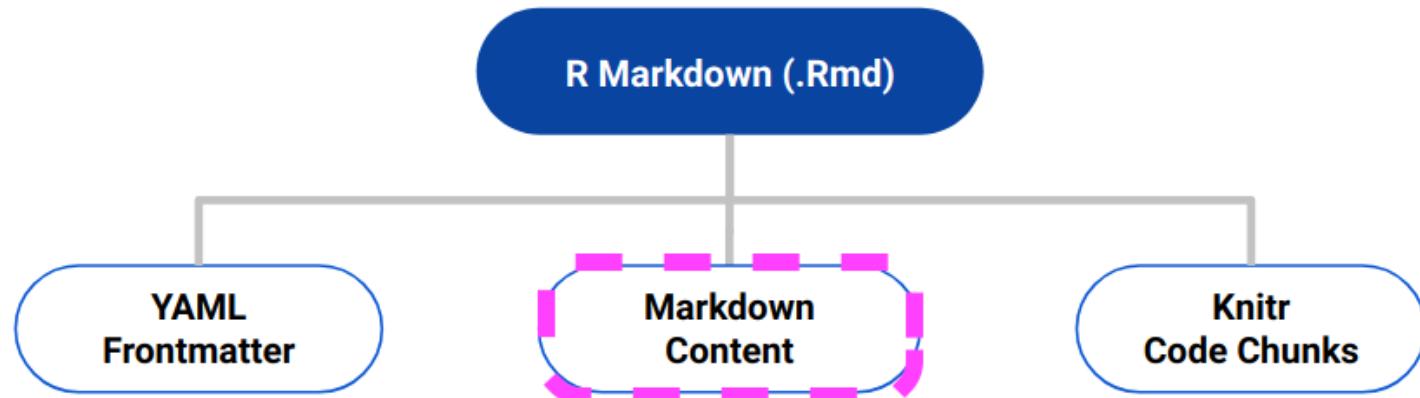
Text: markdown

Text: markdown

Structure of a R Markdown document



Structure of a R Markdown document



Format your text with Markdown

What is Markdown?

- A way to write stuff
- Mostly plain words, with some formating

```
# Say Hello  
To my little  
friend, markdown.
```

Markdown is

- * easy to use
- * simple
- * fun?



Say Hello

To my little friend, markdown.
Markdown is

- easy to use
- simple
- fun?

Websites that use Markdown

- GitHub <https://github.com/>
- StackOverflow <https://stackoverflow.com/>
- HackMD <https://hackmd.io>
- Many more

Headers

- Use # to create headers
- Multiple #'s create lower level headers

```
# Header 1  
## Header 2  
### Header 3  
#### Header 4  
##### Header 5  
##### Header 6
```



Header 1
Header 2
Header 3
Header 4
Header 5
Header 6

Text

- Text is rendered as plain text

Add two spaces at
the end of a line to
start a new line

Text
italics
bold
'code'



Text
italics
bold
code

Lists

- Use asterisks to make bullet points
- Use numbers to make numbered lists
- Use 4 spaces or 1 tab for indentation

Bullets

- * bullet 1
- * bullet 2

Numbered list

1. item 1
2. item 2



Bullets

- bullet 1
- bullet 2

Numbered list

1. item 1
2. item 2

Hyperlinks

- To add a hyperlink, put your text between brackets
- Then place the URL between parentheses

This is a
[link](www.git.com).

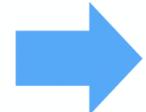


This is a link.

Equations

- Write equations with Latex syntax

According to
Einstein,
 $E=mc^2$



According to
Einstein, $E = mc^2$

Equation blocks

According to Einstein,

$$E=mc^2$$



According to Einstein,

$$E = mc^2$$

Images

- Use a link preceded by an ! to insert an image
- The link text should be
 - a URL if the image is hosted online
 - a file path if the image is saved on your computer

```
  
The RStudio logo.
```



Tables

| header A | header B |
|----------|----------|
| data | data |

Table:title

| header A | header B |
|----------|----------|
| data | data |

Table:title

- A bit of a hassle...
- Use a [generator of Tables for Markdown](#)
- Wait for next section to learn how to generate tables from R

R Markdown Reference Guide

<https://rstudio.com/wp-content/uploads/2015/03/rmarkdown-reference.pdf>



R Markdown Reference Guide

Learn more about R Markdown at rmarkdown.rstudio.com

Learn more about Interactive Docs at shiny.rstudio.com/articles

Contents:

1. **Markdown Syntax**
2. Knitr chunk options
3. Pandoc options

Syntax

Plain text

End a line with two spaces
to start a new paragraph.

italics and _italics_

bold and __bold__

superscript^{^2}

~~strikethrough~~

[link] (www.rstudio.com)

Header 1

Header 2

Becomes

Plain text

End a line with two spaces to start a new paragraph.

italics and *italics*

bold and **bold**

superscript²

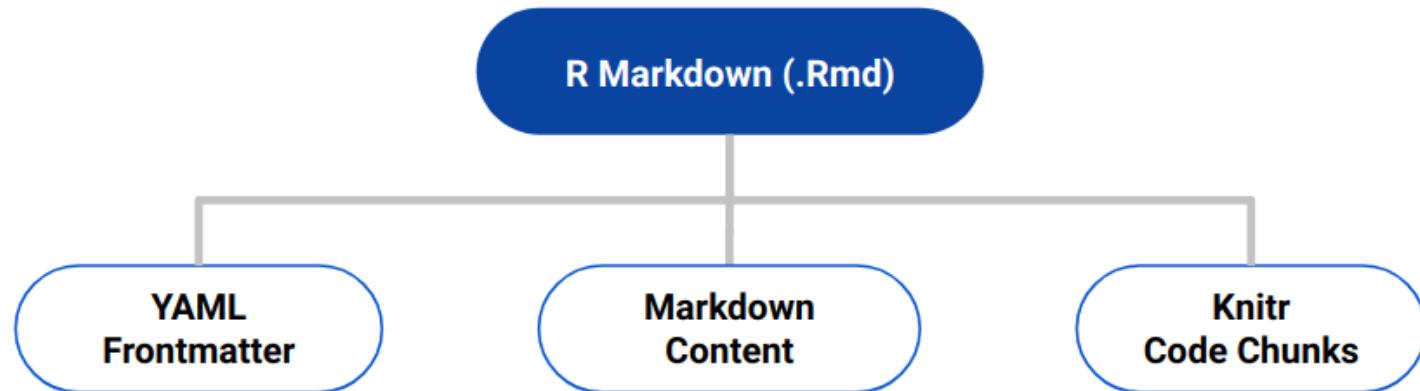
strikethrough

link

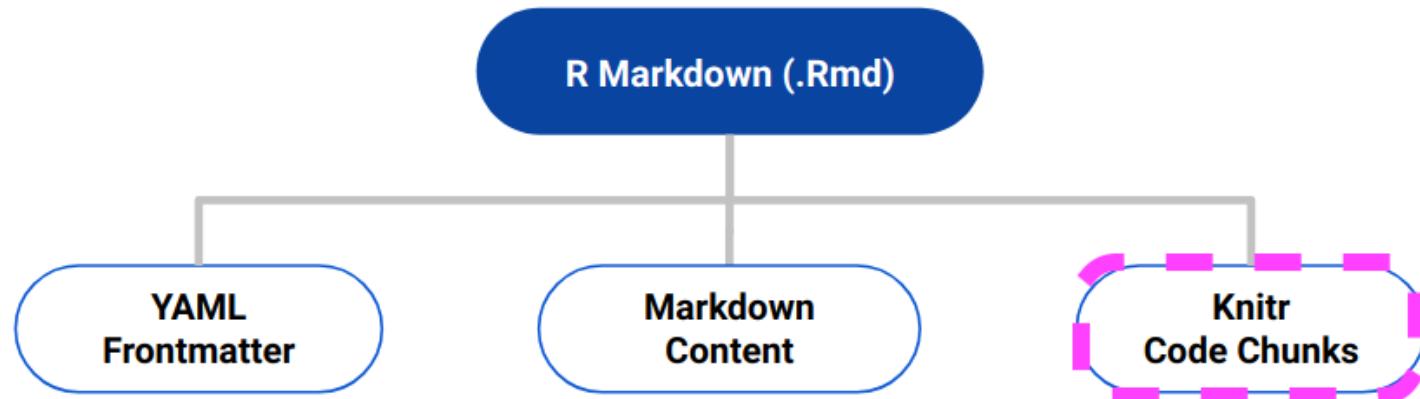
Header 1

Header 2

Structure of a R Markdown document



Structure of a R Markdown document



Code, figures and tables

Embed code

- Insert chunk of R code
- R Markdown runs code and includes results.

```
```{r}
some code
```

```
```
```

Inline code

- Place code in a sentence with
- R Markdown replaces code with results

```
Today is  
`r Sys.Date()`.
```

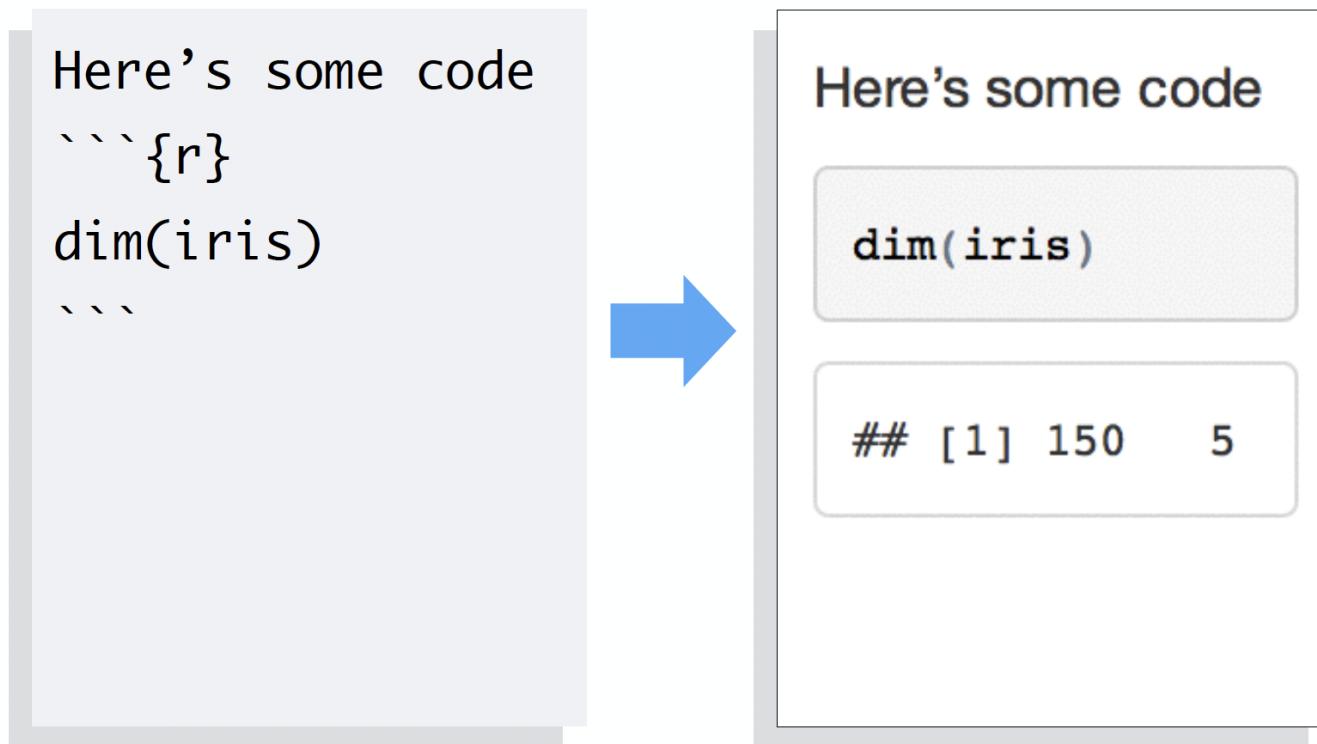


```
Today is 2015-04-16.
```

.

Chunk options

- By default, R markdown includes both code and results



echo

- Add options between brackets after r.
- echo = FALSE hides code.

```
Here's some code  
```{r echo=FALSE}  
dim(iris)
```
```



Here's some code

```
## [1] 150 5
```

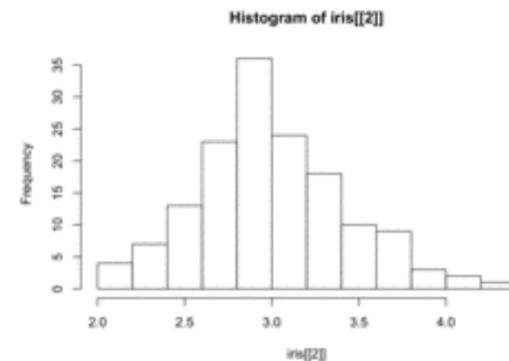
echo

- Add options between brackets after r.
- echo = FALSE hides code.

```
Here's a plot  
```{r echo=FALSE}  
hist(iris[[2]])
```
```



Here's a plot



eval

- eval = FALSE prevents code from being run
- No results is displayed, only code

Here's some code

```
```{r eval=FALSE}  
dim(iris)
```
```



Here's some code

```
dim(iris)
```

fig.height, fig.width

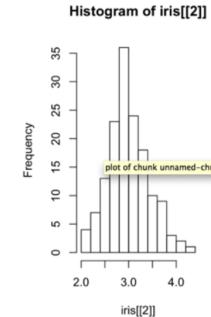
- Specify dimension of plots (in inches) with `fig.width` and `fig.height`
- Separate multiple arguments with commas.

Here's a plot

```
```{r echo=FALSE, fig.width=3, fig.height=5}
hist(iris[[2]])
````
```



Here's a plot

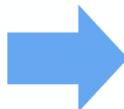


message

- `message = FALSE` prevents messages from appearing in output

Here's some code

```
```{r message=FALSE}  
library(forecast)
```
```



Here's some code

```
library(forecast)
```

Default chunk options

- Repeating chunk options can be painful
- If you have echo = FALSE in every single chunk, how to set the default chunk option to echo = FALSE ?
- Use knitr::opts_chunk\$set(echo = FALSE)
- You may overwrite the default for each chunk
- For chunk options, check out <https://yihui.name/knitr/options/>

Including tables

```
# cars is a built-in-to-R data set of cars
# and their stopping distances
cars %>%
  head(5) %>%
  knitr::kable(format = "html", caption = "A kable table")
```

| A kable table | |
|---------------|------|
| speed | dist |
| 4 | 2 |
| 4 | 10 |
| 7 | 4 |
| 7 | 22 |
| 8 | 16 |

- The `kable` package is often used with the `kableExtra` package
- A number of other packages are available for making pretty tables, see rmarkdown.rstudio.com

R Markdown Reference Guide

<https://rstudio.com/wp-content/uploads/2015/03/rmarkdown-reference.pdf>



R Markdown Reference Guide

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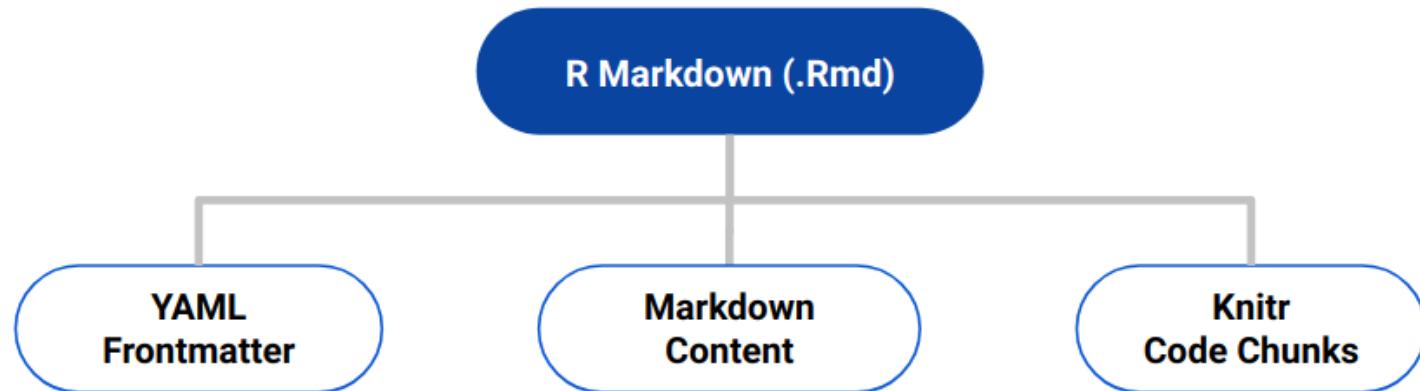
Learn more about Interactive Docs at shiny.rstudio.com/articles

Contents:

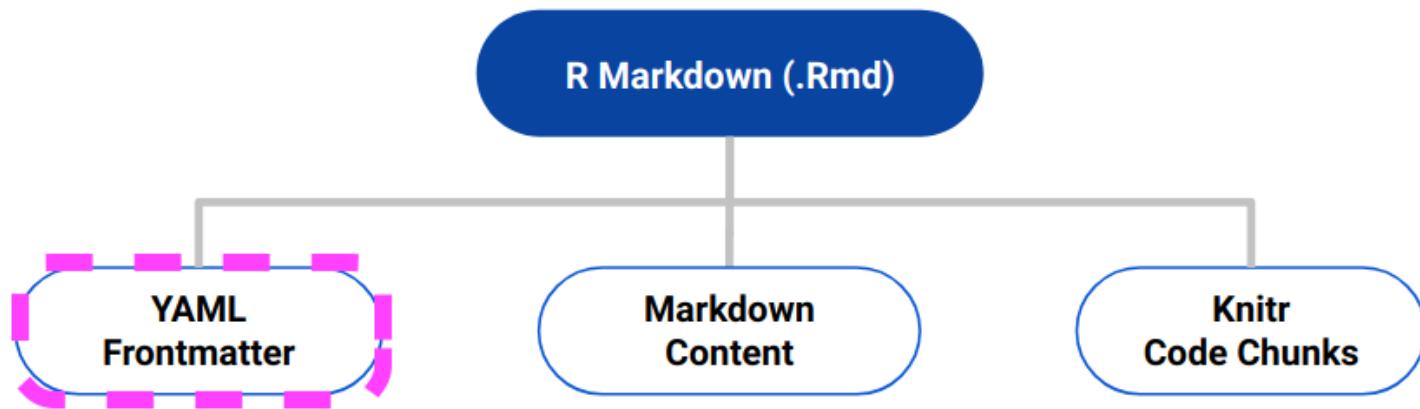
1. Markdown Syntax
- 2. Knitr chunk options**
3. Pandoc options

| Syntax | Becomes |
|---|--|
| <p>Make a code chunk with three back ticks followed by an r in braces. End the chunk with three back ticks:</p> <pre>```{r} paste("Hello", "World!") ```</pre> | <p>Make a code chunk with three back ticks followed by an r in braces. End the chunk with three back ticks:</p> <div style="border: 1px solid #ccc; padding: 5px;"><pre>paste("Hello", "World!")</pre></div> <div style="border: 1px solid #ccc; padding: 5px; margin-top: 10px;"><pre>## [1] "Hello World!"</pre></div> |
| <p>Place code inline with a single back ticks. The first back tick must be followed by an R, like this `r paste("Hello", "World!")`.</p> | <p>Place code inline with a single back ticks. The first back tick must be followed by an R, like this Hello World!.</p> |
| <p>Add chunk options within braces. For example, `echo=FALSE` will prevent source code from being displayed:</p> <pre>```{r eval=TRUE, echo=FALSE} paste("Hello", "World!") ```</pre> | <p>Add chunk options within braces. For example, <code>echo=FALSE</code> will prevent source code from being displayed:</p> <div style="border: 1px solid #ccc; padding: 5px;"><pre>## [1] "Hello World!"</pre></div> |

Structure of a R Markdown document



Structure of a R Markdown document



YAML Yet Another Markup Language

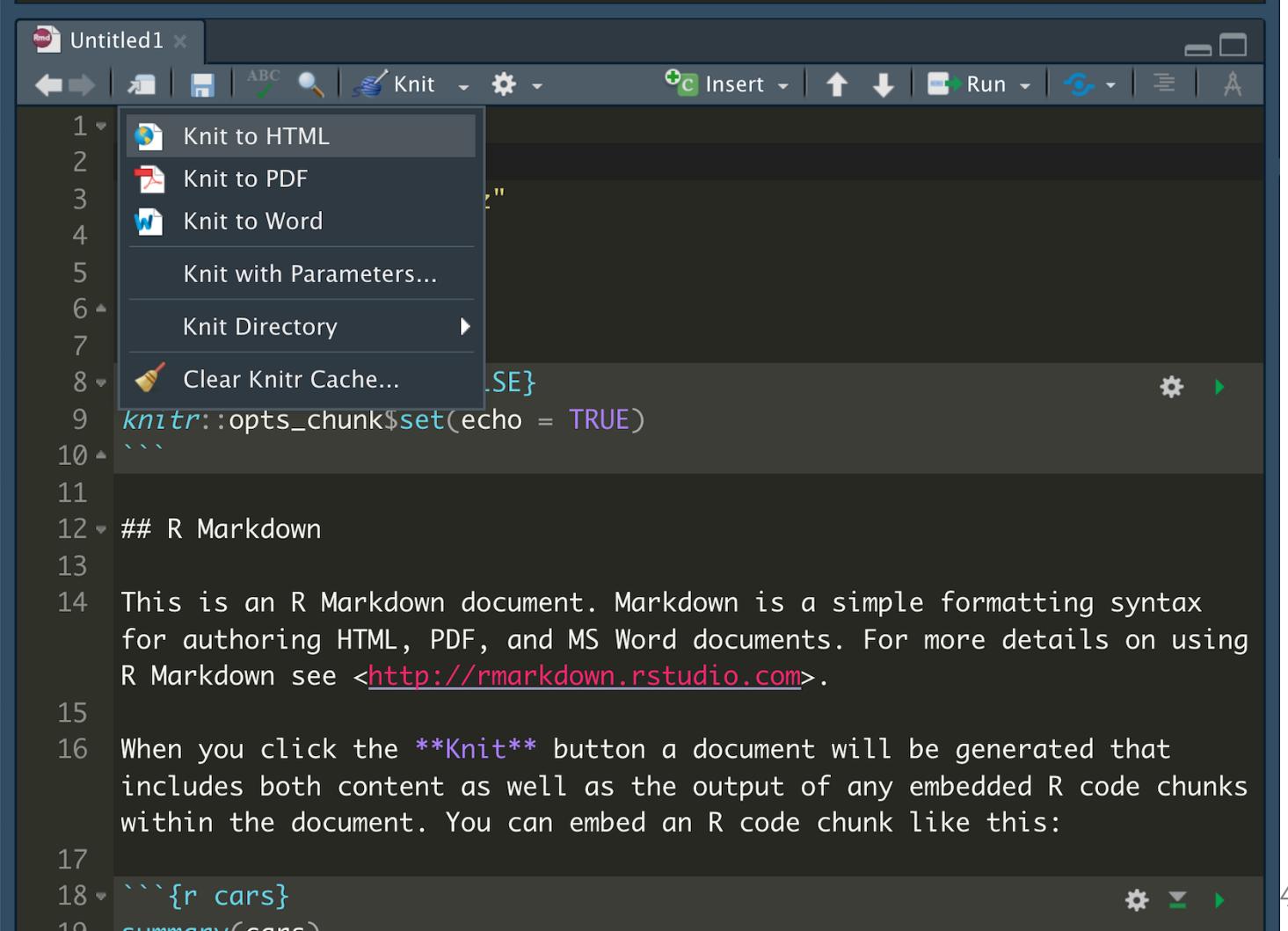
YAML in brief

- Contains the metadata of the document
- Starts and ends by three dashes
- Comes first in the document

Simplest example

```
1 ▼ ---
2   title: Writing a report with R Markdown
3   subtitle: Practical
4   author: "Julien Martin"
5   date: ``r format(Sys.time(), '%d %B, %Y')``
6   output:
7     html_document: default
8     pdf_document:
9       latex_engine: xelatex
10      extra_dependencies: ["xelatexemoji"]
11      bibliography: mabiblio.bib
12 ▲ ---
13
```

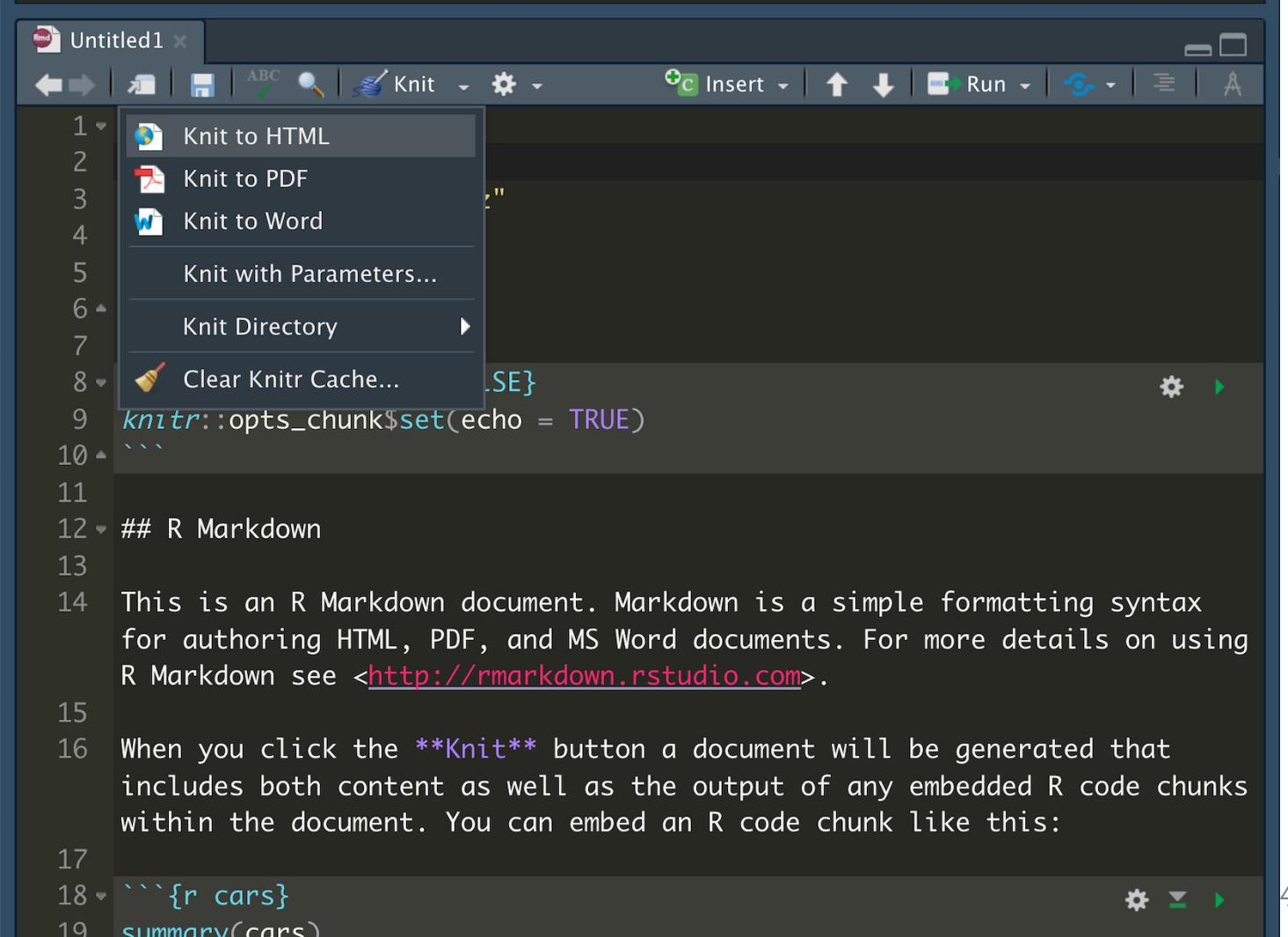
Knit



The screenshot shows the RStudio interface with the title bar "Untitled1". The "Knit" button in the toolbar is highlighted. A dropdown menu is open under the "Knit" button, listing options: "Knit to HTML", "Knit to PDF", "Knit to Word", "Knit with Parameters...", "Knit Directory", and "Clear Knitr Cache...". Below the menu, the R Markdown document content is visible:

```
1 Knit to HTML
2 Knit to PDF
3 Knit to Word
4 Knit with Parameters...
5 Knit Directory
6 Clear Knitr Cache...
7
8 knitr::opts_chunk$set(echo = TRUE)
9 ``
10 ``
11
12 ## R Markdown
13
14 This is an R Markdown document. Markdown is a simple formatting syntax
15 for authoring HTML, PDF, and MS Word documents. For more details on using
16 R Markdown see <http://rmarkdown.rstudio.com>.
17
18 ``
19 ``{r cars}
20 summary(cars)
```

Knit



The screenshot shows the RStudio interface with the title bar "Untitled1". The "Knit" button in the toolbar is highlighted. A context menu is open from the "Knit" button, displaying options: "Knit to HTML" (selected), "Knit to PDF", "Knit to Word", "Knit with Parameters...", "Knit Directory", and "Clear Knitr Cache...". The main workspace shows an R Markdown document with the following content:

```
1 Knit to HTML
2 Knit to PDF
3 Knit to Word
4 Knit with Parameters...
5 Knit Directory
6 Clear Knitr Cache...
7
8 knitr::opts_chunk$set(echo = TRUE)
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14 This is an R Markdown document. Markdown is a simple formatting syntax
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19 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:
20
21 ``{r cars}
22 summary(cars)
```

Output formats

Untitled

Oliver Gimenez
10/25/2020

R Markdown

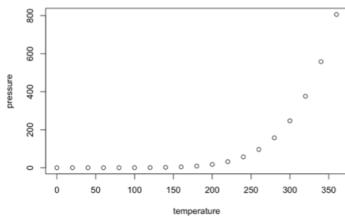
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When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```
summary(cars)
```

```
## # speed      dist
## Min. : 4.0  Min. :  2.00
## 1st Qu.:12.0  1st Qu.: 24.00
## Median :15.4  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



html

Untitled

Oliver Gimenez
10/25/2020

R Markdown

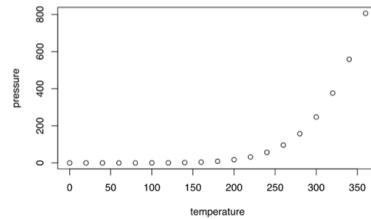
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## 3rd Qu.:19.0  3rd Qu.: 56.00
## Max. :25.0   Max. :120.00
```

Including Plots



pdf

Untitled

Oliver Gimenez
10/25/2020

R Markdown

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```
summary(cars)
```

```
##
```

```
## # speed      dist
```

```
##
```

```
## Min. : 4.0  Min. :  2.00
```

```
##
```

```
## 1st Qu.:12.0  1st Qu.: 24.00
```

```
##
```

```
## Median :15.0  Median : 36.00
```

```
##
```

```
## Mean   :15.4  Mean   : 42.98
```

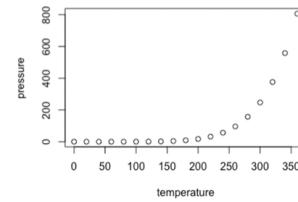
```
##
```

```
## 3rd Qu.:19.0  3rd Qu.: 56.00
```

```
##
```

```
## Max. :25.0   Max. :120.00
```

Including Plots



docx

Appearance and style

- In HTML output, you can use theme or a custom **.css** style sheet
- theme options (bootswatch.com) : “cerulean”, “journal”, “flatly”, “darkly”, “readable”, “spacelab”, “united”, “cosmo”, “lumen”, “paper”, “sandstone”, “simplex”, “yeti”
- You may also use LaTeX templates with R Markdown, and write **reproducible scientific paper**
- You can also **use Word templates in R Markdown** (see also [this short video](#))

Managing bibliography

1. Put references in a plain text file with the extension **.bib**, in **BibTex** format (my advice: use **Zotero**)

```
@article{Shea2014,
  author = {Shea, Nicholas and Boldt, Annika},
  journal = {Trends in Cognitive Sciences},
  pages = {186--193},
  title = {{Supra-personal cognitive control}},
  volume = {18},
  year = {2014},
  doi = {10.1016/j.tics.2014.01.006},
}
```

2. Reference this file in your YAML header

```
---
title: "Citation test"
bibliography: example.bib
output: html_document
---
```

Citations

3. In your text, citations go inside brackets and separated by semicolons

This...

Blah blah [@Shea2014;
@Lottridge2012].

turns into this...

Blah blah (Shea et al. 2014;
Lottridge et al. 2012).

Citations

3. In your text, citations go inside brackets and separated by semicolons

This...

Blah blah [@Shea2014;
@Lottridge2012].

@Shea2014 says blah.

Blah blah [see @Shea2014, pp. 33–
35; also @Wu2016, ch. 1].

turns into this...

Blah blah (Shea et al. 2014;
Lottridge et al. 2012).

Shea et al. (2014) says blah.

Blah blah (see Shea et al. 2014, 33–
35; also Wu 2016, ch. 1).

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3. In your text, citations go inside brackets and separated by semicolons

This...

Blah blah [@Shea2014;
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Lottridge et al. 2012).

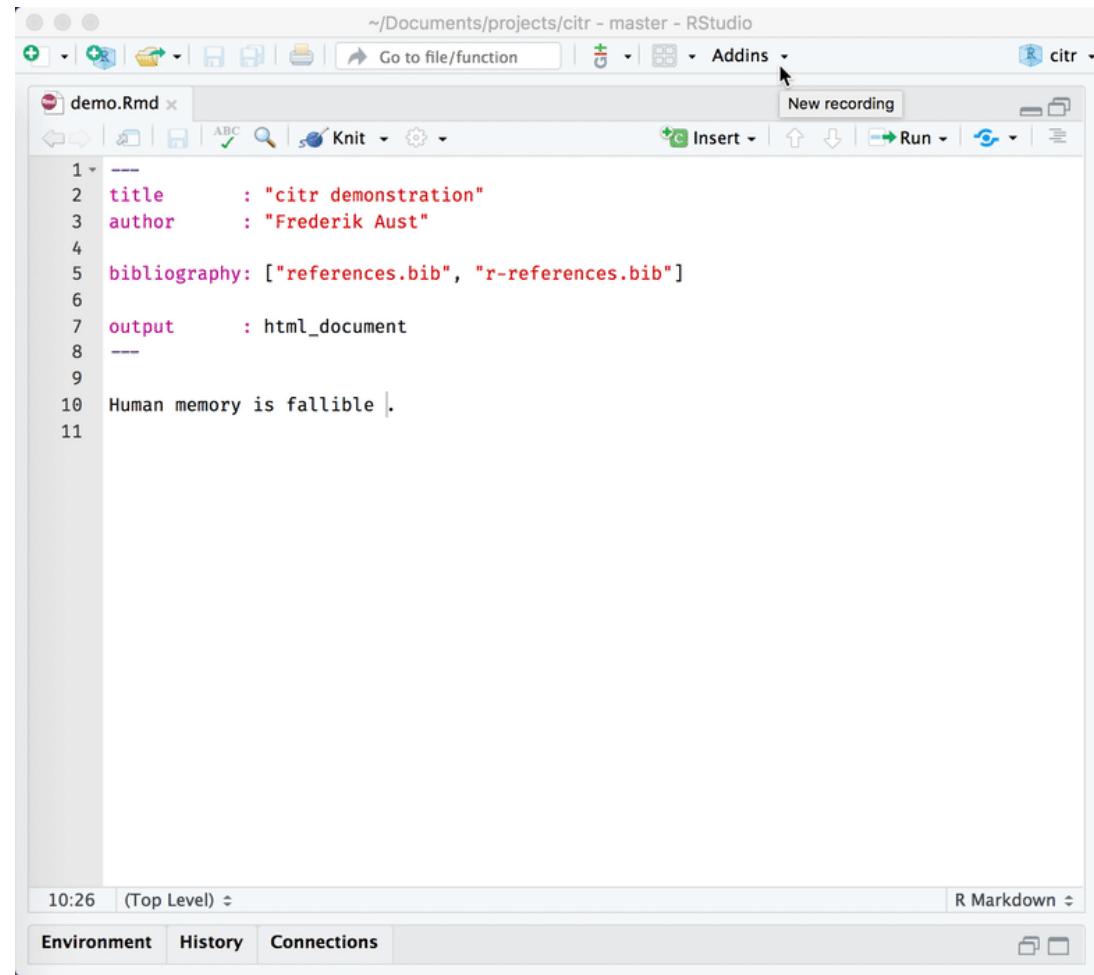
Shea et al. (2014) says blah.

Blah blah (see Shea et al. 2014, 33–
35; also Wu 2016, ch. 1).

- Add e.g `csl: my-style.csl` in the YAML header to change to other formats
- Browse through and download styles at zotero.org/styles

Citations

For an easy way to insert citations, try the `citr` RStudio add-in.



The screenshot shows the RStudio interface with the following details:

- Title Bar:** ~/Documents/projects/citr - master - RStudio
- Addins Menu:** An open dropdown menu under the "Addins" button in the toolbar.
- Toolbar:** Includes buttons for Go to file/function, Insert, Run, and other RStudio functions.
- Code Editor:** A text editor window titled "demo.Rmd x" containing R Markdown code:

```
1 ---  
2 title      : "citr demonstration"  
3 author     : "Frederik Aust"  
4  
5 bibliography: ["references.bib", "r-references.bib"]  
6  
7 output      : html_document  
8 ---  
9  
10 Human memory is fallible |.  
11
```
- Status Bar:** Shows the time (10:26), project level (Top Level), and mode (R Markdown).
- Bottom Navigation:** Environment, History, Connections tabs.

Notebook vs console in Rstudio

In Rstudio, Rmarkdown file = notebook

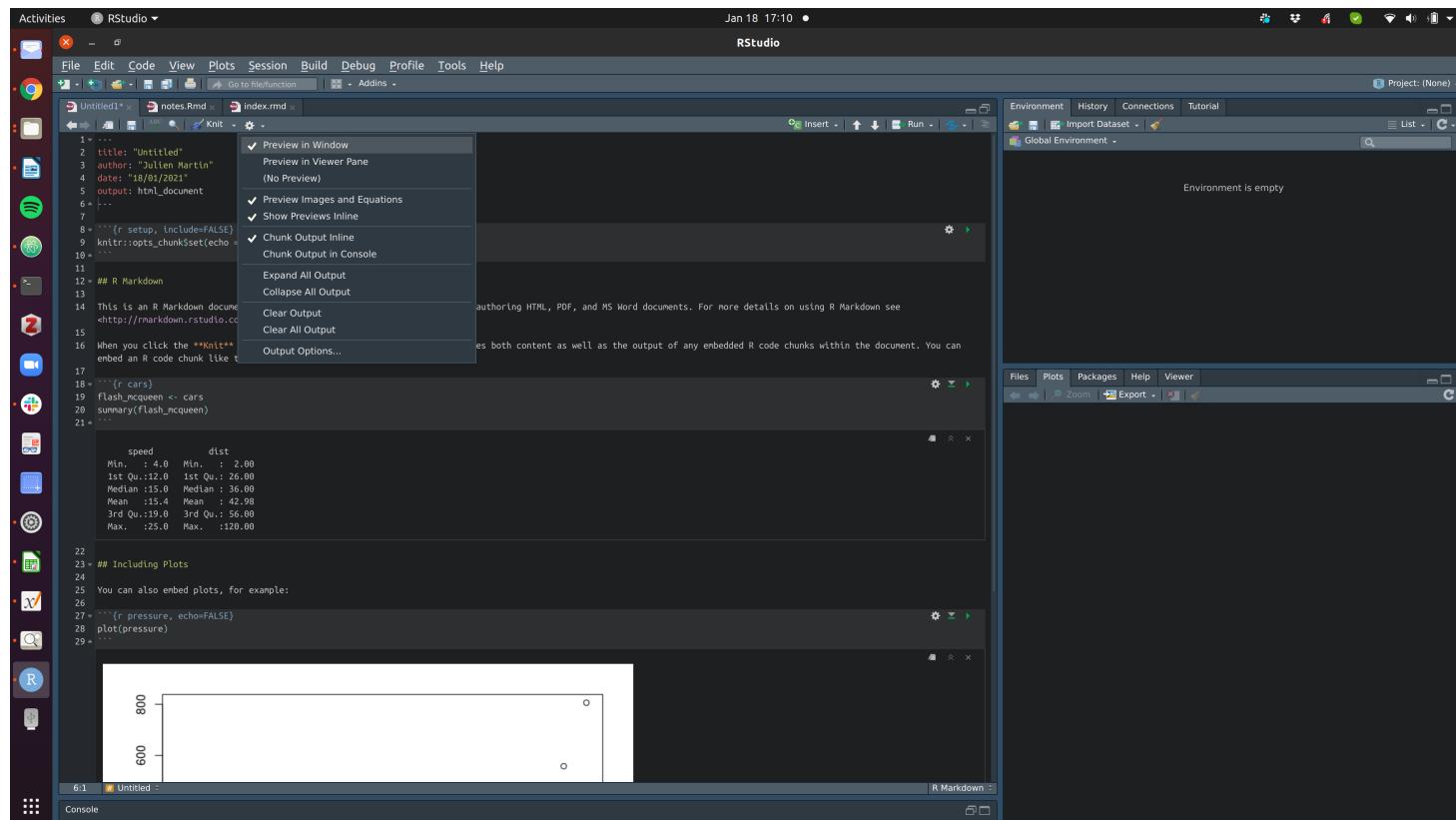
Meaning that R output:

- are embedded in doc
- not available in R envir and console

If you don't like the notebook and want the console, add to YAML header

```
editor_options:  
  chunk_output_type: console
```

Notebook



Console

Activities RStudio ▾

File Edit Code View Plots Session Build Debug Profile Tools Help

Untitled1.Rmd index.Rmd

Jan 18 17:12 ●

RStudio

Preview in Window
Preview in Viewer Pane
(No Preview)

Preview Images and Equations
Show Previews Inline

Chunk Output Inline
Chunk Output in Console

Output Options...

2 title: "Julien Martin"
3 author: "Julien Martin"
4 date: "18/01/2021"
5 output: html_document
6 editor_options:
7 chunk_output_type: console
8 +
9
10 ````{r setup, include=FALSE}
11 knitr::opts_chunk\$set(echo =
12 TRUE)
13
14 ## R Markdown
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16 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>>.
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19
20 ````{r cars}
21 flash_mcqueen <- cars
22 summary(flash_mcqueen)
23
24
25 ## Including Plots
26
27 You can also embed plots, for example:
28
29 ````{r pressure, echo=FALSE}
30 plot(pressure)
31
32
34:1 Including Plots

Console Terminal Jobs

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

> knitr::opts_chunk\$set(echo = TRUE)
> flash_mcqueen <- cars
> summary(flash_mcqueen)
 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. :28.0 Max. :120.00
> plot(pressure)

Project: (None) ▾

Environment History Connections Tutorial

Global Environment ▾

data

Flash_mcqueen 50 obs. of 2 variables

Files Plots Packages Help Viewer

pressure

temperature

R Markdown Reference Guide

<https://rstudio.com/wp-content/uploads/2015/03/rmarkdown-reference.pdf>



R Markdown Reference Guide

Learn more about R Markdown at rmarkdown.rstudio.com

Learn more about Interactive Docs at shiny.rstudio.com/articles

Contents:

1. Markdown Syntax
2. Knitr chunk options
- 3. Pandoc options**

| Templates | Basic YAML | Template options | Latex options | Interactive Docs |
|-----------------------|----------------------------|----------------------------------|-----------------------------|----------------------------|
| html_document | --- | --- | --- | --- |
| pdf_document | title: "A Web Doc" | title: "Chapters" | title: "My PDF" | title: "Slides" |
| word_document | author: "John Doe" | output: html_document: | output: pdf_document | output: |
| md_document | date: "May 1, 2015" | toc: true | fontsize: 11pt | slidy_presentation: |
| ioslides_presentation | output: md_document | toc_depth: 2 | geometry: margin=1in | incremental: true |
| slidy_presentation | --- | --- | --- | runtime: shiny |
| beamer_presentation | --- | --- | --- | --- |

Rmarkdown

TEXT. CODE. OUTPUT.
(GET IT TOGETHER, PEOPLE.)



What else can we reproduce with R Markdown?

Let's have a tour

R Markdown from R Studio

Ge

Gallery

Check out the range of outputs and formats you can create using R Markdown.

Documents

With R Markdown, you write a single .Rmd file and then use it to render finished output in a variety of forms.

Great NYT Interactive -- Now Reusable with rCharts

Chauhan and Atkinson

Let's take advantage of the built-in `isIn` requirement, which will make one of the members have `true` value. All we need to do is to change the condition to be `if (isIn == true)`. Please note that in Java, it is very frequently occurring approach to using `!=` to check applicable requirements.

Another Photo by Jason Dettman



A Pandoc Markdown Article Starter and Template

Stephen V. Miller — Content Assessment

This document provides an introduction to R Markdown, allows for its benefits, and presents a simple non-interactive template intended for its academic audience. I will use basic syntax in R Markdown and a minimal working example of how the `analysis.Rmd` file can be rendered within R studio or as a package.

• 199

Ambitious, well-funded, university-based publications, as at *Harvard*, the *American Journal of Psychology* (*AJP*) attempted a wider range "descriptive work," according to which studies were necessarily relevant to problems of the "normal intellectual development" areas, and that was the main criterion for publication. The *AJP* was the first journal to publish the results of the *Stanford-Binet* test, for example. Pending successful replication, the *Binet-Simon* theory was adopted by the *AJP*. The *AJP*'s range of influence was at the time of its inception, and it had a major influence on educational psychology, educational institutions, and other professions involved had begun to adopt the *Binet-Simon* classification system. In 1908, the *Journal of Educational Psychology* (*JEP*) was established. As a result, *negative* approaches involving the *Binet-Simon* concept of "intelligence" were to become dominant in the United States.

These are welcome improvements to the Lawler committee's as well. Yet it is curious, for the insurance-future, why people will do most of the hard hand-pelvicizing by Michael Lewis

R Mackay

This is an [OpenMark workspace](#).
10794...9987 and 365 is
located on the [OpenMark](#) website.

What you click, do **Kai**
well-as the majority of us
do. Woods think like thi

19 April 1961
19 May 1961
19 June 1961
19 July 1961
19 August 1961
19 September 1961
19 October 1961

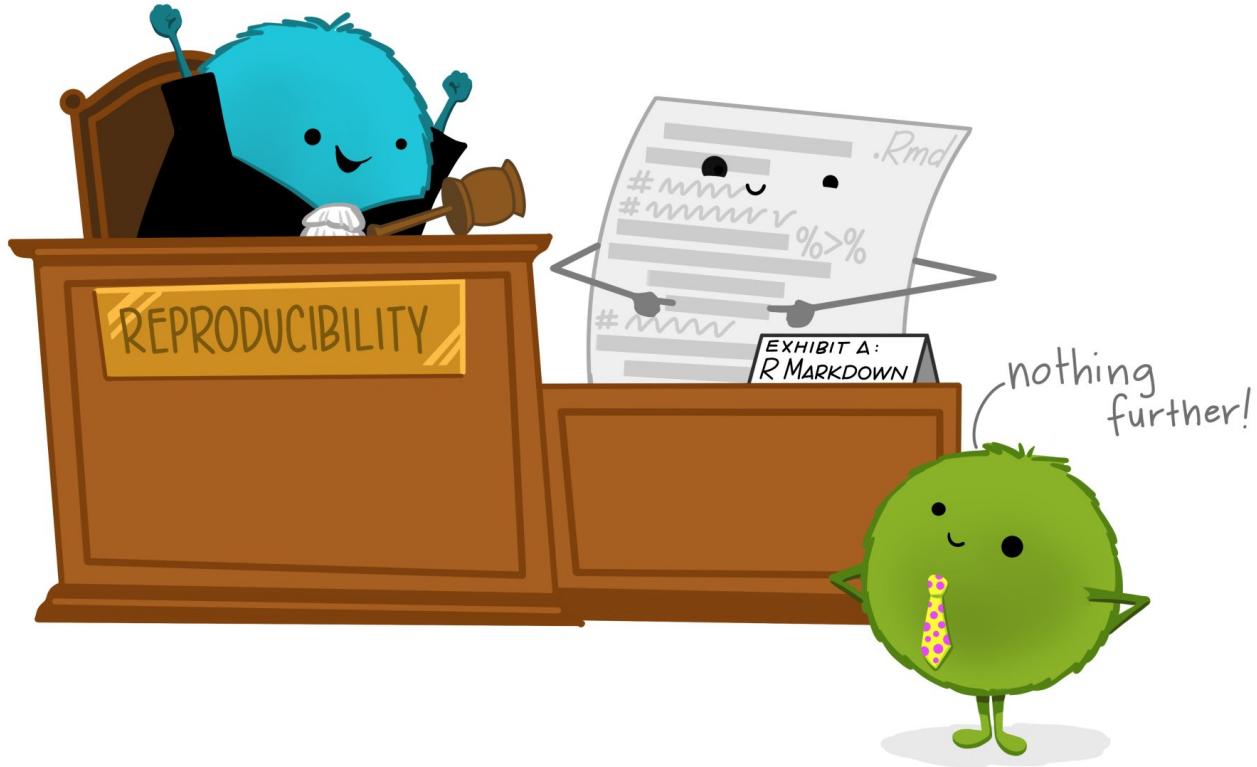
Including Plots

Wijziging van systeem geïn

R Markdown gallery <https://rmarkdown.rstudio.com/gallery.html>

Websites

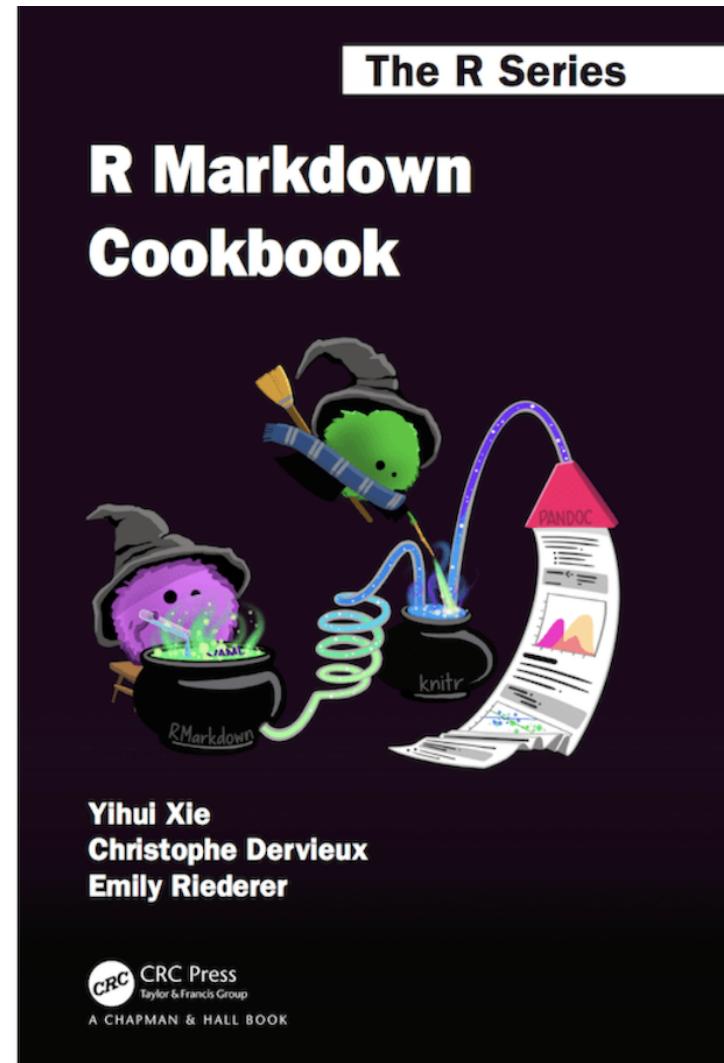
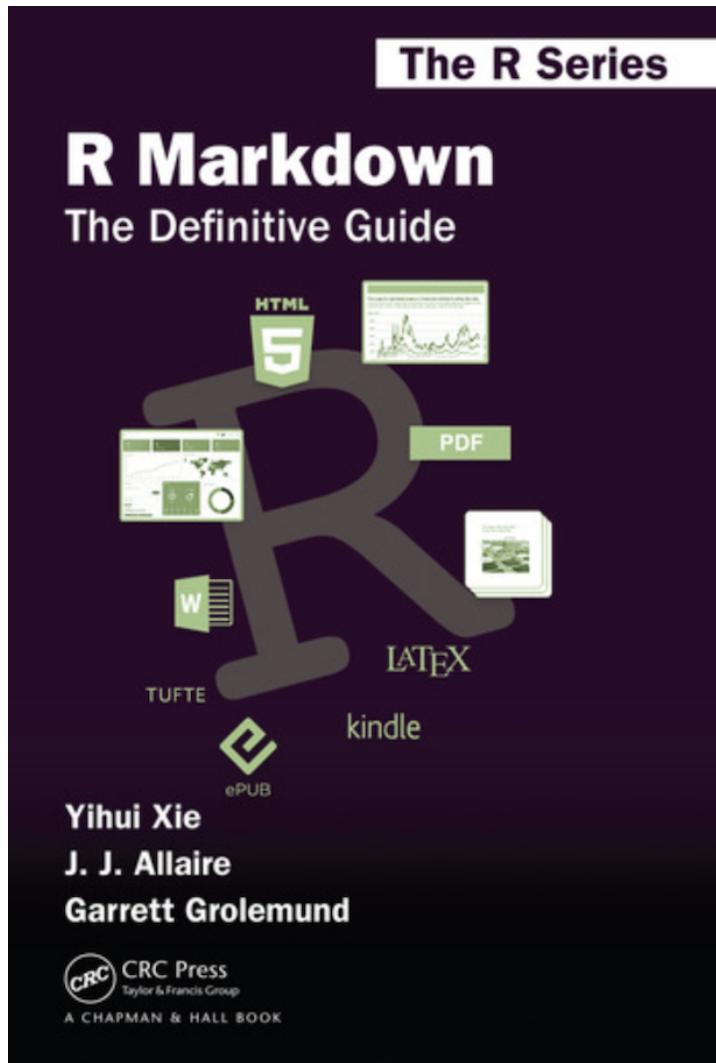
- Use package blogdown <https://bookdown.org/yihui/blogdown/>
- Customize with Hugo <https://themes.gohugo.io/>
- Deploy via GitHub pages or Netlify



@allison_horst

To go further

Books



Thanks!

I created these slides with **xaringan** and **R Markdown** using the **rutgers** css that I slightly modified.

Credit: I borrowed slides from **Garrett Grolemund**, **Ulrik Lyngs**, **Olivier Gimenez** (<https://oliviergimenez.github.io>) . I also used the beautiful illustrations shared by **Allison Horst**.



Julien.martin@uottawa.ca



<https://juliengamartin.github.io/>



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