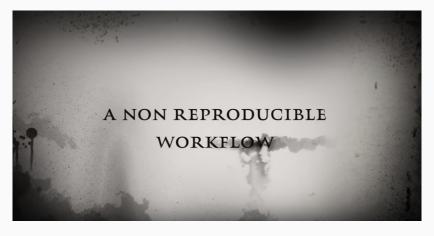
Reproducible dynamic documents with Rmarkdown

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https://frodriguezsanchez.net

A scary movie... with happy ending



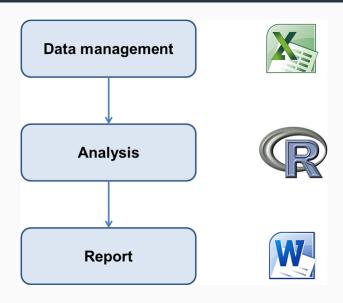
https://youtu.be/s3JldKoA0zw

A typical research workflow

- 1. Prepare data (spreadsheet)
- 2. Analyse data (R)
- 3. Write report/paper (Word)
- 4. Start the email attachments nightmare...



This workflow is broken



4

Problems of a broken workflow

How did you do this? What analysis is behind this figure? Did you account for ...?

Problems of a broken workflow

- How did you do this? What analysis is behind this figure? Did you account for ...?
- What dataset was used? Which individuals were left out? Where is the clean dataset?

Problems of a broken workflow

- How did you do this? What analysis is behind this figure? Did you account for ...?
- What dataset was used? Which individuals were left out? Where is the clean dataset?
- Oops, there is an error in the data. Can you repeat the analysis? And update figures/tables in Word!

Manual copy-paste is tedious & problematic

'Transcribing numbers from stats software by hand was the largest source of errors'

(Eubank 2016)



≗ Follow

My rule of thumb: every analysis you do on a dataset will have to be redone 10–15 times before publication. Plan accordingly. #Rstats

Your **closest collaborator** is you 6 months ago, and you don't respond to emails.

Even **you** will struggle to reproduce

(P. Wilson)

your own results from a few weeks/months ago.

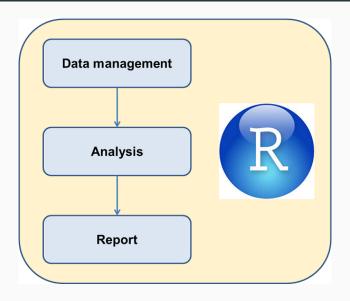
Writing reproducible manuscripts is hard

Revising non-reproducible manuscripts is even harder

•

Also, please note that because rev#1 asked to re-calculate effect sizes (...) we need to change every single number in the main text.

Dynamic reports

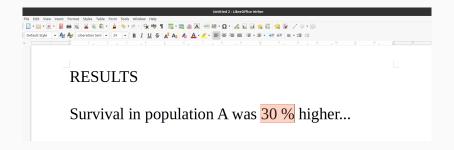


Rmarkdown documents

- · Fully reproducible (trace all results inc. tables and plots)
- Dynamic (regenerate with 1 click)
- · Multiple outputs:
 - · documents (HTML, Word, PDF)
 - · presentations (HTML, PDF, PowerPoint)
 - · books
 - · websites...



Where does this value come from?



Dynamic documents with Rmarkdown

Rmarkdown:

Survival in population A was `r surv.diff` % higher

Output:

Survival in population A was 30 % higher

Dynamic documents with Rmarkdown

```
mydata <- read.csv("data.txt")</pre>
```

Rmarkdown:

We measured `r nrow(mydata)` individuals

Output:

We measured 100 individuals

Much better than copy-paste!

Rmarkdown: code (R, Python, etc) + text (Markdown)

title: "Does sunshine make people happy?" author: "FRS" output: word_document	Metadata (YAML)
## Introduction It is well known that individual well-being can be influenced by climatic conditions. ## Methods	Text (Markdown)
<pre>"``{r echo=FALSE} ## Read data data <- read.table("data.txt", header = TRUE) # Fit linear model model <- lm(happiness ~ sunshine, data = data)</pre>	Code (R, Python)
We collected data on `r nrow(data)` individuals and fitted a linear model.	

Code chunk options

```
```{r echo=FALSE, eval=TRUE, cache=TRUE, fig.height=3}
plot(iris)
...
https://yihui.org/knitr/options/
```

## Code chunk options

```
"\{r\}
#| echo = FALSE
#| eval = TRUE
#| fig.cap = "My figure caption"
plot(iris)
```

# Naming chunks helps debugging

```
processing file: test.Rmd
 1......
 14%
 ordinary text without R code
 29%
 1......
label: setup (with options)
List of 1
$ include: logi FALSE
 1.........
 43%
 ordinary text without R code
 1......
 57%
label: read.data
 1.....
 71%
 ordinary text without R code
 1.....
 86%
label: plot (with options)
List of 1
$ echo: logi FALSE
Ouitting from lines 28-29 (test.Rmd)
Error in eval(predvars, data, env) : object 'specie' not found
Calls: <Anonymous> ... plot.formula -> eval -> eval -> <Anonymous> -> eval -> eval
Execution halted
```

## Naming chunks helps navigating long docs

```
1 -
 2 title: "My Analysis"
 3 author: "FRS"
 4 output: html_document
 5 - - - -
 6
 7 ```{r setup, include=FALSE}
 £ }
 knitr::opts chunk$set(echo = TRUE)
 9 -
 10
 11
 This is an R Markdown document. Markdown is a simple
 My Analysis
 for authoring HTML, PDF, and MS Word
 Chunk 1: setup
 re details on using R Markdown see
 Chunk 2: read.data
 .rstudio.com>.
 Chunk 3: plot
 12
11:60
 (Top Level) $
 R Markdown
```

## Naming chunks: figure files take chunk name

- unnamed-chunk-1-1.png
- unnamed-chunk-1-2.png
- unnamed-chunk-1-3.png
- unnamed-chunk-1-4.png

## ¡Not only R! Python, Julia, C++, SQL, Stan, etc

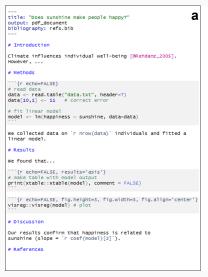
#### knitr engines:

```
[1] "asis"
 "awk"
 "bash"
 "block"
 "block2"
 "asy"
[7] "bslib"
 "cat"
 "cc"
 "coffee"
 "comment"
[13] "css"
 "ditaa"
 "dot"
 "embed"
 "exec"
 "fortran"
[19] "fortran95" "gawk"
 "go"
 "groovy"
 "haskell"
 "highlight"
[25] "js"
 "julia"
 "lein"
 "mysql"
 "node"
 "octave"
[31] "perl"
 "psql"
 "python"
 "R"
 "Rcpp"
 "Rscript"
 "sed"
[37] "rubv"
 "sas"
 "sass"
 "scala"
 "scss"
[43] "sh"
 "sql"
 "stan"
 "stata"
 "targets"
 "tikz"
[49] "verbatim"
 "zsh"
```

# Markdown: easy text formatting

```
Header
Subheader
italic
bold
[a link](https://example.com)
Handy: https://thinkr-open.github.io/remedy/
Or use Visual Markdown Editor
```

## Regenerate Word/PDF/HTML with one click



#### Does sunshine make people happy?

#### b

#### Introduction

Climate influences individual well-being (Rehdanz and Maddison 2005). However,  $\dots$ 

#### Methods

We collected data on 100 individuals and fitted a linear model.

#### Results

We found that...

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	-0.0986	0.4271	-0.23	0.8180
sunshine	0.0101	0.0004	23.75	0.0000



#### Discussion

Our results confirm that happiness is related to sunshine (slope = 0.0100652).

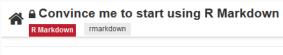
#### References

Rehdanz, Katrin, and David Maddison. 2005. "Climate and Happiness." Ecological Economics 52 (1). Elsevier BV: 111–25. doi:10.1016/j.ecolecon.2004.06.015.

## Spotted error in the data? No problem!

- · Make changes in Rmarkdown document
- · Click **Knit** in Rstudio
- Report will update automatically!

### Why Rmarkdown?





Darren\_Dahly

- 1. Start using R Markdown to generate reports of your data analyses.
- 2. If the data changes, rerun the report with a click of the mouse.
- 3. Take 3 days off of work.
- On the 4th day, tell your collaborators that the re-analysis is complete.
- 5. Be hailed as a hero.

https://community.rstudio.com/t/convince-me-to-start-using-r-markdown/1636/12

# Your turn

## Create, edit and share Rmarkdown document

File > New File > Rmarkdown

Write text

Insert code chunks

Change chunk options (echo, eval, etc)

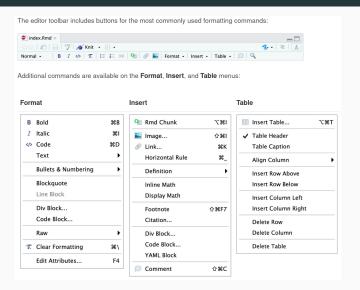
HTML/Word/PDF output

#### PDF generation requires LaTeX

```
library('tinytex')
install_tinytex()
```

# Rmarkdown bells and whistles

## 'Visual Rmarkdown': Rmd as in word processor



https://rstudio.github.io/visual-markdown-editing

## Automatic table generation

```
model <- lm(happiness ~ sunshine, data = mydata)
xtable(model)</pre>
```

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	-0.0652	0.4265	-0.15	0.8789
sunshine	0.0100	0.0004	23.68	0.0000

Many alternatives: gtsummary, modelsummary, huxtable, etc

## equatiomatic describes model structure

We fitted a linear model:

```
library('equatiomatic')
model <- lm(happiness ~ sunshine, data = mydata)
extract_eq(model)</pre>
```

happiness = 
$$\alpha + \beta_1(\text{sunshine}) + \epsilon$$
 (1)

#### Models that describe themselves!

```
library("report")
model <- lm(happiness ~ sunshine, data = mydata)
report(model)</pre>
```

We fitted a linear model (estimated using OLS) to predict happiness with sunshine (formula: happiness  $\sim$  sunshine). The model explains a statistically significant and substantial proportion of variance (R2 = 0.85, F(1, 98) = 560.90, p < .001, adj. R2 = 0.85). The model's intercept, corresponding to sunshine = 0, is at -0.07 (95% CI [-0.91, 0.78], t(98) = -0.15, p = 0.879). Within this model:

The effect of sunshine is statistically significant and positive (beta = 0.01, 95% CI [9.18e-03, 0.01], t(98) = 23.68, p < .001; Std. beta = 0.92, 95% CI [0.85, 1.00])</li>

Standardized parameters were obtained by fitting the model on a standardized version of the dataset. 95%

Confidence Intervals (CIs) and p-values were computed using the Wald approximation.

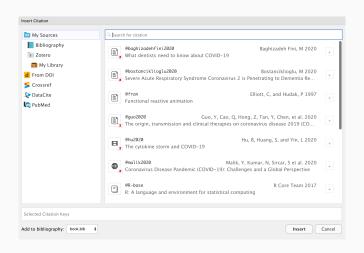
# Insert equations with LaTeX

Using LaTeX:

$$y \sim N(\mu, \sigma^2)$$

Mathpix: https://github.com/jonocarroll/mathpix

## Citing bibliography



https://rstudio.github.io/visual-markdown-editing/#/citations

# Using BibTeX file with references

```
title: "My awesome Rmd"
output: html_document
bibliography: references.bib

```

# Format bibliography for any journal

```
title: "Does sunshine make people happy?"
author: "FRS"
output: word_document
bibliography: myrefs.bib
csl: ecology-letters.csl
```

#### Thousands of Citation Styles:

https://www.zotero.org/styles

https://github.com/citation-style-language/styles

### Rmarkdown templates

- rticles
- papaja
- rrtools
- pinp
- rmdTemplates
- pagedreport
- · GitHub!

#### My cool paper written in Rmarkdown

F. Rodriguez-Genchez<sup>1,1,2</sup> and And Friends<sup>1,1</sup>

\*Some Institute of Sectioning, Department, Street, City, State, Zip; \*Another University Department, Street, City, State, Zip

Please provide an absence of no more than 250 words in a single paragraph. Abstracts should explain to the general reader the major ions of the article. References in the abstract must be ched in full within the abstract lead and cleed in the east.

This PNAS journal template is provided to help you write your work in the correct journal format. Instructions for use

Note: please start year introduction without including the word "Introduction" as a section heading (except for math articles in the Physical Sciences section); this heading is implied in the first paragraphs.

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plete address, with the ZIP/postal code, for each author. Use in the example. Authors with an ORCID ID may supply this

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Manuscript Length, PNAS generally uses a two-column format averaging 67 characters, including spaces, per line. The pages and a PNAS PLUS research article is ten pages includby figures, tables, and equations. When submitting tables, figures, and/or equations in addition to text, keep the text for your manuscript under 20,000 characters (including spaces) for Direct Submissions and 72,000 characters (including spaces)

Returences, References should be cited in numerical order as Place provide details of earlier problems has they appear in test; this will be done automatically via bibter, s.e. (1) and (2. 3). All references, including for the SL should sled in the main manuscript file. References appearing in both sections should not be deplicated. SI references



included in tables should be included with the main reference

to a published article. Where such archiving is not possible, Submitting Manuscripts. All authors must submit their artideposition of data in public databases, such as GenRank, Asrayllopeus, Protein Data Bank, Unidata, and others collined

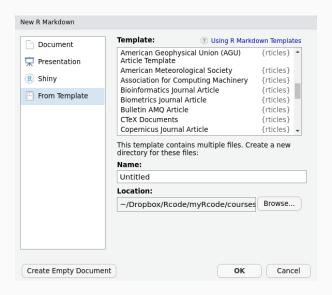
> Language-Editing Services, Prior to submission, authors who their use has no bearing on acceptance of a manuscript for

#### Significance Statement

Authors must submit a 120-word maximum statement about the paper itself and is required for all research papers.

FMS | September 49,000 | vol.XXX | no.XX | 4-2

### Accessing Rmd templates



# Revise writing style: gramr

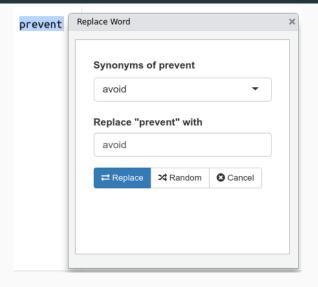


https://github.com/ropenscilabs/gramr

# Spell and grammar checking

https://github.com/nevrome/wellspell.addin

## Find synonyms



https://github.com/gadenbuie/synamyn

# Word count and readability

Method	koRpus	stringi
:	- :	- :
Word count	107	104
Character count	604	603
Sentence count	10	Not available
Reading time	0.5 minutes	0.5 minutes

https://github.com/benmarwick/wordcountaddin

### Write books, theses, with bookdown

#### **BOOKDOWN**

#### Write HTML, PDF, ePub, and Kindle books with R Markdown

 $\label{thm:continuous} The \mbox{\bf bookdown} \mbox{ package is an } \mbox{\underline{open-source} \mbox{\sc R} \mbox{ package} that facilitates writing books and long-form articles/reports with R Markdown. Features include:$ 

- · Generate printer-ready books and ebooks from R Markdown documents.
- A markup language easier to learn than LaTeX, and to write elements such as section headers, lists, quotes, figures, tables, and citations.
- . Multiple choices of output formats: PDF, LaTeX, HTML, EPUB, and Word.
- · Possibility of including dynamic graphics and interactive applications (HTML widgets and Shiny apps).
- Support a wide range of languages: R, C/C++, Python, Fortran, Julia, Shell scripts, and SQL, etc.
- LaTeX equations, theorems, and proofs work for all output formats.
- Can be published to GitHub, bookdown.org, and any web servers.
- Integrated with the RStudio IDE.
- One-click publishing to https://bookdown.org.



https://bookdown.org/

# Slide presentations with xaringan

# Presentation Ninja

Yihui Xie

RStudio, PBC

https://slides.yihui.org/xaringan/

### Parameterised reports

```
title: "My template report"
output: html_document
params:
 sp: Adelie
````{r}
                                               ③ ¥ ▶
library(palmerpenguins)
data("penguins")
mydata <- subset(penguins, species == params$sp)</pre>
plot(mydata$bill_length_mm, mydata$bill_depth_mm,
     main = paste0("Species: ", params$sp))
                     Species: Adelie
 mydata$bill_depth_mm
                  0
                                               0
      8
      16
                   mydata$bill length mm
```

Render thousands of individual reports from Rmd template

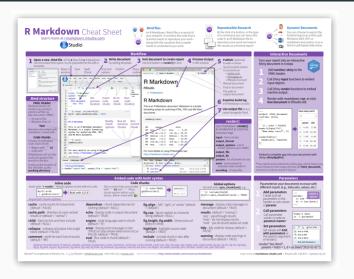
Rmarkdown resources

Rmarkdown website

http://rmarkdown.rstudio.com/

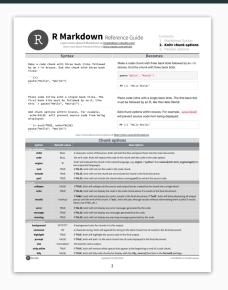


Rmarkdown cheat sheet



https://www.rstudio.org/links/r_markdown_cheat_sheet

Rmarkdown reference guide



https://www.rstudio.org/links/r_markdown_reference_guide

Rmarkdown books



by Yihui Xie, J. J. Allaire, Garrett Grolemund

2018-09-11





The first official book authored by the core R Markdown developers that provides a comprehensive and accurate reference to the R Markdown ecosystem. With R Markdown, you can easily create reproducible data analysis reports, presentations, dashboards, interactive applications, books, dissertations, websites, and journal articles, while enjoying the

simplicity of Markdown and the great power of R and other languages. Read more \rightarrow

https://bookdown.org/yihui/rmarkdown/

https://bookdown.org/yihui/rmarkdown-cookbook/

Welcome to Quarto

Quarto is an open-source scientific and technical publishing system built on Pandoc

- Create dynamic content with Python, R, Julia, and Observable.
- Author documents as plain text markdown or Jupyter notebooks.
- Publish high-quality articles, reports, presentations, websites, blogs, and books in HTML, PDF, MS Word, ePub, and more.
- Author with scientific markdown, including equations, citations, crossrefs, figure panels, callouts, advanced layout, and more.

https://quarto.org/

Your turn

Your turn

- Try visual markdown editor
- Add bibliography
- Try templates (rticles, rmdTemplates)
- Parameterised reports (e.g. different iris or penguin species)