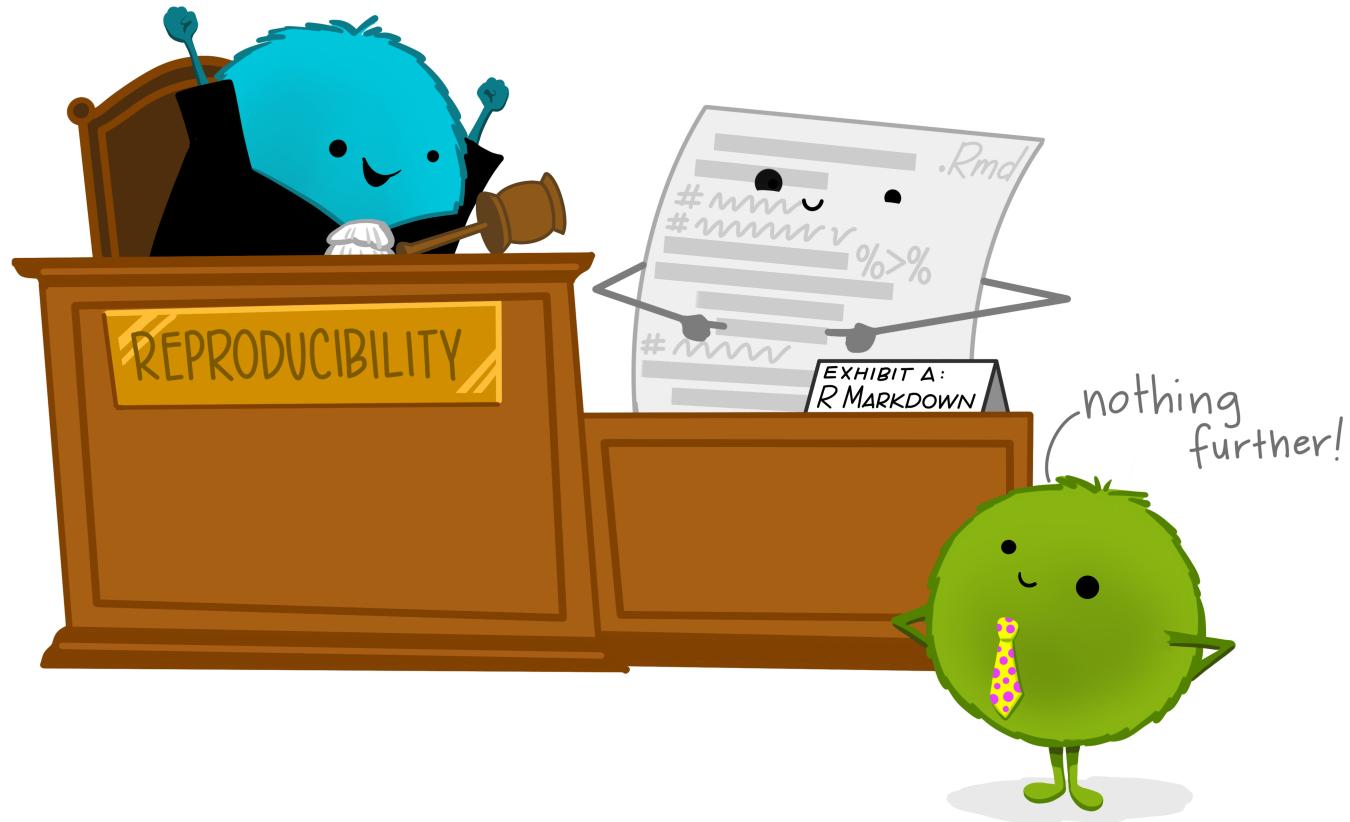




# Writing reproducible manuscripts in R

Shilaan Alzahawi @ Stanford Graduate School of Business  
Artwork by @allison\_horst

# Do your data sci like it's going to need an alibi



@allison\_horst

# Outline

## Introductions

-  Hammer Breaking the ice @ vIACM

## What?

-  Dynamic and Reproducible Manuscripts

## Why?

-  Benefits

## How?

-  Tutorial
  - An introduction to **R Markdown** (pt. 1)
  - An introduction to **papaja** (pt. 2)

# Introductions

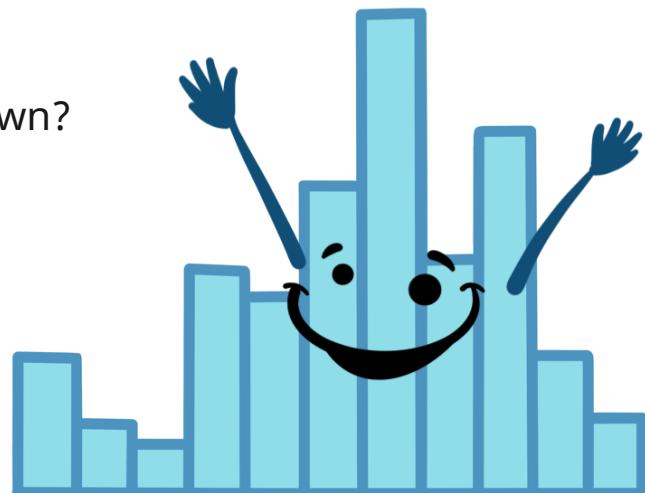


PhD student in Organizational Behavior at Stanford GSB

- 🔍 Statistical inference & hypothesis testing
- 🔍 Open and reproducible science
- 🔍 Crowdsourced & big team science

... your turn!

- ▶ Brief introduction
- ▶ What do you hope to get out of this workshop?
- ▶ Previous experience with R, RStudio, and RMarkdown?



# The typical workflow

When writing a scientific report, the typical workflow is to ...

1. Do your analyses (e.g., in [R](#) or [Python](#))
2. Copy-paste or otherwise save your graphs and results
3. Open a program (e.g., [Microsoft Word](#)) to communicate the results
4. Manually format your results and citations

## Discussion questions

What are common challenges when working in this fashion?

What kind of problems could arise?

# "FINAL".doc



↑ FINAL.doc!



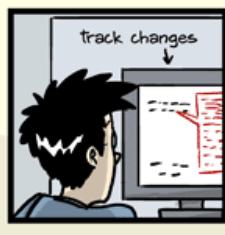
↑ FINAL\_rev.2.doc



↑ FINAL\_rev.6.COMMENTS.doc



↑ FINAL\_rev.8.comments5.  
CORRECTIONS.doc



↑ FINAL\_rev.18.comments7.  
corrections9.MORE.30.doc



↑ FINAL\_rev.22.comments49.  
corrections.10.#@\$%WHYDID  
ICOMETOGRAD SCHOOL????.doc

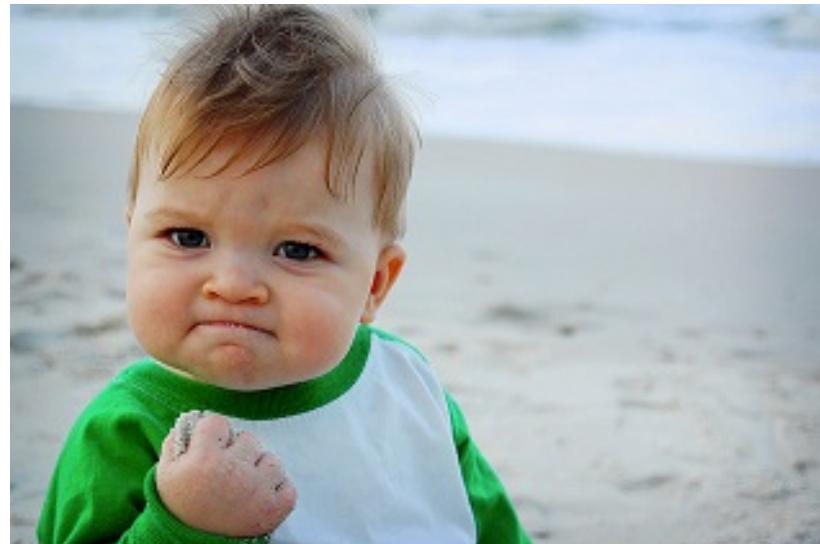
JORGE CHAM © 2012

# Typical workflow challenges

- Time-consuming
- Error-prone (e.g., rounding or transcription errors)
- Lacks transparency; difficult to reproduce (by others **and** yourself!)
- Difficult to maintain and update (endless rewriting and reformatting...)
- Overhead costs of different computing/software environments
- **Anything else...?**

# An alternative workflow: What?

- Fuse your code and writing
- Directly embed results in your report
- Automatically reflect analytic changes in your documentation
- Update all your results, figures, and tables automatically
- Automatic formatting (including citations!)



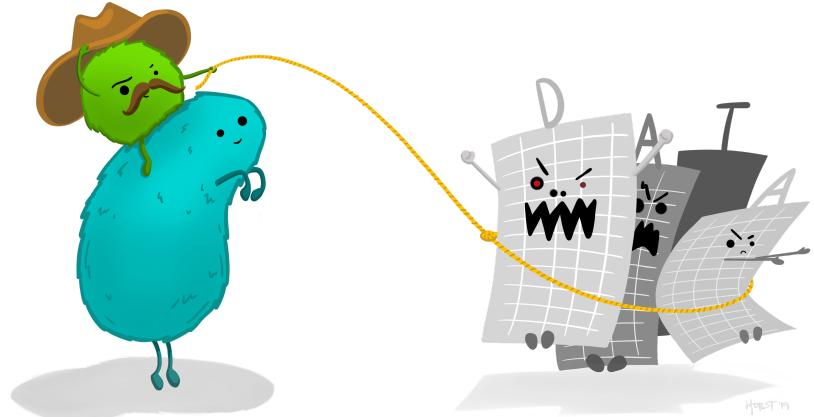
# An alternative workflow: Why?

Less...

- ↓ Error-prone
- ↓ Time-consuming

More...

- ↑ Dynamic
- ↑ Reproducible
- ↑ Transparent



# Our weapon of choice: RMarkdown

- RMarkdown is an **authoring framework for data science**, designed for reproducibility
- The same document holds the code and the narrative surrounding the data
- Results are automatically generated from the code
- You can use a single R Markdown file to
  - ✓ save and execute code, and
  - ✓ generate high quality reports that can be shared with an audience





Artwork by @allison\_horst:

**Get your code, text, and outputs in the same (reproducible) place**

# Introduction to RMarkdown

- Create dynamic analysis documents that combine code, output (incl. figures and tables), and writing
- Can be used to
  - ✓ Reproduce your analyses
  - ✓ Collaborate and share code with others
  - ✓ Communicate your results with others
- Output formats include HTML, PDF, Word and...
  - 👑 Slide shows
  - 👑 Websites ([shilaan.rbind.io](https://shilaan.rbind.io))
  - 👑 Blogs
  - 👑 Books
  - 👑 Dashboards
  - 👑 Manuscripts
  - 👑 Interactive documents

**Bonus question** How did I create my slides...?

# Sneak peek: the power of RMarkdown

```
---
```

```
title      : "Active Choice Hypothesis Testing: Example Manuscript"
shorttitle : "Active Choice Hypothesis Testing"

author:
  - name        : "Shilaan Alzahawi"
  affiliation  : "1"
  corresponding: yes    # Define only one corresponding author
  address     : "655 Knight Way, Graduate School of Business, Stanford, CA 94305"
  email       : "shilaan@stanford.edu"

affiliation:
  - id         : "1"
  institution : "Stanford University, Graduate School of Business"

note: "\\clearpage"

authornote:

abstract:

keywords   : "Hypothesis Testing"
wordcount  : "2,860"

bibliography : ["references.bib", "r-references.bib"]

floatsintext: yes #place figures and tables in the text rather than at the end
numbersections: no #number sections headings
figurelist   : no  #create list of figure captions
tablelist    : no  #create list of table captions
footnotelist: no  ##create list of footnotes
linenumbers  : no  #add line numbers in the margins
mask         : no  #omit identifying information from the title page
draft        : no  #add "draft" watermark across all pages

documentclass: "apa6"
classoption   : "man"
output        : papaja::apa6_word
---
```



Running head: ACTIVE CHOICE HYPOTHESIS TESTING

1

Active Choice Hypothesis Testing: Example Manuscript

Shilaan Alzahawi<sup>1</sup>

<sup>1</sup> Stanford University, Graduate School of Business

Author note

Correspondence concerning this article should be addressed to Shilaan Alzahawi, 655  
Knight Way, Graduate School of Business, Stanford, CA 94305. E-mail: shilaan@stanford.edu

# Sneak peek: the power of RMarkdown

"Whatever else is done about null-hypothesis tests, let us stop viewing statistical analysis as a sanctification process. We are awash in a sea of uncertainty, caused by a flood tide of sampling and measurement errors, and there are no objective procedures that avoid human judgment and guarantee correct interpretations of results." [[@abelson1997](#): p.13]

Psychological science is experiencing a period of widespread methodological reflection [[@nelson2018](#)]. Starting 2010, a chain of events caused psychological scientists to doubt the credibility of psychological research [[@moshontz2018](#)]. These events included a case of widespread academic fraud, a series of failed replications of famous findings, and a paper published in psychology's most prestigious journal claiming that extrasensory perception (ESP) is real [[@nelson2018](#)].

According to some, one of the root causes of the crisis of confidence is the misunderstanding and misuse of statistical methods [[@goodman2019](#)]. In psychological science, one of the most frequently used approaches to statistical inference is the null-hypothesis significance test (NHST). For decades, researchers have been warned about mindless applications of this tool (e.g., [@cohen1994](#); [@gigerenzer2004](#); [@nickerson2000](#); [@rozeboom1960](#)).

"Whatever else is done about null-hypothesis tests, let us stop viewing statistical analysis as a sanctification process. We are awash in a sea of uncertainty, caused by a flood tide of sampling and measurement errors, and there are no objective procedures that avoid human judgment and guarantee correct interpretations of results." (Abelson, 1997: p.13)

Psychological science is experiencing a period of widespread methodological reflection (Nelson, Simmons, & Simonsohn, 2018). Starting 2010, a chain of events caused psychological scientists to doubt the credibility of psychological research (Moshontz et al., 2018). These events included a case of widespread academic fraud, a series of failed replications of famous findings, and a paper published in psychology's most prestigious journal claiming that extrasensory perception (ESP) is real (Nelson et al., 2018).

According to some, one of the root causes of the crisis of confidence is the misunderstanding and misuse of statistical methods (Goodman, 2019). In psychological science, one of the most frequently used approaches to statistical inference is the null-hypothesis significance test (NHST). For decades, researchers have been warned about mindless applications of this tool (e.g., Cohen, 1994; Gigerenzer, 2004; Nickerson, 2000; Rozeboom, 1960).

# Sneak peek: the power of RMarkdown

```
```{r setup, include = FALSE}
library(papaja)
library(citr)
library(rpact)
library(dplyr)
r_refs("r-references.bib")
```

## Acknowledgement
This manuscript was created using `r cite_r("r-references.bib")`.
```



## Acknowledgement

This manuscript was created using R (Version 3.6.2; R Core Team, 2019) and the R-packages *citr* (Version 0.3.2; Aust, 2019), *dplyr* (Version 1.0.4.9000; Wickham, François, Henry, & Müller, 2021), *papaja* (Version 0.1.0.9997; Aust & Barth, 2020), *rpact* (Version 3.0.2; Wassmer & Pahlke, 2020), and *tinylabels* (Version 0.2.0; Barth, 2021).

# Discussion question

Are there good reasons for **not** using RMarkdown?

Ethan @SEthanMilne

Do people really write their code in R and not Rmarkdown? .Rmd files are so much better for actually documenting what you're doing - I don't understand why you'd write a script in isolation

7:07 AM · Apr 22, 2021 · Twitter for iPhone

2 Likes

Shilaan Alzahawi @shilaan01 · Apr 22  
Replying to @SEthanMilne

I switch from Rmd to R when I'm doing computationally expensive things (simulations, mcmc, cross-validation, etc.). Rmd is incredibly slow for those things, but you can still source in your R script to an Rmd to document what you've done :)

Ari Dyckovsky @adyckovsky · Apr 22  
This. Splitting computationally expensive functions from the documentation of their output is also better for maintaining code and working with others on it!

Steve Rathje @steverathje2 · Apr 22  
Replying to @SEthanMilne

I generally like Rmarkdown for smaller datasets and R for big datasets, because Rmarkdown can be more buggy for big data.

Also who says I like to document my code... 😊😊

Paul Connor @paulrconnor · Apr 22  
Replying to @SEthanMilne

I just use r files. No need to go back and forth between the Rmd file and the knitted output, seems easier to me. But each to their own. Diversity is our strength!

Lucas A. Keefer @keefer\_lucas · Apr 22  
Dinosaurs like me code fluently in R; but it takes a bit more time to make Rmd do what you want/look pretty doing it.

# Part 1: RMarkdown

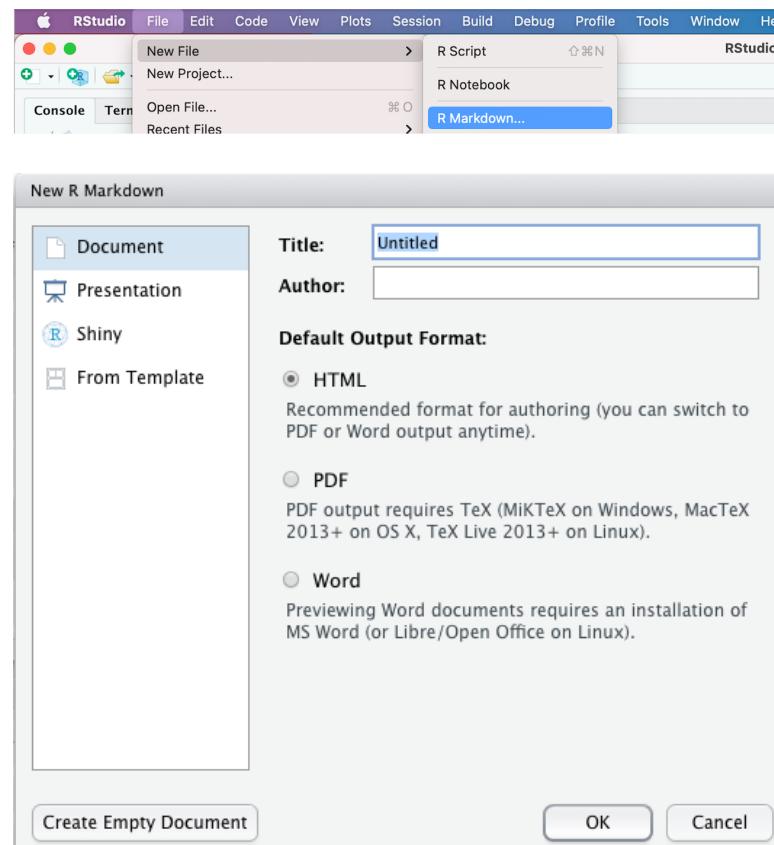
# Getting started with RMarkdown

- Install R
- Install RStudio
- Install the [RMarkdown](#) package
- Install *L<sup>A</sup>T<sub>E</sub>X* (e.g., [TinyTeX](#))

```
install.packages("rmarkdown")
install.packages('tinytex') # for generating PDF output
tinytex::install_tinytex() # install TinyTeX
```

# Opening a new R Markdown

- Create a new R Markdown document from the menu  
File -> New File -> R Markdown



# Notebook interface

- Allows for direct interaction with R (execute code and display results inline)
- Makes it easy to test and iterate
- Produces a reproducible document with publication-quality output

The screenshot shows the RStudio interface with the following details:

- File Bar:** Shows the current file is "1-example.Rmd".
- Toolbar:** Includes standard icons for file operations like Open, Save, Print, and a "Knit" button.
- Environment Tab:** Shows tabs for Environment, History, Build, and Git.
- Files Tab:** Shows tabs for Files, Plots, Packages, Help, and Viewer.
- Code Editor:** Displays R code in the "1-example.Rmd" file. Lines 12-16 show the creation of a Viridis color map for a volcano plot. Lines 17-22 show the creation of a Magma color map for the same plot.
- Plot Area:** Displays a heatmap of the volcano plot using the Viridis color scheme, showing a central yellow/green peak fading into blue/purple at the edges.
- Console:** Shows the command "R Markdown" was run.
- Status Bar:** Shows "1.1" and "Viridis Demo".

# Three types of content

- YAML meta-data / frontmatter (between `---` and `---`)
- Text with Markdown formatting
- R code

The screenshot shows the RStudio IDE interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Window, and Help. The status bar at the bottom shows "4:25" and "R Markdown".

The main workspace displays the following R Markdown code:

```
1 ---  
2 title: "Untitled"  
3 author: "Shilaan Alzahawi"  
4 date: "February 18, 2021"  
5 output: html_document  
---  
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
```

The right side of the interface shows the Environment pane, which is currently empty, and the Files pane, which also contains no files.

# Metadata

# YAML metadata

<so meta>

The YAML header contains basic metadata and rendering instructions

```
---
title: My R Markdown Report
author: Shilaan Alzahawi
output: pdf_document
date: "2021-07-11"
---
```

The date will be **dynamically updated** every time we knit the report, with the help of the following line of code (more on **in-line code** later):

```
date: ``r Sys.Date()``
```

# Rendering a document



- ✓ Windows/Linux: Control + Shift + K
- ✓ OS X: Command + Shift + K



Artwork by @allison\_horst:  
**Become an RMarkdown knitting wizard**

# Output formats

~/Documents/rmarkdown - gh-pages ~

1-example.Rmd x

Go file/function Knit Addins Run

```
1 ---  
2 title: "Viridis Demo"  
3 output: html_document  
4 ---  
5  
6 ```{r include = FALSE}  
7 library(viridis)  
8 ```  
9  
10 The code below demonstrates two color palettes in the  
[viridis](https://github.com/sjmgarnier/viridis) package. Each plot  
displays a contour map of the Maunga Whau volcano in Auckland, New  
Zealand.  
11  
12 ## Viridis colors  
13  
14 ```{r}  
15 image(volcano, col = viridis(200))  
16 ```  
17  
18 ## Magma colors  
19  
20 ```{r}  
21 image(volcano, col = viridis(200, option = "A"))  
22 ```

3.22 Viridis Demo R Markdown
```

Console R Markdown x

~/Documents/rmarkdown/demos/

```
> render("1-example.Rmd", output_format = "word_document")
```

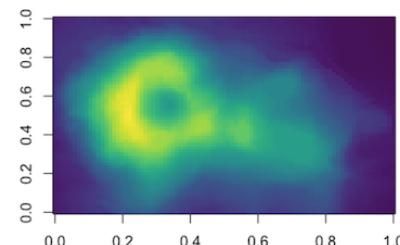


## Viridis Demo

The code below demonstrates two color palettes in the [viridis](#) package. Each plot displays a contour map of the Maunga Whau volcano in Auckland, New Zealand.

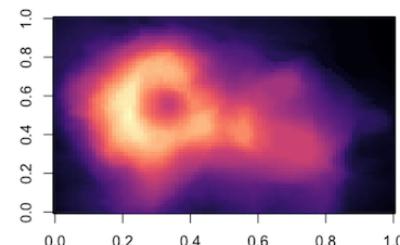
### Viridis colors

```
image(volcano, col = viridis(200))
```



### Magma colors

```
image(volcano, col = viridis(200, option = "A"))
```



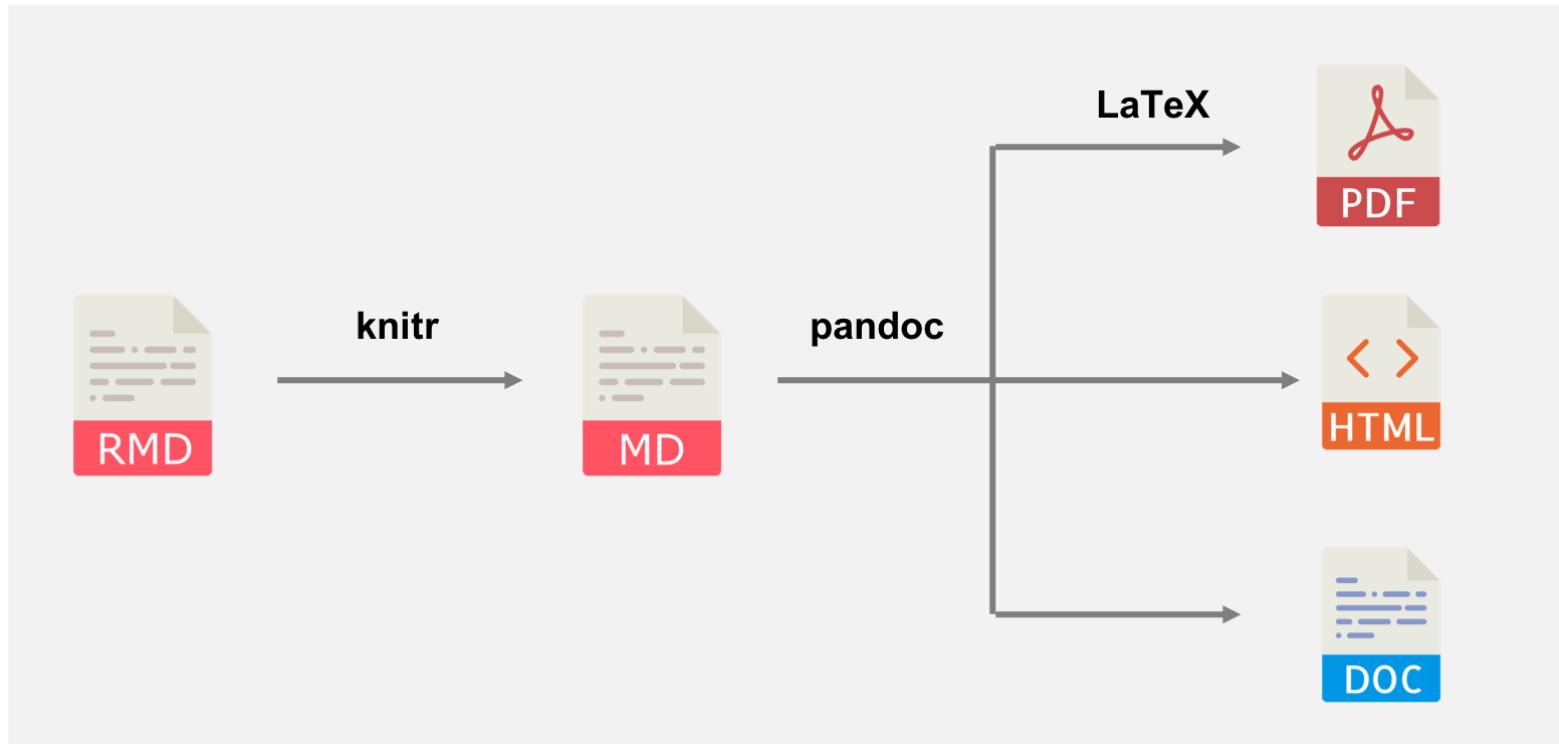
# Output formats

The screenshot shows the RStudio interface with a document titled "1-example.Rmd". The "Knit" menu is open, showing options: Knit to HTML (selected), Knit to PDF, Knit to Word, and Knit with Parameters... Below the menu, the R code in the document is displayed:

```
1 - Knit to HTML
2 t Knit to PDF
3 o Knit to Word
4 - Knit with Parameters...
5
6 ```{r include = FALSE}
7 library(viridis)
8 ```
9
10 The code below demonstrates two color palettes in the
11 [viridis](https://github.com/sjmrgarnier/viridis) package.
12 Each plot displays a contour map of the Maunga Whau volcano
13 in Auckland, New Zealand.
14
15 ## Viridis colors
16
17
18 ## Magma colors
19
20
21 image(volcano, col = viridis(200), option = "A")
22
23
```

The right side of the interface shows a "View PDF" window titled "Viridis Demo". It contains a title "Viridis Demo", a subtitle explaining the code demonstrates two color palettes, and two plots. The top plot is titled "Viridis colors" and shows a contour map of the Maunga Whau volcano using the viridis color palette. The bottom plot is titled "Magma colors" and shows a contour map of the same volcano using the magma color palette. Both plots have axes ranging from 0.0 to 1.0.

# What's happening behind the scenes?



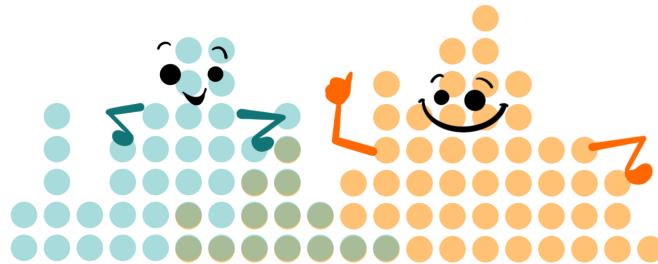
- ☞ The code within the `.Rmd` file is executed and converted into an `.md` file;
- ☞ The `.md` file is converted to the output format specified in the metadata

# What's happening behind the scenes?

Knitting an RMarkdown file...

1. Starts a new R session
  - ✓ No packages or objects loaded
2. Sets your working directory to the location of the RMarkdown file
3. Executes all code chunks from top to bottom

⚠ **Make sure to load all R packages you use!**



Artwork by @allison\_horst

# Code

# Two types of code in RMarkdown

1. A code chunk, surrounded by three backticks and `{r}`
2. An inline code expression, surrounded by one backtick and `r`

The screenshot shows the RStudio interface with an RMarkdown document titled "3-inline.Rmd". The code editor on the left contains the following R code:

```
1---  
2 title: "More colors"  
3 output: html_document  
4---  
5  
6```{r include = FALSE}  
7  
8 colorFunc <- "heat.colors"  
9 # colorFunc <- "terrain.colors"  
10 # colorFunc <- "topo.colors"  
11 # colorFunc <- "cm.colors"  
12 # colorFunc <- "rainbow"  
13  
14  
15 Base R comes with many functions for generating colors. The code below demonstrates the `r colorFunc` function.  
16  
17## `r colorFunc`  
18  
19```{r fig.cap = "The Maunga Whau volcano.", echo = FALSE}  
20 image(volcano, col = get(colorFunc)(200))  
21  
22
```

The R Markdown preview pane on the right displays the title "More colors" and a section titled "heat.colors". Below it is a heatmap plot of the Maunga Whau volcano, with axes ranging from 0.0 to 1.0. The plot shows a central yellow/orange peak transitioning to red at the edges. The caption "The Maunga Whau volcano." is displayed below the plot.

# Code chunks

*"Code chunks are the beating heart of our R Markdown."* Xie, Dervieux, Riederer 2021

```
summary(Orange)
```

```
##   Tree      age      circumference
## 3:7   Min.   :118.0   Min.   : 30.0
## 1:7   1st Qu.:484.0   1st Qu.: 65.5
## 5:7   Median :1004.0   Median :115.0
## 2:7   Mean    :922.1   Mean    :115.9
## 4:7   3rd Qu.:1372.0   3rd Qu.:161.5
##          Max.   :1582.0   Max.   :214.0
```

## Inserting a code chunk

- ✓ Windows/Linux: **Control + Alt + I**
- ✓ OS X: **Command + Option + I**
- ✓ Enclosing code with three backticks and **{r}**
- ✓

# Chunk options

Control a chunk's behavior by passing additional, comma-separated arguments

- ✓ `echo = TRUE` show code and output (*default*)
- ✓ `echo = FALSE` show output only (hide code)
- ✓ `include = FALSE` do not show output (run code)
- ✓ `eval = FALSE` show code (do not run; no output)
- ✓ `warning = FALSE` removes warning messages
- ✓ `error = FALSE` removes error messages
- ✓ `message = FALSE` removes all messages

```
summary(Orange)
```

**Bonus question:** What chunk option did I set here?

# More on code chunks

## Name your chunks

Naming your chunks allows you to quickly navigate code, automatically name figures, and troubleshoot errors.

⚠ Avoid spaces, underscores (\_), and periods (.) in your chunk name

## Chunk execution

Execute a chunk with **Ctrl + Enter** or **Command + Enter** or press 

# In-line code

To insert in-line code, wrap your code in a single backtick. RMarkdown will always

- display the results of inline code, but not the code
- apply relevant text formatting to the results

## R Markdown document

```
## Inline code
```

To avoid copy-pasting, we can execute R code in-line using backticks. For instance,

```
M = `r mean(sleep$extra)` should yield M = 1.54.
```

## Knitted HTML document

# Inline code

To avoid copy-pasting, we can execute R code in-line using backticks. For instance,

M = 1.54 should yield M = 1.54.

# Text

# Markdown formatting basics

The screenshot shows the RStudio interface with a Markdown file open. The left pane displays the Rmd source code, and the right pane shows the generated HTML output.

**Left Pane (Source Code):**

```
1 ---  
2 title: "Markdown Demo"  
3 output: html_document  
4 bibliography: rmarkdown.bib  
5 ---  
6  
7 Markdown provides an easy way to make standard types of formatted  
text, like  
8  
9 - *italics*  
10 - **bold**  
11 - `code`  
12 - [links](rmarkdown.rstudio.com)  
13 - etc.  
14  
15 But did you know that you can also use R Markdown's markdown to make  
16  
17 - Latex equations, $E = mc^2$  
18 - And bibliographies [@rmarkdown15].  
19  
20 # References  
21  
22
```

**Right Pane (HTML Output):**

Markdown Demo

Markdown provides an easy way to make standard types of formatted text, like

- *italics*
- **bold**
- `code`
- [links](#)
- etc.

But did you know that you can also use R Markdown's markdown to make

- Latex equations,  $E = mc^2$
- And bibliographies (JJ Allaire 2015).

## References

JJ Allaire, et. al. 2015. *R Markdown*. <http://rmarkdown.rstudio.com>.

## 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  
  
### Header 3  
  
#### Header 4  
  
##### Header 5  
  
##### Header 6  
  
endash: --  
  
emdash: ---  
  
ellipsis: ...  
  
inline equation: $A = \pi * r^2$
```

## Becomes

Plain text  
  
End a line with two spaces to start a new paragraph.  
  
*italics* and *italics*  
  
**bold** and **bold**  
  
superscript<sup>2</sup>  
  
~~strikethrough~~  
  
[link](#)

# Header 1

## Header 2

### Header 3

#### Header 4

##### Header 5

###### Header 6

endash: –

emdash: —

ellipsis: ...

inline equation:  $A = \pi * r^2$

For more formatting options, see the [R Markdown Reference guide](#)

# Tables

The screenshot shows the RStudio interface with an R Markdown file named "6-tables.Rmd" open. The code editor on the left contains R code demonstrating various ways to create tables in R. The preview pane on the right shows the rendered content, which includes a section titled "Table options" and a table of car data from the mtcars dataset.

```
1 ---  
2 title: "Table options"  
3 output: html_document  
4 ---  
5  
6 Several packages support making beautiful tables with R, such as  
7  
8 * [xtable](https://cran.r-project.org/web/packages/xtable/)  
9 * [stargazer](https://cran.r-project.org/web/packages/stargazer/)  
10 * [pander](http://rapporter.github.io/pander/)  
11 * [tables](https://cran.r-project.org/web/packages/tables/)  
12 * [ascii](http://eusebe.github.io/ascii/)  
13 * etc.  
14  
15 It is also very easy to make tables with knitr's `kable` function:  
16  
17 ```{r echo = FALSE, results = 'asis'}  
18 library(knitr)  
19 kable(mtcars[1:5, ], caption = "A knitr kable.")  
20 ```  
21
```

**Table options**

Several packages support making beautiful tables with R, such as

- xtable
- stargazer
- pander
- tables
- ascii
- etc.

It is also very easy to make tables with knitr's `kable` function:

A knitr kable.

|                   | mpg  | cyl | disp | hp  | drat | wt    | qsec  | vs | am | gear | carb |
|-------------------|------|-----|------|-----|------|-------|-------|----|----|------|------|
| Mazda RX4         | 21.0 | 6   | 160  | 110 | 3.90 | 2.620 | 16.46 | 0  | 1  | 4    | 4    |
| Mazda RX4 Wag     | 21.0 | 6   | 160  | 110 | 3.90 | 2.875 | 17.02 | 0  | 1  | 4    | 4    |
| Datsun 710        | 22.8 | 4   | 108  | 93  | 3.85 | 2.320 | 18.61 | 1  | 1  | 4    | 1    |
| Hornet 4 Drive    | 21.4 | 6   | 258  | 110 | 3.08 | 3.215 | 19.44 | 1  | 0  | 3    | 1    |
| Hornet Sportabout | 18.7 | 8   | 360  | 175 | 3.15 | 3.440 | 17.02 | 0  | 0  | 3    | 2    |

More on **APA tables** in Pt. 2!

# R Markdown tips and tricks

📦 Load all R packages in the first code chunk

⚠️ Do not include `install.packages()` or `setwd()`

ABC ✅ RMarkdown checks your spelling!

🆘 File > Help > Cheatsheets > R Markdown Cheat Sheet

❓ File > Help > Markdown Quick Reference

## Resources

- R Markdown: The Definitive Guide
- R Markdown Cookbook

# Part 2: papaja

# Getting started with papaja

papaja = Preparing APA journal articles  
created by Frederik Aust



# Sneak peek: APA title page

```
---
```

```
title      : "Active Choice Hypothesis Testing: Example Manuscript"
shorttitle : "Active Choice Hypothesis Testing"

author:
  - name      : "Shilaan Alzahawi"
  affiliation : "1"
  corresponding : yes    # Define only one corresponding author
  address     : "655 Knight Way, Graduate School of Business, Stanford, CA 94305"
  email       : "shilaan@stanford.edu"

affiliation:
  - id        : "1"
  institution : "Stanford University, Graduate School of Business"

note: "\\clearpage"

authornote:

abstract:

keywords      : "Hypothesis Testing"
wordcount     : "2,860"

bibliography   : ["references.bib", "r-references.bib"]

floatsintext  : yes #place figures and tables in the text rather than at the end
numbersections: no #number sections headings
figurelist     : no #create list of figure captions
tablelist      : no #create list of table captions
footnotelist   : no ##create list of footnotes
linenumbers    : no #add line numbers in the margins
mask          : no #omit identifying information from the title page
draft         : no #add "draft" watermark across all pages

documentclass  : "apa6"
classoption    : "man"
output         : papaja::apa6_word
---
```



Running head: ACTIVE CHOICE HYPOTHESIS TESTING

1

Active Choice Hypothesis Testing: Example Manuscript

Shilaan Alzahawi<sup>1</sup>

<sup>1</sup> Stanford University, Graduate School of Business

Author note

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Knight Way, Graduate School of Business, Stanford, CA 94305. E-mail: shilaan@stanford.edu

# Sneak peek: APA tables

```
```{r}
mod1 = lm(wb_overall_mean ~ religiosity + age + gender + ses + education, data = df)
apa_lm = apa_print(mod1)
apa_table(apa_lm$table, caption = "Well-being regression table.")
```

```

Table 1:

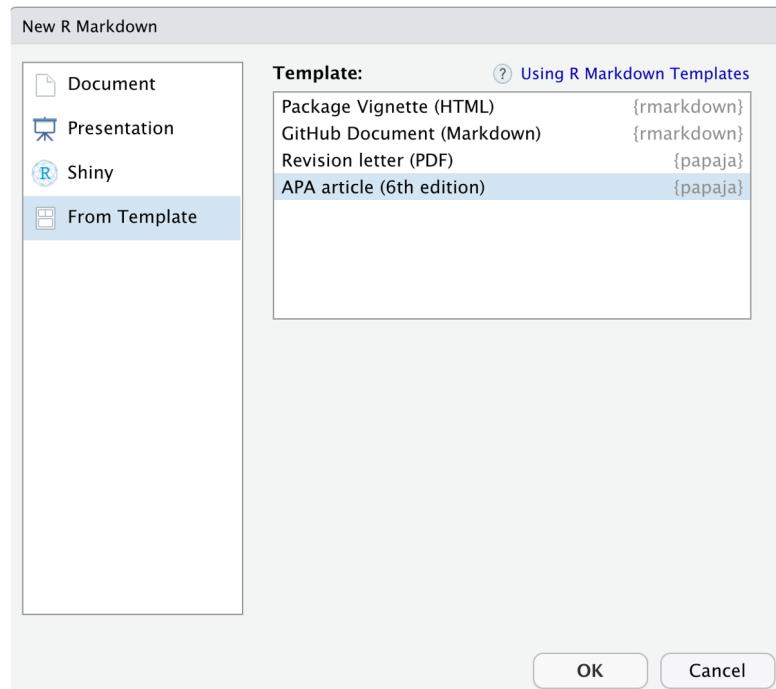
*Well-being regression table.*

| Predictor   | b     | 95% CI        | t(10106) | p      |
|-------------|-------|---------------|----------|--------|
| Intercept   | 3.68  | [3.66, 3.69]  | 442.81   | < .001 |
| Religiosity | 0.06  | [0.05, 0.07]  | 10.26    | < .001 |
| Age         | 0.00  | [0.00, 0.00]  | 2.64     | .008   |
| Gender      | -0.01 | [-0.03, 0.01] | -0.89    | .374   |
| Ses         | 0.25  | [0.24, 0.26]  | 43.68    | < .001 |
| Education   | 0.03  | [0.02, 0.04]  | 5.09     | < .001 |

# Getting started with papaja

```
# make sure you've already installed tinytex!
install.packages("devtools")
devtools::install_github("crsh/papaja@devel") #install papaja
```

File > New File > R Markdown > From Template > APA article



# APA citations

"Whatever else is done about null-hypothesis tests, let us stop viewing statistical analysis as a sanctification process. We are awash in a sea of uncertainty, caused by a flood tide of sampling and measurement errors, and there are no objective procedures that avoid human judgment and guarantee correct interpretations of results." [[@abelson1997](#): p.13]

Psychological science is experiencing a period of widespread methodological reflection [[@nelson2018](#)]. Starting 2010, a chain of events caused psychological scientists to doubt the credibility of psychological research [[@moshontz2018](#)]. These events included a case of widespread academic fraud, a series of failed replications of famous findings, and a paper published in psychology's most prestigious journal claiming that extrasensory perception (ESP) is real [[@nelson2018](#)].

According to some, one of the root causes of the crisis of confidence is the misunderstanding and misuse of statistical methods [[@goodman2019](#)]. In psychological science, one of the most frequently used approaches to statistical inference is the null-hypothesis significance test (NHST). For decades, researchers have been warned about mindless applications of this tool (e.g., [@cohen1994](#); [@gigerenzer2004](#); [@nickerson2000](#); [@rozeboom1960](#)).

"Whatever else is done about null-hypothesis tests, let us stop viewing statistical analysis as a sanctification process. We are awash in a sea of uncertainty, caused by a flood tide of sampling and measurement errors, and there are no objective procedures that avoid human judgment and guarantee correct interpretations of results." (Abelson, 1997: p.13)

Psychological science is experiencing a period of widespread methodological reflection (Nelson, Simmons, & Simonsohn, 2018). Starting 2010, a chain of events caused psychological scientists to doubt the credibility of psychological research (Moshontz et al., 2018). These events included a case of widespread academic fraud, a series of failed replications of famous findings, and a paper published in psychology's most prestigious journal claiming that extrasensory perception (ESP) is real (Nelson et al., 2018).

According to some, one of the root causes of the crisis of confidence is the misunderstanding and misuse of statistical methods (Goodman, 2019). In psychological science, one of the most frequently used approaches to statistical inference is the null-hypothesis significance test (NHST). For decades, researchers have been warned about mindless applications of this tool (e.g., Cohen, 1994; Gigerenzer, 2004; Nickerson, 2000; Rozeboom, 1960).

# Getting started with APA citations

1. Download [Zotero](#)
2. Download the [Better BibTex for Zotero](#) extension
3. Install citr: an RStudio Addin to Insert Markdown Citations
  - citr can directly access your reference database
  - citr can keep your reference file updated

```
devtools::install_github("crsh/citr")
```

# Inserting citations

1. Create a reference file using a reference manager (e.g., Zotero)
2. Supply the reference file in the ---front matter---

**bibliography** : ["**references.bib**"]

3. Insert citations

- ▶ Insert using your citation key

[@yarkoni2019]

- ▶ Insert using Addins > Insert citations

Addins ▾

BOOKDOWN



Preview Book

CITR

Insert citations

## Insert citation



Search references

Aust & Barth (2020). *papaja*: Create APA manuscripts with R Markdown.

Barth (2020). *tinylabes*: Lightweight Variable Labels.

R Core Team (2019). R: A Language and Environment for Statistical Computing.

Yarkoni (2019). The Generalizability Crisis.

Bibliography files found in YAML front matter: [./r-references.bib](#), [./refs.bib](#)

[Reload files](#)

Zotero connection available. [Connect and load libraries](#)



Insert citation



Settings

# Inserting citations

| Citation Type               | Syntax                          | Rendered Citation                 |
|-----------------------------|---------------------------------|-----------------------------------|
| Citation within parentheses | [@dienes2016]                   | (Dienes, 2016)                    |
| Multiple citations          | [@gigerenzer2004; @goodman2019] | (Gigerenzer, 2004; Goodman, 2019) |
| In-text citations           | @lakens2014                     | Lakens (2014)                     |
| Year only                   | [‐@oakes1986]                   | (1986)                            |
| Prefix                      | [e.g., @wagenmakers2007]        | (e.g., Wagenmakers, 2007)         |
| Suffix                      | [@neyman1957: p. 10]            | (Neyman, 1957: p. 10)             |

# Inserting citations

- You can cite R packages, too!
- After loading all packages, run `r_refs()` to create a BibTex file with references to all currently loaded packages

```
```{r setup, include = FALSE}
library(papaja)
library(citr)
library(rpact)
library(dplyr)
r_refs("r-references.bib")
```

## Acknowledgement
This manuscript was created using `r cite_r("r-references.bib")`.
```

## Acknowledgement

This manuscript was created using R (Version 3.6.2; R Core Team, 2019) and the R-packages *citr* (Version 0.3.2; Aust, 2019), *dplyr* (Version 1.0.4.9000; Wickham, François, Henry, & Müller, 2021), *papaja* (Version 0.1.0.9997; Aust & Barth, 2020), *rpact* (Version 3.0.2; Wassmer & Pahlke, 2020), and *tinylabels* (Version 0.2.0; Barth, 2021).



# Harnessing the power of meta-data, code, and text

## R Markdown document

```
```{r}
n_fixed = ceiling(power.t.test(delta = 0.5, sig.level = .05, power = 0.8,
                                type = "two.sample", alternative = "one.sided")$n)
```

```

For example, if a researcher wants to conduct a one-sided, two-sample *t* test ( $H_0: \delta = 0$  against  $H_+: \delta > 0$ ) with 80% power to detect a Cohen's *d* (i.e., a standardized mean difference) of 0.5, a conventional Null-Hypothesis Significance Test with an overall  $\alpha$  of 5% would require `r n\_fixed` participants per group.

## Knitted APA manuscript

For example, if a researcher wants to conduct a one-sided, two-sample *t* test ( $H_0: \delta = 0$  against  $H_+: \delta > 0$ ) with 80% power to detect a Cohen's *d* (i.e., a standardized mean difference) of 0.5, a conventional Null-Hypothesis Significance Test with an overall  $\alpha$  of 5% would require 51 participants per group.

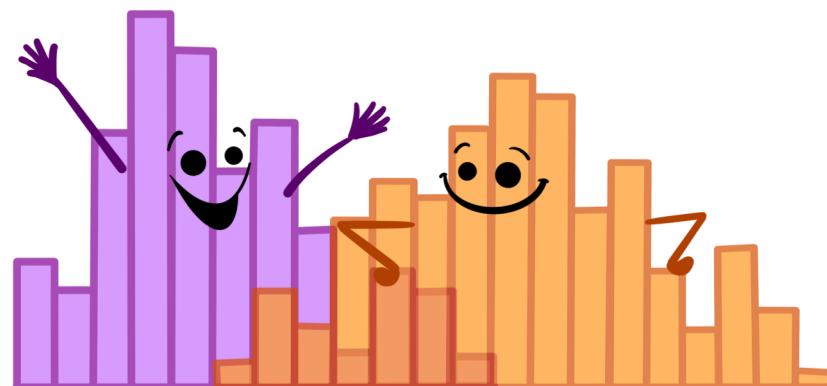
# Statistical output

```
```{r}
mod1 = lm(wb_overall_mean ~ religiosity + age + gender + ses + education, data = df)
apa_lm = apa_print(mod1)
apa_table(apa_lm$table, caption = "Well-being regression table.")
````
```



The estimate for religiosity is `r apa\_lm\$estimate\$religiosity`

The estimate for religiosity is  $b = 0.06$ , 95% CI [0.05,0.07]



# Another look at APA tables

```
```{r}
mod1 = lm(wb_overall_mean ~ religiosity + age + gender + ses + education, data = df)
apa_lm = apa_print(mod1)
apa_table(apa_lm$table, caption = "Well-being regression table.")
```

```

Table 1:

*Well-being regression table.*

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| Age         | 0.00  | [0.00, 0.00]  | 2.64     | .008   |
| Gender      | -0.01 | [-0.03, 0.01] | -0.89    | .374   |
| Ses         | 0.25  | [0.24, 0.26]  | 43.68    | < .001 |
| Education   | 0.03  | [0.02, 0.04]  | 5.09     | < .001 |

# pajaja tips and tricks

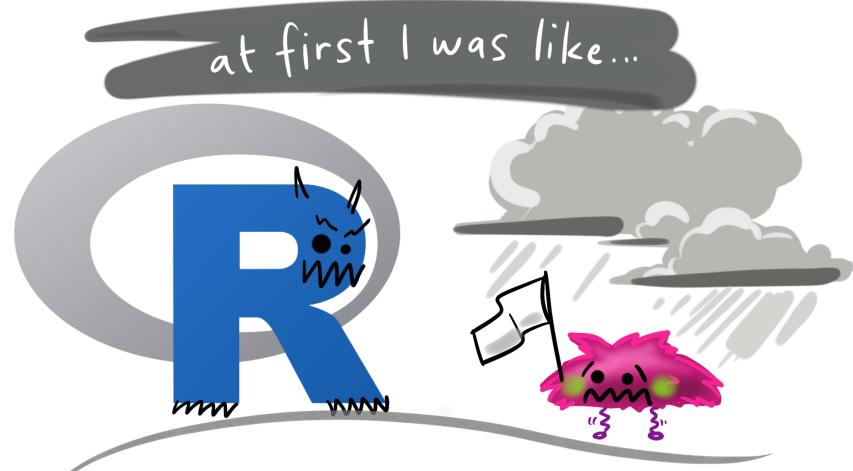
Define a keyboard shortcut for inserting citations

⌘ Tools > Addins > Browse Addins > citr > Keyboard Shortcuts

## Helpful resources

- The [papaja manual](#)
- [Papers written with papaja](#)





...but now it's like...



Artwork by @allison\_horst

# Thank you!

♥ Slides created with the R package [xaringan](#).

**Questions?** Reach out to me at [shilaan@stanford.edu](mailto:shilaan@stanford.edu)