Reproducible Manuscripts in R Markdown

Juli Tkotz

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ZI Mannheim, RG Psychology and Neurobiology of Sleep and Memory

Nice to meet(up) you!

- Juli Tkotz
- PhD student ZI Mannheim
- RG Psychology and Neurobiology of Sleep and Memory

What is a reproducible manuscript?

- A manuscript that directly embeds your **research data** and **analysis code**.
- Any person with the raw data can run the code and **reproduce** your manuscript.
- Interactive stand-alone versions are possible.

Why do we need it?

Analysis of Open Data and Computational Reproducibility in Registered Reports in Psychology

Pepijn Obels[1], Daniel Lakens[1], Nicholas A. Coles[2], Jaroslav Gottfried[3], & Seth Ariel Green[4]

[1] Eindhoven University of Technology, The Netherlands
[2] University of Tennessee, Knoxville, USA
[3] Masaryk University, Brno, Czech Republic
[4] Code Ocean, New York, USA

Ongoing technological developments have made it easier than ever before for scientists to share their data, materials, and analysis code. Sharing data and analysis code makes it easier for other researchers to re-use or check published research. These benefits will only emerge if researchers can reproduce the analysis reported in published articles, and if data is annotated well enough so that it is clear what all variables mean. Because most researchers have not been trained in computational reproducibility, it is important to evaluate current practices to identify practices that can be improved. We examined data and code sharing, as well as computational reproducibility of the main results, without contacting the original authors, for Registered Reports published in the psychological literature between 2014 and 2018. Of the 62 articles that met our inclusion criteria, data was available for 40 articles, and analysis scripts for 37 articles. For the 35 articles that shared both data and code and performed analyses in SPSS, R, Python, MATLAB, or JASP, we could run the scripts for 31 articles, and reproduce the main results for 20 articles. Although the articles that shared both data and code (35 out of 62, or 56%) and articles that could be computationally reproduced (20 out of 35, or 57%) was relatively high compared to other studies, there is clear room for improvement. We provide practical recommendations based on our observations, and link to examples of good research practices in the papers we reproduced.

Obels et al. (2019)

Beyond reproducible analyses

3.1 Epistemic Trustworthiness

Participants placed more epistemic trust in the debaters when reading a neutral debate: Student teachers in the neutral condition ($M = 5.06$, $SD = 1.00$) perceived the debaters to have more expertise than those in the uncivil condition ($M = 5.06$, $SD = 1.00$), $t(218.49) = 1.99$, $p = .047$, $d = 0.27$. Furthermore, participants reading a neutral debate ($M = 4.76$, $SD = 1.02$) reported higher ratings of debaters' integrity than those reading an uncivil debate ($M = 4.05$, $SD = 1.15$), $t(219.41) = 4.87$, $p < .001$, $d = 0.65$. Additionally, ratings of benevolence were higher in the neutral condition ($M = 4.77$, $SD = 0.98$) than in the uncivil condition ($M = 4.05$, $SD = 0.89$), $t(214.11) = 5.67$, $p < .001$, $d = 0.76$ (see Figure 2).

We further explored the correlation between the conflict explanation items and the METI subscales, that is, if the perception of various aspects of a conflict was associated with different degrees of epistemic trust. Those who agreed that the debaters in the scenario referred to different research results also thought them to have more expertise, $r(220) = .14$, $p = .039$. There was no relation with integrity, $r(220) = .07$, $p = .321$, or benevolence, $r(220) = .03$, $p = .679$. Assuming personal reasons for the conflict had the strongest relationship with epistemic trust. The more participants perceived the conflict to be personal, the less expertise they assigned to the debaters $r(220) = -.25$, $p < .001$. In a similar manner, perception of a personal conflict lead to decreased ratings of integrity, $r(220) = -.36$, $p < .001$, and benevolence, $r(220) = -.41$, $p < .001$. How much participants agreed that the debaters referred to different goals of PAVLOV did not correlate with any of the METI subscales, neither with expertise, $r(220) = .10$, $p = .122$, nor with integrity, $r(220) = -.00$, $p = .946$, nor with benevolence $r(220) = -.00$, $p = .994$. Embracement of the statement that debaters referred to different effects of PAVLOV was not associated with epistemic trust either, neither with expertise, $r(220) = .01$, $p = .863$, nor with integrity, $r(220) = -.06$, $p = .348$, nor with benevolence $r(220) = -.05$, $p = .475$. Internal consistency of the METI subscales was somewhat lower than initially found by Hendriks et al. (2015), with a Cronbach's α of .87 for expertise, .83 for integrity and .76 for benevolence.

R Markdown to the rescue

````
## R Markdown to the rescue

```{r intext_stats, echo = TRUE}
nerd <- read.csv("./data/nerd.csv", sep = "\t")
```

```{r copy_paste_hell}
include_graphics("./pics/slide_inception.png")
```

This example dataset consists of $N =$ `r nrow(nerd)` participants with an age range
between `r min(nerd[["age"]])` and `r max(nerd[["age"]])` years.
Overall, `r sum(nerd$age > 100)` participants reported to be older than 100, so we probably
can't trust this data set a lot.
````

This example dataset consists of $N = 14955$ participants with an age range between 13 and 38822 years. Overall, 8 participants reported to be older than 100, so we probably can't trust this data set a lot.

Data retrieved from https://openpsychometrics.org/

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Detecting errors

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Wait a minute ...

Detecting errors

```
## Epistemic Trustworthiness
Participants placed more epistemic trust in the debaters when reading a neutral debate: Student
teachers in the neutral condition `r print_mean_sd(meti$expertise_sum[meti$condition ==
"neutral"])` perceived the debaters to have more expertise than those in the uncivil condition
`r print_mean_sd(meti$expertise_sum[meti$condition == "neutral"])`, `r print_ttest(t_meti_exp,
d_meti_exp)`. Furthermore, participants reading a neutral debate `r
print_mean_sd(meti$integrity_sum[meti$condition == "neutral"])` reported higher ratings of
debaters' integrity than those reading an uncivil debate `r
```

There it is!

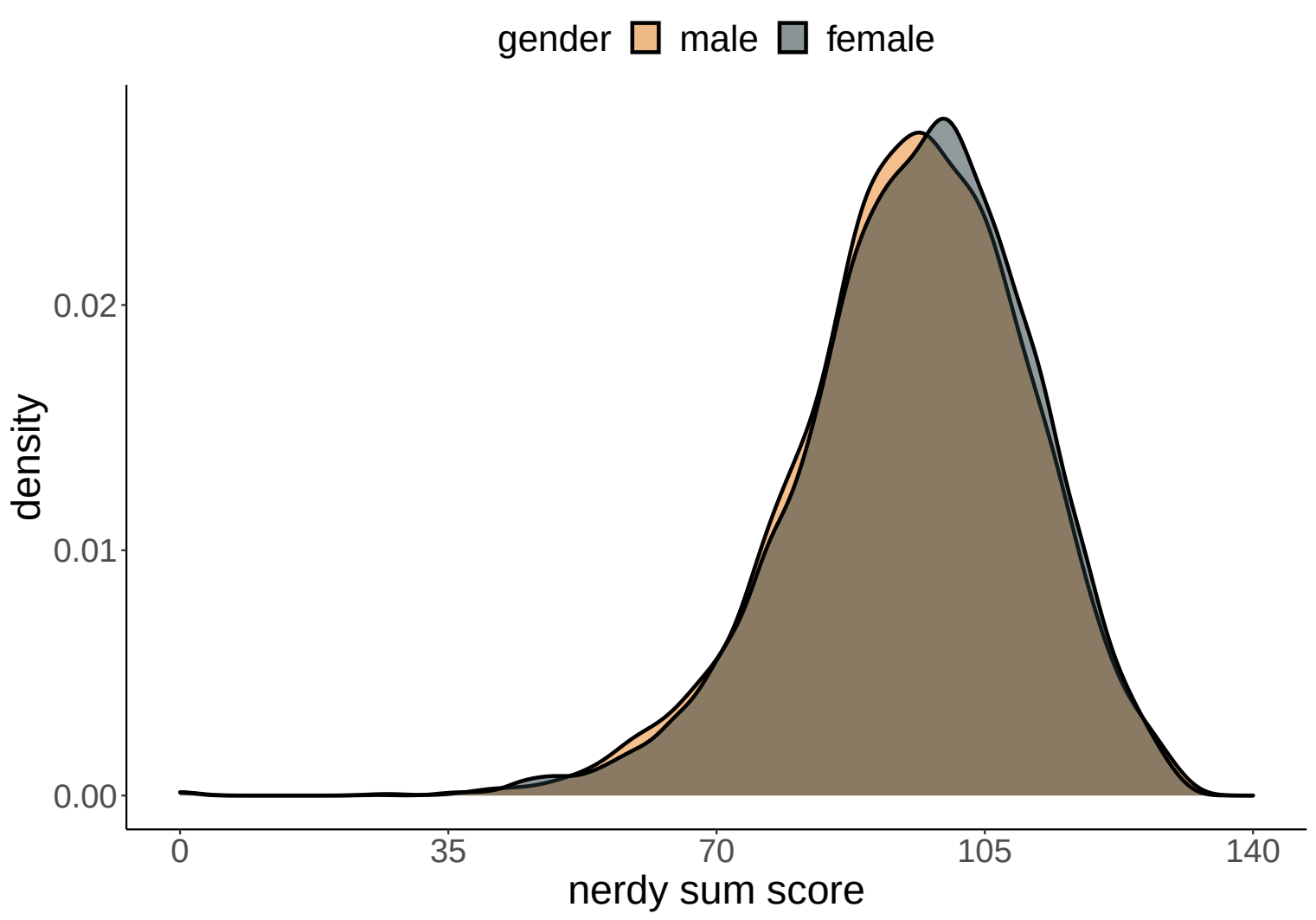
How about some stats?

```
nerd_ttest <- t.test(sum_score ~ gender, data = nerd)
nerd_effsize <- cohen.d(sum_score ~ gender, data = nerd)
```

```
In this dataset, men `r print_mean_sd(nerd[["sum_score"]][nerd[["gender"]] == "male"])` have a
significantly lower nerd score than women `r print_mean_sd(nerd[["sum_score"]][nerd[["gender"]]
== "female"])`, `r print_ttest(nerd_ttest, nerd_effsize)`.
```

In this dataset, men ($M = 95.18$, $SD = 15.27$) have a significantly lower nerd score than women ($M = 95.82$, $SD = 15.16$), $t(9800.06) = -2.39$, $p = .017$, $d = -0.04$.

Yeah, plots!


gender
male
female
density
0.02
0.01
0.00
0
35
70
105
140
nerdy sum score

Yeah, references!

````
## Yeah, references!

```{r citation}
include_graphics("./pics/citation.png")
```

If I want to cite a paper, I can do this [@san_martin_1968].
This also works if I cite @san_martin_1968 as an in-text citation.
````

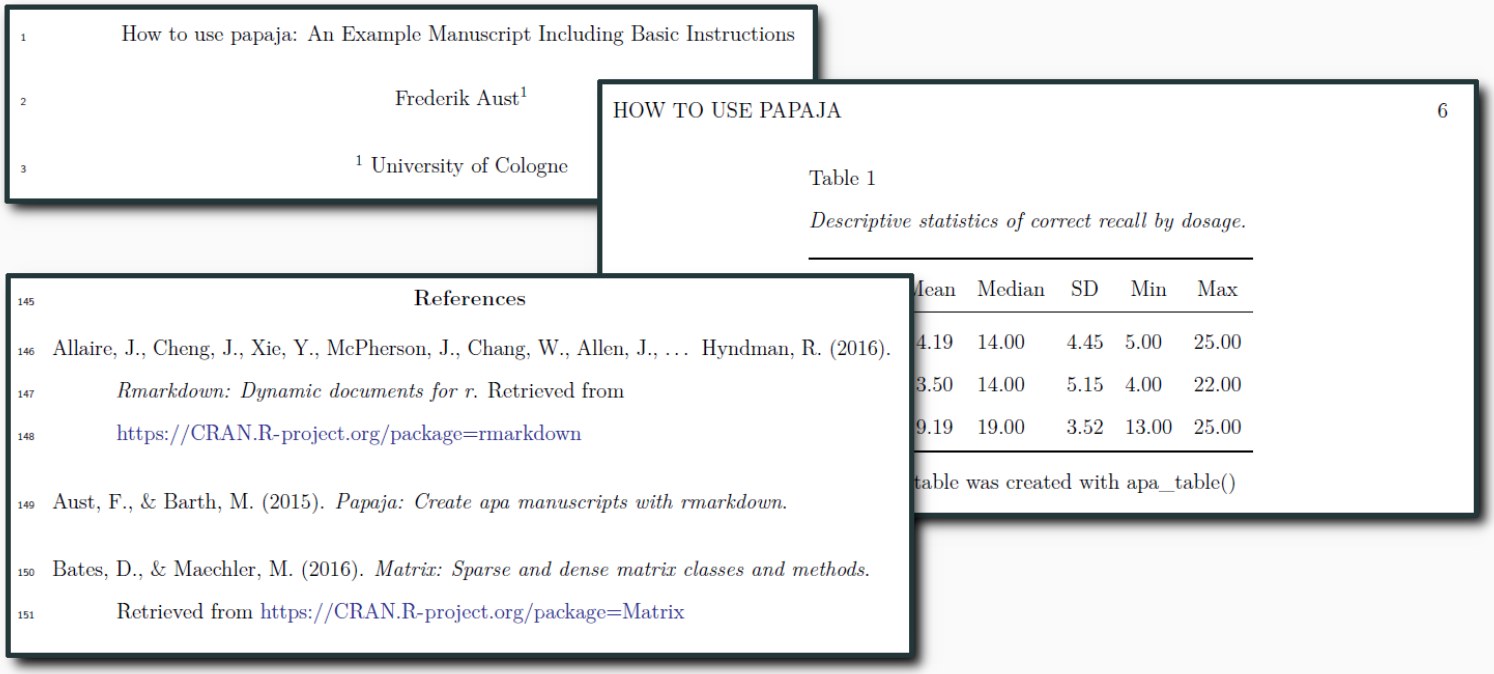
If I want to cite a paper, I can do this (San-Martin et al. 1968). This also works if I cite San-Martin et al. (1968) as an in-text citation.

How to get bibtex references

Fully formatted articles

The R-package papaja offers you documents that are formatted according to APA (6) style.

https://github.com/crsh/papaja



How to use papaja: An Example Manuscript Including Basic Instructions

Frederik Aust[1]

[1] University of Cologne

HOW TO USE PAPAJA 6

Table 1

Descriptive statistics of correct recall by dosage.

	Mean	Median	SD	Min	Max
	14.19	14.00	4.45	5.00	25.00
	13.50	14.00	5.15	4.00	22.00
	19.19	19.00	3.52	13.00	25.00

table was created with apa_table()

References

Allaire, J., Cheng, J., Xie, Y., McPherson, J., Chang, W., Allen, J., ... Hyndman, R. (2016). *Rmarkdown: Dynamic documents for r.* Retrieved from https://CRAN.R-project.org/package=rmarkdown

Aust, F., & Barth, M. (2015). *Papaja: Create apa manuscripts with rmarkdown.*

Bates, D., & Maechler, M. (2016). *Matrix: Sparse and dense matrix classes and methods.* Retrieved from https://CRAN.R-project.org/package=Matrix

Or a whole book?

R for Data Science

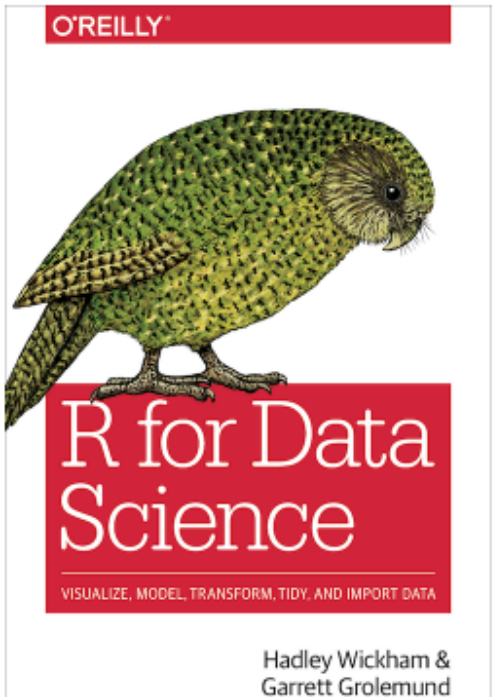
build passing

This repository contains the source of R for Data Science book. The book is built using bookdown.

The R packages used in this book can be installed via

```
devtools::install_github("hadley/r4ds")
```

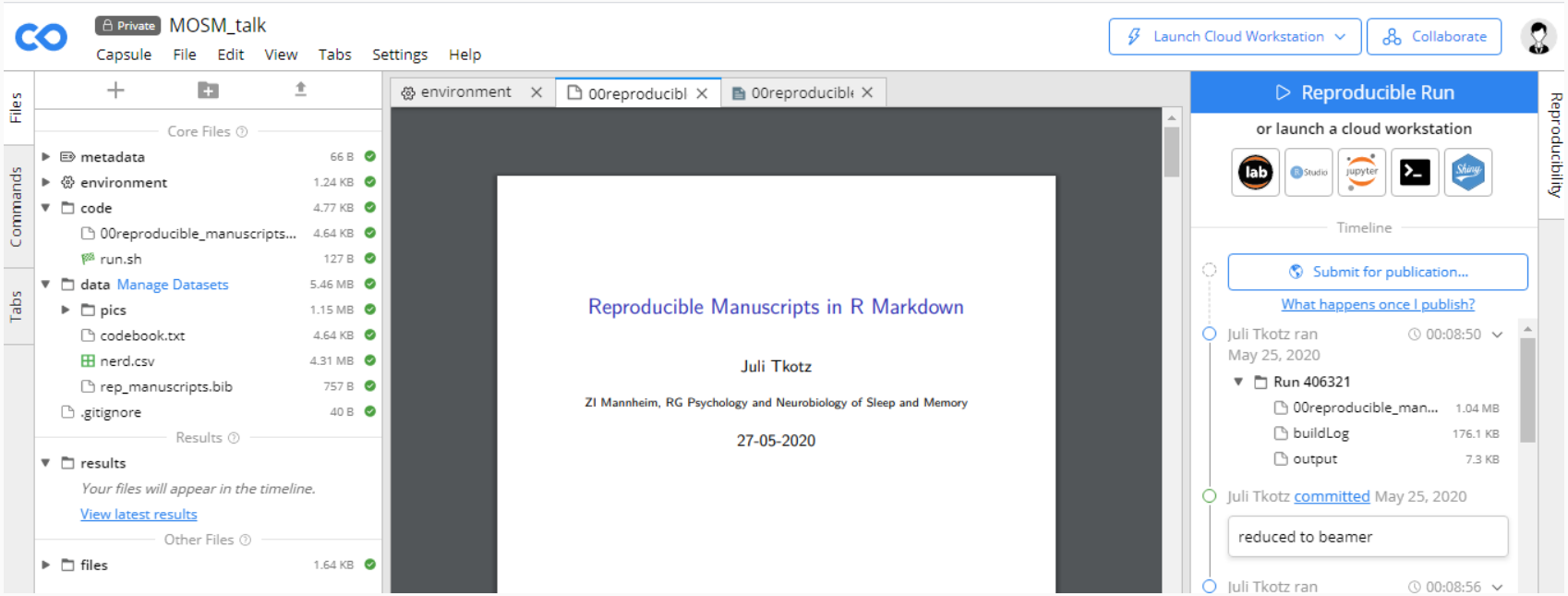
This is the website for **"R for Data Science"**. This book will teach you how to do data science with R: You'll learn how to get your data into R, get it into the most useful structure, transform it, visualise it and model it. In this book, you will find a practicum of skills for data science. Just as a chemist learns how to clean test tubes and stock a lab, you'll learn how to clean data and draw plots—and many other things besides. These are the skills that allow data science to happen, and here you will find the best practices for doing each of these things with R. You'll learn how to use the grammar of graphics, literate programming, and reproducible research to save time. You'll also learn how to manage cognitive resources to facilitate discoveries when wrangling, visualising, and exploring data.



Talking about reproducibility ...

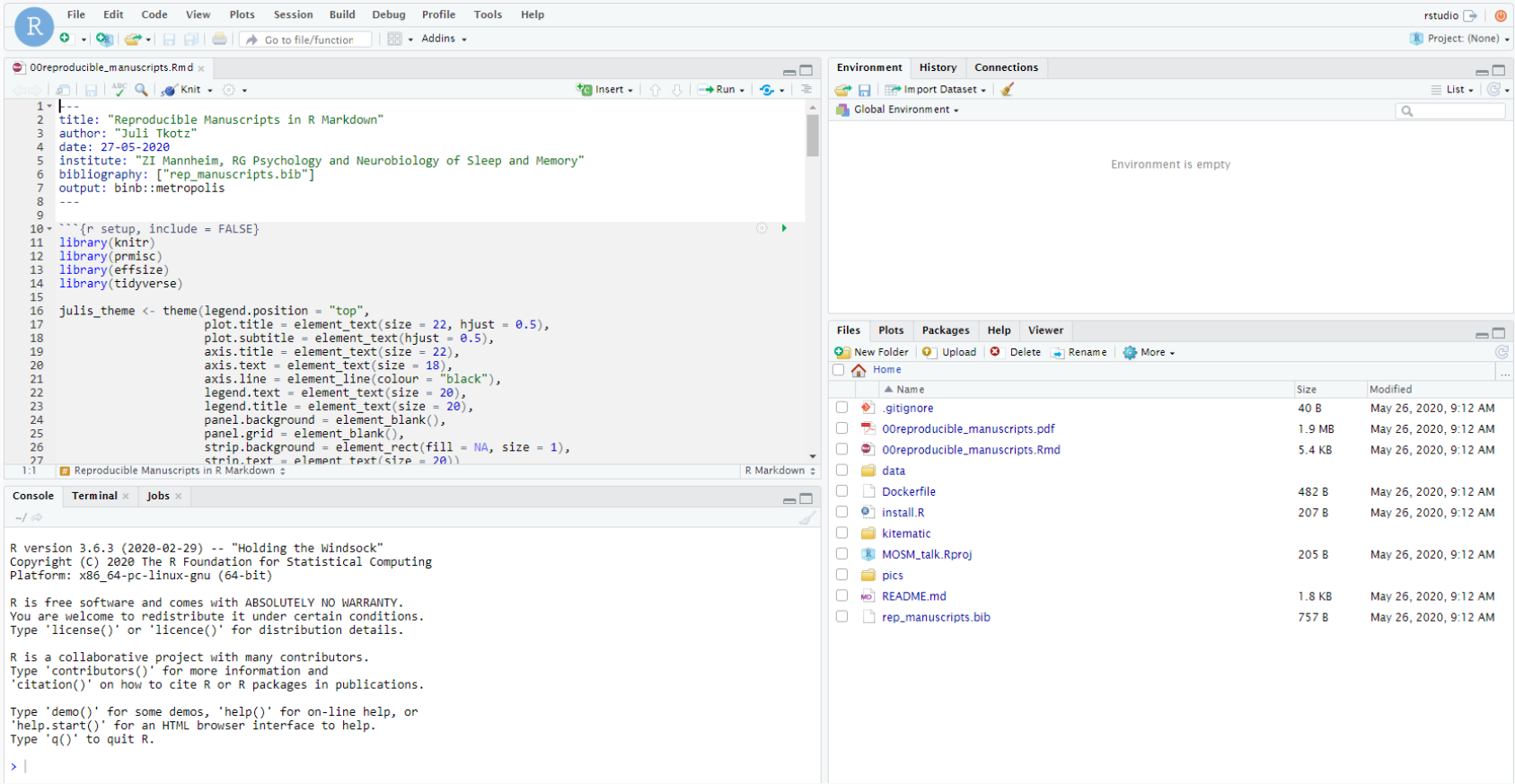
```
> anticlusters <- anticlust::anticlustering(
+   iris[, -5],
+   K = 3,
+   objective = "variance",
+   method = "exchange"
+ )
Error in loadNamespace(name) : there is no package called 'anticlust'
```

Code capsules



CodeOcean

Code capsules



Binder

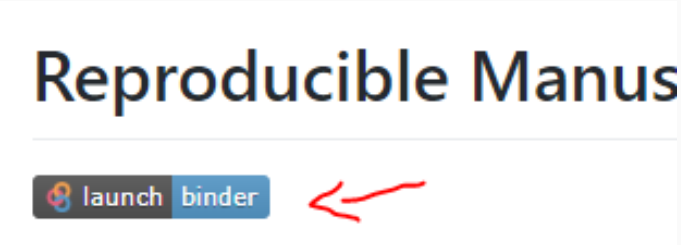
There will be pain

But it's worth it

- Saves time for others and for future you.
- Mistakes are easier to spot and easier to correct.
- Your data and your manuscript will survive longer.
- Others can learn from your analyses.

Thank you!

Find this presentation on GitHub.



And definitely check the binder button! Thank you, Philipp Zumstein!

Or on CodeOcean.

Or on the OSF.

Useful Ressources

- Tutorial for a reproducible workflow with R Markdown, Git, Make and Docker by Peikert and Brandmaier (2019)
- Example capsule for papaja on CodeOcean (also see the papaja manual and give Frederik Aust a cookie)
- The computational reproducibility part (week 5) of Daniel Laken's coursera course "Improving Statistical Questions"
- R Markdown - The Definitive Guide by Yihui Xie, J. J. Allaire and Garrett Grolemund

References

Obels, Pepijn, Daniel Lakens, Nicholas A Coles, Jaroslav Gottfried, and Seth A Green. 2019. "Analysis of Open Data and Computational Reproducibility in Registered Reports in Psychology." PsyArXiv. https://doi.org/10.31234/osf.io/fk8vh.

Peikert, Aaron, and Andreas M Brandmaier. 2019. "A Reproducible Data Analysis Workflow with R Markdown, Git, Make, and Docker." PsyArXiv. https://doi.org/10.31234/osf.io/8xzqy.

San-Martin, M., M. Copaira, J. Zuniga, R. Rodreguez, G. Bustinza, and L. Acosta. 1968. "Aspects of Reproduction in the Alpaca." *Reproduction* 16 (3): 395–99. https://rep.bioscientifica.com/view/journals/rep/16/3/jrf_16_3_009.xml.