



Intro to This Course; Getting Started with R

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Why becoming an R user?

- **Mainstream in academia** for data science, increasingly used in business. *Job market advantage!*
- **Free & open-source:** wherever you go, R will be with you at no costs (unlike *MPLUS, MATLAB, SPSS*, etc.)
- **Real programming language:** difficult at the beginning, but: 1) gives you lots of flexibility; 2) has transfer on other programming languages (e.g., *Python*).
- **Vast community support** thanks to a large and active community (also, *chatGPT, Lucrez-IA*, etc., know it pretty well!).
- **Huge ecosystem**, >20,000 packages on CRAN, more from other sources (e.g., GitHub), to do amazing stuff with statistical data analysis, machine learning, data visualization, developing webapps [*shiny*], writing reports and even entire books [*bookdown, rmarkdown*]), can integrate with *quarto, github*.
- Facilitates **reproducible research** by sharing code and workflows.

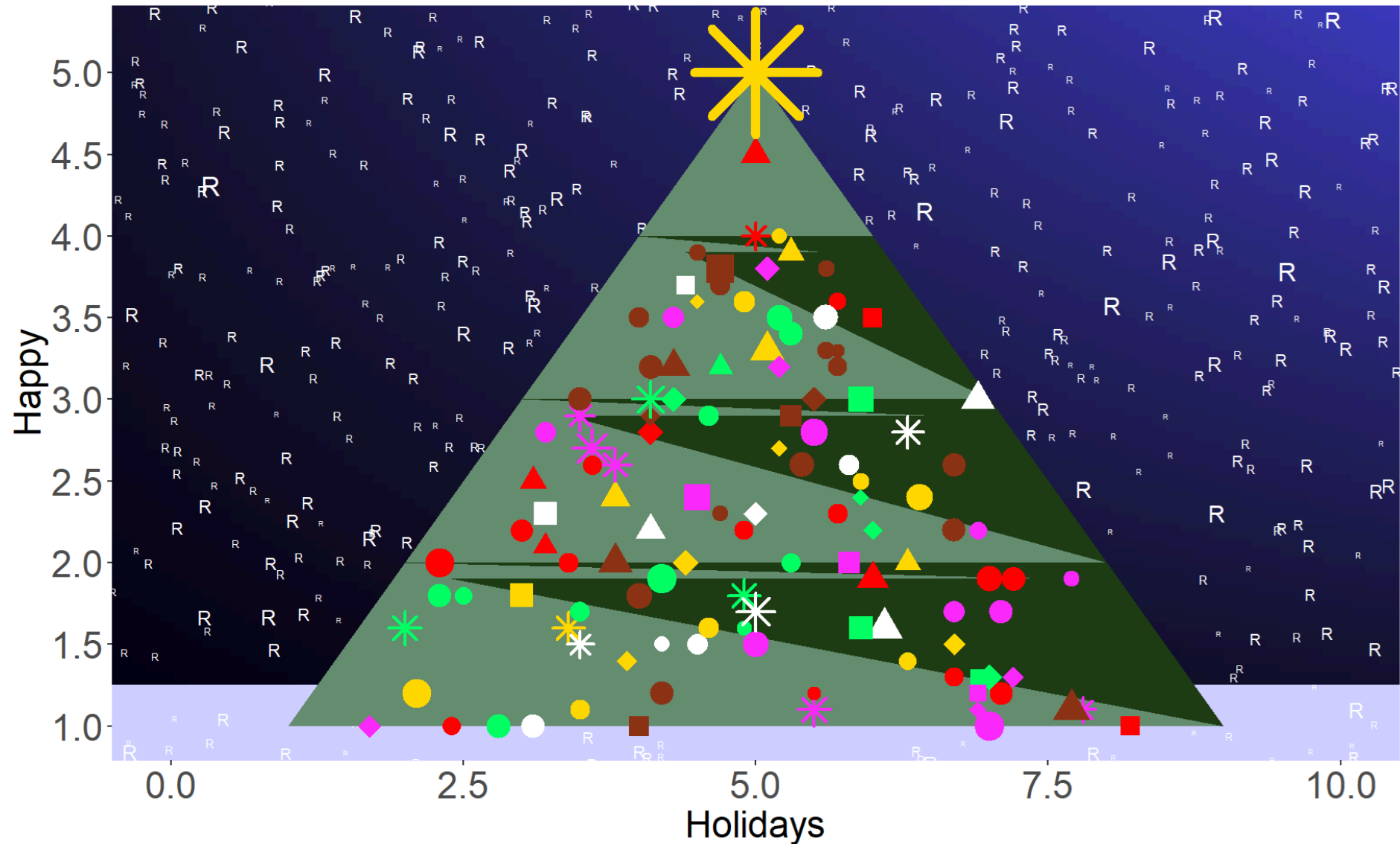
What you may expect to learn in this course:

- Executing fundamental operations and using basic functions;
- Working with essential data types and structures;
- Gaining some proficiency in managing and manipulating data with vectors and dataframes;
- Understanding some fundamental concepts of programming.

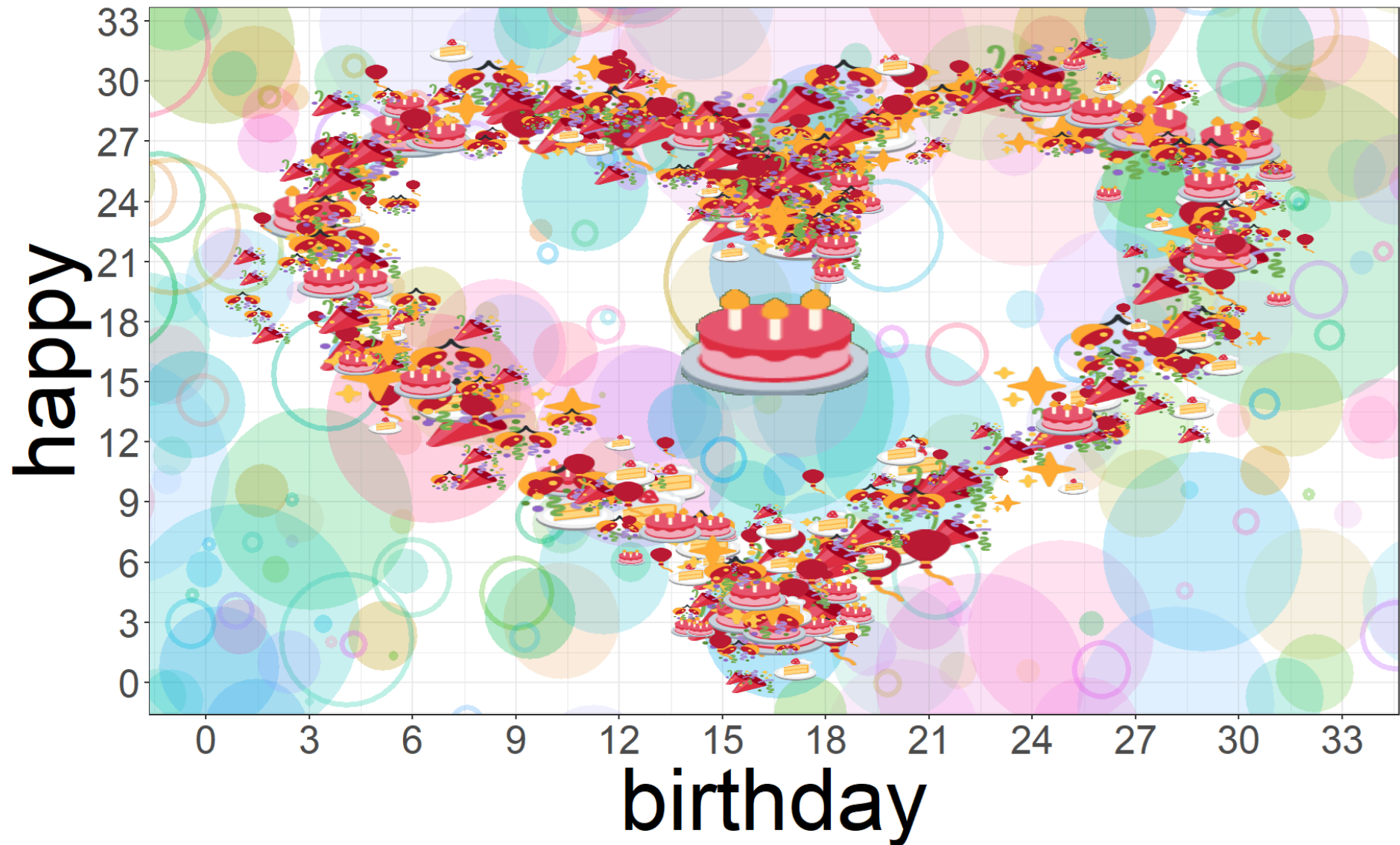
Over the next *couple of years*, following this PhD program, you may have the opportunity to learn to use R to perform at least some fundamentals about:

- Core statistical inference methods;
- (Generalized) linear (mixed-effects) modeling;
- Data visualization using *ggplot2*;
- Power analysis via data simulation ;
- Structural Equation Modeling (SEM);
- Conducting Meta-Analysis.

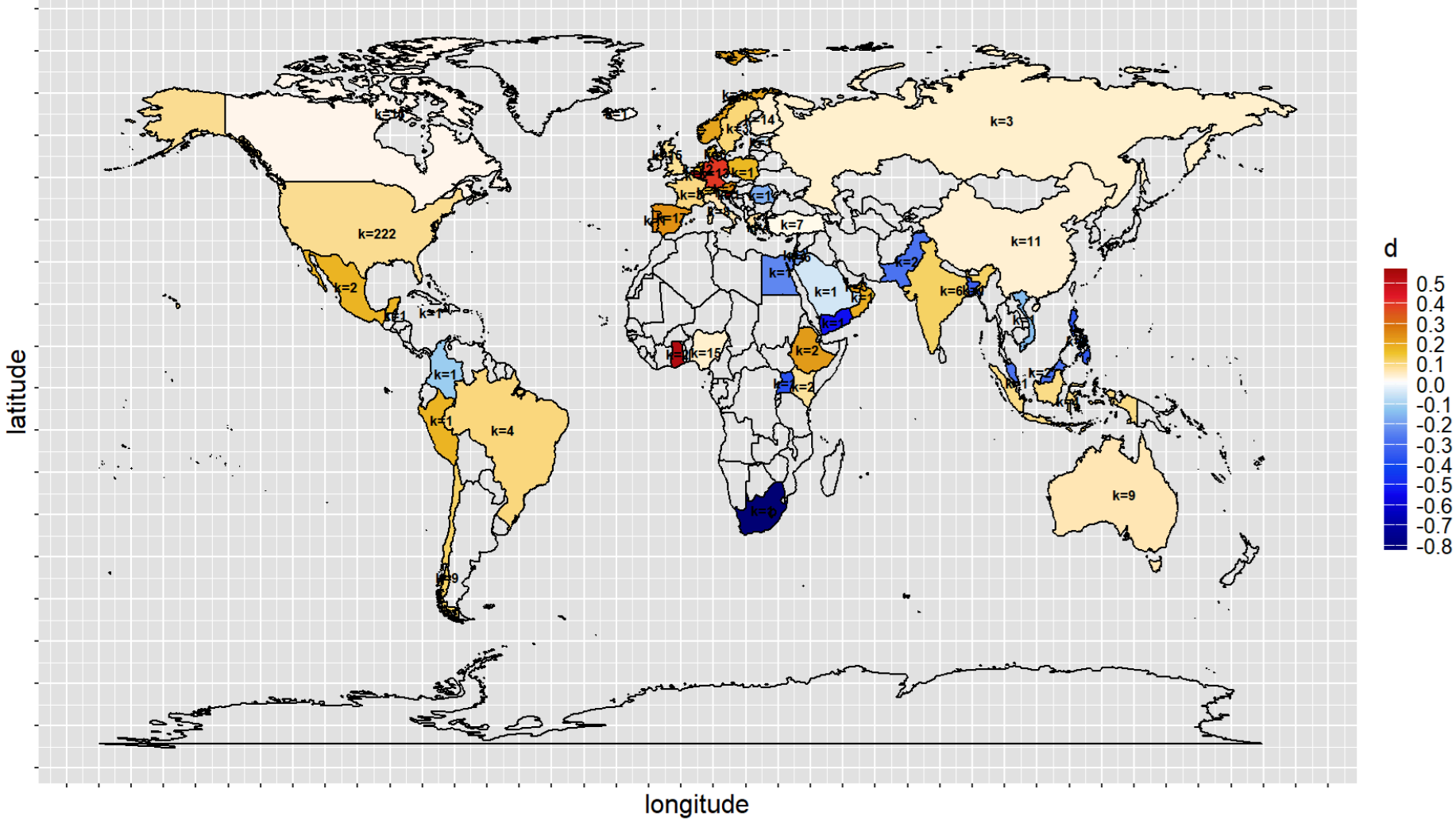
you may even create greeting cards



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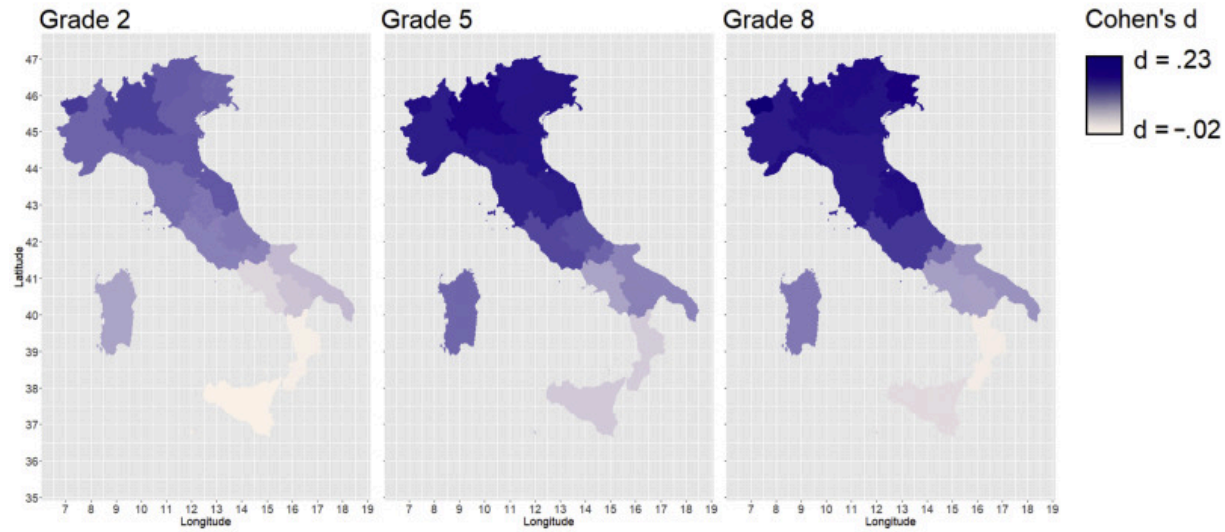


or like fancy infographics

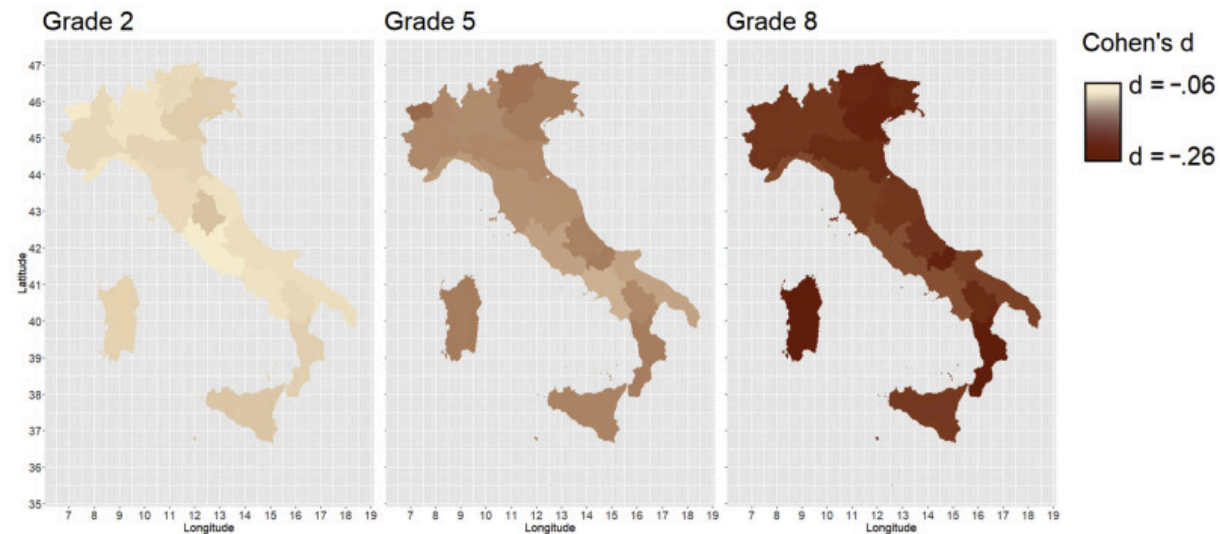


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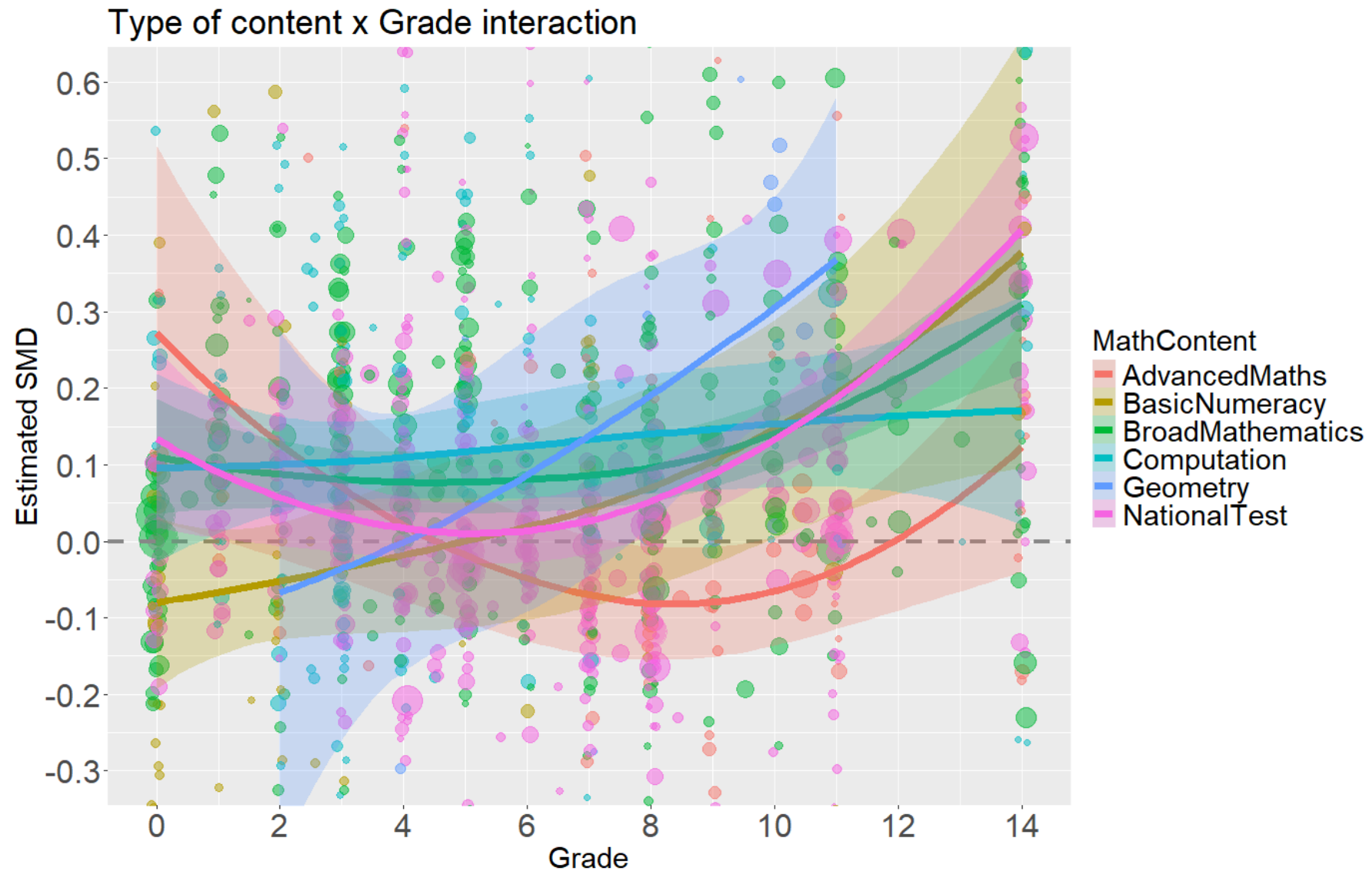
A.



B.



perform classical data analysis



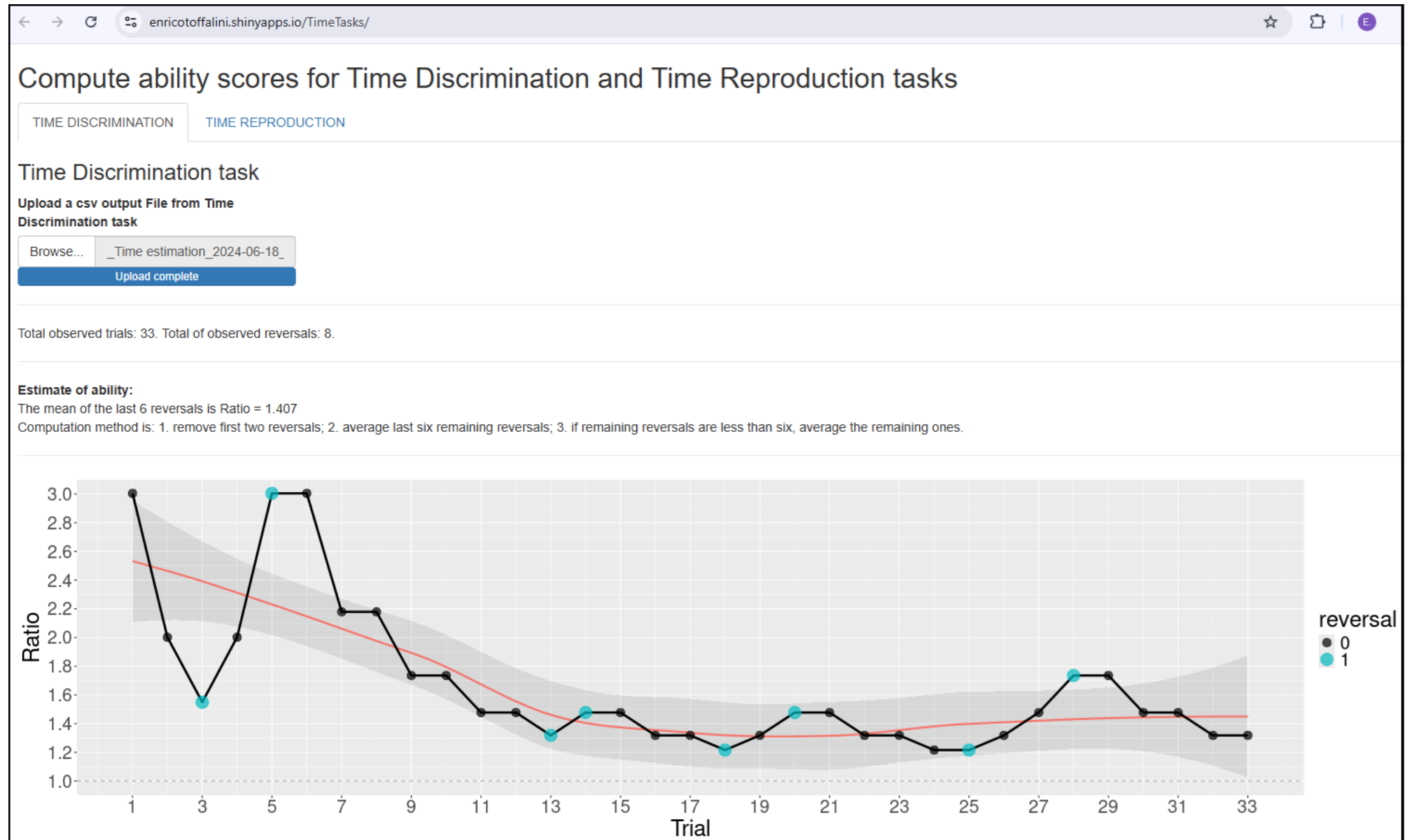
you may create interactive webapps with Shiny

see [Shiny gallery](#)

here's a couple of recent real examples from **Psicostat** members:

- this [game-like shiny app](#) developed for the science4all event in Padova; see [here](#) some explanation in Italian
- practical [ad-hoc shiny app](#) for scoring experimental data collected by students

you may create interactive webapps with Shiny



or entire websites and books

examples of other resources that can be created within the R ecosystem, integrating other tools such as *GitHub* and *Quarto*:

- this very **course support material** is a website in its own right
- this very **course textbook** is a book/website
- **this book** by Daniël Lakens explaining Statistical Inference

R and its *Integrated Development Environment(s)*

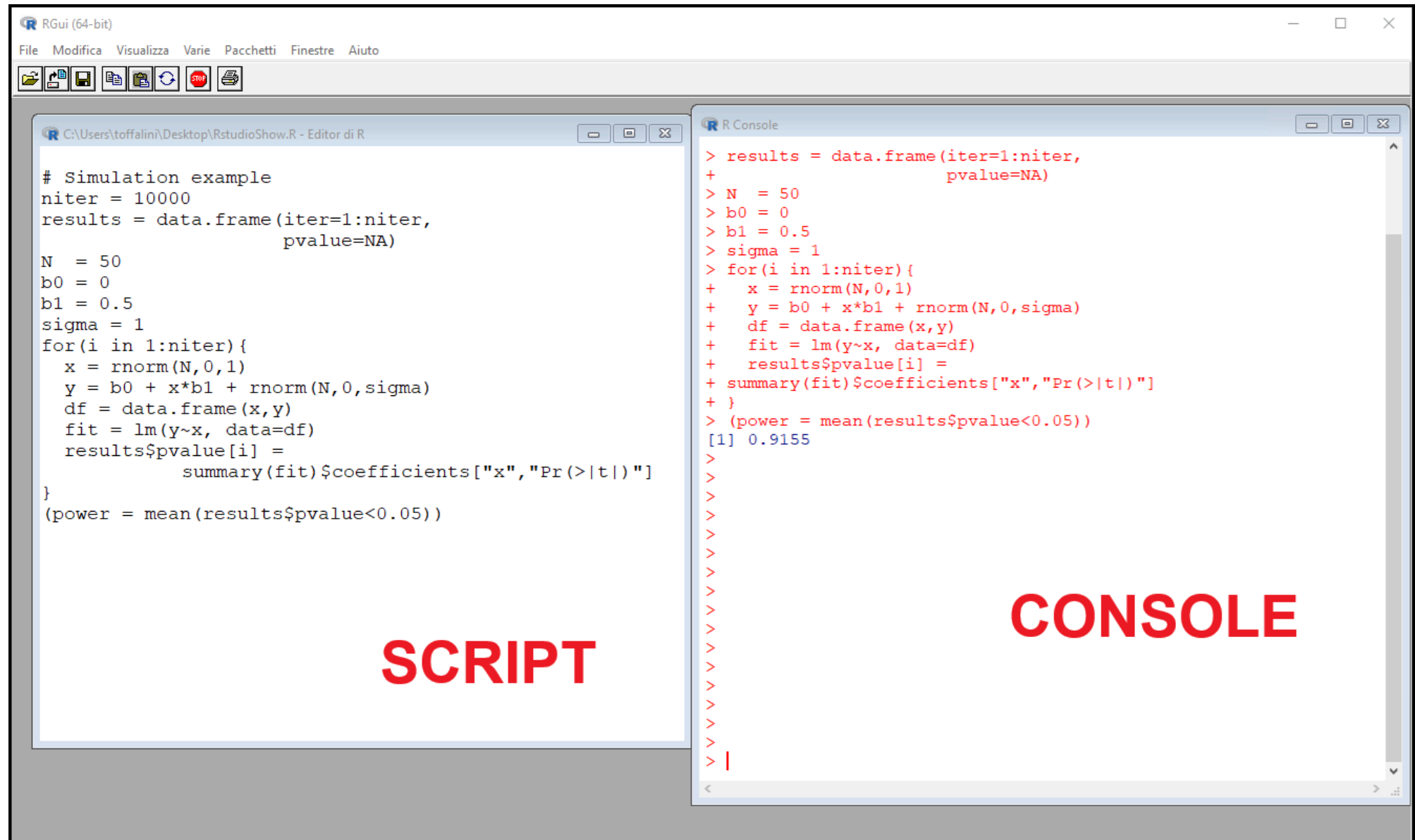
Make sure you install:

- **R** as the programming language interpreter and the basic environment and packages
- **RStudio** is the IDE of election to make writing R code easy

Interesting alternatives to installing RStudio:

- **Positron** (based on MS Visual Studio)
- **Posit.cloud** (fully online, actually RStudio)
- **Google Colab** (fully online, make sure to set *R runtime type*; actually a Jupyter notebook)

R Console (just base R)



R Studio (full IDE)

The screenshot displays the R Studio IDE interface with four main panes:

- SCRIPT**: The top-left pane shows R code for a simulation example. The code defines parameters (N=50, b0=0, b1=0.5, sigma=1, niter=10000) and a loop that generates data, fits a linear model, and calculates p-values. The code is as follows:

```
1  
2 # Simulation example  
3 niter = 10000  
4 results = data.frame(iter=1:niter,  
5                       pvalue=NA)  
6  
7 N = 50  
8 b0 = 0  
9 b1 = 0.5  
10 sigma = 1  
11 for(i in 1:niter){  
12   x = rnorm(N,0,1)  
13   y = b0 + x*b1 + rnorm(N,0,sigma)  
14   df = data.frame(x,y)  
15   fit = lm(y~x, data=df)  
16   results$pvalue[i] = summary(fit)$coefficients["x","Pr(>|t|)"]  
17 }  
18 (power = mean(results$pvalue<0.05))  
19
```
- CONSOLE**: The top-right pane shows the output of the R code, including the calculated power (0.918) and the results of the simulation loop.

```
> (power = mean(results$pvalue<0.05))  
[1] 0.918  
> # Simulation example  
> niter = 10000  
> results = data.frame(iter=1:niter,  
+                       pvalue=NA)  
> N = 50  
> b0 = 0  
> b1 = 0.5  
> sigma = 1  
> for(i in 1:niter){  
+   x = rnorm(N,0,1)  
+   y = b0 + x*b1 + rnorm(N,0,sigma)  
+   df = data.frame(x,y)  
+   fit = lm(y~x, data=df)  
+   results$pvalue[i] = summary(fit)$coefficients["x","Pr(>|t|)"]  
+ }  
> (power = mean(results$pvalue<0.05))  
[1] 0.9105  
>
```
- ENVIRONMENT**: The bottom-left pane shows the current environment with variables: df (50 obs. of 2 variables), fit (List of 12), results (10000 obs. of 2 variables), b0 (0), b1 (0.5), i (10000L), N (50), niter (10000), power (0.9105), and results (1).
- FILE EXPLORER, ETC.**: The bottom-right pane shows the file explorer with a list of files in the current directory:

Name	Size	Modified
..		
faviconpsicostat2.png	79.8 KB	Oct 31, 2024, 10:25 AM
psicostatLogo.png	264 KB	Mar 4, 2024, 2:05 PM
RstudioShow.R	378 B	Oct 31, 2024, 5:08 PM

Some R packages that you will or may need in the future (1/3)

Package	Used for what	Example(s) of functions
<code>base</code> (base R)	Basic functions	<code>sum</code> , <code>mean</code> , <code>sqrt</code> , <code>abs</code> , <code>c</code> , <code>data.frame</code> , <code>summary</code> , <code>scale</code> , <code>plot</code> , <code>+</code> , <code>-</code>
<code>stats</code> (base R)	Basic statistical calculations and functions	<code>sd</code> , <code>cor</code> , <code>cor.test</code> , <code>t.test</code> , <code>lm</code> , <code>glm</code> , <code>AIC</code> , <code>rnorm</code> , <code>rbinom</code>
<code>graphics</code> (base R)	Basic statistical calculations and functions	<code>plot</code> , <code>boxplot</code> , <code>hist</code> , <code>barplot</code>

(You may actually use these “base” packages very often without even realizing that they are packages)

Some R packages that you will or may need in the future (2/3)

Package	Used for what	Example(s) of functions
<code>effectsize</code>	Compute different effect sizes	<code>cohens_d</code> , <code>hedges_g</code> , <code>cohens_f</code> , <code>d_to_r</code>
<code>lme4</code>	Fitting (generalized) (non-)linear mixed-effects models	<code>lmer</code> , <code>glmer</code> , <code>ranef</code>
<code>performance</code>	Useful tools for models	<code>check_collinearity</code> , <code>r2_nagelkerke</code> , <code>icc</code>
<code>effects</code>	Display effects for various statistical models	<code>allEffects</code>
<code>emmeans</code>	Estimate marginal means for various models	<code>emmeans</code>

Some R packages that you will or may need in the future (3/3)

Package	Used for what	Example(s) of functions
<code>ggplot2</code>	Create beautiful plots using The Grammar of Graphics	<code>ggplot</code> , <code>geom_point</code> , <code>geom_line</code> , ...
<code>lavaan</code>	Structural Equation Models (SEM)	<code>sem</code> , <code>cfa</code>
<code>semTools</code>	Useful tools for SEMs	<code>compRelSEM</code> , <code>measEq.syntax</code>
<code>metafor</code>	Perform meta-analysis	<code>rma</code> , <code>rma.mv</code> , <code>forest</code> , <code>funnel</code> , <code>regtest</code>
<code>brms</code>	Fitting practically any Bayesian model via MCMC with STAN	<code>brm</code> , <code>set_prior</code>
<code>blavaan</code>	Fitting Bayesian SEMs	<code>bcfa</code> , <code>bsem</code>

Let's Test the Environment!

Let's run a few commands in RStudio to familiarize with its console and see if the installation works properly

```
rmnorm(10) # draw 10 random values from a Standard Normal distribution
```

```
[1] -0.6790134  0.5173610 -0.9890813 -0.6538885 -2.8993340 -1.1826100  
[7]  0.3177626 -0.9854805  0.5988272 -1.2425435
```

```
?rmnorm # open the help tab for the "rmnorm" function
```

```
round( rmnorm(10, mean=100, sd=15) ) # draw 10 values from IQ distribution, round them
```

```
[1]  89 129  86  95 111  94 100 104  76 101
```

```
install.packages("psych") # install a package from CRAN
```

```
library(psych) # load the newly installed package
```

```
fisherz(rho=0.5) # use it to transform a correlation into a Fisher's z
```

```
[1] 0.5493061
```