## **Best Practices in Writing Reproducible Code in R**

Ms.C. Diego Angeles-Valdez University of Groningen | Instituto de Neurobiología, UNAM



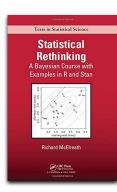


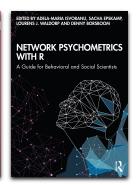
### **About me**













machine learning

Progress in Neuropsychopharmacology & Biological Psychiatry Identifying cognitive deficits in cocaine dependence using standard tests and

Said Jiménez<sup>1,5</sup>, Diego Angeles-Valdez<sup>1,5</sup>, Viviana Villicaña<sup>1,6</sup>, Ernesto Reyes-Zamorano<sup>1</sup>, Ruth Alcala-Lousno<sup>1</sup>, Jorge J. Goroalez-Overa<sup>1</sup>, Eduardo A. Garza-Villarreal<sup>1,6,6,6</sup>



Machine learning detects predictors of symptom severity and impulsivity after dialectical behavior therapy skills training group in borderline personality disorder

Said Jiménez<sup>\*\*</sup>, Diego Angeles-Valdez<sup>†</sup>, Andrés Rodríguez-Delgado<sup>\*</sup>, Ana Fresin<sup>†</sup>, Edgar Misanda<sup>\*</sup>, Ruth Alcalè-Lezano<sup>\*</sup>, Xóchill Daque-Alarcón<sup>\*</sup>, Iván Anargo de Montis<sup>\*</sup>, Eduardo A. Gozza-Villarreal<sup>†</sup>.

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#### nature neuroscience

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#### A consensus protocol for fun connectivity analysis in the r

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A list of authors and their affiliation

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First vs recurrent episode symptomatology in Major Depressive Disorder and its relation to brain function and structure; a network approach

Diego Angeles-Valdez \*\*\*\*, M.J. van Tol \*\*. Eduardo A. Garza-Villarreal \*\*

\* Institute of Neurobiology, Universidad Nacional Autónoma de México campus Juriquilla, Querétaro, México.

Cognitive Neuroscience Center, Department of Biomedical Sciences, University Medical Center Groningen, University of Groningen, The Netherlands.

6 Research School of Behavioural and Cognitive Neurosciences, University of Groningen, Groningen, The Netherlands.

#### \*Corresponding author:

#### Eduardo A. Garza-Villarreal, MD, PhD

Instituto de Neurobiología, Laboratorio D-12, Universidad Nacional Autónoma de México (UNAM) campus Juriquilla, Boulevard Juriguilla 3001, Santiago de Querétaro, Querétaro, México

Email: egarza@comunidad.unam.mx

#### Phone: (442) 238-1038 Diego Angeles-Valdez, M. Sc.

PhD candidate. Instituto de Neurobiología, Laboratorio D-12, Universidad Nacional Autónoma de México (UNAM) campus Juriquilla, University Medical Center Groningen, Cognitive Neuroscience Center, Hanzeplein 1, 9713 GZ Groningen

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### **Outline**



### R Packages

Overview of essential R packages used in data analysis

### Glimpse of the Data

Initial exploration and summary of data

### **Statistical Analysis**

Applying statistical methods to interpret data

#### **Visualization**

Creating visual representations to illustrate findings

### **Course Material**





*Tidyverse* 

*Tidy* for "bien rangé" and *verse* for "univers"

A collection of R will developed by H. Wickham and others at Rstudio

Initial release: Sep, 2016



**Hadley Wickham** 



Tidyverse is most importantly a philosophy for data analysis.

- More efficient code
- Easier to remember syntax
- Easier to read syntax



### Remember install and load the package

```
#install.packages("tidyverse")
library(tidyverse)
```



```
library(tidyverse)
                                                                tidyverse 1.3.0 —
## — Attaching packages
## / ggplot2 3.3.3
                                0.3.4
                      ✓ purrr
## ✓ tibble 3.1.0

✓ dplyr 1.0.4

## / tidyr 1.1.2
                      ✓ forcats 0.5.1
## / readr 1.4.0
## — Conflicts
                                                         - tidyverse conflicts() —
## * dplyr::collapse()
                        masks IRanges::collapse()
## * dplyr::combine()
                        masks Biobase::combine(), BiocGenerics::combine()
## * dplyr::desc()
                        masks IRanges::desc()
## * tidyr::expand()
                        masks S4Vectors::expand()
## * tidyr::extract()
                        masks magrittr::extract()
## * dplyr::filter()
                        masks stats::filter()
                        masks S4Vectors::first()
## * dplyr::first()
## * dplyr::lag()
                        masks stats::lag()
## * ggplot2::Position() masks BiocGenerics::Position(), base::Position()
## * purrr::reduce()
                        masks GenomicRanges::reduce(), IRanges::reduce()
## * dplyr::rename()
                        masks S4Vectors::rename()
```



Tidyverse is a collection of R



ggplot2 - visualising stuff

**dplyr**, **tidyr** - data manipulation

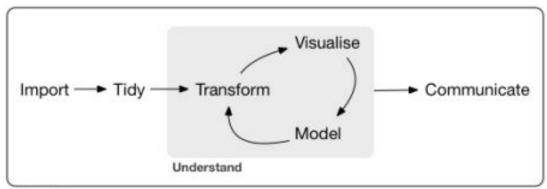
purrr - advanced programming

readr - import data

**tibble** - improved data.frame format

forcats - working w/ factors

**stringr** - working w/ chain of characters



Program

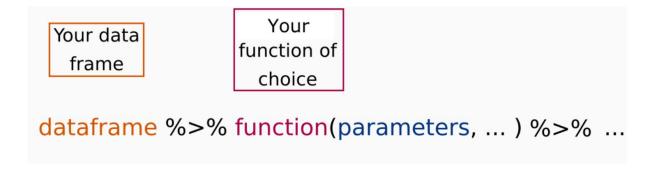
## Introduction to dplyr

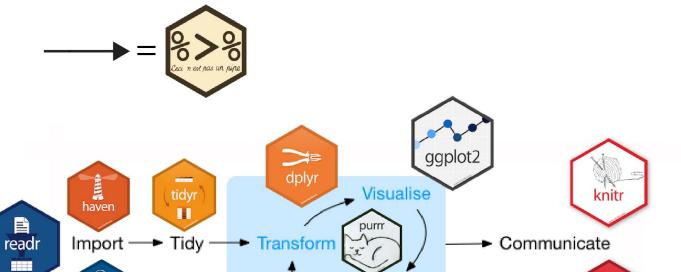


All of the dplyr functions take a data frame (or tibble) as the first argument.

dplyr provides the %>%

You can use the pipe to rewrite multiple operations that you can read left-to-right, top-to-bottom.



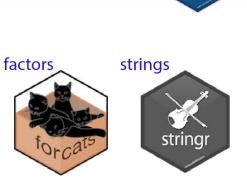


Explore

readxl

data.frames

7133LE



Model

broom

rmarkdown

## Graphics in R



The ggplot2 package was created by Hadley Wickham to provide an intuitive plotting system.

In order to produce a ggplot2 graph we need a minimum of:

- Data to be used in graph
- Mappings of data to the graph (aesthetic mapping)
- What type of graph we want to use (The geom to use).

### **Table**



Descriptive statistics are an essential part of data analysis as they give you an initial overview of your data.

To create descriptive tables in R, you can use:

- moonBook
- table1
- tableone
- tables

# **Examples**



	Stratifie	by trt				
	1		2		p	tes
n	158		154			
time (mean (SD))	2,015.62	(1,094.12)	1,996.86	(1,155.93)	0.883	
status (%)					0.894	
0		(52.5)		(55.2)		
1		(6.3)		(5.8)		
2		(41.1)		(39.0)		
trt = 2 (%)		(0.0)		(100.0)	<0.001	
age (mean (SD))	51.42	(11.01)	48.58	(9.96)	0.018	
sex = f (%)		(86.7)	139	(90.3)	0.421	
ascites = 1 (%)	14	(8.9)	10	(6.5)	0.567	
hepato = 1 (%)	73	(46.2)	87	(56.5)	0.088	
spiders = 1 (%)	45	(28.5)	45	(29.2)	0.985	
edema (%)					0.877	
0	132	(83.5)	131	(85.1)		
0.5	16	(10.1)	13	(8.4)		
1	10	(6.3)	10	(6.5)		
bili (median [IQR])	1.40	[0.80, 3.20]	1.30	[0.72, 3.60]	0.842	
onnorm						
chol (median [IQR])	315.50	[247.75, 417.00]	303.50	[254.25, 377.00]	0.544	
onnorm						
albumin (mean (SD))	3.52	(0.44)	3.52	(0.40)	0.874	
copper (median [IQR])	73.00	[40.00, 121.00]	73.00	[43.00, 139.00]	0.717	
onnorm						
alk.phos (median [IQR])	1,214.50	[840.75, 2,028.00]	1,283.00	[922.50, 1,949.75]	0.812	
onnorm						
ast (median [IQR])	111.60	[76.73, 151.51]	117.40	[83.78, 151.90]	0.459	
onnorm		-				
trig (median [IQR])	106.00	[84.50, 146.00]	113.00	[84.50, 155.00]	0.370	
onnorm						
platelet (mean (SD))	258.75	(100.32)	265.20	(90.73)	0.555	
protime (median [IQR])				[10.00, 11.40]	0.588	
onnorm						
stage (%)					0.201	
1	12	(7.6)	4	( 2.6)		
2		(22.2)		( 20.8)		
3		(35.4)		(41.6)		
		(34.8)		(35.1)		

	NSTEMI (N=153)	STEMI (N=304)	Unstable Angina (N=400)	p
age	64.3 ± 12.3	62.1 ± 12.1	63.8 ± 11.0	0.073
sex				0.013
- Female	50 (32.7%)	84 (27.6%)	153 (38.2%)	
- Male	103 (67.3%)	220 (72.4%)	247 (61.8%)	
cardiogenicShoc	k			0.000
- No	149 (97.4%)	256 (84.2%)	400 (100.0%)	
- Yes	4 ( 2.6%)	48 (15.8%)	0 (0.0%)	
entry				0.00
- Femoral	58 (37.9%)	133 (43.8%)	121 (30.2%)	
- Radial	95 (62.1%)	171 (56.2%)	279 (69.8%)	
EF	55.0 ± 9.3	52.4 ± 9.5	59.2 ± 8.7	0.00
height	163.3 ± 8.2	165.1 ± 8.2	161.7 ± 9.7	0.000
weight	64.3 ± 10.2	65.7 ± 11.6	64.5 ± 11.6	0.36
BMI	24.1 ± 3.2	24.0 ± 3.3	24.6 ± 3.4	0.06
obesity				0.18
- No	106 (69.3%)	209 (68.8%)	252 (63.0%)	
- Yes	47 (30.7%)	95 (31.2%)	148 (37.0%)	
TC	193.7 ± 53.6	183.2 ± 43.4	183.5 ± 48.3	0.05
LDLC	126.1 ± 44.7	116.7 ± 39.5	112.9 ± 40.4	0.004
HDLC	38.9 ± 11.9	38.5 ± 11.0	37.8 ± 10.9	0.50
TG	130.1 ± 88.5	106.5 ± 72.0	137.4 ± 101.6	0.00
DM				0.20
- No	96 (62.7%)	208 (68.4%)	249 (62.2%)	
- Yes	57 (37.3%)	96 (31.6%)	151 (37.8%)	
HBP	7.CA - 7.04 - 7.00 - 8	A CONTRACTOR OF THE CONTRACTOR	are a second of Victor	0.002
- No	62 (40.5%)	150 (49.3%)	144 (36.0%)	
- Yes		154 (50.7%)		
smoking			**************************************	0.00
- Ex-smoker	42 (27.5%)	66 (21.7%)	96 (24.0%)	
- Never		97 (31.9%)		
- Smoker		141 (46.4%)		

#### Basic stats

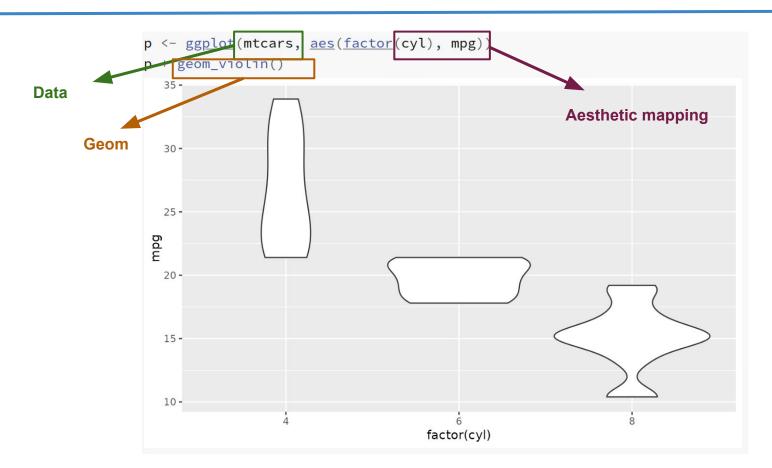
		Daoio otato			
			Death		
	Total (N=205)	Alive (N=134)	Melanoma (N=57)	Non-melanoma (N=14)	
Sex					
Male	79 (39 %)	43 (32 %)	29 (51 %)	7 (50 %)	
Female	126 (61 %)	91 (68 %)	28 (49 %)	7 (50 %)	
Age (years)					
Mean (SD)	52 (± 17)	50 (± 16)	55 (± 18)	65 (± 11)	
Ulceration					
Absent	115 (56 %)	92 (69 %)	16 (28 %)	7 (50 %)	
Present	90 (44 %)	42 (31 %)	41 (72 %)	7 (50 %)	
Thicknessa (mm)					
Mean (SD)	2.9 (± 3.0)	2.2 (± 2.3)	4.3 (± 3.6)	3.7 (± 3.6)	

Also known as Breslow thickness

		Sepal. Length		Sepal.Width	
Species	$\mathbf{n}$	mean	sd	mean	$_{ m sd}$
setos a	50	5.01	0.35	3.43	0.38
versicolor	50	5.94	0.52	2.77	0.31
virginica	50	6.59	0.64	2.97	0.32
Overall, w	e see i	the follo	wing:		
All	150	5.84	0.83	3.06	0.44

# Our first ggplot2 graph



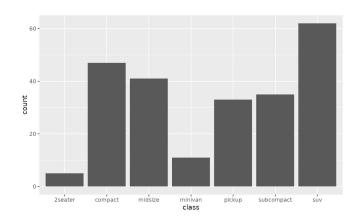


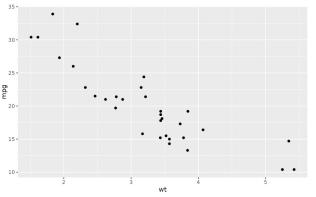
## Our first ggplot2 graph

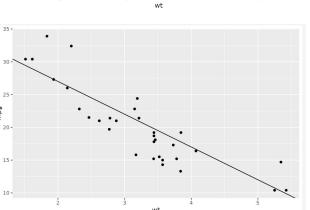


### For example:

- geom\_point() for scatter plots,
- geom\_line() for line charts,
- geom\_bar() for bar plots,
- geom\_histogram() for histograms,
- geom\_smooth() to add trend lines.









# ggplot2



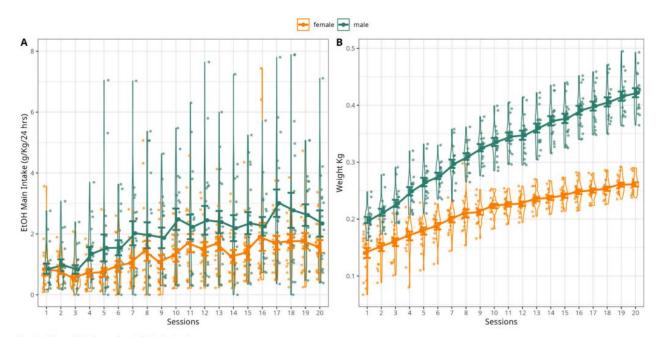




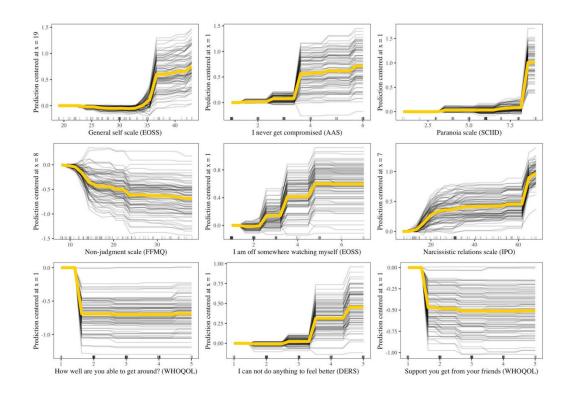
Fig. 1. Ethanol intake and weight trajectories.

Overview of (A) ethanol main intake, (B) and the weight of all rats over IA2BC model by sex. The values are expressed as mean EtOH Main intake (g/kg/24 h), and weight (Kg)  $\pm$  SEM at each drinking session.

# ggpubr



The 'ggpubr' package provides some easy-to-use functions for creating and customizing 'ggplot2'-based publication ready plots.



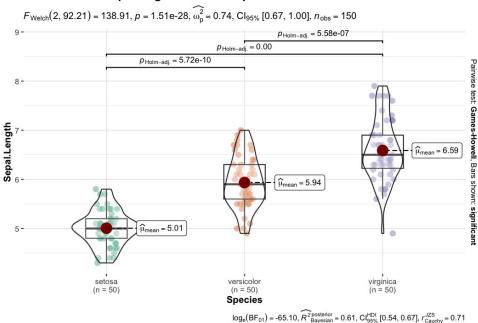
# Other R packages for plotting





Based Plots with Statistical Details

#### Distribution of sepal length across Iris species



### Other R packages for plotting



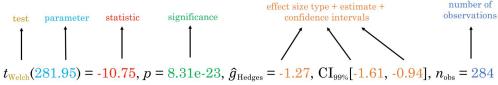


Based Plots with Statistical Details

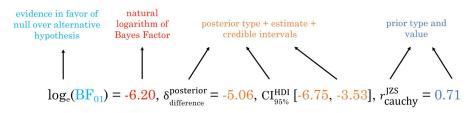


Results from Welch's t-test with {statsExpressions}

#### Template for Frequentist analysis



#### Template for Bayesian analysis



### **Extra information**



### Linear Mixed models Network analysis

- 1mer
- broom

- SEM or path model
  - lavaan

- bootnet
- psychonetrics
- qgraph

### Machine Learning

- caret
- randomForest
- o xgboost
- o e1071
- tidymodels

## Thank you



### Contact me

M. Sc. Diego Angeles-Valdez, PhD candidate,

University Medical Center Groningen, Cognitive Neuroscience Center, Biomedical Sciences

> Universidad Nacional Autónoma de México (UNAM) Institute of Neurobiology (INB)

Personal Website: <a href="https://diegoangls.github.io/">https://diegoangls.github.io/</a>

Twitter: <a>@diegoangls</a>

Bluesky: @dangeles.bsky.social

Phone: +31 6 39 88 71 29

Email: d.angeles.valdez@rug.nl | d.angeles.valdez@umcg.nl

Work address: P.O. Box 196, 9700 AD GRONINGEN, The Netherlands