




# Bayesian Statistics and Hierarchical Bayesian Modeling for Psychological Science

## Lecture 02

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[https://github.com/lei-zhang/BayesCog\\_Wien](https://github.com/lei-zhang/BayesCog_Wien)

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**Bayesian warm-up?**

# BASICS OF R PROGRAMMING



# R Basics

cognitive model

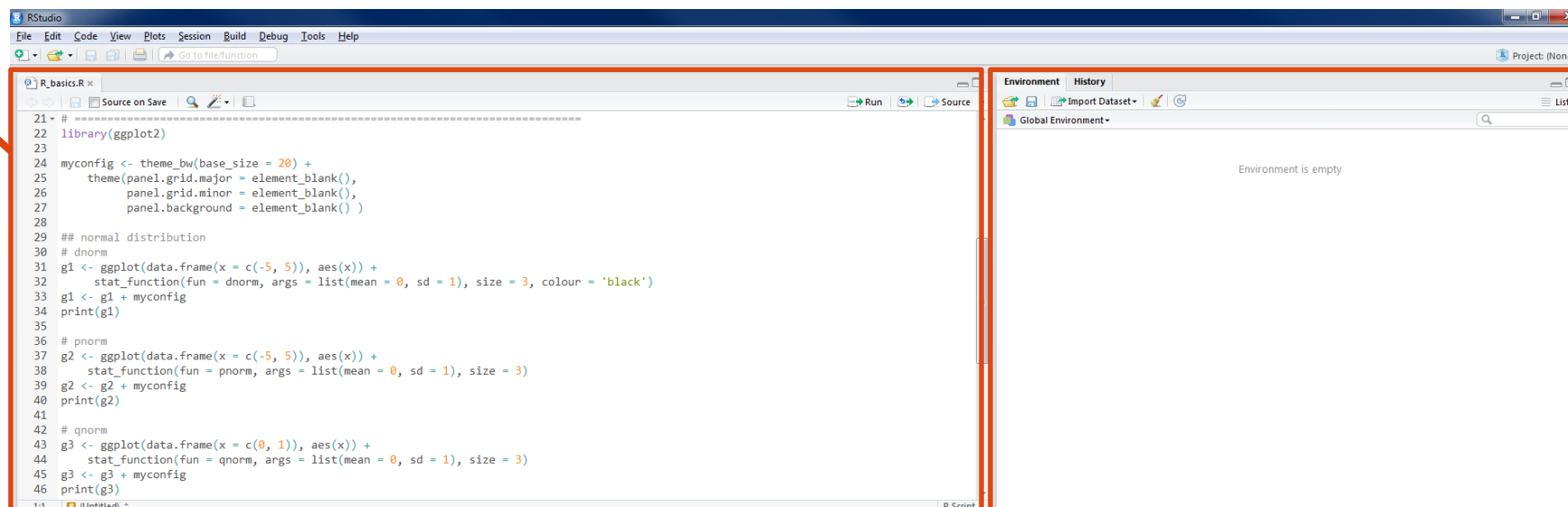
statistics

computing

- R
  - a programming language for statistical computing
  - R has its own user interface
  - freely available on Windows, Mac, and Linux
- R Studio
  - integrated development environment (IDE) for R
  - a more sophisticated R-friendly editor, with helpful syntax highlight



script editor

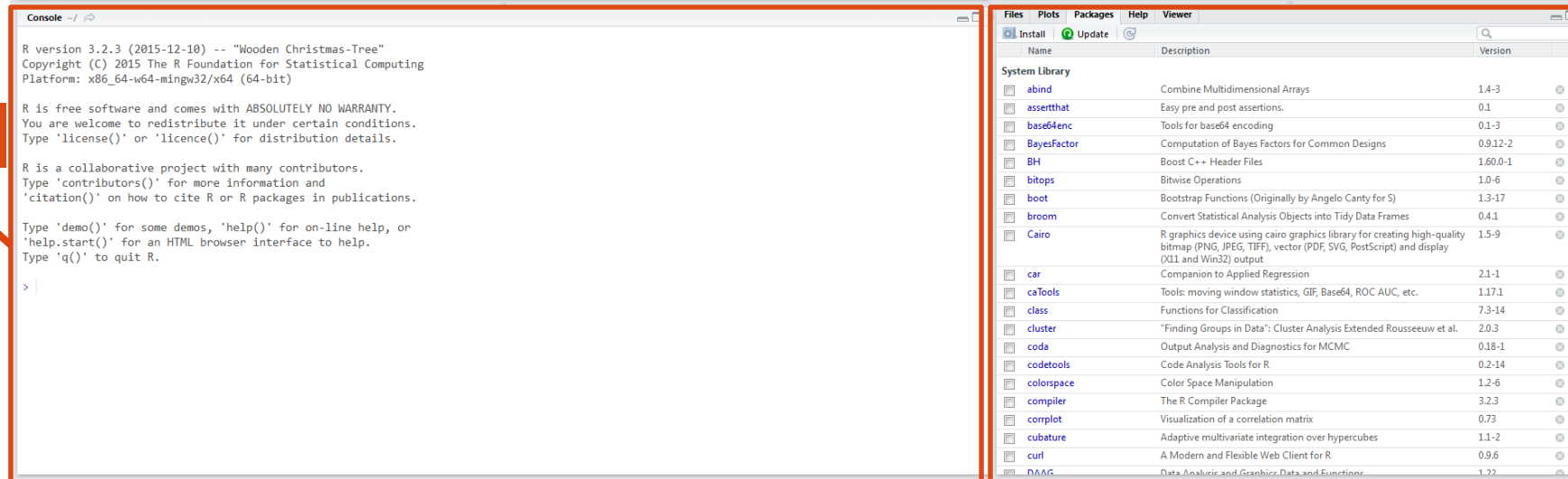


The image shows the RStudio interface. The top-left pane is the script editor, displaying R code for creating a ggplot2 theme and three plots (g1, g2, g3). The top-right pane is the Environment/History pane, which is currently empty, showing 'Global Environment' and 'Environment is empty'.

```
21 #  
22 library(ggplot2)  
23  
24 myconfig <- theme_bw(base_size = 20) +  
25   theme(panel.grid.major = element_blank(),  
26         panel.grid.minor = element_blank(),  
27         panel.background = element_blank() )  
28  
29 ## normal distribution  
30 # dnorm  
31 g1 <- ggplot(data.frame(x = c(-5, 5)), aes(x)) +  
32   stat_function(fun = dnorm, args = list(mean = 0, sd = 1), size = 3, colour = 'black')  
33 g1 <- g1 + myconfig  
34 print(g1)  
35  
36 # pnorm  
37 g2 <- ggplot(data.frame(x = c(-5, 5)), aes(x)) +  
38   stat_function(fun = pnorm, args = list(mean = 0, sd = 1), size = 3)  
39 g2 <- g2 + myconfig  
40 print(g2)  
41  
42 # qnorm  
43 g3 <- ggplot(data.frame(x = c(0, 1)), aes(x)) +  
44   stat_function(fun = qnorm, args = list(mean = 0, sd = 1), size = 3)  
45 g3 <- g3 + myconfig  
46 print(g3)
```

environment/  
command history

console



The image shows the RStudio interface. The bottom-left pane is the console, displaying the R version (3.2.3), copyright information, and instructions for using R. The bottom-right pane is the Packages pane, showing a list of installed and available packages with their descriptions and versions.

R version 3.2.3 (2015-12-10) -- "Wooden Christmas-Tree"  
Copyright (C) 2015 The R Foundation for Statistical Computing  
Platform: x86\_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.  
You are welcome to redistribute it under certain conditions.  
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.  
Type 'contributors()' for more information and  
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or  
'help.start()' for an HTML browser interface to help.  
Type 'q()' to quit R.

> |

Name	Description	Version
<b>System Library</b>		
abind	Combine Multidimensional Arrays	1.4-3
assertthat	Easy pre and post assertions.	0.1
base64enc	Tools for base64 encoding	0.1-3
BayesFactor	Computation of Bayes Factors for Common Designs	0.912-2
BH	Boost C++ Header Files	1.60.0-1
bitops	Bitwise Operations	1.0-6
boot	Bootstrap Functions (Originally by Angelo Canty for S)	1.3-17
broom	Convert Statistical Analysis Objects into Tidy Data Frames	0.4.1
Cairo	R graphics device using cairo graphics library for creating high-quality bitmap (PNG, JPEG, TIFF), vector (PDF, SVG, PostScript) and display (X11 and Win32) output	1.5-9
car	Companion to Applied Regression	2.1-1
caTools	Tools: moving window statistics, GIF, Base64, ROC AUC, etc.	1.17.1
class	Functions for Classification	7.3-14
cluster	"Finding Groups in Data": Cluster Analysis Extended Rousseeuw et al.	2.0.3
coda	Output Analysis and Diagnostics for MCMC	0.18-1
codetools	Code Analysis Tools for R	0.2-14
colorspace	Color Space Manipulation	1.2-6
compiler	The R Compiler Package	3.2.3
corplot	Visualization of a correlation matrix	0.73
cubature	Adaptive multivariate integration over hypercubes	1.1-2
curl	A Modern and Flexible Web Client for R	0.9.6
DAAG	Data Analysis and Graphics: Data and Functions	1.22

file/pkg/img/  
etc.

# Know your R

```
>R.version
```

```
platform      _  
arch          x86_64  
os            mingw32  
system        x86_64, mingw32  
status  
major         3  
minor         5.1  
year          2018  
month         07  
day           02  
svn rev       74947  
language      R  
version.string R version 3.5.1 (2018-07-02)  
nickname      Feather Spray
```

# R Console as a Calculator

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computing

## Addition and Subtraction

```
> 3+2  
[1] 5
```

```
> 3-2  
[1] 1
```

## Multiplication and Division

```
> 3*2  
[1] 6
```

```
> 3/2  
[1] 1.5
```

## Exponents in R

```
> 3^2  
[1] 9
```

```
> 2^3  
[1] 8
```

## Constants in R

```
> pi  
[1] 3.141593
```

```
> exp(1)    base of the natural logarithm  
[1] 2.718282
```

# Special values

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## Infinite Values

```
> Inf  
[1] Inf
```

```
> 1+Inf  
[1] Inf
```

## Machine Epsilon

```
> .Machine$double.eps  
[1] 2.220446e-16
```

```
> 0>.Machine$double.eps  
[1] FALSE
```

## Empty Values

```
> NULL  
NULL
```

```
> 1+NULL  
numeric(0)
```

## Missing Values

```
> NA  
[1] NA
```

```
> 1+NA  
[1] NA
```



# Storing and manipulating variables

Define objects `x` and `y` with values of 3 and 2, respectively:

```
> x=3
```

```
> y=2
```

Some calculations with the defined objects `x` and `y`:

```
> x+y
```

```
[1] 5
```

```
> x*y
```

```
[1] 6
```

Warning: R is case sensitive, so `x` and `X` are not the same object.

# Basic R functions

## Combine

```
> c(1, 3, -2)
[1] 1 3 -2
```

```
> c("a", "a", "b", "b", "a")
[1] "a" "a" "b" "b" "a"
```

## Sum and Mean

```
> sum(c(1, 3, -2))
[1] 2
```

```
> mean(c(1, 3, -2))
[1] 0.6666667
```

## Variance and Std. Dev.

```
> var(c(1, 3, -2))
[1] 6.333333
```

```
> sd(c(1, 3, -2))
[1] 2.516611
```

## Minimum and Maximum

```
> min(c(1, 3, -2))
[1] -2
```

```
> max(c(1, 3, -2))
[1] 3
```

# Basic R functions (cont.)

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Define objects `x` and `y`:

```
> x=c(1,3,4,6,8)
```

```
> y=c(2,3,5,7,9)
```

Calculate the correlation:

```
> cor(x,y)
```

```
[1] 0.988765
```

Calculate the covariance:

```
> cov(x,y)
```

```
[1] 7.65
```

Combine as columns

```
> cbind(x,y)
```

	x	y
[1,]	1	2
[2,]	3	3
[3,]	4	5
[4,]	6	7
[5,]	8	9

Combine as rows

```
> rbind(x,y)
```

	[,1]	[,2]	[,3]	[,4]	[,5]
x	1	3	4	6	8
y	2	3	5	7	9

# Basic Commands

```
getwd()
setwd('E:/teaching/BayesCog_Wien/')
dir() # folders/files in the wd
ls()  # anything in the environment/workspace
print('Hello World!')
cat('Hello', 'World!')
paste0('C:/', 'Group1')
help(func)
? func # and Google!
a <- 5
a = 5
head(d) # first 6 entries
tail(d) # last 6 entries
save(varname, file = "pathname/varname.RData")
load("pathname/varname.RData")
rm(list = ls())
q()
```

# RStudio - Shortcuts

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computing

Ctrl + L: clean console

Ctrl + Shift + N: create a new script

↑: command history

Ctrl(hold) + ↑: command history with certain starts

Ctrl + Enter: execute selected codes (in a script)

# Editor (WIN general) - Shortcuts

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Ctrl + home/Pos: go to the very top of a script

Ctrl + end/Ende: go to the very end of a script

Shift(hold) + ↑/↓: select line(s)

Ctrl(hold) + ←/→: select word(s)

# Data Classes

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numeric: 1.1 2.0

integer: 1 2 3

character / string: "hello world!"

logical: TRUE FALSE

factors: "male" / "female"

(complex: 1+2i)

# Data Types

cognitive model

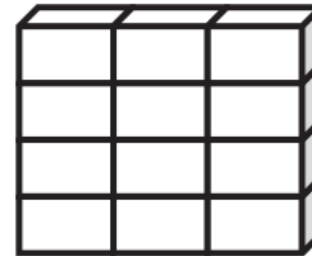
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computing

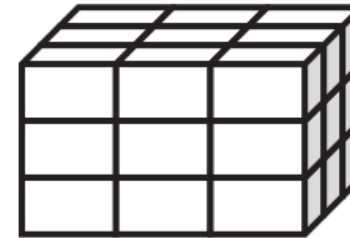
(a) Vector



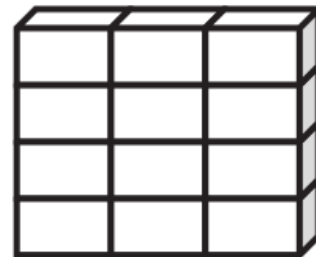
(b) Matrix



(c) Array

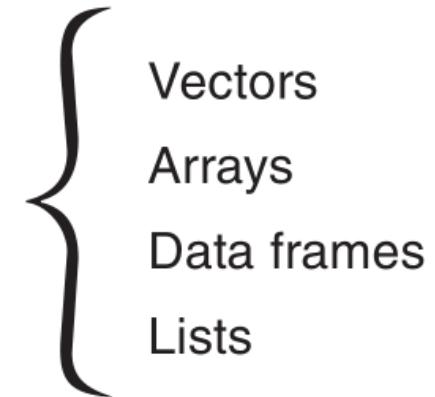


(d) Data frame



**Columns can be different modes**

(e) List





# Exercise I

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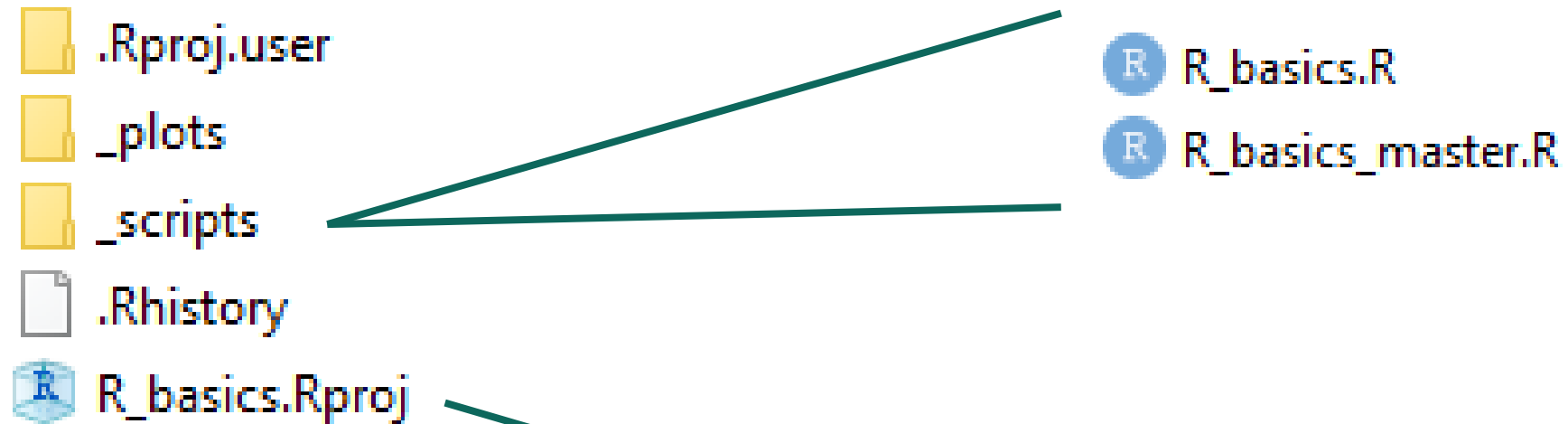
```
.../01.R_basics/_scripts/R_basics.R
```

up to “Control Flow”

TASK: practise basic R commands and data type

TIP: `class()`, `str()`

## Side note: folder structure



click this to start each exercise,  
then no need to set directory