

STAT5003

Week 1: Basics of R programming & static graphics

Dr. Justin Wishart
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Aims of this course






- Learn **concepts** and **methods** related to statistical data analysis and statistical learning



- Apply the methods on **real datasets** in (the statistical computing language)
- Aim is to teach you to use the methods, not necessarily to go into all the mathematical details

Basics of Statistical Computing

- Review basic statistical concepts
- Introduction to 
- Reproducible coding using Rmarkdown 
- Recommended IDE via  Studio[®]

Review of basic statistical concepts



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Population

- **Definition:**

- The set of data (numeric or otherwise) corresponding to the entire collection of units about which information is sought.

- **Examples:**

- Blood pressure – Blood pressure readings of ALL people in Australia.
- The number of languages spoken from ALL currently enrolled students in University of Sydney

Sample

- **Definition:**

- A subset of the population data that are actually collected in the course of a study.

- **Examples:**

- Blood pressure readings of 1000 randomly selected people in Australia.
- The number of languages spoken from 500 randomly selected students currently enrolled in University of Sydney.

In most studies, it is difficult to obtain information about the whole population. That is why we rely on samples to make estimates and inferences related to the whole population.

Parameters vs statistics

- A **parameter** is a number that describes a population.
 - Notation usually denoted with Greek letters. e.g. μ , σ
- A **statistic** is a number that describes a sample.
 - Sample statistics are usually denoted using Roman letters, e.g. x , s .
- A parameter is a fixed number (usually unknown). A statistic is a variable whose value varies from sample to sample.

Descriptive statistics – numeric and graphics

Many methods are available for summarising data in both **numeric** and **graphical** form

Numeric measures:

- Measure of location – Mean, Median, Mode for numeric data
 - Counts, proportions for categorical data
- Measure of spread – Standard deviation, MAD (median absolute deviation), IQR
- Others: – Min, Max, Quartile, Five number summaries (used later in boxplot)

Basic statistical graphics and





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Types of graphics covered in this course

- Become familiar with simple graphics using base  and ggplot graphics



- base  use the built in plotting functions
 - typically good for quick plots of simple datasets

- ggplot graphics 
 - Name meaning the grammar of graphics
 - Typically better for more complicated datasets

- Not covered but honorable mention  plotly
 - Plotly is a powerful plotting library
 - Can do interactive graphics

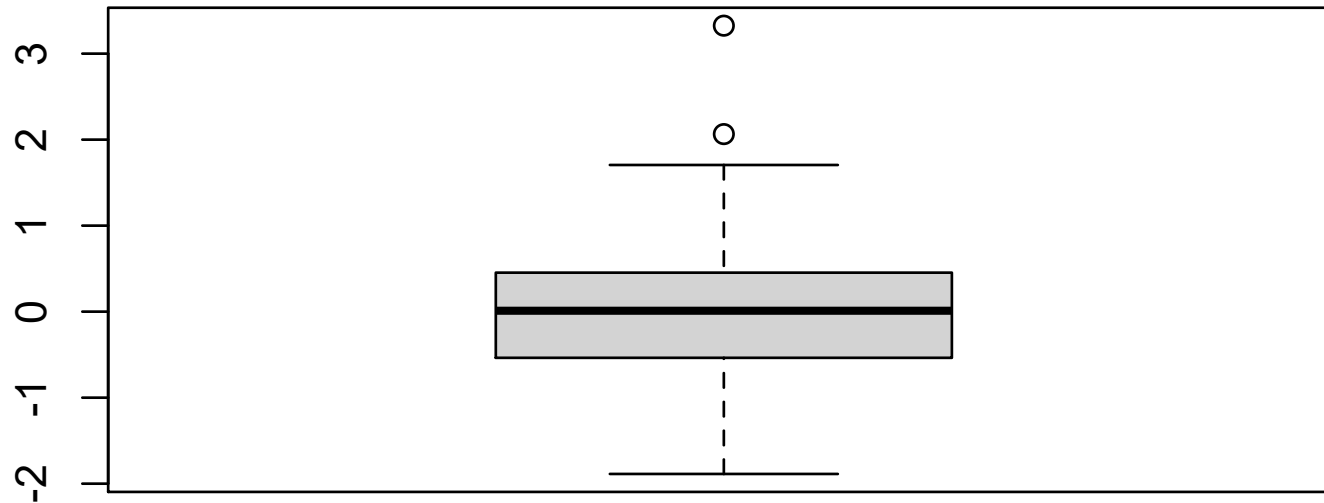
Simple example dataframe for plots

```
example.dat <- data.frame(x = rnorm(100),  
                           y = runif(100),  
                           cat = sample(LETTERS[1:2], prob = c(1, 3), size = 100, replace = TRUE))  
head(example.dat)
```

```
##           x           y cat  
## 1 -1.01720533 0.53678627  B  
## 2  0.66728073 0.90411240  B  
## 3 -0.34239565 0.10107771  B  
## 4 -0.80917484 0.03485421  A  
## 5 -0.17392371 0.08812804  B  
## 6  0.01421694 0.35850014  B
```

Single numeric variable: Boxplot in base

```
boxplot(example.dat$x)
```



Single numeric variable: Boxplot in

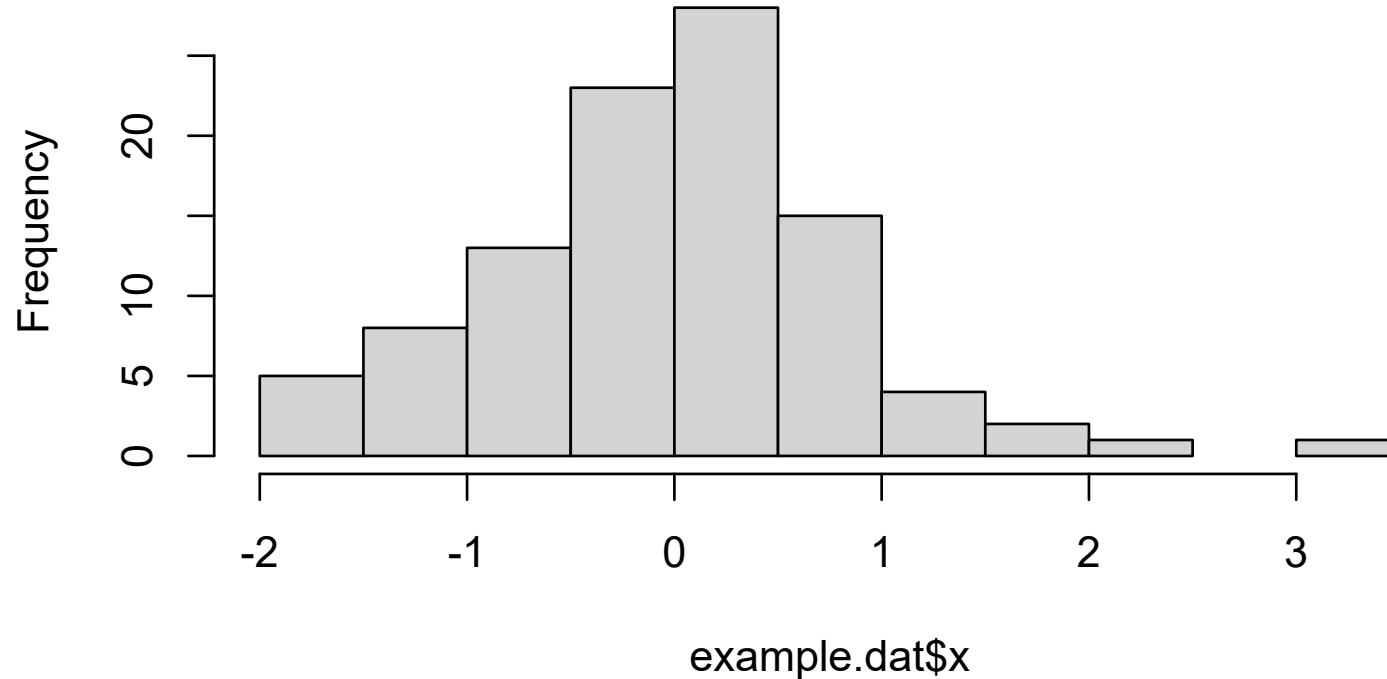


```
library(ggplot2) # Only need to load the library once in an R session  
ggplot(example.dat, aes(y = x)) + geom_boxplot() + theme_minimal()
```

Single numeric variable: Histogram in base

```
hist(example.dat$x)
```

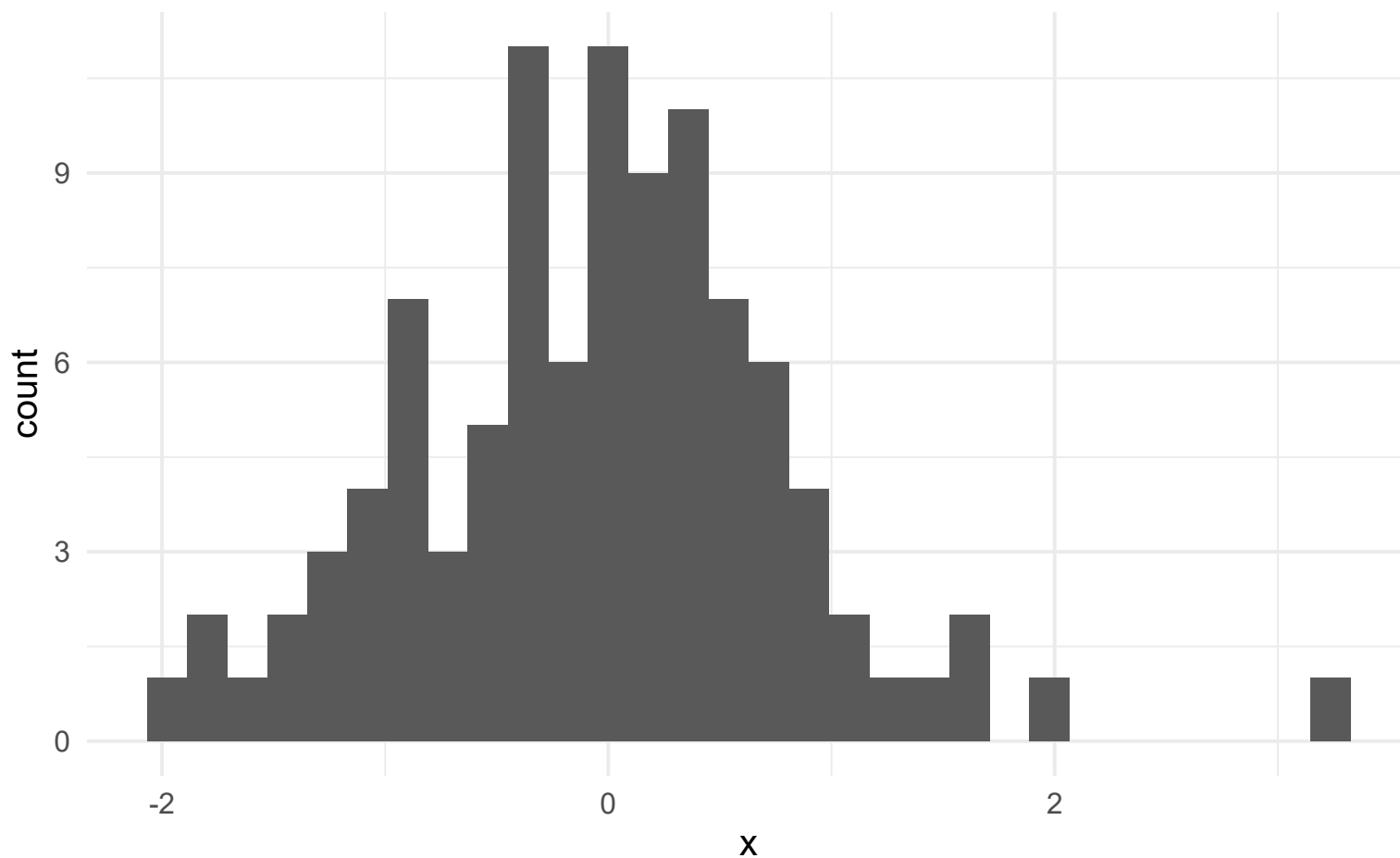
Histogram of example.dat\$x



Single numeric variable: Histogram in

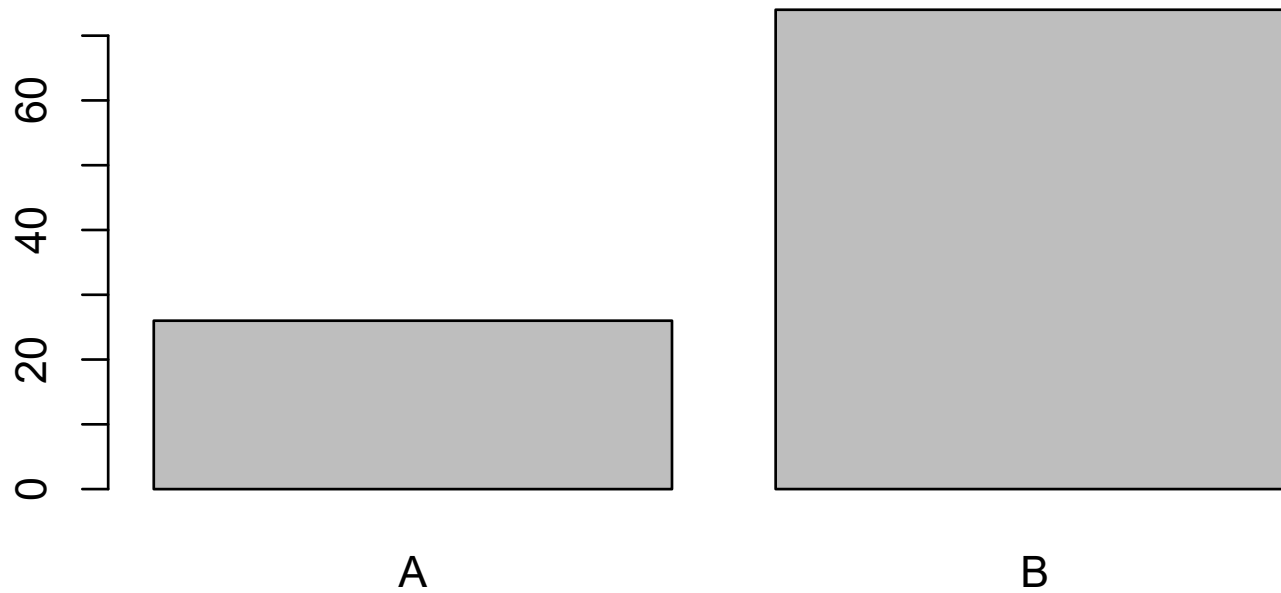


```
ggplot(example.dat, aes(x = x)) + geom_histogram() + theme_minimal()
```



Single categorical variable: Bar plot in base

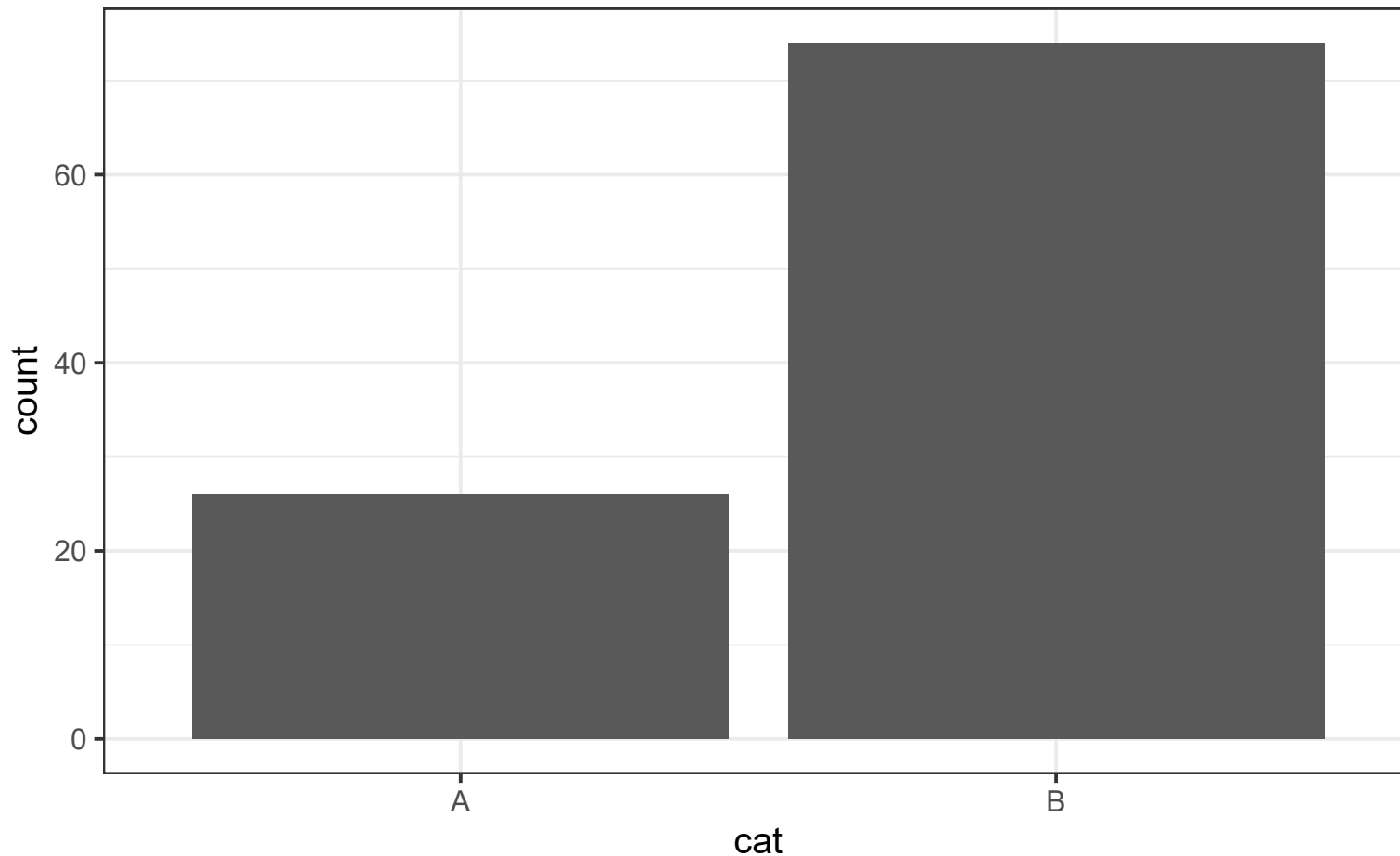
```
barplot(table(example.dat$cat))
```



Single categorical variable: Bar plot



```
ggplot(example.dat, aes(x = cat)) + geom_bar() + theme_bw() # Change the theme
```



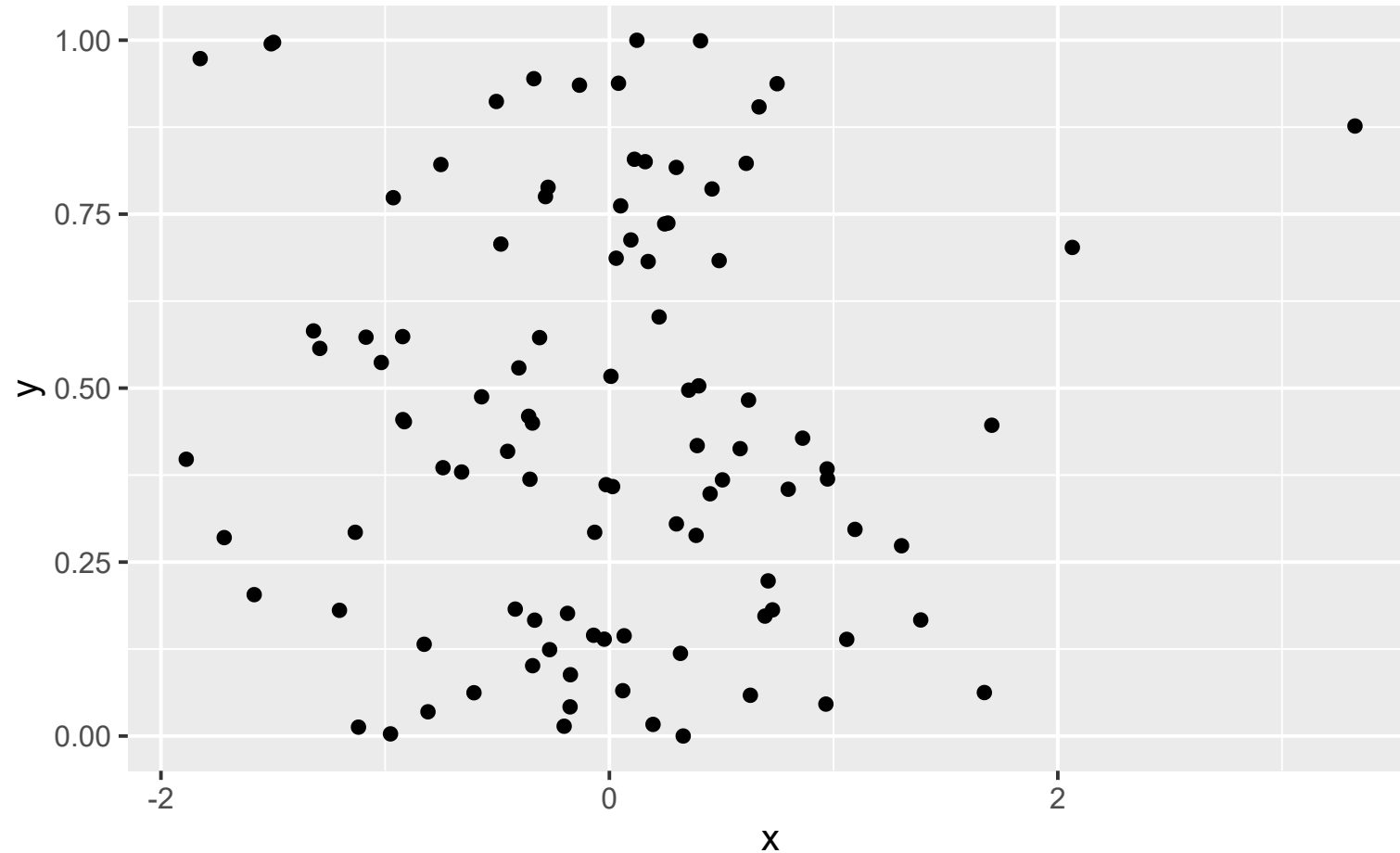
Two numeric variables: Scatterplot in base

```
# These two plot commands are near equivalent  
plot(y ~ x, data = example.dat, main = "formula input")  
plot(example.dat$x, example.dat$y, main = "argument input")
```

Two numeric variables: Scatterplot in



```
ggplot(example.dat, aes(x = x, y = y)) + geom_point() # default theme here
```





A crash course in


What is ?

- Free, open source software designed for statistical computing
- Runs on Windows, Mac, Linux and other flavours of Unix
- Provides an interactive environment, but it is also an interpreted programming language
- Its power lies in the thousands of contributed packages on

Base and the

- The tidyverse popularised by Hadley Wickham and the team at  Studio
 - Has a (somewhat) standardised syntax (pipes `%>%` are king except for `+` in `ggplot2`)
 - Produces more human readable code
 - Not as stable as base, breaking changes occur as tidyverse develops.
 - Good for interactive data analyst
- Core base 
 - Good for production level code
 - Stable
 - Function syntax inconsistent

What is R Studio?

- RStudio is an integrated development environment (IDE) for 
- Think of it as the front-end, like a powerful text editor
- R needs to be installed first before RStudio.

Session

- **Working Directory:** Each session runs from a working directory
 - `getwd()` shows the current working directory for R.
 - `setwd(<path>)` to change the working directory where `<path>` is a string
 - E.g. `setwd("C:/Users/usyd-student")` for a windows user.
- **Workspace:** Includes
 - Global environment: Data and variables loaded or defined
 - package environments: Any loaded packages with their functions/data.
- **History:**
 - Can view your recent commands in the History pane
 - Can navigate previous commands using up and down arrows at your prompt

Packages

- Inspect the current environment
 - `sessionInfo()`: shows everything in the current R session.
- To install a new package,
 - `install.packages("cluster")` will install the `cluster` package from the Comprehensive R Archive Network (CRAN) repository
- To load a package to use in the environment `library(cluster)`
 - After loading a package, you will be able to use the functions provided in that package
- If name conflicts arise you can specify the desired function using `::`
 - E.g. `dplyr::filter` will use the `filter` function from the `dplyr` package instead of the `stats::filter` function.

Help

- CRAN requires every exported function in every contributed package to have a help file
 - `help.start()`
 - `help(plot)`
 - `? plot`
- In general, the help file for each function gives a brief description of what the function does, the required inputs, the expected outputs and some examples
 - Some packages also include a "vignette", a short document with guidance on using the package.

Quirks of R syntax

- `<-` is the symbol for 'assign'
 - Example: `x <- 14`
 - which is equivalent to: `x = 14` when used at the prompt
- Should use `=` for argument matching in a function
- The period symbol `.` can be used in variable names
 - Example: `new.vector <- c("A", "B", "C")`
- Element indexing starts at 1

```
new.vector <- c("A", "B", "C")  
new.vector[0]
```

```
## character(0)
```

```
new.vector[1]
```

```
## [1] "A"
```

Basic data types in R

Classical data types

- Numeric
- Integer
- Logical
- Character
- Complex

- Factor : Categorical data type
 - Unique to R (integer with some attributes)

```
data("ToothGrowth")  
levels(ToothGrowth$supp)
```

```
## [1] "OJ" "VC"
```

```
class(ToothGrowth$supp)
```

```
## [1] "factor"
```

```
str(ToothGrowth$supp)
```

```
## Factor w/ 2 levels "OJ","VC": 2 2 2 2 2 2 2 2 2 2 1
```

Homogeneous vs non-homogenous data types in R

Homogeneous

- Vector
 - Sequence of data elements of the same basic data type
- Matrix
 - Collection of data elements in a 2-dimensional array with rows and columns

Non-homogeneous

- List
 - More general structure containing other objects (including possibly other lists)
- Data frame
 - Used for storing data, each column can be a different basic type
 - All columns must have the same length

Vectors

```
new.vector <- c(1, 2, 3)  
class(new.vector)
```

```
## [1] "numeric"
```

```
length(new.vector)
```

```
## [1] 3
```

```
new.vector[1:2]
```

```
## [1] 1 2
```

```
new.vector <- c(1, 2, "hello")  
class(new.vector)
```

```
## [1] "character"
```

Matrix

```
A <- matrix(c(2, 4, 3, 1, 7, 8), nrow = 3)
# Unless specified otherwise, it will fill the matrix by column.
A
```

```
##      [,1] [,2]
## [1,]    2    1
## [2,]    4    7
## [3,]    3    8
```

```
A[2, 1]
```

```
## [1] 4
```

```
A[1, ]
```

```
## [1] 2 1
```

```
A[5]
```

```
## [1] 7
```

List

```
vector.a <- c(1, 2, 3)
vector.b <- c("hello", "world", "!!")
new.list <- list(c(vector.a, vector.b))
new.list
```

```
## [[1]]
## [1] "1"      "2"      "3"      "hello" "world" "!!!"
```

```
new.list <- list(vector.a, vector.b)
new.list
```

```
## [[1]]
## [1] 1 2 3
##
## [[2]]
## [1] "hello" "world" "!!!"
```

```
new.list[[1]]
```

```
## [1] 1 2 3
```


Data frames

```
head(warpbreaks)
```

```
##   breaks wool tension
## 1     26    A        L
## 2     30    A        L
## 3     54    A        L
## 4     25    A        L
## 5     70    A        L
## 6     52    A        L
```

```
class(warpbreaks)
```

```
## [1] "data.frame"
```

```
head(warpbreaks$wool)
```

```
## [1] A A A A A A
## Levels: A B
```

```
str(warpbreaks)
```

```
## 'data.frame':   54 obs. of  3 variables:
## $ breaks : num  26 30 54 25 70 52 51 26 67 18 ..
## $ wool : Factor w/ 2 levels "A","B": 1 1 1 1 1
## $ tension: Factor w/ 3 levels "L","M","H": 1 1 1
```

```
names(warpbreaks)
```

```
## [1] "breaks" "wool" "tension"
```

Rprojects

- Each Rstudio project has its own working R session, workspace, history, and source documents
- You can either create an Rproject in a new directory or within an existing directory
- When you open an .Rproj file, the following happens:
 - A new R session (process) is started
 - If it exists, the .Rprofile in the project's main directory is loaded
 - If applicable, the .RData file in the main directory is loaded
 - If set, the .Rhistory file in the main directory is loaded
 - The current working directory is set to the project directory
 - If set, previously edited documents appear in the source editor.