

R and the tidyverse

Winter Institute in Data Science

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What is R?

R Functions

Data Structures

Core tidyverse Transformation Functions

Other Common Transformation Functions

Helper Functions

R + RTM

► \approx 20th anniversary

R + RTM

- ▶ \approx 20th anniversary
- ▶ Author of 3.5 R packages

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 - ▶ Experimental design (`blockTools`)

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 - ▶ Experimental design (**blockTools**)
 - ▶ Ecological inference (**eiPack**)

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 - ▶ Twitter conversation analysis (**botscan**)

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 - ▶ Web-scraping, mapping, mail-merging (**muRL**)

R + RTM

- ▶ \approx 20th anniversary
- ▶ Author of 3.5 R packages
 - ▶ Experimental design (`blockTools`)
 - ▶ Ecological inference (`eiPack`)
 - ▶ Twitter conversation analysis (`botscan`)
 - ▶ Web-scraping, mapping, mail-merging (`muRL`)
- ▶ Research in R, teach with R, teach R, consult with R, run family gift exchange with R, War, ...

What is R?

What is R?

“R is a language and environment
for statistical computing and graphics”

What is R?

“R is a language and environment
for statistical computing and graphics”

- Software for calculation, computation, data analysis

What is R?

“R is a language and environment
for statistical computing and graphics”

- ▶ Software for calculation, computation, data analysis
- ▶ Well-developed graphical facilities
- ▶ A programming language

Why use R (and Python)?

- ▶ Standard for data analysis, modeling, graphics
- ▶ High-quality, powerful, flexible, extensible
- ▶ International community (including here)
- ▶ Platform independent (Mac OSX, Windows, Linux/Unix)
- ▶ Free + Open Source
- ▶ Reads `.xlsx`, `.dta`, `.csv`, `.txt`, `.json`, ...
- ▶ Interfaces with C, C++, Ruby, Java, Python, Unix, ...
- ▶ Command line (Mac OS Terminal prompt),
Windows/Mac/Linux GUIs
- ▶ RStudio: excellent IDE (code, plots, etc. 1 window;
GitHub)
- ▶ Let R teach you R: `swirl`

How does R Work?

How does R Work?

```
5 + 2
```


How does R Work?

```
5 + 2
```

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

How does R Work?

```
5 + 2
```

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

```
sum(5, 2)
```

How does R Work?

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How does R Work?

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5 + 2
```

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## [1] 7
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```
sum(5, 2)
```

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

But not just printing:

How does R Work?

```
5 + 2
```

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

```
sum(5, 2)
```

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

But not just printing:

```
a <- sum(5, 2)
```

```
b <- median(1:10)
```

```
a + b # (Hi -- Notes after the '#' R ignores)
```

How does R Work?

```
5 + 2
```

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

```
sum(5, 2)
```

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

But not just printing:

```
a <- sum(5, 2)
```

```
b <- median(1:10)
```

```
a + b # (Hi -- Notes after the '#' R ignores)
```

```
## [1] 12.5
```

How does R Work?

```
5 + 2
```

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

```
sum(5, 2)
```

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

But not just printing:

```
a <- sum(5, 2)
```

```
b <- median(1:10)
```

```
a + b # (Hi -- Notes after the `#` R ignores)
```

```
## [1] 12.5
```

```
difftime("2025-07-04", "2025-01-03")
```

How does R Work?

```
5 + 2
```

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

```
sum(5, 2)
```

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

But not just printing:

```
a <- sum(5, 2)
```

```
b <- median(1:10)
```

```
a + b # (Hi -- Notes after the `#` R ignores)
```

```
## [1] 12.5
```

```
difftime("2025-07-04", "2025-01-03")
```

```
## Time difference of 181.9583 days
```


How to Work in R

- ▶ Open R/RStudio

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- ▶ Create a `.R` file

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- ▶ Run them to get output, results, graphics, ...

How to Work in R

- ▶ Open R/RStudio
- ▶ Create a `.R` file
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 - ↪ Mac: Cmd-Return to execute a line
(better than copy-paste)
 - ↪ At `>`, [Up Arrow] recalls previous command

How to Work in R

- ▶ Open R/RStudio
- ▶ Create a `.R` file
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- ▶ Run them to get output, results, graphics, ...
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- ▶ Save `.R` file

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How to Work in R

- ▶ Open R/RStudio
- ▶ Create a `.R` file
- ▶ Add code and comments to the `.R` file
- ▶ Run them to get output, results, graphics, ...
 - ↪ Mac: Cmd-Return to execute a line
(better than copy-paste)
 - ↪ At `>`, [Up Arrow] recalls previous command
- ▶ Save `.R` file
- ▶ Quit (do not save workspace)

How to Work in R

- ▶ Open R/RStudio
- ▶ Create a `.R` file
- ▶ Add code and comments to the `.R` file
- ▶ Run them to get output, results, graphics, ...
 - ↪ Mac: Cmd-Return to execute a line
(better than copy-paste)
 - ↪ At `>`, [Up Arrow] recalls previous command
- ▶ Save `.R` file
- ▶ Quit (do not save workspace)

Later, ...

- ▶ Open `.R` file
- ▶ Add more code and comments ...

How do I get help?

Within R:

```
help(mean)  
help.search("median")
```

How do I get help?

Within R:

```
help(mean)  
help.search("median")
```

```
example(mean)
```

```
##  
## mean> x <- c(0:10, 50)  
##  
## mean> xm <- mean(x)  
##  
## mean> c(xm, mean(x, trim = 0.10))  
## [1] 8.75 5.50
```

How do I get help?

Outside of R:

- ▶ Q & A

- ▶ Stack Overflow (tags `r`, `rstats`)
- ▶ DATASCIENCE-L@listserv.american.edu (info here)

How do I get help?

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▶ Q & A

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▶ Courses and references

- ▶ `rseek.org` (custom Google search)
- ▶ `CRANsearcher` (RStudio add-in for pkgs)
- ▶ Lynda.com video courses through AU Portal
- ▶ Many good books and documents: Cookbook, Intro Statistics, Student Companion, Graphics, Mapping, Programming, Short Ref Card, ...
- ▶ Wickham, Çetinkaya-Rundel, and Golemund (2023)

R Functions

Functions

```
function(arg1, arg2, ...){  
  <the function code here...>  
}
```

Functions

```
function(arg1, arg2, ...){  
  <the function code here...>  
}
```

```
sum(5, 2)
```

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


Functions

```
function(arg1, arg2, ...){  
  <the function code here...>  
}
```

```
sum(5, 2)
```

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

```
mean(1:4)
```

```
## [1] 2.5
```

Functions

```
## [1] "(Ready, Andrew?)"
```

Functions

```
## [1] "(Ready, Andrew?)"
```

```
nchar("greetings")
```

Functions

```
## [1] "(Ready, Andrew?)"
```

```
nchar("greetings")
```

```
## [1] 9
```

Functions

```
## [1] "(Ready, Andrew?)"
```

```
nchar("greetings")
```

```
## [1] 9
```

```
## [1] "(Ready, Natalie?)"
```

Functions

```
## [1] "(Ready, Andrew?)"
```

```
nchar("greetings")
```

```
## [1] 9
```

```
## [1] "(Ready, Natalie?)"
```

```
length(us)
```

Functions

```
## [1] "(Ready, Andrew?)"
```

```
nchar("greetings")
```

```
## [1] 9
```

```
## [1] "(Ready, Natalie?)"
```

```
length(us)
```

```
## [1] 8
```

A Useful Function: `c()`

To concatenate objects into a vector, use `c()`:

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```
c(1, 3, 8, 20)
```

```
## [1] 1 3 8 20
```

A Useful Function: `c()`

To concatenate objects into a vector, use `c()`:

```
c(1, 3, 8, 20)
```

```
## [1] 1 3 8 20
```

```
c("a", "merican", "u")
```

A Useful Function: `c()`

To concatenate objects into a vector, use `c()`:

```
c(1, 3, 8, 20)
```

```
## [1] 1 3 8 20
```

```
c("a", "merican", "u")
```

```
## [1] "a" "merican" "u"
```

A Useful Function: `c()`

To concatenate objects into a vector, use `c()`:

```
c(1, 3, 8, 20)
```

```
## [1] 1 3 8 20
```

```
c("a", "merican", "u")
```

```
## [1] "a" "merican" "u"
```

```
c(1, 2, "hello")
```

A Useful Function: `c()`

To concatenate objects into a vector, use `c()`:

```
c(1, 3, 8, 20)
```

```
## [1] 1 3 8 20
```

```
c("a", "merican", "u")
```

```
## [1] "a" "merican" "u"
```

```
c(1, 2, "hello")
```

```
## [1] "1" "2" "hello"
```

Functions' Arguments

What arguments does a function have?

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What arguments does a function have?

```
help(median)
```

```
args(median)
```

Functions' Arguments

What arguments does a function have?

```
help(median)
```

```
args(median)
```

```
## function (x, na.rm = FALSE, ...)
```

```
## NULL
```


Functions' Arguments

```
median(1:3)
```

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

Functions' Arguments

```
median(1:3)
```

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

```
x <- c(1, 2, 3, NA)  
median(x)
```

Functions' Arguments

```
median(1:3)
```

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

```
x <- c(1, 2, 3, NA)  
median(x)
```

```
## [1] NA
```

Functions' Arguments

```
median(1:3)
```

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

```
x <- c(1, 2, 3, NA)  
median(x)
```

```
## [1] NA
```

```
median(x, na.rm = TRUE)
```

Functions' Arguments

```
median(1:3)
```

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

```
x <- c(1, 2, 3, NA)  
median(x)
```

```
## [1] NA
```

```
median(x, na.rm = TRUE)
```

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

Functions' Arguments

You can specify arguments in order or by name:

Functions' Arguments

You can specify arguments in order or by name:

```
median(x, TRUE)
```

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

Functions' Arguments

You can specify arguments in order or by name:

```
median(x, TRUE)
```

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

```
median(na.rm = TRUE, x)
```

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


Functions' Arguments

You can specify arguments in order or by name:

```
median(x, TRUE)
```

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

```
median(na.rm = TRUE, x)
```

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

```
median(TRUE, x)
```

Functions' Arguments

You can specify arguments in order or by name:

```
median(x, TRUE)
```

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

```
median(na.rm = TRUE, x)
```

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

```
median(TRUE, x)
```

```
## Error in if (na.rm) x <- x[!is.na(x)] else if (any(
```

Some Useful Functions

Managing the workspace:

```
# Get the working directory ("Where am I?"):  
getwd()
```

```
## [1] "/Users/rtm/Documents/github/winter-inst/01-intro"
```

Some Useful Functions

Managing the workspace:

```
# Get the working directory ("Where am I?"):  
getwd()
```

```
## [1] "/Users/rtm/Documents/github/winter-inst/01-intro"
```

```
# Set the working directory:  
setwd("~/Desktop/")
```

Some Useful Functions

Managing the workspace:

```
# Get the working directory ("Where am I?"):  
getwd()
```

```
## [1] "/Users/rtm/Documents/github/winter-inst/01-intro"
```

```
# Set the working directory:  
setwd("~/Desktop/")
```

Better, use “R projects” and the `here` package:

```
library(here)
```

```
## here() starts at /Users/rtm/Documents/github/winter-
```

Some Useful Functions

Managing the workspace:

```
# Get the working directory ("Where am I?"):  
getwd()
```

```
## [1] "/Users/rtm/Documents/github/winter-inst/01-intro"
```

```
# Set the working directory:  
setwd("~/Desktop/")
```

Better, use “R projects” and the `here` package:

```
library(here)
```

```
## here() starts at /Users/rtm/Documents/github/winter-
```

```
here()
```

```
## [1] "/Users/rtm/Documents/github/winter-inst" 70 / 265
```

Some Useful Functions

Managing the workspace:

```
# List objects in working dir:  
ls()
```

```
## [1] "a"    "b"    "tmp"  "us"   "x"    "xm"
```

```
# Remove `x' from working dir:  
rm(x)
```

```
# Remove everything from working dir:  
# rm(list = ls())
```

Some Useful Functions

Managing the workspace:

```
# List objects in working dir:  
ls()
```

```
## [1] "a"    "b"    "tmp"  "us"   "x"    "xm"
```

```
# Remove `x` from working dir:  
rm(x)
```

```
# Remove everything from working dir:  
# rm(list = ls())
```

Better, start a fresh session to *really* reset environment:

RStudio - Session - Restart R

Mac: Shift - Cmd - 0

Some Useful Mathematical Functions

```
5 + 2
```

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

```
5 - 2
```

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

```
5 * 2
```

```
## [1] 10
```

```
5 / 2
```

```
## [1] 2.5
```

Some Useful Mathematical Functions

```
5^2
```

```
## [1] 25
```

```
sqrt(25)
```

```
## [1] 5
```

```
20 %% 3
```

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

Some Useful Mathematical Functions and Values

```
pi
```

```
## [1] 3.141593
```

```
abs(-3)
```

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

```
exp(1)
```

```
## [1] 2.718282
```

```
log(exp(2))
```

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

```
sin(pi / 2)
```

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

Logicals

TRUE

```
## [1] TRUE
```

FALSE

```
## [1] FALSE
```

Logicals

```
TRUE
```

```
## [1] TRUE
```

```
FALSE
```

```
## [1] FALSE
```

```
TRUE == FALSE
```

Logicals

```
TRUE
```

```
## [1] TRUE
```

```
FALSE
```

```
## [1] FALSE
```

```
TRUE == FALSE
```

```
## [1] FALSE
```

Logicals

```
c(1, 2) == c(1, 3)
```

Logicals

```
c(1, 2) == c(1, 3)
```

```
## [1] TRUE FALSE
```


Logicals

```
c(1, 2) == c(1, 3)
```

```
## [1] TRUE FALSE
```

```
c(1, 2) != c(1, 3)
```

Logicals

```
c(1, 2) == c(1, 3)
```

```
## [1] TRUE FALSE
```

```
c(1, 2) != c(1, 3)
```

```
## [1] FALSE TRUE
```

Logicals

```
c(1, 2) == c(1, 3)
```

```
## [1] TRUE FALSE
```

```
c(1, 2) != c(1, 3)
```

```
## [1] FALSE TRUE
```

```
c(1, 2) < c(1, 3)
```

Logicals

```
c(1, 2) == c(1, 3)
```

```
## [1] TRUE FALSE
```

```
c(1, 2) != c(1, 3)
```

```
## [1] FALSE TRUE
```

```
c(1, 2) < c(1, 3)
```

```
## [1] FALSE TRUE
```

Logicals

```
c(1, 2) > c(1, 3)
```

```
## [1] FALSE FALSE
```

```
c(1, 2) <= c(1, 3)
```

```
## [1] TRUE TRUE
```

```
c(1, 2) >= c(1, 3)
```

```
## [1] TRUE FALSE
```

How to Write a New Function

```
sumDiff <- function(num1 = 3, num2 = 5){  
  
  sum <- num1 + num2  
  
  diff <- num1 - num2  
  
  return(c(sum, diff))  
}
```

How to Write a New Function

```
sumDiff <- function(num1 = 3, num2 = 5){  
  
  sum <- num1 + num2  
  
  diff <- num1 - num2  
  
  return(c(sum, diff))  
}
```

Now, cut and paste function into R prompt.

How to Write a New Function

```
sumDiff <- function(num1 = 3, num2 = 5){  
  
  sum <- num1 + num2  
  
  diff <- num1 - num2  
  
  return(c(sum, diff))  
}
```

Now, cut and paste function into R prompt.
(R will tell you if syntax error.)

My New Function

```
sumDiff()
```

My New Function

```
sumDiff()
```

```
## [1] 8 -2
```

My New Function

```
sumDiff()
```

```
## [1] 8 -2
```

```
sumDiff(3, 5)
```

My New Function

```
sumDiff()
```

```
## [1] 8 -2
```

```
sumDiff(3, 5)
```

```
## [1] 8 -2
```

My New Function

```
sumDiff()
```

```
## [1] 8 -2
```

```
sumDiff(3, 5)
```

```
## [1] 8 -2
```

```
sumDiff(num2 = 5, num1 = 3)
```

My New Function

```
sumDiff()
```

```
## [1] 8 -2
```

```
sumDiff(3, 5)
```

```
## [1] 8 -2
```

```
sumDiff(num2 = 5, num1 = 3)
```

```
## [1] 8 -2
```

My New Function

```
sumDiff()
```

```
## [1] 8 -2
```

```
sumDiff(3, 5)
```

```
## [1] 8 -2
```

```
sumDiff(num2 = 5, num1 = 3)
```

```
## [1] 8 -2
```

```
sumDiff(5, 3)
```

My New Function

```
sumDiff()
```

```
## [1] 8 -2
```

```
sumDiff(3, 5)
```

```
## [1] 8 -2
```

```
sumDiff(num2 = 5, num1 = 3)
```

```
## [1] 8 -2
```

```
sumDiff(5, 3)
```

```
## [1] 8 2
```


My New Function

```
sumDiff(2, 20)
```

My New Function

```
sumDiff(2, 20)
```

```
## [1] 22 -18
```

My New Function

```
sumDiff(2, 20)
```

```
## [1] 22 -18
```

```
sumDiff(1, "yes")
```

My New Function

```
sumDiff(2, 20)
```

```
## [1] 22 -18
```

```
sumDiff(1, "yes")
```

```
## Error in num1 + num2: non-numeric argument
```

Data Structures

Data Types

- ▶ Numeric
- ▶ Integer
- ▶ Complex
- ▶ Logical
- ▶ Character
- ▶ Factor

Data Types

- ▶ Numeric

- ▶ Integer

- ▶ Complex

- ▶ Logical

- ▶ Character

- ▶ Factor

↪ categorical vars: stored as numeric, but w/
char label

↪ great for statistical modeling, graphics
(auto indicators, e.g.)

Data Structures

- ▶ Scalar
- ▶ Vector
- ▶ Matrix

Data Structures

- ▶ Scalar
- ▶ Vector
- ▶ Matrix
- ▶ Data frame (like matrix, w/ attributes)

Data Structures

- ▶ Scalar
- ▶ Vector
- ▶ Matrix
- ▶ Data frame (like matrix, w/ attributes)
- ▶ Tibble (tidyverse dataframe)

Data Structures

- ▶ Scalar
- ▶ Vector
- ▶ Matrix
- ▶ Data frame (like matrix, w/ attributes)
- ▶ Tibble (tidyverse dataframe)
- ▶ List (flexible storage; regression/cluster output)

What is this thing?

```
x <- 1:4  
is.vector(x)
```

What is this thing?

```
x <- 1:4  
is.vector(x)
```

```
## [1] TRUE
```

What is this thing?

```
x <- 1:4  
is.vector(x)
```

```
## [1] TRUE
```

```
is.numeric(x)
```

What is this thing?

```
x <- 1:4  
is.vector(x)
```

```
## [1] TRUE
```

```
is.numeric(x)
```

```
## [1] TRUE
```

What is this thing?

```
x <- 1:4  
is.vector(x)
```

```
## [1] TRUE
```

```
is.numeric(x)
```

```
## [1] TRUE
```

```
is.character(x)
```


What is this thing?

```
x <- 1:4  
is.vector(x)
```

```
## [1] TRUE
```

```
is.numeric(x)
```

```
## [1] TRUE
```

```
is.character(x)
```

```
## [1] FALSE
```

What is this thing?

```
y <- c("a", "hello")  
is.vector(y)
```

What is this thing?

```
y <- c("a", "hello")  
is.vector(y)
```

```
## [1] TRUE
```

What is this thing?

```
y <- c("a", "hello")  
is.vector(y)
```

```
## [1] TRUE
```

```
is.numeric(y)
```

What is this thing?

```
y <- c("a", "hello")  
is.vector(y)
```

```
## [1] TRUE
```

```
is.numeric(y)
```

```
## [1] FALSE
```

What is this thing?

```
y <- c("a", "hello")  
is.vector(y)
```

```
## [1] TRUE
```

```
is.numeric(y)
```

```
## [1] FALSE
```

```
is.character(y)
```

What is this thing?

```
y <- c("a", "hello")  
is.vector(y)
```

```
## [1] TRUE
```

```
is.numeric(y)
```

```
## [1] FALSE
```

```
is.character(y)
```

```
## [1] TRUE
```

What is this thing?

```
z <- c(1, 2, 3, NA)
isNAz <- is.na(z)
```


What is this thing?

```
z <- c(1, 2, 3, NA)
isNAz <- is.na(z)
```

```
isNAz
```

```
## [1] FALSE FALSE FALSE  TRUE
```

What is this thing?

```
z <- c(1, 2, 3, NA)
isNAz <- is.na(z)
```

```
isNAz
```

```
## [1] FALSE FALSE FALSE  TRUE
```

```
sum(isNAz)
```

What is this thing?

```
z <- c(1, 2, 3, NA)
isNAz <- is.na(z)
```

```
isNAz
```

```
## [1] FALSE FALSE FALSE  TRUE
```

```
sum(isNAz)
```

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

What is this thing?

```
z <- c(1, 2, 3, NA)
isNAz <- is.na(z)
```

```
isNAz
```

```
## [1] FALSE FALSE FALSE  TRUE
```

```
sum(isNAz)
```

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

```
mean(isNAz)
```

What is this thing?

```
z <- c(1, 2, 3, NA)
isNAz <- is.na(z)
```

```
isNAz
```

```
## [1] FALSE FALSE FALSE  TRUE
```

```
sum(isNAz)
```

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

```
mean(isNAz)
```

```
## [1] 0.25
```

What is this thing?

```
z <- c(1, 2, 3, NA)
isNAz <- is.na(z)
```

```
isNAz
```

```
## [1] FALSE FALSE FALSE  TRUE
```

```
sum(isNAz)
```

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

```
mean(isNAz)
```

```
## [1] 0.25
```

(“coercion”)

Data from Where?

- ▶ From the keyboard
- ▶ From within a package
- ▶ From `.RData/.RDS` file
- ▶ From a local `.txt`, `.csv`, `.dta`, `.xlsx`, etc. file
- ▶ From a remote file on the web
- ▶ From remote HTML

Data: Extracting and Assigning Vector Elements

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
x[2]
```


Data: Extracting and Assigning Vector Elements

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
x[2]
```

```
## [1] 20
```

Data: Extracting and Assigning Vector Elements

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
x[2]
```

```
## [1] 20
```

```
y[3:5]
```

Data: Extracting and Assigning Vector Elements

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
x[2]
```

```
## [1] 20
```

```
y[3:5]
```

```
## [1] 30 70 10
```

Data: Extracting and Assigning Vector Elements

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
x[2]
```

```
## [1] 20
```

```
y[3:5]
```

```
## [1] 30 70 10
```

```
x[c(1, 5)]
```

Data: Extracting and Assigning Vector Elements

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
x[2]
```

```
## [1] 20
```

```
y[3:5]
```

```
## [1] 30 70 10
```

```
x[c(1, 5)]
```

```
## [1] 10 25
```

Data: Extracting and Assigning Vector Elements

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
x[2]
```

```
## [1] 20
```

```
y[3:5]
```

```
## [1] 30 70 10
```

```
x[c(1, 5)]
```

```
## [1] 10 25
```

```
x[3] <- 100
x
```

Data: Extracting and Assigning Vector Elements

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
x[2]
```

```
## [1] 20
```

```
y[3:5]
```

```
## [1] 30 70 10
```

```
x[c(1, 5)]
```

```
## [1] 10 25
```

```
x[3] <- 100
x
```

```
## [1] 10 20 100 40 25
```

Data: Extracting and Assigning Matrix Elements

```
m <- matrix(c(20, 20, 30, 10, 20, 30), 3, 2)
```

```
m
```

```
##      [,1] [,2]  
## [1,]   20  10  
## [2,]   20  20  
## [3,]   30  30
```


Data: Extracting and Assigning Matrix Elements

```
m <- matrix(c(20, 20, 30, 10, 20, 30), 3, 2)
```

```
m
```

```
##      [,1] [,2]  
## [1,]   20  10  
## [2,]   20  20  
## [3,]   30  30
```

```
m[1, 2]
```

Data: Extracting and Assigning Matrix Elements

```
m <- matrix(c(20, 20, 30, 10, 20, 30), 3, 2)
```

```
m
```

```
##      [,1] [,2]  
## [1,]   20  10  
## [2,]   20  20  
## [3,]   30  30
```

```
m[1, 2]
```

```
## [1] 10
```

Data: Extracting and Assigning Matrix Elements

```
m <- matrix(c(20, 20, 30, 10, 20, 30), 3, 2)
```

```
m
```

```
##      [,1] [,2]  
## [1,]   20  10  
## [2,]   20  20  
## [3,]   30  30
```

```
m[1, 2]
```

```
## [1] 10
```

```
m[2, 2] <- NA
```

```
m
```

Data: Extracting and Assigning Matrix Elements

```
m <- matrix(c(20, 20, 30, 10, 20, 30), 3, 2)
```

```
m
```

```
##      [,1] [,2]  
## [1,]   20  10  
## [2,]   20  20  
## [3,]   30  30
```

```
m[1, 2]
```

```
## [1] 10
```

```
m[2, 2] <- NA
```

```
m
```

```
##      [,1] [,2]  
## [1,]   20  10  
## [2,]   20  NA  
## [3,]   30  30
```

Data from Keyboard, into a Data Frame

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
df <- data.frame(age = y, score = x)
```

Data from Keyboard, into a Data Frame

```
y <- c(20, 20, 30, 70, 10)
x <- c(10, 20, 30, 40, 25)
df <- data.frame(age = y, score = x)
```

```
df
```

```
##   age score
## 1  20    10
## 2  20    20
## 3  30    30
## 4  70    40
## 5  10    25
```

Data from Keyboard, into a Data Frame

```
df$age
```

```
## [1] 20 20 30 70 10
```

Data from Keyboard, into a Data Frame

```
df$age
```

```
## [1] 20 20 30 70 10
```

```
rownames(df)
```

```
## [1] "1" "2" "3" "4" "5"
```


Data from Keyboard, into a Data Frame

```
df$age
```

```
## [1] 20 20 30 70 10
```

```
rownames(df)
```

```
## [1] "1" "2" "3" "4" "5"
```

```
colnames(df)
```

```
## [1] "age" "score"
```

Data: From Keyboard, into a List

```
my_list <- list(x = 1:3, y = letters[1:5],  
               final = matrix(1:4, 2, 2))
```

Data: From Keyboard, into a List

```
my_list <- list(x = 1:3, y = letters[1:5],  
               final = matrix(1:4, 2, 2))
```

```
my_list
```

```
## $x  
## [1] 1 2 3  
##  
## $y  
## [1] "a" "b" "c" "d" "e"  
##  
## $final  
##      [,1] [,2]  
## [1,]    1    3  
## [2,]    2    4
```

Data: From Keyboard, into a List

```
my_list[[1]]
```

Data: From Keyboard, into a List

```
my_list[[1]]
```

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

Data: From Keyboard, into a List

```
my_list[[1]]
```

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

```
my_list[["final"]]
```

Data: From Keyboard, into a List

```
my_list[[1]]
```

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

```
my_list[["final"]]
```

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

Data: Lists

```
my_list$x
```

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

```
my_list$y
```

```
## [1] "a" "b" "c" "d" "e"
```


Data: Lists

```
my_list$x
```

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

```
my_list$y
```

```
## [1] "a" "b" "c" "d" "e"
```

A data frame is a list.

Data from a Package

```
library(car)  
data(Chile)
```

Data from a Package

```
library(car)  
data(Chile)
```

```
head(Chile)
```

##	region	population	sex	age	education	income	status
## 1	N	175000	M	65	P	35000	1.008
## 2	N	175000	M	29	PS	7500	-1.296
## 3	N	175000	F	38	P	15000	1.230
## 4	N	175000	F	49	P	35000	-1.031
## 5	N	175000	F	23	S	35000	-1.104
## 6	N	175000	F	28	P	7500	-1.046

Core tidyverse Transformation Functions

What is a Package?

An R package is an extension of R that includes

- ▶ a set of functions for users
- ▶ datasets
- ▶ demonstration code
- ▶ “background” code (in R or a compiled language)
- ▶ documentation
- ▶ metadata (authors, license, e.g.)

How do I get package `thispackage`?

How do I get package `thispackage`?

```
install.packages("thispackage")
```

(Once, per R version, at the Console.)

How do I get package `thispackage`?

```
install.packages("thispackage")
```

(Once, per R version, at the Console.)

Then, in my R file,

```
library(thispackage)
```


When we refer to a package (in English), we sometimes put it inside { }:

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- ▶ “Consider the `{lubridate}` package for that problem.”

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When we explicitly refer to a function from a package (in English or in code), we use ::

When we refer to a package (in English), we sometimes put it inside { }:

- ▶ “Consider the {lubridate} package for that problem.”

When we explicitly refer to a function from a package (in English or in code), we use ::

- ▶ English: “Use janitor::clean_names()”
- ▶ code:

```
df <- df |> janitor::clean_names()
```

What is the tidyverse?

Coherent, consistent *set* of R packages for data import, manipulation, visualization, etc.

What is the tidyverse?

Coherent, consistent *set* of R packages for data import, manipulation, visualization, etc.

How do I get the tidyverse?

```
## [1] "(Ready, Ryan?)"
```

What is the tidyverse?

Coherent, consistent *set* of R packages for data import, manipulation, visualization, etc.

How do I get the tidyverse?

```
## [1] "(Ready, Ryan?)"
```

What is the tidyverse?

Coherent, consistent *set* of R packages for data import, manipulation, visualization, etc.

How do I get the tidyverse?

```
## [1] "(Ready, Ryan?)"
```

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


What is the tidyverse?

Coherent, consistent *set* of R packages for data import, manipulation, visualization, etc.

How do I get the tidyverse?

```
## [1] "(Ready, Ryan?)"
```

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

```
library(tidyverse)
```

The Core tidyverse Transformation Functions

First:

```
library(tidyverse)
```

The Core tidyverse Transformation Functions

First:

```
library(tidyverse)
```

```
(or just library(dplyr))
```

The Core tidyverse Transformation Functions

First:

```
library(tidyverse)
```

```
(or just library(dplyr))
```

- ▶ `filter()`
- ▶ `arrange()`
- ▶ `group_by()` (and `ungroup()`)
- ▶ `select()` (and `rename()`)
- ▶ `mutate()`
- ▶ `transmute()`
- ▶ `summarise()`

Core Transformation Funcs: Social Pressure Experiment

```
# URL is "https://raw.githubusercontent.com/kosukeimai/  
#      qss/master/CAUSALITY/social.csv"  
social <- read_csv("http://j.mp/2Et71U0")  
dim(social)
```

```
## [1] 305866      6
```

Core Transformation Funcs: Social Pressure Experiment

```
# URL is "https://raw.githubusercontent.com/kosukeimai/  
#       qss/master/CAUSALITY/social.csv"  
social <- read_csv("http://j.mp/2Et71U0")  
dim(social)
```

```
## [1] 305866      6
```

```
head(social, 4)
```

```
## # A tibble: 4 x 6  
##   sex      yearofbirth primary2004 messages      primary2006 hhsize  
##   <chr>      <dbl>      <dbl> <chr>      <dbl>      <dbl>  
## 1 male      1941          0 Civic Duty      0          2  
## 2 female    1947          0 Civic Duty      0          2  
## 3 male      1951          0 Hawthorne      1          3  
## 4 female    1950          0 Hawthorne      1          3
```

`filter()`

Keep only voters in households that might have interference:

filter()

Keep only voters in households that might have interference:

```
table(social$hhsize)
```

```
##  
##      1      2      3      4      5      6      7  
## 42524 190294 51057 18596  2955   390   42
```


filter()

Keep only voters in households that might have interference:

```
table(social$hhsize)
```

```
##  
##      1      2      3      4      5      6      7  
## 42524 190294 51057 18596  2955   390   42
```

```
df_interf <- filter(social, hhsize > 1)  
dim(df_interf)
```

```
## [1] 263342      6
```

`filter()`

Keep only non-voters who might be subject to interference:

`filter()`

Keep only non-voters who might be subject to interference:

```
filter(social, (hhsiz > 1) & (primary 2004 == 0))
```

filter()

Keep only non-voters who might be subject to interference:

```
filter(social, (hhsiz > 1) & (primary 2004 == 0))
```

```
## Error: <text>:1:40: unexpected numeric constant
## 1: filter(social, (hhsiz > 1) & (primary 2004
##                                     ^
```

filter()

Keep only non-voters who might be subject to interference:

```
filter(social, (hysize > 1) & (primary 2004 == 0))
```

```
## Error: <text>:1:40: unexpected numeric constant
## 1: filter(social, (hysize > 1) & (primary 2004
##                                     ^
```

```
filter(social, (hysize > 1) & (primary2004 == 0))
```

```
## # A tibble: 161,275 x 6
```

```
##   sex      yearofbirth primary2004 messages      primary2006 hhsi
##   <chr>         <dbl>         <dbl> <chr>             <dbl>    <dbl>
## 1 male          1941             0 Civic Duty         0
## 2 female        1947             0 Civic Duty         0
## 3 male          1951             0 Hawthorne          1
## 4 female        1950             0 Hawthorne          1
## 5 female        1982             0 Hawthorne          1
## 6 male          1981             0 Control            0
## 7 female        1959             0 Control            0
```

`arrange()`

Sort by birth year, then household size

arrange()

Sort by birth year, then household size

```
arrange(social, yearofbirth, hhsize)
```

```
## # A tibble: 305,866 x 6
```

```
##   sex      yearofbirth primary2004 messages  primary2006 hhsize
##   <chr>      <dbl>      <dbl> <chr>      <dbl>    <dbl>
## 1 female    1900          0 Control      0        1
## 2 female    1900          0 Control      0        2
## 3 male      1900          1 Control      0        2
## 4 male      1900          1 Control      1        2
## 5 female    1900          0 Hawthorne    0        2
## 6 female    1900          1 Control      1        3
## 7 female    1902          1 Control      0        1
## 8 female    1902          1 Control      0        3
## 9 male      1903          1 Control      0        1
## 10 female   1904          0 Control      0        1
## # i 305,856 more rows
```

```
# social |> arrange(yearofbirth, hhsize)
```

`mutate()`

Create new variable (`under_30`), TRUE/FALSE

mutate()

Create new variable (under_30), TRUE/FALSE

```
social |> mutate(under_30 = yearofbirth > 1976)
```

```
## # A tibble: 305,866 x 7
##   sex      yearofbirth primary2004 messages  primary2006 hhsize under_30
##   <chr>      <dbl>      <dbl> <chr>      <dbl>  <dbl> <lgl>
## 1 male      1941            0 Civic Duty      0      2 FALSE
## 2 female    1947            0 Civic Duty      0      2 FALSE
## 3 male      1951            0 Hawthorne      1      3 FALSE
## 4 female    1950            0 Hawthorne      1      3 FALSE
## 5 female    1982            0 Hawthorne      1      3 TRUE
## 6 male      1981            0 Control        0      3 TRUE
## 7 female    1959            0 Control        1      3 FALSE
## 8 male      1956            0 Control        1      3 FALSE
## 9 female    1968            0 Control        0      2 FALSE
## 10 male     1967            0 Control        0      2 FALSE
## # i 305,856 more rows
```

mutate()

Create new variable (under_30), TRUE/FALSE

```
social |> mutate(under_30 = yearofbirth > 1976)
```

```
## # A tibble: 305,866 x 7
##   sex      yearofbirth primary2004 messages  primary2006 hhsize under_30
##   <chr>      <dbl>      <dbl> <chr>      <dbl>  <dbl> <lgl>
## 1 male      1941          0 Civic Duty      0      2 FALSE
## 2 female    1947          0 Civic Duty      0      2 FALSE
## 3 male      1951          0 Hawthorne      1      3 FALSE
## 4 female    1950          0 Hawthorne      1      3 FALSE
## 5 female    1982          0 Hawthorne      1      3 TRUE
## 6 male      1981          0 Control        0      3 TRUE
## 7 female    1959          0 Control        1      3 FALSE
## 8 male      1956          0 Control        1      3 FALSE
## 9 female    1968          0 Control        0      2 FALSE
## 10 male     1967          0 Control        0      2 FALSE
## # i 305,856 more rows
```

(There is also `recode().`)

`mutate_all()`, `mutate_at()`, `mutate_if()`

```
soc_numeric <- select(social, -sex, -messages)
```

```
mutate_all(), mutate_at(), mutate_if()
```

```
soc_numeric <- select(social, -sex, -messages)
```

```
# Halve every column's values:
```

```
divide_by_two <- function(x){x / 2}
```

```
mutate_all(soc_numeric, divide_by_two)
```

```
## # A tibble: 305,866 x 4
```

```
##   yearofbirth primary2004 primary2006 hhsize
```

```
##           <dbl>         <dbl>         <dbl>  <dbl>
```

```
## 1         970.           0           0       1
```

```
## 2         974.           0           0       1
```

```
## 3         976.           0           0.5     1.5
```

```
## 4         975           0           0.5     1.5
```

```
## 5         991           0           0.5     1.5
```

```
## 6         990.           0           0       1.5
```

```
## 7         980.           0           0.5     1.5
```

```
## 8         978           0           0.5     1.5
```

```
## 9         984           0           0       1
```

```
mutate_all(), mutate_at(), mutate_if()
```

```
# Double values of columns:
```

```
mult_by_two <- function(x){x * 2}
```

```
mutate_at(soc_numeric, c(2, 3), mult_by_two)
```

```
## # A tibble: 305,866 x 4
```

```
##   yearofbirth primary2004 primary2006 hhsize
```

```
##           <dbl>         <dbl>         <dbl>  <dbl>
```

```
## 1      1941           0           0       2
```

```
## 2      1947           0           0       2
```

```
## 3      1951           0           2       3
```

```
## 4      1950           0           2       3
```

```
## 5      1982           0           2       3
```

```
## 6      1981           0           0       3
```

```
## 7      1959           0           2       3
```

```
## 8      1956           0           2       3
```

```
## 9      1968           0           0       2
```

```
## 10     1967           0           0       2
```

```
## # i 305,856 more rows
```

`mutate_all()`, `mutate_at()`, `mutate_if()`

What does this do?

```
mutate_at(soc_numeric, vars(matches("primary")),  
          mult_by_two)
```


`mutate_all()`, `mutate_at()`, `mutate_if()`

What does this do?

```
mutate_if(social, is.numeric, mean)
```



```
mutate_all(), mutate_at(), mutate_if()
```

What does this do?

```
mutate_if(social, is.numeric, mean)
```

```
## # A tibble: 305,866 x 6
```

```
##   sex      yearofbirth primary2004 messages      primary2006
```

```
##   <chr>          <dbl>          <dbl> <chr>          <dbl>
```

```
## 1 male         1956.          0.401 Civic Duty    0.312
```

```
## 2 female       1956.          0.401 Civic Duty    0.312
```

```
## 3 male         1956.          0.401 Hawthorne     0.312
```

```
## 4 female       1956.          0.401 Hawthorne     0.312
```

```
## 5 female       1956.          0.401 Hawthorne     0.312
```

```
## 6 male         1956.          0.401 Control      0.312
```

```
## 7 female       1956.          0.401 Control      0.312
```

```
## 8 male         1956.          0.401 Control      0.312
```

```
## 9 female       1956.          0.401 Control      0.312
```

```
## 10 male        1956.          0.401 Control      0.312
```

```
## # i 305,856 more rows
```

`mutate_all()`, `mutate_at()`, `mutate_if()`

Warning: `mutate_all()`, `_at()`, `_if()` **overwrite** columns that are processed.

`mutate_all()`, `mutate_at()`, `mutate_if()`

Warning: `mutate_all()`, `_at()`, `_if()` **overwrite** columns that are processed.

Do **not** append new columns to the end.

`mutate_all()`, `mutate_at()`, `mutate_if()`

Warning: `mutate_all()`, `_at()`, `_if()` **overwrite** columns that are processed.

Do **not** append new columns to the end.

Useful for recoding, if want values of a function:

```
is_CD <- function(x){ x == "Civic Duty"}  
mutate_at(social, vars(matches("messages")), is_CD)
```

`mutate_all()`, `mutate_at()`, `mutate_if()`

Warning: `mutate_all()`, `_at()`, `_if()` **overwrite** columns that are processed.

Do **not** append new columns to the end.

Useful for recoding, if want values of a function:

```
is_CD <- function(x){ x == "Civic Duty"}  
mutate_at(social, vars(matches("messages")), is_CD)
```

A tibble: 305,866 x 6

##	sex	yearofbirth	primary2004	messages	primary2006	hhsize
##	<chr>	<dbl>	<dbl>	<lgl>	<dbl>	<dbl>
##	1 male	1941	0	TRUE	0	2
##	2 female	1947	0	TRUE	0	2
##	3 male	1951	0	FALSE	1	3
##	4 female	1950	0	FALSE	1	3
##	5 female	1982	0	FALSE	1	3
##	6 male	1981	0	FALSE	0	3
##	7 female	1959	0	FALSE	1	3
##	8 male	1956	0	FALSE	1	3

transmute() for new variables, summaries

```
transmute(social, age = 2006 - yearofbirth)
```

transmute() for new variables, summaries

```
transmute(social, age = 2006 - yearofbirth)
```

```
## # A tibble: 305,866 x 1
```

```
##       age
```

```
##    <dbl>
```

```
##  1     65
```

```
##  2     59
```

```
##  3     55
```

```
##  4     56
```

```
##  5     24
```

```
##  6     25
```

```
##  7     47
```

```
##  8     50
```

```
##  9     38
```

```
## 10     39
```

```
## # i 305,856 more rows
```

transmute() for new vars, summaries as new vars

```
social_msg_grps <- group_by(social, messages)
```


transmute() for new vars, summaries as new vars

```
social_msg_grps <- group_by(social, messages)
```

```
transmute(social_msg_grps,  
          avg_age = mean(2006 - yearofbirth))
```

```
## # A tibble: 305,866 x 2  
## # Groups:   messages [4]  
##   messages    avg_age  
##   <chr>         <dbl>  
## 1 Civic Duty    49.7  
## 2 Civic Duty    49.7  
## 3 Hawthorne     49.7  
## 4 Hawthorne     49.7  
## 5 Hawthorne     49.7  
## 6 Control       49.8  
## 7 Control       49.8  
## 8 Control       49.8  
## 9 Control       49.8
```

What if I wanted just mean age per message?

What if I wanted just mean age per message?

```
summarise(social_msg_grps,  
          avg_age = mean(2006 - yearofbirth))
```

```
## # A tibble: 4 x 2  
##   messages    avg_age  
##   <chr>      <dbl>  
## 1 Civic Duty    49.7  
## 2 Control       49.8  
## 3 Hawthorne     49.7  
## 4 Neighbors     49.9
```

What if I wanted just mean age per message?

```
summarise(social_msg_grps,  
          avg_age = mean(2006 - yearofbirth))
```

```
## # A tibble: 4 x 2  
##   messages    avg_age  
##   <chr>      <dbl>  
## 1 Civic Duty    49.7  
## 2 Control       49.8  
## 3 Hawthorne     49.7  
## 4 Neighbors     49.9
```

What information does this provide about the experiment?

select()

```
select(social, yearofbirth, messages, primary2006) # or  
social |> select(yearofbirth, messages, primary2006)
```

```
select()
```

```
select(social, yearofbirth, messages, primary2006) # or  
social |> select(yearofbirth, messages, primary2006)
```

```
## # A tibble: 305,866 x 3  
##   yearofbirth messages    primary2006  
##           <dbl> <chr>          <dbl>  
## 1      1941 Civic Duty            0  
## 2      1947 Civic Duty            0  
## 3      1951 Hawthorne            1  
## 4      1950 Hawthorne            1  
## 5      1982 Hawthorne            1  
## 6      1981 Control              0  
## 7      1959 Control              1  
## 8      1956 Control              1  
## 9      1968 Control              0  
## 10     1967 Control              0  
## # i 305,856 more rows
```

Other Common Transformation Functions

Other Common Transformation Functions: `slice()`

```
slice(social, 1000:1004)
```

```
## # A tibble: 5 x 6
```

```
##   sex      yearofbirth primary2004 messages  primary2006
```

```
##   <chr>         <dbl>         <dbl> <chr>         <dbl>
```

```
## 1 male          1955             1 Neighbors      1
```

```
## 2 female        1952             0 Control       1
```

```
## 3 male          1947             1 Control       1
```

```
## 4 female        1985             0 Hawthorne     0
```

```
## 5 male          1956             0 Hawthorne     0
```


Other Common Transformation Functions: `slice()`

```
slice(social, n())
```

```
## # A tibble: 1 x 6
```

```
##   sex      yearofbirth primary2004 messages primary2006 h...
```

```
##   <chr>      <dbl>      <dbl> <chr>      <dbl> <...
```

```
## 1 female      1949          1 Control          1
```

Other Common Transformation Functions:

`sample_n()`, `sample_frac()`

```
sample_n(social, 4)
```

```
## # A tibble: 4 x 6
```

```
##   sex      yearofbirth primary2004 messages primary2006 h...
```

```
##   <chr>          <dbl>          <dbl> <chr>          <dbl> <...
```

```
## 1 female        1962              0 Control        0
```

```
## 2 female        1953              1 Control        0
```

```
## 3 male          1969              1 Control        0
```

```
## 4 female        1954              0 Control        0
```

Other Common Transformation Functions:

`sample_n()`, `sample_frac()`

```
sample_frac(social, 0.00001)
```

```
## # A tibble: 3 x 6
```

```
##   sex      yearofbirth primary2004 messages  primary2006 l
```

```
##   <chr>          <dbl>          <dbl> <chr>          <dbl>
```

```
## 1 female        1957              0 Hawthorne        0
```

```
## 2 male          1963              0 Neighbors        1
```

```
## 3 male          1946              1 Control          0
```

Other Common Transformation Functions: `distinct()`

```
social_distinct <- distinct(social)  
dim(social_distinct)
```

```
## [1] 9235    6
```

Other Common Transformation Functions: `distinct()`

```
social_distinct <- distinct(social)
dim(social_distinct)
```

```
## [1] 9235      6
```

$(100 \text{ yrs}) \cdot (4 \text{ msgs}) \cdot (4 \text{ votes}) \cdot (2 \text{ sex}) \cdot (3 \text{ HHsize}) = 9600$

Common Structure

```
verb(df, <conditions or calculations>)
```

Common Structure

```
verb(df, <conditions or calculations>)
```

Value: a dataframe

Common Structure

This structure:

dataframe in \rightsquigarrow dataframe out

enables the pipe: `|>`

The pipe inserts the previous result as the first argument of the subsequent function.

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```
x |> f(y)
```

is the same as

```
f(x, y)
```

The pipe inserts the previous result as the first argument of the subsequent function.

```
x |> f(y)
```

is the same as

```
f(x, y)
```

(also, ...)

```
x %>% f(y)
```

The Pipe

- ▶ Suppose we have functions `f()`, `g()`, and `h()`

The Pipe

- ▶ Suppose we have functions $f()$, $g()$, and $h()$
- ▶ We want to apply $f()$ to x , then apply $g()$ to the output, then $h()$ to the output of $g()$, ...

The Pipe

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- ▶ $f(x)$

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- ▶ $f(x)$
- ▶ $g(f(x))$

The Pipe

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- ▶ $f(x)$
- ▶ $g(f(x))$
- ▶ $h(g(f(x)))$

The Pipe

- ▶ Suppose we have functions $f()$, $g()$, and $h()$
- ▶ We want to apply $f()$ to x , then apply $g()$ to the output, then $h()$ to the output of $g()$, ...
- ▶ $f(x)$
- ▶ $g(f(x))$
- ▶ $h(g(f(x)))$

The Pipe

- ▶ Suppose we have functions `f()`, `g()`, and `h()`
- ▶ We want to apply `f()` to `x`, then apply `g()` to the output, then `h()` to the output of `g()`, ...
- ▶ `f(x)`
- ▶ `g(f(x))`
- ▶ `h(g(f(x)))`

Or, with more assignments,

- ▶ `y <- f(x)`

The Pipe

- ▶ Suppose we have functions `f()`, `g()`, and `h()`
- ▶ We want to apply `f()` to `x`, then apply `g()` to the output, then `h()` to the output of `g()`, ...
- ▶ `f(x)`
- ▶ `g(f(x))`
- ▶ `h(g(f(x)))`

Or, with more assignments,

- ▶ `y <- f(x)`
- ▶ `z <- g(y)`

The Pipe

- ▶ Suppose we have functions $f()$, $g()$, and $h()$
- ▶ We want to apply $f()$ to x , then apply $g()$ to the output, then $h()$ to the output of $g()$, ...
- ▶ $f(x)$
- ▶ $g(f(x))$
- ▶ $h(g(f(x)))$

Or, with more assignments,

- ▶ $y \leftarrow f(x)$
- ▶ $z \leftarrow g(y)$
- ▶ $h(z)$

The Pipe

The pipe (`|>`) allows us to write

```
x |> f() |> g() |> h()
```

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The pipe (`|>`) allows us to write

```
x |> f() |> g() |> h()
```

Likely better,

```
x |>  
  f() |>  
  g() |>  
  h()
```

The Pipe

The pipe (`|>`) allows us to write

```
x |> f() |> g() |> h()
```

Likely better,

```
x |>  
  f() |>  
  g() |>  
  h()
```

To be able to reorder *depends* on functions all

- ▶ taking same first input
- ▶ producing output of same type as input

The Pipe

The $|>$ is like \circ for function composition, but still reads in order.

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(Unlike $h(g(f(x)))$ or $(h \circ g \circ f)(x)$)

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The $|>$ is like \circ for function composition, but still reads in order.

(Unlike $h(g(f(x)))$ or $(h \circ g \circ f)(x)$)

Read “then”.

The Pipe

Suppose each function takes more than 1 argument:

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Suppose each function takes more than 1 argument:

```
h(g(f(x, arg1 = value_here), arg2 = another_val),  
  arg3 = 5, arg4 = TRUE)
```

The Pipe

Suppose each function takes more than 1 argument:

```
h(g(f(x, arg1 = value_here), arg2 = another_val),  
  arg3 = 5, arg4 = TRUE)
```

Messy. Which function is `arg2`? `arg3`?

The Pipe

Suppose each function takes more than 1 argument:

```
h(g(f(x, arg1 = value_here), arg2 = another_val),  
  arg3 = 5, arg4 = TRUE)
```

Messy. Which function is arg2? arg3?

```
x |>  
  f(arg1 = value_here) |>  
  g(arg2 = another_val) |>  
  h(arg3 = 5, arg4 = TRUE)
```

The Pipe

Suppose each function takes more than 1 argument:

```
h(g(f(x, arg1 = value_here), arg2 = another_val),  
  arg3 = 5, arg4 = TRUE)
```

Messy. Which function is `arg2`? `arg3`?

```
x |>  
  f(arg1 = value_here) |>  
  g(arg2 = another_val) |>  
  h(arg3 = 5, arg4 = TRUE)
```

Better.

The Pipe

Fun note: The `%>%` pipe is defined in package `magrittr`

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The motif is played **all** the way out:
<http://j.mp/2Eu679T>

The Pipe

Fun note: The `%>%` pipe is defined in package `magrittr`

The motif is played **all** the way out:

<http://j.mp/2Eu679T>

(For similar missing data example, see Amelia.)

Helper Functions

Helpers for `select()`-ing Variables

- ▶ `contains()`
- ▶ `starts_with()`, `ends_with()`
- ▶ `matches()`
- ▶ `num_range()`
- ▶ `one_of()`
- ▶ `everything()`

Helpers for `select()`-ing Variables

```
social |> select(contains("s")) |> slice(1:2) # literal strings
```

```
## # A tibble: 2 x 3  
##   sex      messages  hhsize  
##   <chr>   <chr>         <dbl>  
## 1 male    Civic Duty      2  
## 2 female Civic Duty      2
```

Helpers for `select()`-ing Variables

```
social |> select(contains("s")) |> slice(1:2) # literal string
```

```
## # A tibble: 2 x 3
##   sex      messages    hhsize
##   <chr>   <chr>         <dbl>
## 1 male    Civic Duty      2
## 2 female Civic Duty      2
```

```
social |> select(starts_with("primary")) |> slice(1:2)
```

```
## # A tibble: 2 x 2
##   primary2004 primary2006
##         <dbl>         <dbl>
## 1           0           0
## 2           0           0
```

Helpers for `select()`-ing Variables

```
social |> select(ends_with("size")) |> slice(1:2)
```

```
## # A tibble: 2 x 1
```

```
##   hhsize
```

```
##   <dbl>
```

```
## 1     2
```

```
## 2     2
```

Helpers for `select()`-ing Variables

```
social |> select(ends_with("size")) |> slice(1:2)
```

```
## # A tibble: 2 x 1
##   hhsizes
##   <dbl>
## 1     2
## 2     2
```

```
social |> select(matches(".00.")) |> slice(1:2) # regex
```

```
## # A tibble: 2 x 2
##   primary2004 primary2006
##   <dbl>         <dbl>
## 1         0           0
## 2         0           0
```


Helpers for `select()`-ing Variables

```
social |> select(num_range("primary", 2000:2008)) |> slice
```

```
## # A tibble: 2 x 2  
##   primary2004 primary2006  
##         <dbl>         <dbl>  
## 1           0           0  
## 2           0           0
```

Helpers for `select()`-ing Variables

```
social |> select(num_range("primary", 2000:2008)) |> slice
```

```
## # A tibble: 2 x 2
##   primary2004 primary2006
##         <dbl>         <dbl>
## 1           0           0
## 2           0           0
```

But

```
social |> select(num_range("primary", 2000:2005)) |> slice
```

```
## # A tibble: 2 x 1
##   primary2004
##         <dbl>
## 1           0
## 2           0
```

Helpers for `select()`-ing Variables

```
social |> select(one_of(c("sex", "height"))) |> slice(1:5)
```

```
## # A tibble: 5 x 1
```

```
##   sex
```

```
##   <chr>
```

```
## 1 male
```

```
## 2 female
```

```
## 3 male
```

```
## 4 female
```

```
## 5 female
```

Helpers for select()-ing Variables

```
social |> select(primary2006, messages, everything()) |>  
  slice(1:9)
```

```
## # A tibble: 9 x 6  
##   primary2006 messages    sex   yearofbirth primary2004  
##         <dbl> <chr>      <chr>         <dbl>         <dbl>  
## 1           0 Civic Duty male           1941           0  
## 2           0 Civic Duty female          1947           0  
## 3           1 Hawthorne male           1951           0  
## 4           1 Hawthorne female          1950           0  
## 5           1 Hawthorne female          1982           0  
## 6           0 Control  male           1981           0  
## 7           1 Control  female          1959           0  
## 8           1 Control  male           1956           0  
## 9           0 Control  female          1968           0
```

Helpers for `select()`-ing Variables

```
social |> select(primary2006, messages, everything()) |>  
  slice(1:9)
```

```
## # A tibble: 9 x 6  
##   primary2006 messages    sex   yearofbirth primary2004  
##         <dbl> <chr>      <chr>         <dbl>         <dbl>  
## 1           0 Civic Duty male          1941           0  
## 2           0 Civic Duty female          1947           0  
## 3           1 Hawthorne male           1951           0  
## 4           1 Hawthorne female          1950           0  
## 5           1 Hawthorne female          1982           0  
## 6           0 Control    male           1981           0  
## 7           1 Control    female          1959           0  
## 8           1 Control    male           1956           0  
## 9           0 Control    female          1968           0
```

(Use `select()` as the `arrange()` of columns.)

Helpers for `mutate()`

- ▶ Offsets
- ▶ Cumulative aggregates
- ▶ Ranking functions

Viewing the Data

- ▶ `df`
- ▶ `View(df)`
- ▶ `as.data.frame(tbl)`
- ▶ `tbl |> as.data.frame()`

Recently, at The Lab... preprocessing

```
df_outcomes <- df_outcomes |>
  rename(ic_case_id = "IC# (Household)",
         pdc_number = "TANF PDC Case #",
         pdc_status = "PDC Current Status",
         renewal_date = "Renewal Date",
         )
```


Recently, at The Lab... preprocessing

```
df_outcomes <- df_outcomes |>
  rename(ic_case_id = "IC# (Household)",
         pdc_number = "TANF PDC Case #",
         pdc_status = "PDC Current Status",
         renewal_date = "Renewal Date",
         )
```

(though, see `janitor::clean_names()`)

Recently, at The Lab...

```
df_arrest <- df_arrest |>
  rename(age = Age,
         race = `Defendant Race`)

df_stop <- df_stop |>
  rename(age = `Subject Age`,
         race = `Subject_Race`)
```

Recently, at The Lab...

```
df_stop$sex <- recode(df_stop$sex,  
                      Female = "F", Male = "M")  
  
df_stop$sex <- na_if(df_stop$sex, "Unknown")
```

Recently, at The Lab... deduplication

```
final_baseline_data <- final_baseline_data |>
  filter(!((ic_case_id == 1234) & (pdc_number == 2))) |>
  filter(!((ic_case_id == 5678) &
            (address == "1600 Pennsylvania Ave NW"))) |>
  filter(!((ic_case_id == 6961) & (pdc_number == 9))) |>
  filter(!((ic_case_id == 2087) & (pdc_number == 7)))
```

Recently, at The Lab...

```
df_only_dup_months <- df_only_duplicated |>
  group_by(ic_case_id) |>
  summarise(month_count = n_distinct(recert_month)) |>
  filter(month_count > 1) |>
  select(ic_case_id)
```

Comparing Base R vs. the Tidyverse

Which do you prefer?

```
df[1, 3]
```

vs.

```
df |>  
  slice(1) |>  
  select(3)
```

Comparing Base R vs. the Tidyverse

Which do you prefer?

```
select(df, x1, x2)
```

vs.

```
df |> select(x1, x2)
```

vs.

```
df[, c("x1", "x2")]
```

Core Transformation Functions Quiz

Suppose we have dataframe `df` with 100 rows, continuous variable `x` and categorical `y`.

Hand-write code¹ to

1. sort `df` by the values of `x`? (largest first)
2. create a new variable `x_sq` – the square of each row's `x` value – and attach it as a column of `df`?
3. create `df2`, which has only the rows of `df` where `x > 5`?
4. calculate the median value of `x` within categories of `y`?

¹`filter()`, `arrange()`, `group_by()`, `ungroup()`, `select()`, `rename()`, `mutate()`, `transmute()`, `summarise()`

References

Wickham, Hadley, Mine Çetinkaya-Rundel, and Garrett Golemund. 2023. *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data*. 2nd ed. O'Reilly Media. <http://r4ds.hadley.nz/>.