Functions

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Adapted from *Tidy Tools* by Hadley Wickham

What does this code do?

```r
df <- tibble::tibble(
  a = c(rnorm(9), -99),
  b = c(-999, -99, rnorm(8)),
  c = c(0, rnorm(9)),
  d = rnorm(10)
)

df$a <- (df$a - min(df$a)) / (max(df$a) - min(df$a))
df$b <- (df$b - min(df$b)) / (max(df$b) - min(df$b))
df$c <- (df$c - min(df$c)) / (max(df$c) - min(df$c))
df$d <- (df$d - min(df$d)) / (max(df$d) - min(df$c))
```

Writing functions

The when and the how

Rule of three: make a function if you've copy-pasted threes times

```
(df$a - min(df$a)) / (max(df$a) - min(df$a))
(df$b - min(df$b)) / (max(df$b) - min(df$b))
(df$c - min(df$c)) / (max(df$c) - min(df$c))
(df$d - min(df$d)) / (max(df$d) - min(df$c))
```

Rule of three: make a function if you've copy-pasted threes times

```
(df$a - min(df$a)) / (max(df$a) - min(df$a))
(df$b - min(df$b)) / (max(df$b) - min(df$b))
(df$c - min(df$c)) / (max(df$c) - min(df$c))
(df$d - min(df$d)) / (max(df$d) - min(df$c))
```

Rule of three: make a function if you’ve copy-pasted threes times

```
(df$a - min(df$a)) / (max(df$a) - min(df$a))
(df$b - min(df$b)) / (max(df$b) - min(df$b))
(df$c - min(df$c)) / (max(df$c) - min(df$c))
(df$d - min(df$d)) / (max(df$d) - min(df$d))
```

First, identify the parts that might change

```
(df$a - min(df$a)) / (max(df$a) - min(df$a))
(df$b - min(df$b)) / (max(df$b) - min(df$b))
(df$c - min(df$c)) / (max(df$c) - min(df$c))
(df$d - min(df$d)) / (max(df$d) - min(df$d))
```

Then give them names

```
   x         x              x          x
(df$a - min(df$a)) / (max(df$a) - min(df$a))
(df$b - min(df$b)) / (max(df$b) - min(df$b))
(df$c - min(df$c)) / (max(df$c) - min(df$c))
(df$d - min(df$d)) / (max(df$d) - min(df$d))
```

Make the function template

function name

argument name

```
rescale01 <- function(x) {

}
```

Then copy in one example

```
rescale01 <- function(x) {
  (df$a - min(df$a)) / (max(df$a) - min(df$a))
}
```

And use the argument name

```
rescale01 <- function(x) {
  (x - min(x)) / (max(x) - min(x))
}
```

And maybe refactor a little…

```r
rescale01 <- function(x) {
  rng <- range(x)
  (x - rng[1]) / (rng[2] - rng[1])
}
```

And handle more cases

```
rescale01 <- function(x) {
  rng <- range(x, na.rm = TRUE, finite = TRUE)
  (x - rng[1]) / (rng[2] - rng[1])
}
```

the last evaluated expression is the return value

Rule of three: make a function if you've copy-pasted threes times

```
(df$a - min(df$a)) / (max(df$a) - min(df$a))
(df$b - min(df$b)) / (max(df$b) - min(df$b))
(df$c - min(df$c)) / (max(df$c) - min(df$c))
(df$d - min(df$d)) / (max(df$d) - min(df$d))
```

Rule of three: make a function if you've copy-pasted threes times

```
df$a <- rescale01(df$a)
df$b <- rescale01(df$b)
df$c <- rescale01(df$c)
df$d <- rescale01(df$d)
```

Still some repetition, we'll solve that later.

Why create a function? Because a function:

1. Prevents inconsistencies
2. Emphasises what varies
3. Makes change easier
4. Can have informative name

Write a function to remove the duplication

```r
df <- tibble::tibble(
  a = c(rnorm(9), -99),
  b = c(-999, -99, rnorm(8)),
  c = c(0, rnorm(9)),
  d = rnorm(10)
)

# Fix missing values
df$a[df$a == -99] <- NA
df$b[df$b == -99] <- NA
df$c[df$c == -99] <- NA
df$d[df$d == -99] <- NA
```

You'll want to rerun this to get back the original data

Write a function to remove the duplication

```
# Fix missing values
df$a[df$a == -99] <- NA
df$b[df$b == -99] <- NA
df$c[df$c == -99] <- NA
df$d[df$d == -99] <- NA
```

```
 x      x
```

```
fix_missing <- function(x) {

}
```

Write a function to remove the duplication

```
# Fix missing values
df$a[df$a == -99] <- NA
df$b[df$b == -99] <- NA
df$c[df$c == -99] <- NA
df$d[df$d == -99] <- NA
```

x x

```
fix_missing <- function(x) {
  df$a[df$a == -99] <- NA
}
```

Write a function to remove the duplication

```
# Fix missing values
df$a[df$a == -99] <- NA
df$b[df$b == -99] <- NA
df$c[df$c == -99] <- NA
df$d[df$d == -99] <- NA
```

x x

```
fix_missing <- function(x) {
  x[x == -99] <- NA
}
fix_missing(c(0, -99, 2))  # nothing comes out!
```

This expression doesn't return a value

Write a function to remove the duplication

```
# Fix missing values
df$a[df$a == -99] <- NA
df$b[df$b == -99] <- NA
df$c[df$c == -99] <- NA
df$d[df$d == -99] <- NA
```

x x

```
fix_missing <- function(x) {
  x[x == -99] <- NA
  x
}
fix_missing(c(0, -99, 2))  # Fixed!
```

How can we extend our function?

```
# Rescale to [0, 1]
0  + (1 -  0) * ((df$a - min(df$a)) / (max(df$a) - min(df$a)))

# Rescale to [-1, 1]
-1 + (1 - -1) * ((df$b - min(df$b)) / (max(df$b) - min(df$b)))

# Rescale to [0, 10]
0 + (10 -  0) * ((df$c - min(df$c)) / (max(df$c) - min(df$c)))
```

Identify the parts that might change,

```
# Rescale to [0, 1]
 0 + (1 -  0) * ((df$a - min(df$a)) / (max(df$a) - min(df$a)))

# Rescale to [-1, 1]
-1 + (1 - -1) * ((df$b - min(df$b)) / (max(df$b) - min(df$b)))

# Rescale to [0, 10]
 0 + (10-  0) * ((df$c - min(df$c)) / (max(df$c) - min(df$c)))
```

And give them names

```
# Rescale to [0, 1]
 0 + (1  -  0) * ((df$a - min(df$a)) / (max(df$a) - min(df$a)))

# Rescale to [-1, 1]
-1 + (1  - -1) * ((df$b - min(df$b)) / (max(df$b) - min(df$b)))

# Rescale to [0, 10]
 0 + (10-  0) * ((df$c - min(df$c)) / (max(df$c) - min(df$c)))
```

min   max   min   x

Starting from our earlier function…

```r
rescale01 <- function(x) {
  rng <- range(x, na.rm = TRUE, finite = TRUE)
  (x - rng[1]) / (rng[2] - rng[1])
}
```

Add new arguments,

```r
rescale <- function(x, min, max) {
  rng <- range(x, na.rm = TRUE, finite = TRUE)
  min + (max - min) * ((x - rng[1]) / (rng[2] - rng[1]))
}
```

And give them default values

```r
rescale <- function(x, min = 0, max = 1) {
  rng <- range(x, na.rm = TRUE, finite = TRUE)
  min + (max - min) * ((x - rng[1]) / (rng[2] - rng[1]))
}
```

How can we extend our function?

```
# Rescale to [0, 1]
rescale(df$a)

# Rescale to [-1, 1]
rescale(df$b, min = -1, max = 1)

# Rescale to [0, 10]
rescale(df$c, max = 10)
```

Extend to allow for different codes for missing

```
fix_missing <- function(x) {
  x[x == -99] <- NA
  x
}

# Fix missing values
df$a[df$a == -99] <- NA
df$b[df$b == -999] <- NA
df$c[df$c == -0] <- NA
```

Typo

Extend to allow for different codes for missing

```r
fix_missing <- function(x, missing_val = -99) {
  x[x == missing_val] <- NA
  x
}

# Fix missing values
fix_missing(df$a)
fix_missing(df$b, missing_val = -999)
fix_missing(df$c, missing_val = 0)
```

Debugging

https://adv-r.hadley.nz/debugging.html

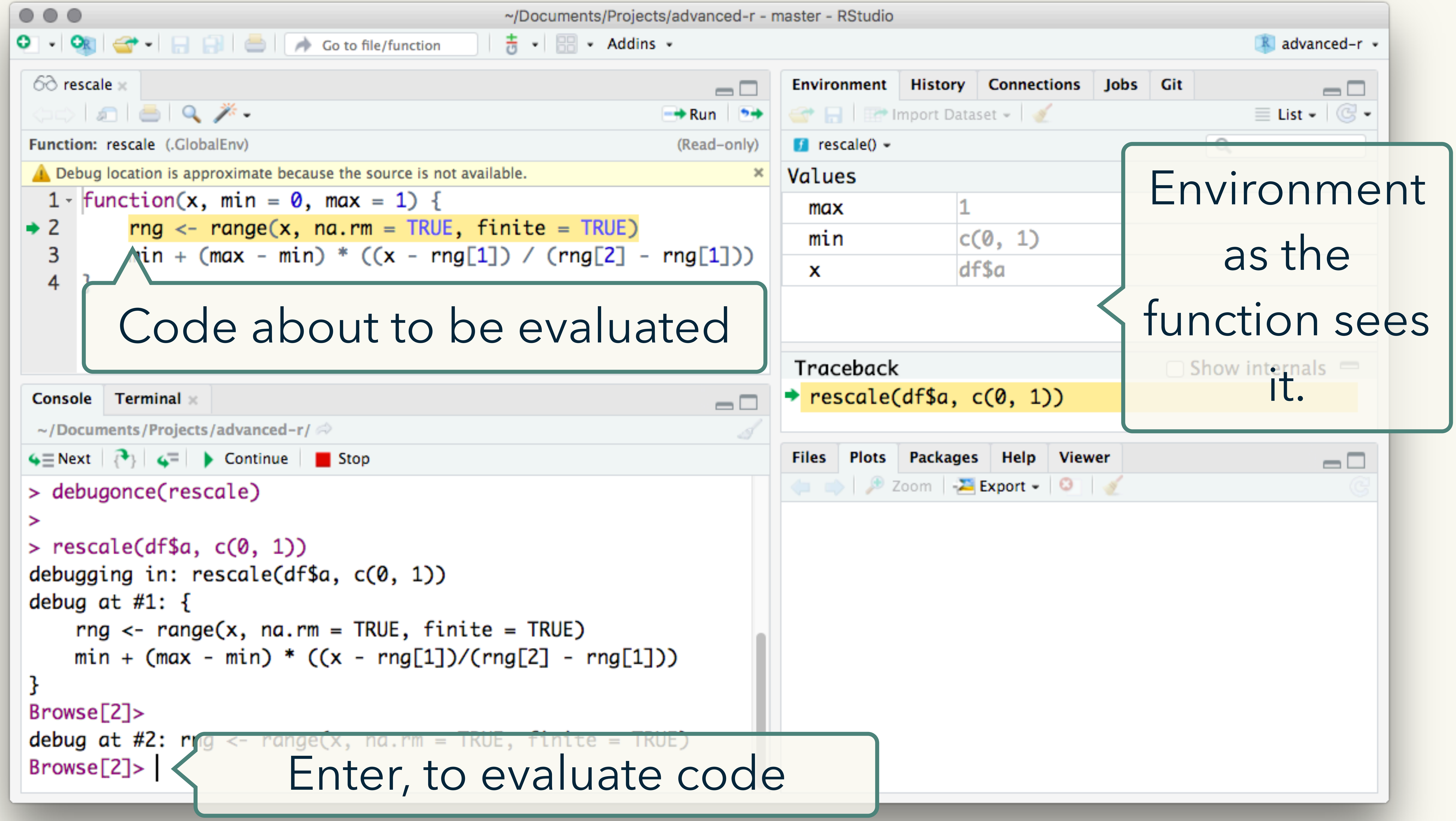
To track down what is happening inside a function,

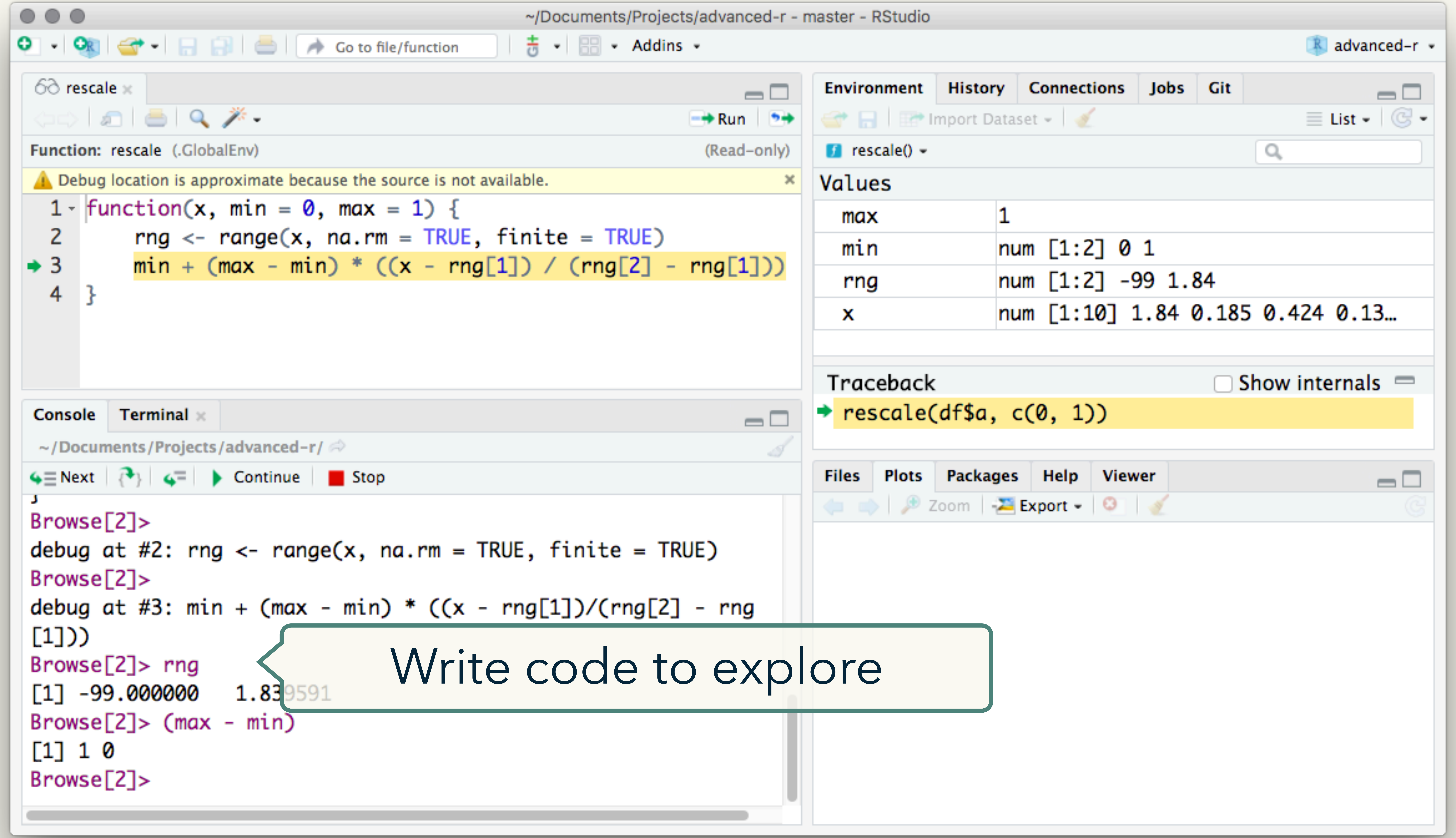
```
# This seems wrong...
rescale(df$a, c(0, 1))
# [1] 0.9910347 1.0000000 0.9929693 1.0000000
# [5] 0.9785413 1.0000000 0.9881966 1.0000000
# [9] 0.9754588 1.0000000
```

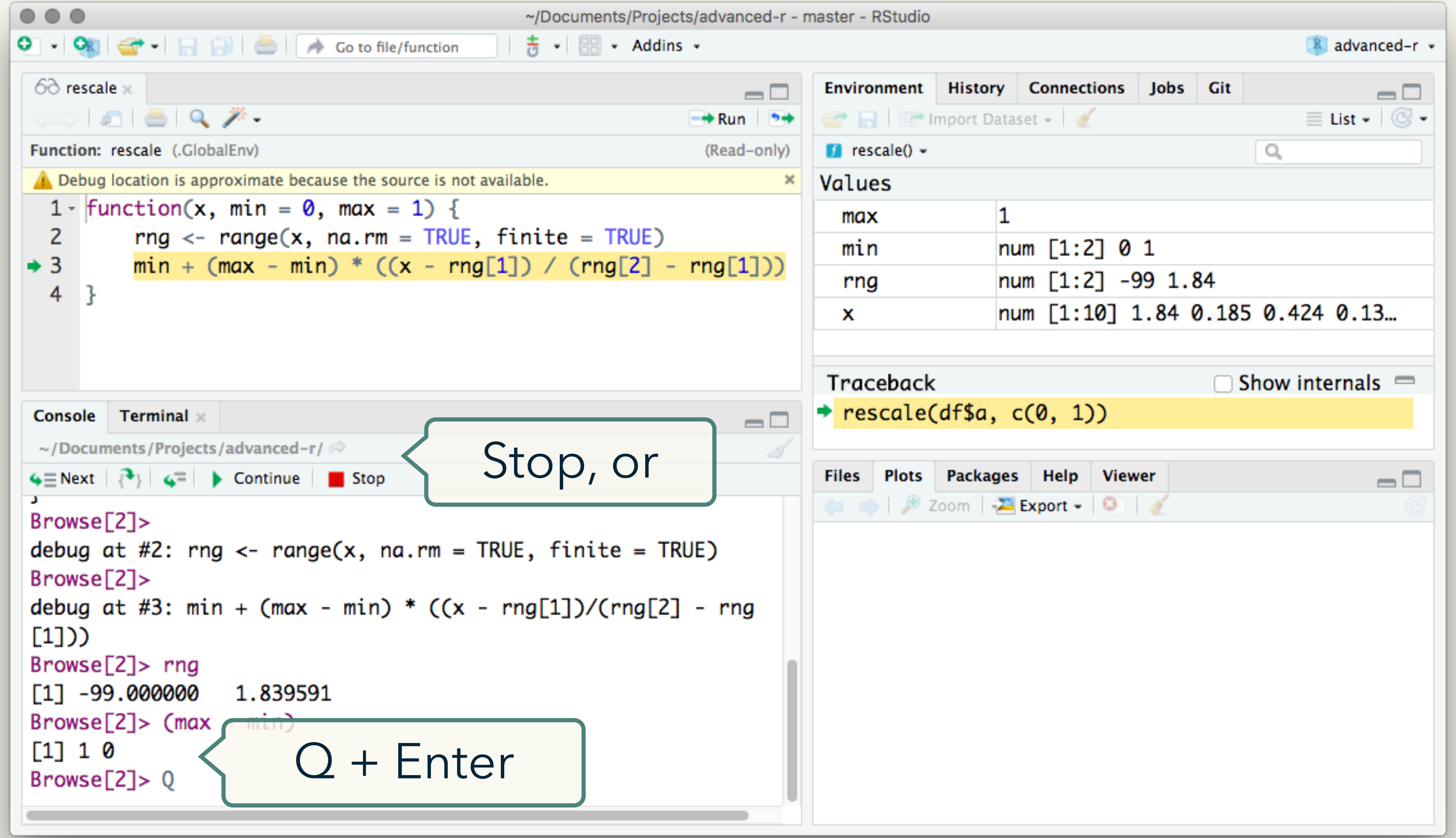
Use debugonce() to invoke the debugger

```r
# Tells R to enter debugger, when rescale is called
debugonce(rescale)

# Call the problem case
rescale(df$a, c(0, 1))
```


~/Documents/Projects/advanced-r - master - RStudio
Go to file/function
Addins
advanced-r
rescale
Run
Function: rescale (.GlobalEnv)
(Read-only)
Debug location is approximate because the source is not available.
function(x, min = 0, max = 1) {
rng <- range(x, na.rm = TRUE, finite = TRUE)
min + (max - min) * ((x - rng[1]) / (rng[2] - rng[1]))
}
Code about to be evaluated
Environment
History
Connections
Jobs
Git
Import Dataset
List
rescale()
Values
max
1
min
c(0, 1)
x
df$a
Environment as the function sees it.
Traceback
Show internals
rescale(df$a, c(0, 1))
Console
Terminal
~/Documents/Projects/advanced-r/
Next
Continue
Stop
> debugonce(rescale)
>
> rescale(df$a, c(0, 1))
debugging in: rescale(df$a, c(0, 1))
debug at #1: {
rng <- range(x, na.rm = TRUE, finite = TRUE)
min + (max - min) * ((x - rng[1])/(rng[2] - rng[1]))
}
Browse[2]>
debug at #2: rng <- range(x, na.rm = TRUE, finite = TRUE)
Browse[2]>
Enter, to evaluate code
Files
Plots
Packages
Help
Viewer
Zoom
Export


~/Documents/Projects/advanced-r - master - RStudio
Go to file/function
Addins
advanced-r
rescale
Run
Function: rescale (.GlobalEnv)
(Read-only)
Debug location is approximate because the source is not available.
function(x, min = 0, max = 1) {
rng <- range(x, na.rm = TRUE, finite = TRUE)
min + (max - min) * ((x - rng[1]) / (rng[2] - rng[1]))
}
Environment
History
Connections
Jobs
Git
Import Dataset
List
rescale()
Values
max 1
min num [1:2] 0 1
rng num [1:2] -99 1.84
x num [1:10] 1.84 0.185 0.424 0.13…
Traceback
Show internals
rescale(df$a, c(0, 1))
Console
Terminal
~/Documents/Projects/advanced-r/
Next
Continue
Stop
Browse[2]>
debug at #2: rng <- range(x, na.rm = TRUE, finite = TRUE)
Browse[2]>
debug at #3: min + (max - min) * ((x - rng[1])/(rng[2] - rng[1]))
Browse[2]> rng
[1] -99.000000 1.839591
Browse[2]> (max - min)
[1] 1 0
Browse[2]>
Files
Plots
Packages
Help
Viewer
Zoom
Export
Write code to explore


~/Documents/Projects/advanced-r - master - RStudio
Go to file/function
Addins
advanced-r
rescale
Run
Function: rescale (.GlobalEnv)
(Read-only)
Debug location is approximate because the source is not available.
1 function(x, min = 0, max = 1) {
2 rng <- range(x, na.rm = TRUE, finite = TRUE)
3 min + (max - min) * ((x - rng[1]) / (rng[2] - rng[1]))
4 }
Environment
History
Connections
Jobs
Git
Import Dataset
List
rescale()
Values
max 1
min num [1:2] 0 1
rng num [1:2] -99 1.84
x num [1:10] 1.84 0.185 0.424 0.13…
Traceback
Show internals
rescale(df$a, c(0, 1))
Console
Terminal
~/Documents/Projects/advanced-r/
Next
Continue
Stop
Stop, or
Browse[2]>
debug at #2: rng <- range(x, na.rm = TRUE, finite = TRUE)
Browse[2]>
debug at #3: min + (max - min) * ((x - rng[1])/(rng[2] - rng[1]))
Browse[2]> rng
[1] -99.000000 1.839591
Browse[2]> (max
[1] 1 0
Browse[2]> Q
Q + Enter
Files
Plots
Packages
Help
Viewer
Zoom
Export

In this case, it was user error...

Not designed to take a length 2 vector

```
# This seems wrong...
rescale(df$a, c(0, 1))
# [1] 0.9910347 1.0000000 0.9929693 1.0000000
# [5] 0.9785413 1.0000000 0.9881966 1.0000000
# [9] 0.9754588 1.0000000
```

Signaling an error

To stop a function early, combine if() and stop()

```
rescale <- function(x, min = 0, max = 1) {
  if () {
    stop()
  }

  rng <- range(x, na.rm = TRUE, finite = TRUE)
  min + (max - min) * ((x - rng[1]) / (rng[2] - rng[1]))
}
```

Check for a logical condition

```
rescale <- function(x, min = 0, max = 1) {
  if (length(min) != 1) {
    stop()
  }

  rng <- range(x, na.rm = TRUE, finite = TRUE)
  min + (max - min) * ((x - rng[1]) / (rng[2] - rng[1]))
}
```

stop() with an informative message

```
rescale <- function(x, min = 0, max = 1) {
  if (length(min) != 1) {
    stop("`min` must have length 1", call. = FALSE)
  }

  rng <- range(x, na.rm = TRUE, finite = TRUE)
  min + (max - min) * ((x - rng[1]) / (rng[2] - rng[1]))
}
```

http://style.tidyverse.org/error-messages.html

```
rescale(df$a, c(0, 1))
# Error: `min` must have length 1
```

What else about the inputs should be checked?

```
rescale <- function(x, min = 0, max = 1) {
  if (length(min) != 1) {
    stop("`min` must have length 1", call. = FALSE)
  }

  rng <- range(x, na.rm = TRUE, finite = TRUE)
  min + (max - min) * ((x - rng[1]) / (rng[2] - rng[1]))
}
```

Brainstorm with your neighbour, then implement one more check.

min and max should be single numbers
min is smaller than max
x is also a vector of numbers

Functions are for humans too

A.K.A API design

Principle:

Design your functions with *a user* in mind.

Principle:

Design your functions with **future you** in mind.

Case study

String manipulation

What makes base R functions hard to learn?

```
strsplit(x, split, ...)
grep(pattern, x, value = FALSE, ...)
grepl(pattern, x, ...)
sub(pattern, replacement, x, ...)
gsub(pattern, replacement, x, ...)
regexpr(pattern, text, ...)
gregexpr(pattern, text, ...)
regexec(pattern, text, ...)
substr(x, start, stop)
nchar(x, type, ...)
```

A few issues

Names: Function names have no common theme, and no common prefix. Names are concise at expense of expressiveness.

Arguments: Argument names & order are not consistent, and data isn't the first argument. Sometimes text, sometimes x.

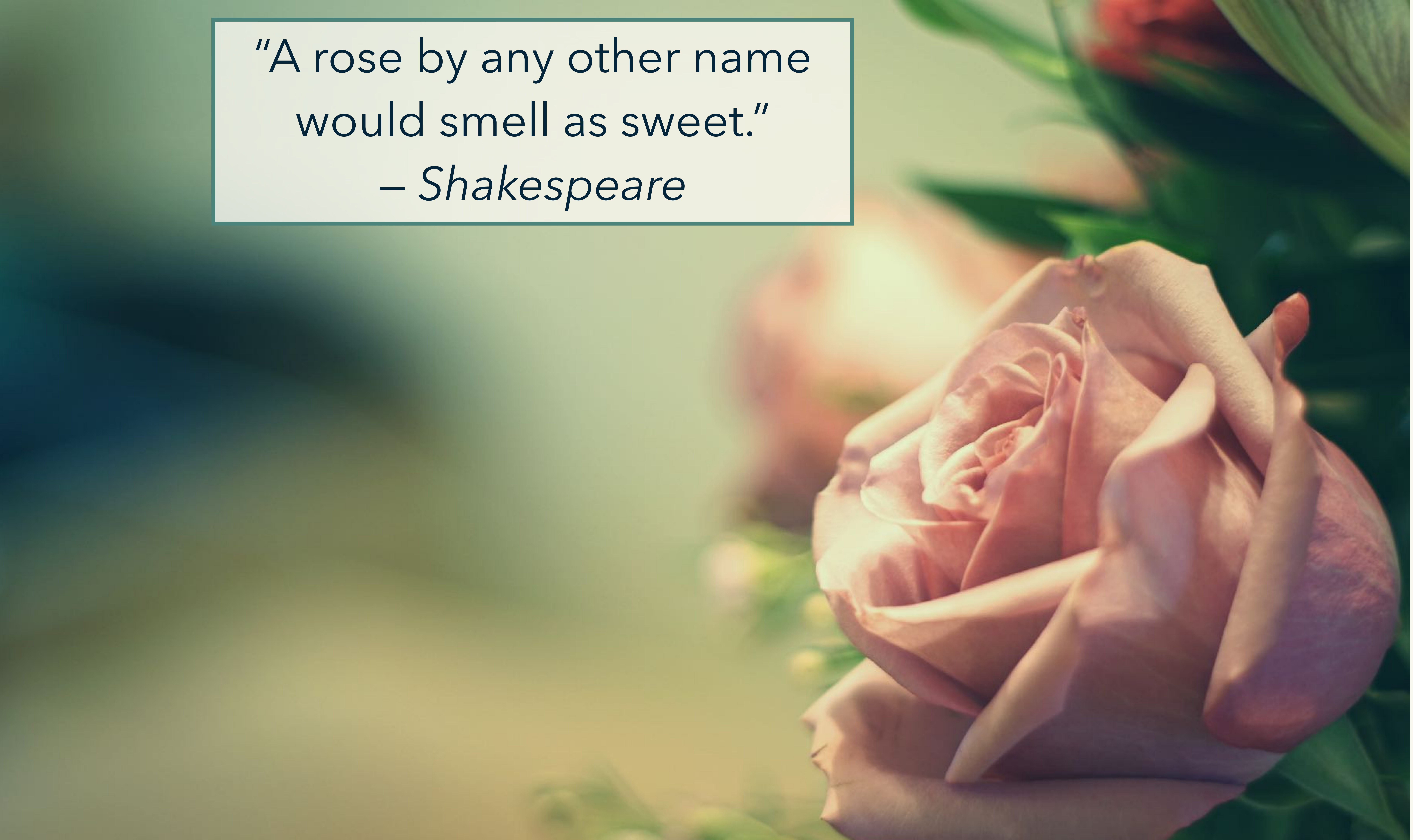
Type stability: grep() is not type stable: can return string or integer. Can't feed output of gregexpr() into substr()

1. Carefully contemplate names
2. Plan for pipes
3. Keep it simple

Each individual problem is small

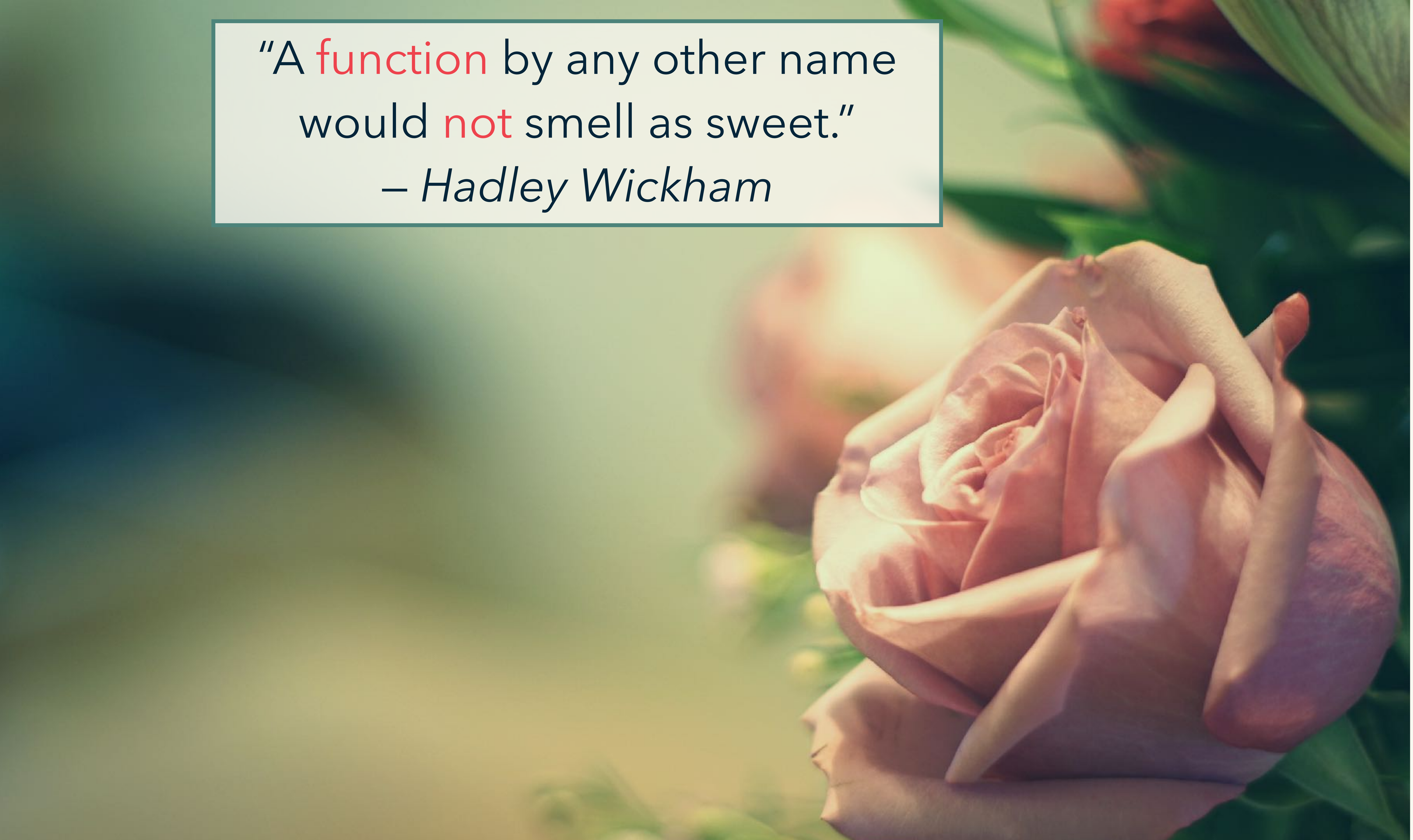
https://unsplash.com/photos/HiiQsQcyO8g

Carefully contemplate names



https://unsplash.com/photos/wwokZzI_gcw

"A function by any other name would not smell as sweet."
– *Hadley Wickham*



https://unsplash.com/photos/wwokZzI_gcw

Principle:

Whenever you can give something an informative name, you should

stringr uses evocative verbs

```
str_split()
str_detect()
str_locate()
str_subset()
str_extract()
str_replace()

# But good verbs don't always exist
str_to_lower()
str_to_upper()
```

stringr uses evocative verbs

```
str_split()
str_detect()
str_locate()
str_subset()
str_extract()
str_replace()
```

A common prefix may be useful to group related functions together

```
# But good verbs don't always exist
str_to_lower()
str_to_upper()
```

Avoid verbs with dual meanings

```
filter()
weather()
cleave()
```

General advice

Be consistent!

Function names should be generally be verbs.

Prefer specific to general; concrete to abstract.

Avoid short names; err on the side of expressiveness.

Avoid names that differ in UK/US dialects.

Avoid names used in base R, or by similar packages.

You might get it wrong the first time

Your turn

Brainstorm names for these functions:

```
f <- function(x){
  mean(is.na(x))
}

h <- function(x){
  length(unique(x))
}

g <- function(x, y){
  ifelse(x > y, x, y)
}
```

Plan for pipes

Why is the pipe useful?

```
library(dplyr)
library(nycflights13)
by_dest <- group_by(flights, dest)
dest_delay <- summarise(by_dest,
  delay = mean(dep_delay, na.rm = TRUE),
  n = n()
)
big_dest <- filter(dest_delay, n > 100)
arrange(big_dest, desc(delay))
```

But naming is hard work

```
foo <- group_by(flights, dest)
foo <- summarise(foo,
  delay = mean(dep_delay, na.rm = TRUE),
  n = n()
)
foo <- filter(foo, n > 100)
arrange(foo, desc(delay))
```

But naming is hard work

```
foo1 <- group_by(flights, dest)
foo2 <- summarise(foo1,
  delay = mean(dep_delay, na.rm = TRUE),
  n = n()
)
foo3 <- filter(foo2, n > 100)
arrange(foo2, desc(delay))
```

Alternatively, you could nest function calls

```
arrange(
  filter(
    summarise(
      group_by(flights, dest),
      delay = mean(dep_delay, na.rm = TRUE),
      n = n()
    ),
    n > 100
  ),
  desc(delay)
)
```

magrittr provides a third option

%>%

No intermediaries; read from left-to-right

```
flights %>%
  group_by(dest) %>%
  summarise(
    delay = mean(dep_delay, na.rm = TRUE),
    n = n()
  ) %>%
  filter(n > 100) %>%
  arrange(desc(delay))
```

	Read left-to-right	Can omit intermediate names	Non-linear
`y <- f(x)` `g(y)`	✅		✅
`g(f(x))`		✅	✅

`x %>%`
`  f() %>%`
`  g()`
	✅	✅	

Principle:

Data arguments should come first

Most arguments fall in one of two classes

Data	Details
Required	Optional
Core data	Additional options
Often vectorised	Scalar
Often called x or data	Names are important

```r
# Typically you can omit the names of the
# data arguments
ggplot(mtcars, aes(x = disp, y = cyl))

ggplot(data = mtcars, mapping = aes(...))

# Typically you shouldn't omit the names of
# of the details argument
mean(1:10, , TRUE)
mean(1:10, na.rm = TRUE)
```

Your turn

Which are the data arguments in grepl()?
Which are the details?

Which are the data arguments in strsplit()?
Which are the details?

Which are the data arguments in merge()?
Which are the details?

Keep it simple

Principle:

Aim for functions that do one thing, on the simplest object possible.

Rely on other tools to combine them in complex ways.

stringr functions work with character vectors

```
# So you can apply them to columns in a data frame with dplyr
storms %>%
  mutate(first_letter = str_sub(name, 1, 1))

# You can apply them consecutively with %>%
c("cwickham@gmail.com") %>%
  str_replace("@", " at ") %>%
  str_replace("\\.", " dot ")

# You can iterate with purrr
sentences %>%
  str_split(" ") %>%
  map_chr(str_c, collapse = "")
```

Case Study

Switch to project

case_study

Your Turn

Examine the code in 01-report.R

Discuss with your neighbour:

1. What are the sources of repetition?
2. How would you describe the steps in the analysis?
3. What functions might you write? What would you call them?

What are the sources of repetition?

Whole analysis is repeated three times - once for each state: BC, OR, WA

Some steps are also repetitive, e.g. save plots for both PDF and PNG

Might imagine further repetition if we also need to do this for other variables in the data, i.e total_dollar_amount, n_existing_customer

How would you describe the steps in the analysis?

1. Check file isn't too old (over 30 days from today)
2. Import data
3. Create a weekly summary
4. Plot weekly summary
5. Output plots

What functions might you write? What would you call them?

1. `check_not_outdated(file_path)`
2. Import data
3. `summarise_weekly(data)`
4. `plot_weekly(data)`
5.
```
ggsave_multiple(plot,
                exts = c(".pdf", ".png"))
```

Challenge

Take a stab at writing `check_not_outdated()`

```
or_file_date <- or_file_path  %>%
  str_extract("[0-9]{4}-[0-9]{2}-[0-9]{2}") %>%
  parse_date()

or_days_old <- difftime(lubridate::today(),
  or_file_date,
  units = "days")

or_days_old > 30
```

One solution

```
check_not_outdated <- function(path){
  date <- path  %>%
    str_extract("[0-9]{4}-[0-9]{2}-[0-9]{2}") %>%
    parse_date()

  age <- difftime(lubridate::today(),
    date,
    units = "days")

  age > 30
}
check_not_outdated(or_file_path)
```

Might break into simpler functions

```r
file_date <- function(path){
  path %>%
    str_extract("[0-9]{4}-[0-9]{2}-[0-9]{2}") %>%
    parse_date()
}

file_age <- function(path){
  difftime(lubridate::today(), file_date(path), units = "days")
}

check_not_outdated <- function(path, threshold_days = 30){
  age <- file_age(path)
  age > threshold_days
}

check_not_outdated(or_file_path)
```

Might force an error if outdated

```
check_not_outdated <- function(path, threshold_days = 30){
  date <- path  %>%
    str_extract("[0-9]{4}-[0-9]{2}-[0-9]{2}") %>%
    parse_date()

  age <- difftime(lubridate::today(),
    date,
    units = "days")

  old <- age > threshold_days

  if(any(old)){
    old_files <- paste(path[old], "is", age[old], "days old", collapse = ", \n* ")
    stop(paste("Some files are outdated: \n*", old_files), call. = FALSE)
  }
  message("No files are outdated")
  invisible(age)
}
check_not_outdated(or_file_path)
```

In this case, we get vectorization for free

```
files <- dir("data") %>% path_ext_remove()
file_paths <- path("data", files, ext = "csv")

file_paths
# data/BC_2018-07-14.csv data/OR_2018-07-15.csv
# data/WA_2018-07-18.csv

check_not_outdated(file_paths)
# No files are outdated
```

Import step

```
or <- read_csv(or_file_path)
bc <- read_csv(bc_file_path)
wa <- read_csv(wa_file_path)
```

Repetition can be removed by **functional programming**.

How might we write summarise_weekly()?

```
or_weekly <-
  or %>%
  mutate(week = lubridate::week(date)) %>%
  group_by(type, week) %>%
  summarise(
    date = first(date),
    n = sum(!is.na(n_sales)),
    mean = mean(n_sales, na.rm = TRUE))
```

What is fragile about this function?

```r
summarise_weekly <- function(data){
  data %>%
  mutate(week = lubridate::week(date)) %>%
  group_by(type, week) %>%
  summarise(
    date = first(date),
    n = sum(!is.na(n_sales)),
    mean = mean(n_sales, na.rm = TRUE))
}
```

What is fragile about this function?

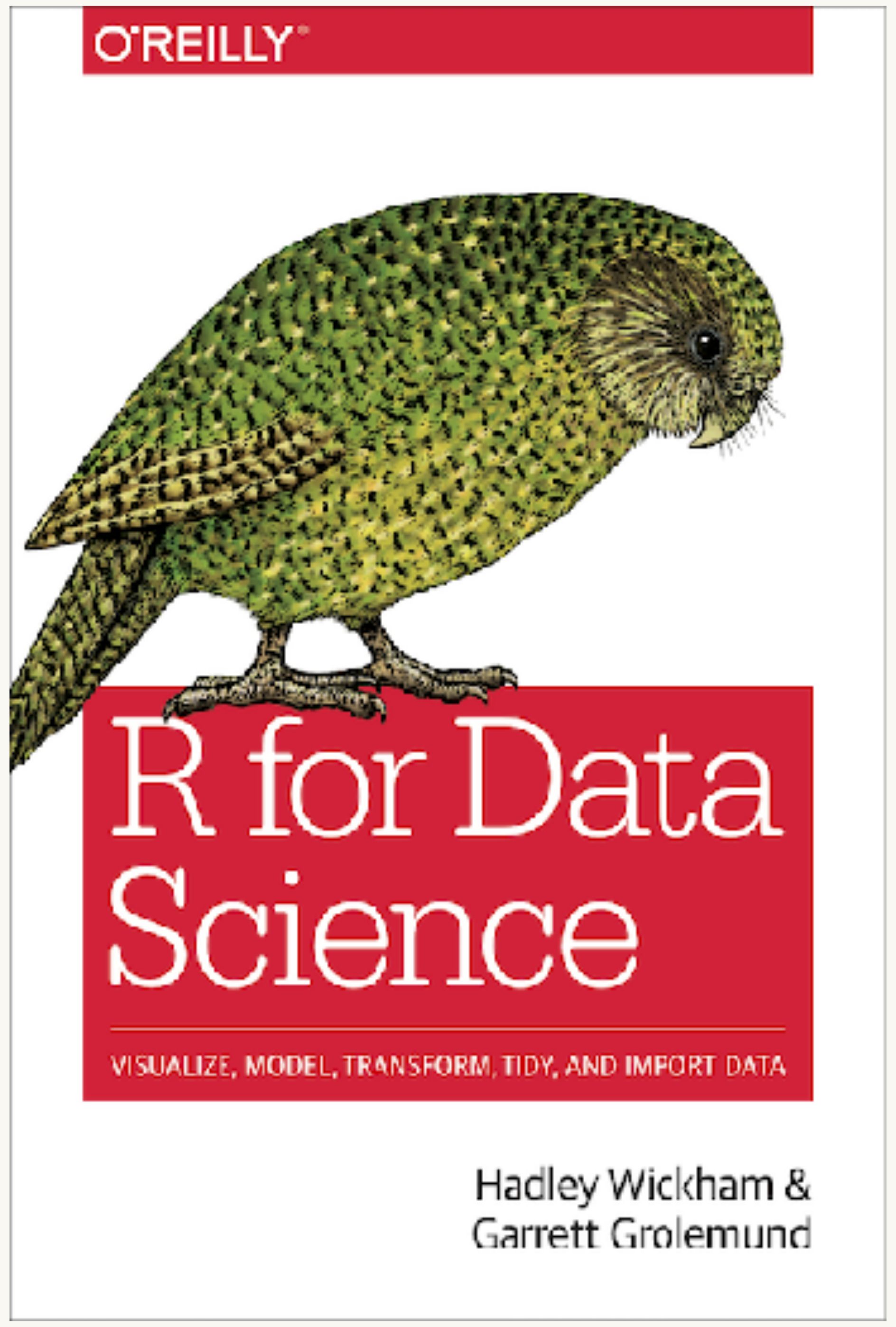
```r
summarise_weekly <- function(data){
  data %>%
  mutate(week = lubridate::week(date)) %>%
  group_by(type, week) %>%
  summarise(
    date = first(date),
    n = sum(!is.na(n_sales)),
    mean = mean(n_sales, na.rm = TRUE))
}
summarise_weekly(or)
```

Makes assumptions about the contents of data.

Solve with **tidy evaluation**.

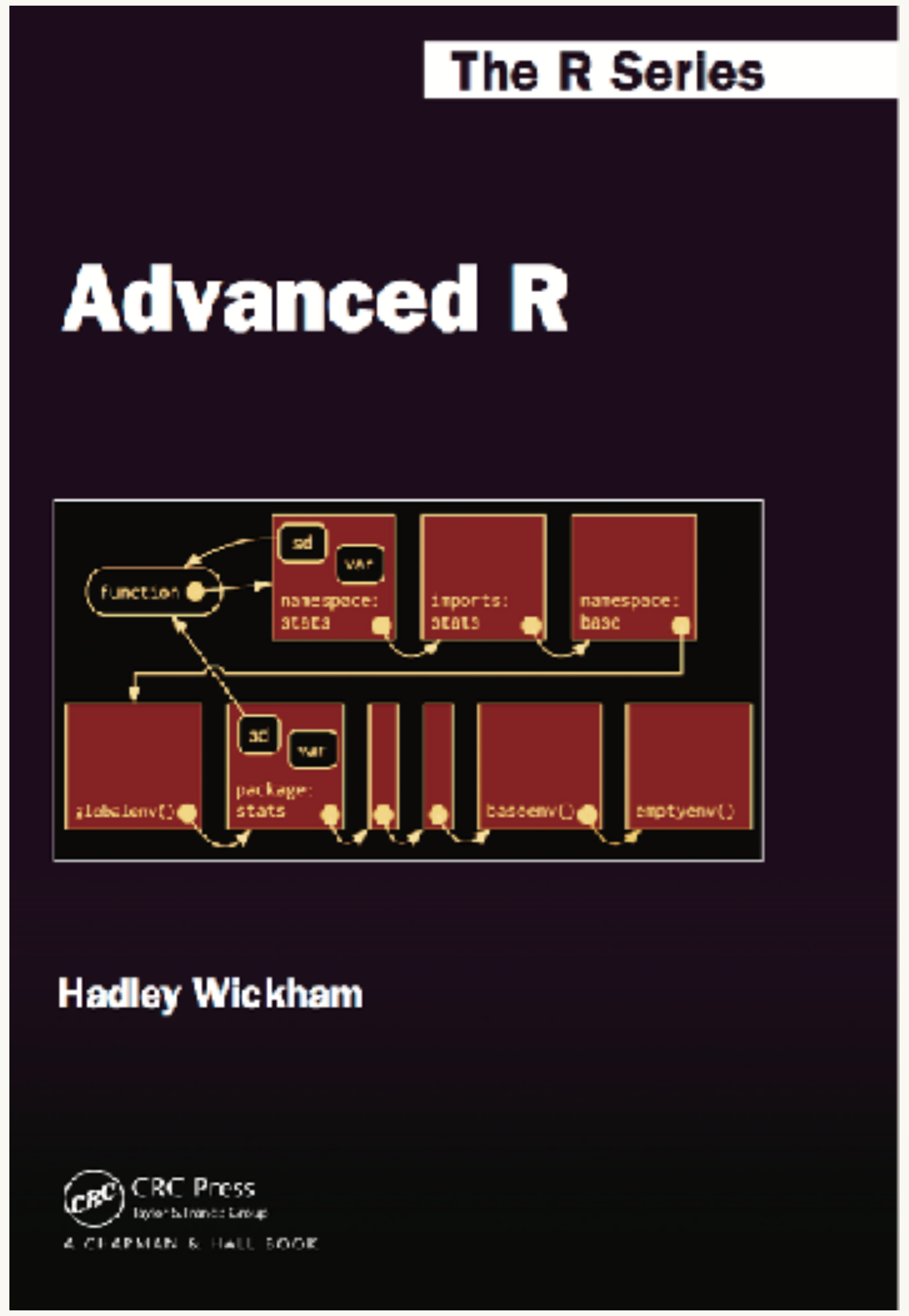
Learning more

Learning more



Functions

http://r4ds.had.co.nz/functions.html



Functions

https://adv-r.hadley.nz/functions.html

Adapted from *Tidy Tools* by Hadley Wickham