Week-5: Functions

NM2207: Computational Media Literacy

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This week

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```
# Example of a function

circle_area <- function(r){

  pi*r^2

}
```

I. Functions and their use

What are functions?

- In mathematics, a function is a rule that maps the input to an output
- In computing, a function is a sequence of instructions within a larger computer program
- We have used so many functions so far, some of them being,
  - `read_csv()`
  - `mean()`
  - `summarize()`
  - `ggplot()`
  - `count()`
- These are functions that are either provided by R or by packages
- But there are times when such an inbuilt function or a package function won't be available

Code repetitions

"You should consider writing a function whenever you've copied and pasted a block of code more than twice (i.e. you now have three copies of the same code)" - Hadley Wickham, for Data Science

Instead of repeating code

```
data %>%
mutate(a = (a - min(a)) / (max(a) - min(a)),

       b = (b - min(b)) / (max(b) - min(b)), # <-- Notice how the only change from previous

       c = (c - min(c)) / (max(c) - min(c)), # line is the change in variables, a to b

       d = (d - min(d)) / (max(d) - min(d))) # b to c, c to d
```

Write a function!

Code repetitions

Write a function

```
# Generic function
rescale_01 <- function(x) {

  (x - min(x)) / (max(x) - min(x)) #<-- Notice how a,b,c,d are replaced by x

}

data %>%
  mutate(a = rescale_01(a),

         b = rescale_01(b),

         c = rescale_01(c),

         d = rescale_01(d))
```

Function anatomy

A function consists of,

- Function arguments
  - They are parameters used by instructions in the body of the function
- Function body
  - They contain statements that are executed when the function is called
- Return value
  - The output inside `return()`
  - Could be a vector, list, data frame, another function, or even nothing
  - If unspecified, will be the last thing calculated

```
# Structure of a function
function_name <- function(arguments) {

  body_of_the_function

  return(output)

}
```

Note: We can assign the function to a name like any other object in R.

Function anatomy: example

- arguments: `x`
- body with instructions: `(x - min(x)) / (max(x) - min(x))`
- assign output to a variable: `rescale_01`
- Note that we don't need to explicitly call `return()`
- the last line of the code will be the value returned by the function.

```
rescale_01 <- function(x) {
  (x - min(x)) / (max(x) - min(x))
  }
```

II. Writing functions

Writing a function: printing output

You start writing code to say "Hello" to all of your friends.

```
print("Hello Kashif!")
```

```
## [1] "Hello Kashif!"
```

```
print("Hello Zach!")
```

```
## [1] "Hello Zach!"
```

```
print("Hello Deniz!")
```

```
## [1] "Hello Deniz!"
```

Writing a function: parameterize the code

- **Start** with the body of the function
- **Ask**: What part of the code is changing?
  - Make this an argument
- **Rewrite** the code to accommodate the parameterization
- Check several **potential inputs** to avoid future headaches
- Insert the body of the code within `{}`
- Name the function, `function_name`
- `?function_name` tells you
  - what arguments the function expects
  - what value it produces

```
# print("Hello Kashif!") becomes ...

name <- "Kashif"

print(paste0("Hello ", name, "!"))
```

```
## [1] "Hello Kashif!"
```

Writing a function: add the structure

```
# name <- "Kashiif"

# print(paste0("Hello ", name, "!"))

function(name) {

print(paste0("Hello ", name, "!"))

}
```

```
## function(name) {
##
## print(paste0("Hello ", name, "!"))
##
## }
```

Writing a function: assign to a name

Try to use names that actively tell the user what the code does

- We recommend `verb_thing()`
- good: `calc_size()` or `compare_prices()`
- bad: `prices()`, `calc()`, or `fun1()`

```
# name <- "Kashif"
# print(paste0("Hello ", name, "!"))
say_hello_to <- function(name) {
  print(paste0("Hello ", name, "!"))
}
```

Simple example: printing output

Test out different inputs!

```
say_hello_to('Kashif')
```

```
## [1] "Hello Kashif!"
```

```
say_hello_to('Zach')
```

```
## [1] "Hello Zach!"
```

```
say_hello_to('Deniz')
```

```
## [1] "Hello Deniz!"
```

Technical aside: typeof(your_function)

Like all R objects, functions have types;

- Primitive functions are of type “built-in”

```
typeof(`+`)
```

```
## [1] "builtin"
```

```
typeof(sum)
```

```
## [1] "builtin"
```

Technical aside: typeof(your_function)

Like all R objects, functions have types;

- The following functions are of type "closure"
    - user-defined functions
    - functions loaded with packages
    - many base R functions

```
typeof(say_hello_to)
```

```
## [1] "closure"
```

```
typeof(mean)
```

```
## [1] "closure"
```

Technical aside: typeof(your_function)

This is background knowledge that might help you understand an error.

- For example, you thought you assigned a number to the name “c” and want to calculate ratio.

```
ratio <- 1/c
```

```
## Error in 1/c: non-numeric argument to binary operator
```

```
as.integer(c)
```

```
## Error in as.integer(c): cannot coerce type 'builtin' to vector of type 'integer'
```

- “built-in” or “closure” in this situation let you know your working

Second example: mean of a sample

- For the sake of simplicity, assume that a sample represents a small collection - sample of height of a population, sample of grades of students, etc.
- This collection, numerically, could either be **random** or **normal** (most common kinds!)

```
mean(rnorm(1))
```

```
## [1] -0.08044514
```

```
mean(rnorm(3))
```

```
## [1] -0.2261543
```

```
mean(rnorm(30))
```

Second example: calculating the mean of a sample

The number is changing, so it becomes the argument.

- The number is the sample size, so I call it `sample_size`.
- `n` would also be appropriate.
- The body code is otherwise identical to the code in the previous slide.

```
calc_sample_mean <- function(sample_size) {
  mean(rnorm(sample_size))
  }
```

Second example: calculating the mean of a sample

For added clarity you can unnest your code, and assign the intermediate results to meaningful names.

- `return()` explicitly tells R what the function will return
  - The last line of code run is returned by default.

```
calc_sample_mean <- function(sample_size) {
  random_sample <- rnorm(sample_size)
  sample_mean <- mean(random_sample)
  return(sample_mean)
}
```

Second example: calculating the mean of a sample

If the function can be fit in one line, then you can write it without the curly brackets like so:

```
calc_sample_mean <- function(n) mean(rnorm(n))
```

Some settings call for ***anonymous*** functions, where the function has no name.

```
function(n) mean(rnorm(n))
```

```
## function(n) mean(rnorm(n))
```

Always test your code

Try to foresee the kind of input you expect to use.

```
calc_sample_mean(1)
```

```
## [1] -0.4800464
```

```
calc_sample_mean(1000)
```

```
## [1] -0.05085521
```

We see below that this function is not vectorized. We might hope to get 3 sample means out but only get 1.

```
# read ?rnorm to understand how rnorm
# inteprets vector input.
calc_sample_mean(c(1, 3, 30))
```

How to deal with unvectorized functions

If we don't want to change our function, but we want to use it to deal with vectors, then we have a couple options:

- Here we are going to use the function `rowwise` from `tidyverse` package

```
library(tidyverse)

#creating a vector to test our function
sample_tibble <- tibble(sample_sizes = c(1, 3

#using rowwise groups the data by row, allowi
sample_tibble %>%
  rowwise() %>%
  mutate(sample_means = calc_sample_mean(samp
```

```
## # A tibble: 4 × 2
## # Rowwise:
##   sample_sizes sample_means
##          <dbl>        <dbl>
## 1            1      -0.541
## 2            3       0.539
## 3           10       0.162
## 4           30       0.0817
```

Adding additional arguments

If we want to be able to adjust the details of how our function runs we can add arguments

- typically, we put “data” arguments first
  - and then “detail” arguments after
  - Mind the order of arguments/parameters, because it can’t change when you call the function in the future

```
calc_sample_mean <- function(sample_size, ou

sample <- rnorm(sample_size,
                mean = our_mean,
                mean(sample),
                sd = our_sd)

}
```

Setting defaults

We usually set default values for “detail” arguments.

```
calc_sample_mean <- function(sample_size,
                             our_mean=0,
                             our_sd=1) {

  sample <- rnorm(sample_size,
                  mean = our_mean,
                  sd = our_sd)

   mean(sample)
}
```

```
# uses the defaults
calc_sample_mean(sample_size = 10)
```

```
## [1] -0.7025336
```

Setting defaults

```
# we can change one or two defaults.
# You can refer by name, or use position
calc_sample_mean(10, our_sd = 2)
```

```
## [1] -1.070941
```

```
calc_sample_mean(10, our_mean = 6)
```

```
## [1] 5.730062
```

```
calc_sample_mean(10, 6, 2)
```

```
## [1] 6.018777
```

Setting defaults

This won't work though:

```
calc_sample_mean(our_mean = 5)
```

```
## Error in rnorm(sample_size, mean = our_mean, sd = our_sd): argument "sample_size" is missing, wi
```

Some more examples

```r
# Add 2 to the input x
add_two <- function(x) {
  x+2
}
```

```r
add_two(4)
```

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

```r
add_two(-34)
```

```
## [1] -32
```

```r
add_two(5.784)
```

III. Common mistakes to avoid

What could go wrong?

```
add_two <- function(x) {
  y+2
}
```

```
add_two(4)
```

```
## Error in add_two(4): object 'y' not found
```

Mismatch in the argument in the definition of the function (`x`) and the variable name used inside the function (`y`)

```
add_two <- function(x) {
  x+2
}
```

```
add_two(4)
```

Another example: adding two numbers

```r
# function definition
add_numbers <- function(x,y) {
  x+y
}
```

```r
# function call
add_numers(45, 12)
```

```
## Error in add_numers(45, 12): could not find function "add_numers"
```

Mismatch in the names of the function in the definition and in the function call

Another example: adding two numbers

```r
# function definition
add_numbers <- function(x,y) {
  x+y
}
```

```r
# function call
add_numers(45, 12, 72)
```

```
## Error in add_numers(45, 12, 72): could not find function "add_numers"
```

Mismatch in the number of arguments in the function definition and in the function call

Another example: adding two numbers

```
# function definition
add_numbers <- function(x,y) {
  z = 20
  x+y
}
```

```
print(z)
```

```
## Error in print(z): object 'z' not found
```

Variables declared inside a function, cannot be accesses outside of it. Unless

```
# function definition
add_numbers <- function(x,y) {
  z = 20
  return(x+y,z)

}
```

IV. Scope of variables

Scoping

Try the code below

```
# Initialize z
z <- 1

# declare a function, notice how we pass a va
foo <- function(z = 2) {
  # reassigning z
  z <- 3
  z
}
```

```
# another reassignment of z
foo(z = 4)
```

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

1. `z` was initially assigned a value 1
2. The function definition passes a default value of 2
3. `z` is redefined inside the function to 3
4. **Notice** despite the initialization of `z` to 4 in the function call, the function returns a value of 3!

Scoping

> The location where we can find a variable and also access it when required is called the scope of a variable

There are mainly two types of variable scopes,

Global

- They are declared outside functions
- They can be accessed from anywhere in the program
- Hence, **global**
- In the code, `z<-1` is the global variable
- Type `z` in the console and check the output

Local

- They are declared inside functions
- They cannot be accessed outside the functions
- Hence, **local**
- In the code, `z<-3` is the local variable

Recap

We learned all about,

a. Functions and how to use them

b. The anatomy of functions

c. Writing functions and configuring arguments

d. Scoping of variables used in functions

e. Some common mistakes to avoid while writing functions

Thanks!

Slides created via the R packages:

xaringan
gadenbuie/xaringanthemer.

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