Functions: Part 1

Daniel Anderson

Week 6, Class 1

Agenda

- Everything is a function
- Components of a function
- Function workflows

Learning objectives

- Understand and be able to fluently refer to the three fundamental components of a function

- Understand the workflows that often lead to writing functions, and how you iterate from interactive work to writing a function

- Be able to write a few basic functions

Functions

Anything that carries out an operation in R is a function. For example

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

The + is a function (what's referred to as an *infix* function).

Any ideas on how we could re-write the above to make it look more "function"-y?

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

What about this?

```
## [1] 15
```

```
## [1] 15
```

or

```
## [1] 15
```

What's going on here?

- The + operator is a function that takes two arguments (both numeric), which it sums.
- The following are also the same (minus what's being assigned)

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

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

Everything is a function!

Being devious

- Want to introduce a devious bug? Redefine +

```
##
## FALSE  TRUE
##     3   497
```

```
## Warning in rm(`+`, envir = globalenv()): object '+' not found
```

```
##
## FALSE  TRUE
##     6   494
```

Tricky...

Functions are also (usually) objects!

```
##
## Call:
## a(formula = hp ~ drat + wt, data = mtcars)
##
## Coefficients:
## (Intercept)         drat           wt
##     -27.782        5.354       48.244
```

What does this all mean?

- Anything that carries out ANY operation in R is a function
- Functions are generally, but not always, stored in an object (otherwise known as binding the function to a name)

Anonymous functions

- The function for computing the mean is bound the name `mean`

- When running things through loops, you may often want to apply a function without binding it to a name

Example

```
##   mpg   cyl  disp    hp  drat    wt  qsec    vs    am  gear  carb
##    25     3    27    22    22    29    30     2     2     3     6
```

Another possibility

- If you have a bunch of functions, you might consider storing them all in a list.
- You can then access the functions in the same way you would subset any list

This is kind of weird...

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

```
## [1] 50
```

```
## [1] 400
```

What does this imply?

- If we can store functions in a vector (list), then we can loop through the vector just like any other!

```
##         n    n_miss   n_valid      mean        sd
## 32.000000  0.000000 32.000000 20.090625  6.026948
```

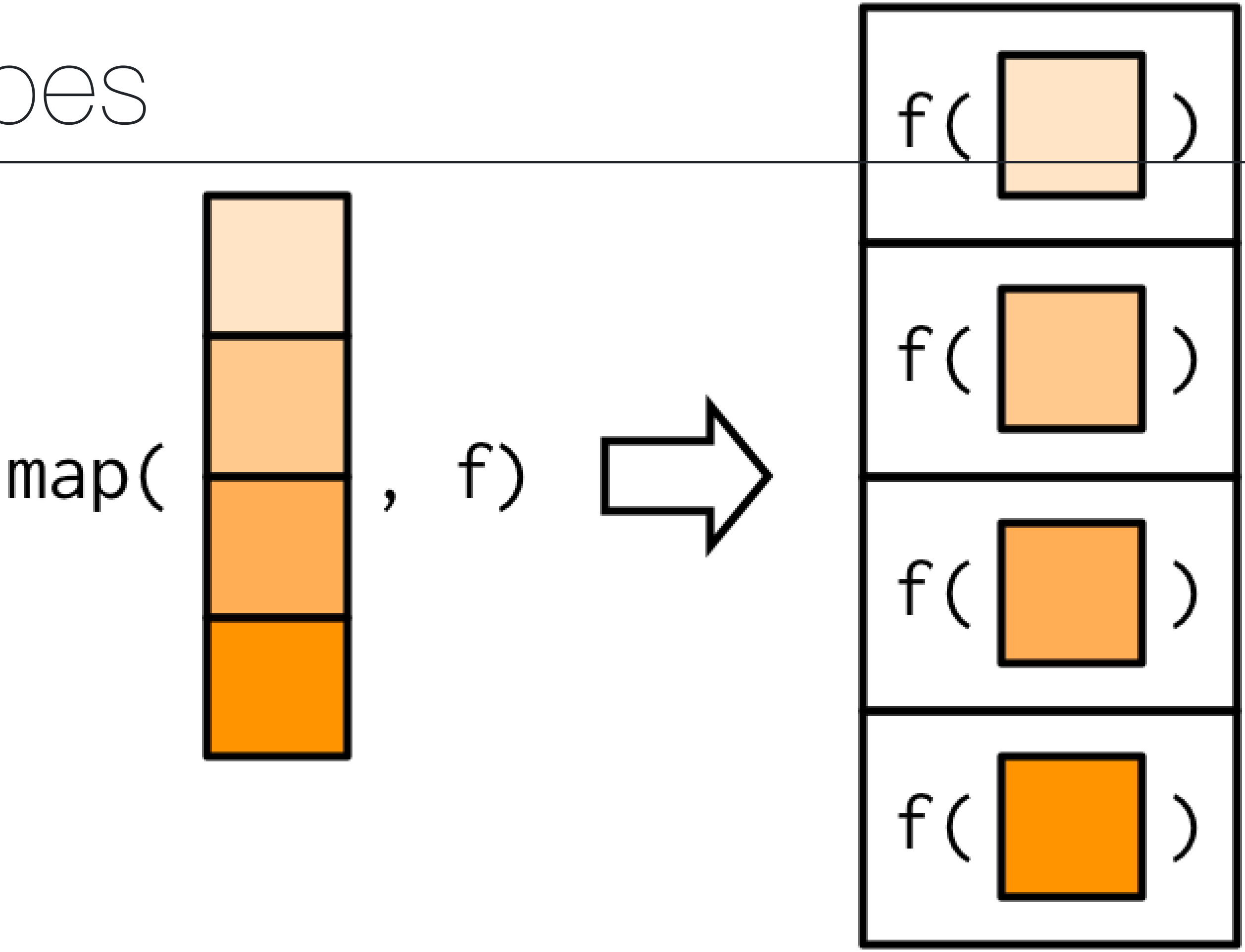
Careful though

This doesn't work

```
## Error: Can't pluck from a builtin
```

Why?

Remember what {purrr} does



With `map_df`

What if we wanted this for all columns?

Challenge

- Can you extend the previous looping to supply the summary for every column? Hint: You'll need to make a nested loop (loop each function through each column)

```
## # A tibble: 11 x 6
##    column      n n_miss n_valid       mean          sd
##    <chr>   <int>  <int>   <int>      <dbl>       <dbl>
##  1 mpg        32      0      32  20.09062    6.026948
##  2 cyl        32      0      32   6.1875     1.785922
##  3 disp       32      0      32 230.7219   123.9387
##  4 hp         32      0      32 146.6875    68.56287
##  5 drat       32      0      32   3.596562   0.5346787
##  6 wt         32      0      32   3.21725    0.9784574
##  7 qsec       32      0      32  17.84875    1.786943
##  8 vs         32      0      32   0.4375     0.5040161
##  9 am         32      0      32   0.40625    0.4989909
## 10 gear       32      0      32   3.6875     0.7378041
## 11 carb       32      0      32   2.8125     1.615200
```

05:00

Maybe easier

- Often when you get into nested loops, it's easier to turn (at least) one of the loops into a function.

Now we can just loop this function through each column

Wrap the whole thing in a function

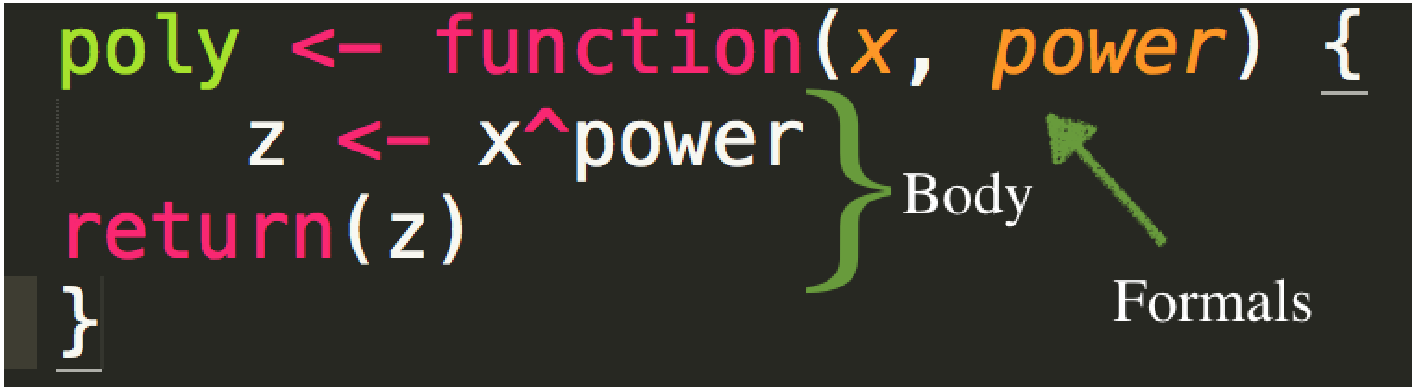
```
## # A tibble: 6 x 6
##   column      n n_miss n_valid      mean        sd
##   <chr>   <int>  <int>   <int>     <dbl>     <dbl>
## 1 Ozone     153     37     116 NA        NA
## 2 Solar.R   153      7     146 NA        NA
## 3 Wind      153      0     153  9.957516  3.523001
## 4 Temp      153      0     153 77.88235   9.465270
## 5 Month     153      0     153  6.993464  1.416522
## 6 Day       153      0     153 15.80392   8.864520
```

Notice the missing data. Why? What should we do?

Function components

Three components

- `body()`
- `formals()`
- `environment()` (we won't focus so much here for now)



```
poly <- function(x, power) {
    z <- x^power
return(z)
}
```

Formals

- The arguments supplied to the function

- What's one way to identify the formals for a function – say, `lm`?

`?`: Help documentation!

Alternative – use a function!

```
## $formula
##
##
## $data
##
##
## $subset
##
##
## $weights
##
##
## $na.action
```

How do you see the body?

- In RStudio: Super (command on mac, cntrl on windows) + click!

[demo]

- Alternative – just print to screen

Or use **body**

```
## {
##     ret.x <- x
##     ret.y <- y
##     cl <- match.call()
##     mf <- match.call(expand.dots = FALSE)
##     m <- match(c("formula", "data", "subset", "weights", "na.action",
##         "offset"), names(mf), 0L)
##     mf <- mf[c(1L, m)]
##     mf$drop.unused.levels <- TRUE
##     mf[[1L]] <- quote(stats::model.frame)
##     mf <- eval(mf, parent.frame())
##     if (method == "model.frame")
##         return(mf)
##     else if (method != "qr")
##         warning(gettextf("method = '%s' is not supported. Using 'qr'",
##             method), domain = NA)
##     mt <- attr(mf, "terms")
##     y <- model.response(mf, "numeric")
##     w <- as.vector(model.weights(mf))
##     if (!is.null(w) && !is.numeric(w))
##         stop("'weights' must be a numeric vector")
##     offset <- model.offset(mf)
##     mlm <- is.matrix(y)
##     ny <- if (mlm)
##         nrow(y)
##     else length(y)
##     if (!is.null(offset)) {
```

Environment

- As I mentioned, we won't focus on this too much, but if you get deep into programming it's pretty important

```
## <environment: 0x7fd29d8ca2d0>
```

```
## <environment: namespace:stats>
```

Why this matters

What will the following return?

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

What will this return?

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

Last one

What do each of the following return?

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

```
## Error in eval(expr, envir, enclos): object 'y' not found
```

Environment summary

- The previous examples are part of *lexical scoping*.
- Generally, you won't have to worry too much about it
- If you end up with unexpected results, this could be part of why

Scoping

- Part of what's interesting about these scoping rules is that your functions can, and very often do, depend upon things in your global workspace, or your specific environment.
- If this is the case, the function will be a "one–off", and unlikely to be useful in any other script

Example 1

Extracting information

- This is a real example

Example 2

Reading in data

Simple example

Pull out specific coefficients

```
## # A tibble: 3 x 3
## # Groups:   cyl [3]
##     cyl data                         model
##   <dbl> <list>                       <list>
## 1     6 <tibble[,10] [7 × 10]>  <lm>
## 2     4 <tibble[,10] [11 × 10]> <lm>
## 3     8 <tibble[,10] [14 × 10]> <lm>
```

Pull a specific coef

Find the solution for one model

```
## (Intercept)        disp          hp        drat 
## 6.284507434 0.026354099 0.006229086 2.193576546 
```

```
##      disp 
## 0.0263541 
```

```
## (Intercept) 
##    6.284507 
```

Generalize it

```
## # A tibble: 3 x 7
## # Groups:   cyl [3]
##     cyl data                    model  intercept        disp           h
##   <dbl> <list>                  <list>     <dbl>       <dbl>        <dbl
## 1     6 <tibble[,10] [7 × 10]>  <lm>    6.284507  0.02635410  0.00622908
## 2     4 <tibble[,10] [11 × 10]> <lm>   46.08662  -0.1225361  -0.04937771
## 3     8 <tibble[,10] [14 × 10]> <lm>   19.00162  -0.01671461 -0.02140236
```

Make it more flexible

- Since the intercept is a little difficult to pull out, we could have it return that by default.

```
## # A tibble: 3 x 4
## # Groups:   cyl [3]
##     cyl data                    model  intercept
##   <dbl> <list>                  <list>     <dbl>
## 1     6 <tibble[,10] [7 × 10]>  <lm>    6.284507
## 2     4 <tibble[,10] [11 × 10]> <lm>   46.08662
## 3     8 <tibble[,10] [14 × 10]> <lm>   19.00162
```

Return all coefficients

```
## # A tibble: 3 x 4
## # Groups:   cyl [3]
##     cyl data                         model  coefs
##   <dbl> <list>                       <list> <list>
## 1     6 <tibble[,10] [7 × 10]>  <lm>   <df[,2] [4 × 2]>
## 2     4 <tibble[,10] [11 × 10]> <lm>   <df[,2] [4 × 2]>
## 3     8 <tibble[,10] [14 × 10]> <lm>   <df[,2] [4 × 2]>
## # A tibble: 12 x 5
## # Groups:   cyl [3]
##      cyl data                    model  coefficient     estimate
##    <dbl> <list>                  <list> <chr>              <dbl>
##  1     6 <tibble[,10] [7 × 10]>  <lm>   (Intercept)  6.284507
##  2     6 <tibble[,10] [7 × 10]>  <lm>   disp         0.02635410
##  3     6 <tibble[,10] [7 × 10]>  <lm>   hp           0.006229086
##  4     6 <tibble[,10] [7 × 10]>  <lm>   drat         2.193577
##  5     4 <tibble[,10] [11 × 10]> <lm>   (Intercept) 46.08662
##  6     4 <tibble[,10] [11 × 10]> <lm>   disp        -0.1225361
##  7     4 <tibble[,10] [11 × 10]> <lm>   hp          -0.04937771
##  8     4 <tibble[,10] [11 × 10]> <lm>   drat        -0.6041857
##  9     8 <tibble[,10] [14 × 10]> <lm>   (Intercept) 19.00162
## 10     8 <tibble[,10] [14 × 10]> <lm>   disp        -0.01671461
## 11     8 <tibble[,10] [14 × 10]> <lm>   hp          -0.02140236
## 12     8 <tibble[,10] [14 × 10]> <lm>   drat         2.006011
```

Slightly nicer

```
## # A tibble: 12 x 3
## # Groups:   cyl [3]
##      cyl coefficient     estimate
##    <dbl> <chr>              <dbl>
##  1     6 (Intercept)  6.284507
##  2     6 disp         0.02635410
##  3     6 hp           0.006229086
##  4     6 drat         2.193577
##  5     4 (Intercept) 46.08662
##  6     4 disp        -0.1225361
##  7     4 hp          -0.04937771
##  8     4 drat        -0.6041857
##  9     8 (Intercept) 19.00162
## 10     8 disp        -0.01671461
## 11     8 hp          -0.02140236
## 12     8 drat         2.006011
```

Create nice table

```
## # A tibble: 3 x 5
## # Groups:   cyl [3]
##     cyl `(Intercept)`        disp           hp       drat
##   <dbl>         <dbl>       <dbl>        <dbl>      <dbl>
## 1     4     46.08662  -0.1225361  -0.04937771  -0.6041857
## 2     6      6.284507  0.02635410  0.006229086  2.193577
## 3     8     19.00162  -0.01671461 -0.02140236   2.006011
```

When to write a function?

Example

```
## # A tibble: 10 x 4
##            a          b           c           d
##        <dbl>      <dbl>       <dbl>       <dbl>
##  1 305.6438   295.7304    54.00421   168.3175
##  2  15.29527  442.9968  -167.1963    205.7256
##  3 154.4693  -108.3291    74.21240   255.2655
##  4 194.9294    58.18168  282.2012      8.661044
##  5 160.6402    80.00180  384.2790    175.7433
##  6  84.08132  195.3926    35.42963  -157.5513
##  7 326.7283    57.36206   61.40959   -17.66885
##  8  85.80114 -298.4683  -164.4745    -27.63614
##  9 402.7636  -266.0700   169.0146   -262.1311
## 10  90.59289  298.0170     4.000769  105.4184
```

Rescale each column to 0/1

Do it for one column

```
## # A tibble: 10 x 4
##            a          b           c           d
##        <dbl>      <dbl>       <dbl>       <dbl>
##  1 0.7493478  295.7304    54.00421   168.3175
##  2 0          442.9968  -167.1963    205.7256
##  3 0.3591881 -108.3291    74.21240   255.2655
##  4 0.4636099   58.18168  282.2012      8.661044
##  5 0.3751145   80.00180  384.2790    175.7433
##  6 0.1775269  195.3926    35.42963  -157.5513
##  7 0.8037639   57.36206   61.40959   -17.66885
##  8 0.1819655 -298.4683  -164.4745    -27.63614
##  9 1         -266.0700   169.0146   -262.1311
## 10 0.1943323  298.0170     4.000769  105.4184
```

Do it for all columns

```
## # A tibble: 10 x 4
##            a          b           c         d
##        <dbl>      <dbl>       <dbl>     <dbl>
##  1 0.7493478 0.8013846  0.4011068   0.8319510
##  2 0         1          0           0.9042516
##  3 0.3591881 0.2564372  0.4377506   1        
##  4 0.4636099 0.4810071  0.8149005   0.5233744
##  5 0.3751145 0.5104355  1           0.8463031
##  6 0.1775269 0.6660608  0.3674252   0.2021270
##  7 0.8037639 0.4799017  0.4145351   0.4724852
##  8 0.1819655 0          0.004935493 0.4532209
##  9 1         0.04369494 0.6096572   0        
## 10 0.1943323 0.8044685  0.3104346   0.7103825
```

An alternative

- What's an alternative we could use *without* writing a function?

```
## # A tibble: 10 x 4
##            a          b           c         d
##        <dbl>      <dbl>       <dbl>     <dbl>
##  1 0.7493478 0.8013846  0.4011068   0.8319510
##  2 0         1          0           0.9042516
##  3 0.3591881 0.2564372  0.4377506   1        
##  4 0.4636099 0.4810071  0.8149005   0.5233744
##  5 0.3751145 0.5104355  1           0.8463031
##  6 0.1775269 0.6660608  0.3674252   0.2021270
##  7 0.8037639 0.4799017  0.4145351   0.4724852
##  8 0.1819655 0          0.004935493 0.4532209
##  9 1         0.04369494 0.6096572   0        
## 10 0.1943323 0.8044685  0.3104346   0.7103825
```

Another alternative

Write a function

- What are the arguments going to be?
- What will the body be?

Arguments

- One formal argument – A numeric vector to rescale

Body

- You try first

02:00

Create the function

Test it!

```
## [1] 0.0 0.5 1.0
```

```
##  [1] 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
```

Make it cleaner

- There's nothing inherently "wrong" about the prior function, but it is a bit hard to read
- How could we make it easier to read?
    - Remove missing data once (rather than every time)
    - Don't calculate things multiple times

A little cleaned up

Test it!

```
## [1] 0.0 0.5 1.0
```

```
##  [1] 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
```

Make sure they give the same output

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

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

Final solution

Could use `modify` here too

```
## # A tibble: 10 x 4
##            a          b           c         d
##        <dbl>      <dbl>       <dbl>     <dbl>
##  1 0.7493478 0.8013846  0.4011068   0.8319510
##  2 0         1          0           0.9042516
##  3 0.3591881 0.2564372  0.4377506   1
##  4 0.4636099 0.4810071  0.8149005   0.5233744
##  5 0.3751145 0.5104355  1           0.8463031
##  6 0.1775269 0.6660608  0.3674252   0.2021270
##  7 0.8037639 0.4799017  0.4145351   0.4724852
##  8 0.1819655 0          0.004935493 0.4532209
##  9 1         0.04369494 0.6096572   0
## 10 0.1943323 0.8044685  0.3104346   0.7103825
```

Getting more complex

- What if you want a function to behave differently depending on the input?

  Add conditions

Lots of conditions?

Easy example

- Given a vector, return the mean if it's numeric, and `NULL` otherwise

Test it

```
## [1] 0.1855869
```

```
## NULL
```

Mean for all numeric columns

- The prior function can now be used within a new function to calculate the mean of all columns of a data frame that are numeric

```
##   Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1          5.1         3.5          1.4         0.2  setosa
## 2          4.9         3.0          1.4         0.2  setosa
## 3          4.7         3.2          1.3         0.2  setosa
## 4          4.6         3.1          1.5         0.2  setosa
## 5          5.0         3.6          1.4         0.2  setosa
## 6          5.4         3.9          1.7         0.4  setosa
```

```
##   Sepal.Length Sepal.Width Petal.Length Petal.Width
## 1     5.843333    3.057333        3.758    1.199333
```

We have a problem though!

```
##   Ozone Solar.R Wind Temp Month Day
## 1    41     190  7.4   67     5   1
## 2    36     118  8.0   72     5   2
## 3    12     149 12.6   74     5   3
## 4    18     313 11.5   62     5   4
## 5    NA      NA 14.3   56     5   5
## 6    28      NA 14.9   66     5   6

##   Ozone Solar.R     Wind     Temp    Month      Day
## 1    NA      NA 9.957516 77.88235 6.993464 15.80392
```

Why is this happening?

How can we fix it?

Easiest way in this case `...`

Pass the dots!

Redefine `means2`

Reefine means_df

```
##   Ozone Solar.R     Wind     Temp    Month      Day
## 1    NA      NA 9.957516 77.88235 6.993464 15.80392
```

```
##       Ozone  Solar.R     Wind     Temp    Month      Day
## 1 42.12931 185.9315 9.957516 77.88235 6.993464 15.80392
```

Next time

Functions: Part 2