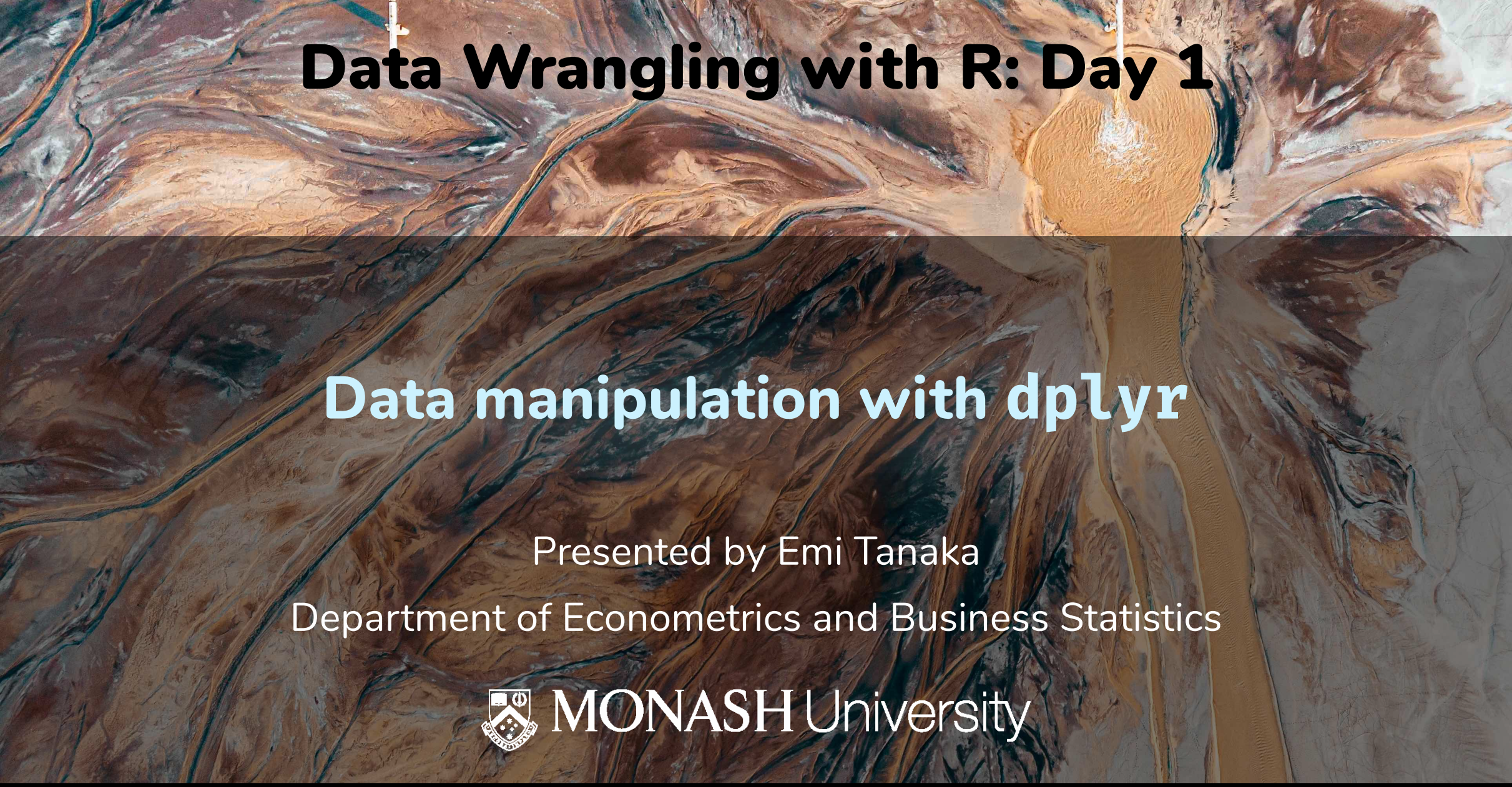
Data Wrangling with R: Day 1



Data manipulation with `dplyr`

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Grammar of data manipulation

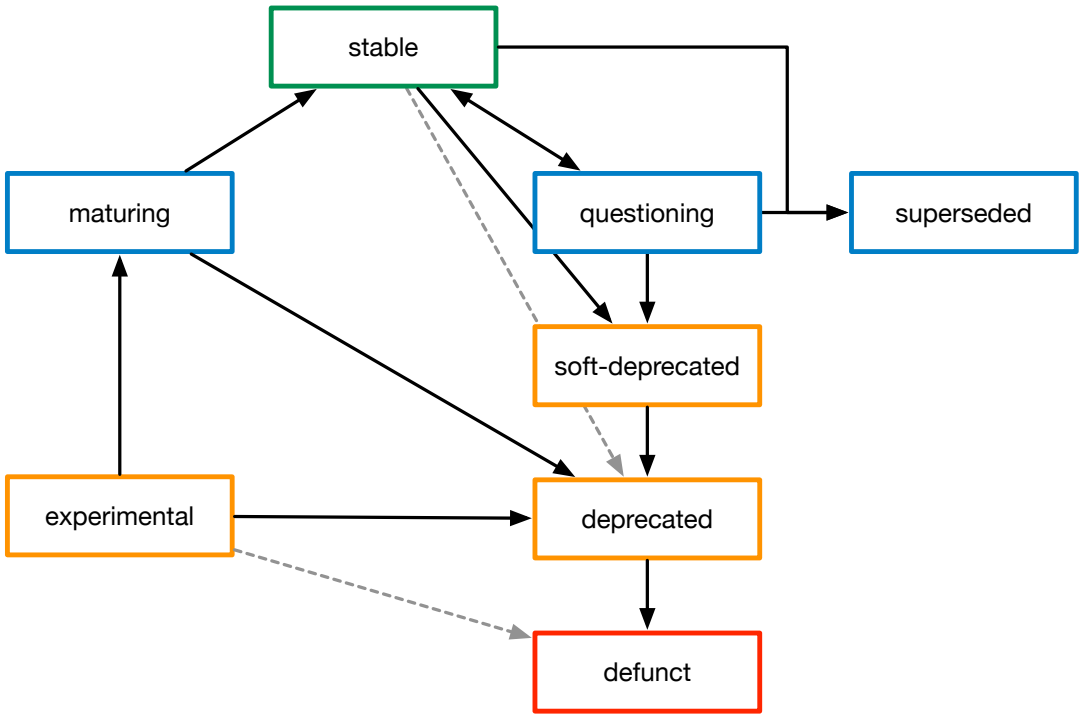
```
library(dplyr) # or library(tidyverse)
```

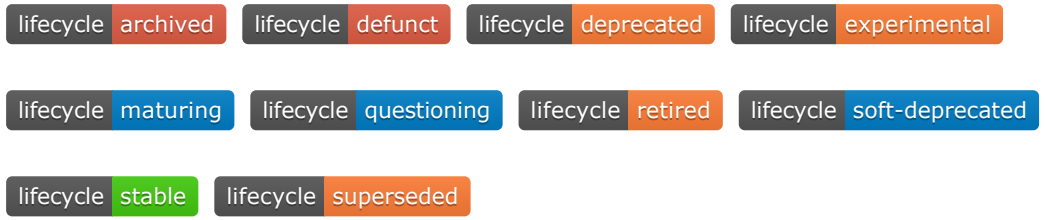
- `dplyr` is a core package in `tidyverse`
- The earlier concept of `dplyr` (first on CRAN in 2014-01-29) was implemented in `plyr` (first on CRAN in 2008-10-08)
- The functions in `dplyr` has been evolving frequently but `dplyr` v1.0.0 was released on CRAN in 2020-05-29
- This new version contained new "verbs"
- The major release suggests that functions in `dplyr` are maturing and thus the user interface is unlikely to change

Hadley Wickham, Romain François, Lionel Henry and Kirill Müller (2020). dplyr: A Grammar of Data Manipulation. R package version 1.0.2.

Hadley Wickham (2011). The Split-Apply-Combine Strategy for Data Analysis. Journal of Statistical Software, 40(1), 1-29.

Lifecycle





- Functions (and sometimes arguments of functions) in `tidyverse` packages often are labelled with a badge like above
- Find definitions of badges here
- Check out documentations below

```
help(mutate, package = "dplyr")
help(mutate_each, package = "dplyr")
```

Lionel Henry (2020). lifecycle: Manage the Life Cycle of your Package Functions. R package version 0.2.0.

dplyr "verbs"

- The main functions of `dplyr` include:

```
arrange   select     mutate
rename    group_by   summarise
```

- Notice that these functions are *verbs*
- Functions in `dplyr` generally have the form:

```
verb(data, args)
```

- I.e., the first argument `data` is a `data.frame` object
- What do you think the following will do?

```
rename(mtcars, miles_per_gallon = mpg)
arrange(mtcars, wt)
```

Pipe operator %>%

- Almost all tidyverse packages import the `magrittr` package to use %>%
- `x %>% f(y)` is the same as `f(x, y)`
- `x %>% f(y) %>% g(z)` is the same as `g(f(x, y), z)`
- When you see the pipe operator %>%, read it as "and then"

```
mtcars %>%                              # take mtcars data, and then
 rename(miles_per_gallon = mpg) %>% # rename mpg as miles_per_gallon, and then
 arrange(wt)                            # arrange row by wt

##                miles_per_gallon cyl  disp  hp drat    wt  qsec vs am gea
## Lotus Europa               30.4   4  95.1 113 3.77 1.513 16.90  1  1
## Honda Civic                30.4   4  75.7  52 4.93 1.615 18.52  1  1
## Toyota Corolla             33.9   4  71.1  65 4.22 1.835 19.90  1  1
## Fiat X1-9                  27.3   4  79.0  66 4.08 1.935 18.90  1  1
```


Stefan Milton Bache and Hadley Wickham (2020). magrittr: A Forward-Pipe Operator for R. R package version 2.0.1.

Lazy and non-standard evaluation

- Remember in Base R:

```
subset(mtcars, mpg > 31)

##                 mpg cyl disp hp drat    wt  qsec vs am gear carb
## Fiat 128       32.4   4 78.7 66 4.08 2.200 19.47  1  1    4    1
## Toyota Corolla 33.9   4 71.1 65 4.22 1.835 19.90  1  1    4    1
```

- But the second argument cannot be evaluated:

```
mpg > 31

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

- R employs what is called **lazy evaluation** for function inputs
- **Non-standard evaluation** uses this feature to capture the input expression within the function and evaluate only when requested

Tidy evaluation Part 1

- Tidy evaluation builds on the lazy and non-standard evaluation and is implemented in `rlang`
- All core tidyverse packages import `rlang`
- So what does it do?
- Let's consider `filter`, the Tidyverse version of `subset`

```
filter(mtcars, mpg > 31)

##                mpg cyl disp hp drat    wt  qsec vs am gear carb
## Fiat 128      32.4   4 78.7 66 4.08 2.200 19.47  1  1    4    1
## Toyota Corolla 33.9   4 71.1 65 4.22 1.835 19.90  1  1    4    1
```

- ⚠ If you get an error using `filter`, replace it with `dplyr::filter`

for those interested, `dplyr::filter` is a conflict with `stats::filter` and it may be using `stats::filter` instead... I've fallen into this trap so many times!

Lionel Henry and Hadley Wickham (2020). rlang: Functions for Base Types and Core R and 'Tidyverse' Features. R package version 0.4.8.

Tidy evaluation Part 2

- Suppose we have a silly function that subsets `mtcars` for a given condition

```
myCarSubset <- function(cond) subset(mtcars, cond)
myCarFilter <- function(cond) filter(mtcars, cond)
```

- This causes an issue because `cond` is evaluated before it is parsed into `subset` or `filter`

```
myCarSubset(mpg > 31)

## Error in eval(e, x, parent.frame()): object 'mpg' not found

myCarFilter(mpg > 31)

## Error: Problem with `filter()` input `..1`.
## x object 'mpg' not found
## ℹ Input `..1` is `cond`.
```

Tidy evaluation Part 3

- Functions that use non-standard evaluation is problematic

```
myCarSubsetNew <- function(cond) subset(mtcars, {{ cond }})
myCarFilterNew <- function(cond) filter(mtcars, {{ cond }})

myCarSubsetNew(mpg > 31)


## Error in eval(e, x, parent.frame()): object 'mpg' not found
```

```
myCarFilterNew(mpg > 31)


##                mpg cyl disp hp drat    wt  qsec vs am gear carb
## Fiat 128      32.4   4 78.7 66 4.08 2.200 19.47  1  1    4    1
## Toyota Corolla 33.9   4 71.1 65 4.22 1.835 19.90  1  1    4    1
```

- `{{ }}` only works if the underlying function implements `rlang`

Data masking Part 1

```
ind <- 1:nrow(cars) # nrow(cars) = 50
subset(cars, ind > 49)

##    speed dist
## 50    25   85

filter(cars, ind > 49)

##   speed dist
## 1    25   85
```

- For any variables that don't exist in the data, R searches the parental environment for evaluation.

```
speed <- c(40, 51)
subset(cars, speed > 24)

##    speed dist
## 50    25   85

filter(cars, speed > 24)

##   speed dist
## 1    25   85
```

- The variables in data take priority for reference over those in parental environment

Data masking Part 2

```
speed <- 1:nrow(cars)
filter(cars, .data$speed > 24)
```

```
##   speed dist
## 1    25   85
```

```
filter(cars, .env$speed > 24)
```

```
##    speed dist
## 1     15   26
## 2     15   54
## 3     16   32
## 4     16   40
## 5     17   32
## 6     17   40
```

- In Tidyverse, you can be explicit whether the variable is in the data or in the parental environment
- `.data` is a special pronoun referring to variables in the data parsed in the first argument
- `.env` is a special pronoun referring to variables in the environment (i.e. *not* in the data parsed in the first argument)

Tidy select Part 1

- Tidyverse packages generally use syntax from the `tidyselect` package for variable/column selection

```
data(frog_signal, package = "dwexercise")
str(frog_signal)

## 'data.frame':    535 obs. of  22 variables:
##  $ FrogID           : chr  "13196" "13197" "13198" "13206" ...
##  $ AlternativeCD    : num  28 27 31 33 26 31 33 28 29 34 ...
##  $ AlternativeCR    : num  12 15 13 15 11 6 15 12 14 12 ...
##  $ AlternativeDF    : num  2315 2304 2646 2281 2789 ...
##  $ AlternativeRA    : num  -10 -8 -12 -7 -8 -6 -12 -16 -12 -10 ...
##  $ AlternativePR    : num  46 49 43 50 57 51 46 55 56 45 ...
##  $ Standard1        : num  47 69 139 112 101 90 79 262 123 47 ...
##  $ Standard2        : num  46 44 102 112 101 68 41 237 106 62 ...
##  $ Standard3        : num  42 36 85 117 80 73 46 166 95 63 ...
```

Tidy select Part 2

```
frog_signal %>%
 select(Standard1, Standard2,
Standard3)
```

```
##     Standard1 Standard2 Standard3
## 1          47        46        42
## 2          69        44        36
## 3         139       102        85
## 4         112       112       117
## 5         101       101        80
## 6          90        68        73
## 7
## 8
## 9
## 10
## 11          95       117        84
```

```
frog_signal %>%
  select(Standard1:Standard3)
```

```
##     Standard1 Standard2 Standard3
## 1          47        46        42
## 2          69        44        36
## 3         139       102        85
## 4         112       112       117
## 5         101       101        80
## 6          90        68        73
## 7          79        41        46
##                      7       166
##                      6        95
##                      2        63
##                      7        84
## 12          56        52        41
```

The `tidyselect` syntax `:` can be used to select contiguous columns in the data

Tidy select Part 3

```
frog_signal %>%
  select(starts_with("Standard"))
```

```
##     Standard1 Standard2 Standard3 Sta
## 1          47        46        42
## 2          69        44        36
## 3         139       102        85
## 4         112       112       117
## 5         101       101        80
## 6          90        68        73
## 7          79        41        46
## 8         262       237       166
## 9         123       106        95
## 10         47        62        63
## 11         95       117        84
## 12         56        52        41
```

```
frog_signal %>%
  select(num_range("Standard", 1:3))
```

```
##     Standard1 Standard2 Standard3
## 1          47        46        42
## 2          69        44        36
## 3         139       102        85
## 4         112       112       117
## 5         101       101        80
## 6          90        68        73
## 7          79        41        46
## 8         262       237       166
## 9         123       106        95
## 10         47        62        63
## 11         95       117        84
## 12         56        52        41
```

Selection language Part 1

- `:` for selecting contiguous variables
- `!` for taking complement set of variables
- `&` or `|` for selecting intersection or union of two sets of variables, e.g.

```
frog_signal %>%
  select(starts_with("Alt") & ends_with("1")) %>%
  str()

## 'data.frame':    535 obs. of  1 variable:
##  $ Alternative1: num  28 33 227 101 126 143 50 123 76 53 ...
```

- `c()` for combining selections
- `everything()` to select all variables
- `last_col()` to select last variable, with option of an offset

Selection language Part 2

- `starts_with()` selects columns with the given prefix
- `ends_with()` selects columns with the given suffix
- `contains()` selects columns with a literal string
- `matches()` selects columns that match the regular expression we'll learn this next!
- `num_range()` selects columns with a numerical range
- `all_of()` for selecting columns based on a character vector
- `any_of()` is the same as `all_of()` but no error when variables do not exist
- `where()` selects based on where given function return TRUE

```
help(language, package = "tidyselect")
```

Subsetting by column Tidyverse

```
select(mtcars, c(mpg, cyl))
select(mtcars, c("mpg", "cyl"))
select(mtcars, mpg, cyl)
select(mtcars, "mpg", "cyl")
```

All the same result as below

```
mtcars %>%
  select(mpg, cyl)
```

```
##                    mpg cyl
## Mazda RX4         21.0   6
## Mazda RX4 Wag     21.0   6
## Datsun 710        22.8   4
## Hornet 4 Drive    21.4   6
## Hornet Sportabout 18.7   8
## Valiant           18.1   6
```

```
mtcars %>% select(mpg)
```

```
##                    mpg
## Mazda RX4         21.0
## Mazda RX4 Wag     21.0
## Datsun 710        22.8
## Hornet 4 Drive    21.4
## Hornet Sportabout 18.7
## Valiant           18.1
## Duster 360        14.3
```

- Selecting one column doesn't "drop" it to a vector.
- If you really want the vector then use `pull(mpg)`.

Subsetting by row Tidyverse

```
mtcars %>%
  slice(3:1)

##
## Datsun 710
## Mazda RX4 Wag
## Mazda RX4
```

- Placeholder binding
  - `x %>% f(y, g(.))` is the same as `f(x, y, g(x))`
  - `x %>% f(y, .)` is the same as `f(y, x)`

⚠ Note: row names do not follow tidy data principles

- Use `tibble::rownames_to_column()` to convert rownames to a column to make into a tidy data

```
mtcars %>%
  filter(rownames(.) %in% c("Datsun 710", "Mazda RX4"))

##               mpg cyl disp  hp drat   wt  qsec vs am gear carb
## Mazda RX4    21.0   6  160 110 3.90 2.62 16.46  0  1    4    4
## Datsun 710   22.8   4  108  93 3.85 2.32 18.61  1  1    4    1
```

- Use `slice` to subset by *index* and `filter` by *logical vector*

Adding or modifying a column Tidyverse

```
mtcars %>%
  mutate(gpm = 1 / mpg,
         wt = gpm^2,
         wt = if_else(cyl==6, 10, wt),
         hp = case_when(cyl==6 ~ 11,
                        cyl==4 ~ 10,
                          TRUE ~ 3))
```

```
##     mpg cyl  disp hp drat             
## 1  21.0   6 160.0 11 3.90 1.000000e+
## 2  21.0   6 160.0 11 3.90 1.000000e+
## 3  22.8   4 108.0 10 3.85 1.923669e-
## 4  21.4   6 258.0 11 3.08 1.000000e+
## 5  18.7   8 360.0  3 3.15 2.859676e-03 17.02  0  0    3    2 0.05347594
## 6  18.1   6 225.0 11 2.76 1.000000e+01 20.22  1  0    3    1 0.05524862
## 7  14.3   8 360.0  3 3.21 4.890215e-03 15.84  0  0    3    4 0.06993007
```

- Evaluation in `mutate` is done sequentially based on input order
- So you refer to the newly created variable in later input
- You can call multiple `mutate` but computational performance is usually better if done within the same `mutate` call

```
mtcars %>%
  mutate(gpm = 1 / mpg) %>%
  mutate(wt = gpm^2)
```

Sorting columns Tidyverse

```
mtcars %>%
  select(sort(names(.)))
```

```
##                    am carb cyl  disp
## Mazda RX4           1    4   6 160.0
## Mazda RX4 Wag       1    4   6 160.0
## Datsun 710          1    1   4 108.0
## Hornet 4 Drive      0    1   6 258.0
```

```
mtcars %>%
  select(wt, gear, everything())
```

```
##                      wt gear  mpg
## Mazda RX4         2.620    4 21.0
## Mazda RX4 Wag     2.875    4 21.0
## Datsun 710        2.320    4 22.8
## Hornet 4 Drive    3.215    3 21.4
```

```
mtcars %>%
  relocate(am, carb, .before = cyl)
```

```
##                    mpg am carb cyl
## Mazda RX4         21.0  1    4   6
## Mazda RX4 Wag     21.0  1    4   6
## Datsun 710        22.8  1    1   4
## Hornet 4 Drive    21.4  0    1   6
```

```
mtcars %>%
  relocate(wt, gear, .after = mpg)
```

```
##                     mpg    wt gear
## Mazda RX4          21.0 2.620    4
## Mazda RX4 Wag      21.0 2.875    4
## Datsun 710         22.8 2.320    4
## Hornet 4 Drive     21.4 3.215    3
```

Calculating statistical summaries by group Tidyverse

🎯 Calculate the *average* weight (`wt`) of a car for each gear type in (`gear`) `mtcars`

```
mtcars %>%
  group_by(gear) %>%
  summarise(avg_wt = mean(wt))

## `summarise()` ungrouping output (over

## # A tibble: 3 x 2
##    gear avg_wt
##   <dbl>  <dbl>
## 1     3   3.89
## 2     4   2.62
## 3     5   2.63
```

🎯 Calculate the *median* weight (`wt`) of (`vs`) type in `mtcars`

```
mtcars %>%
  group_by(gear, vs) %>%
  summarise(avg_wt = mean(wt),
            med_wt = median(wt))

## `summarise()` regrouping output by

## # A tibble: 6 x 4
## # Groups:   gear [3]
##    gear    vs avg_wt med_wt
##   <dbl> <dbl>  <dbl>  <dbl>
## 1     3     0   4.10   3.81
## 2     3     1   3.05   3.22
## 3     4     0   2.75   2.75
```

across

NEW in **dplyr** v1.0.0

- Using `across`, you can more easily apply a function to multiple columns

```
mtcars %>%
  group_by(gear, vs) %>%
  summarise(across(everything(), mean))
```

```
## # A tibble: 6 x 11
## # Groups:   gear [3]
##    gear    vs   mpg   cyl  disp    hp  drat    wt  qsec    am  carb
##   <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1     3     0  15.0  8    358.  194.   3.12  4.10  17.1   0    3.08
## 2     3     1  20.3  5.33 201.  104    3.18  3.05  19.9   0    1
## 3     4     0  21    6    160   110    3.9   2.75  16.7   1    4
## 4     4     1  25.2  4.4  116.   85.4  4.07  2.59  19.4   0.6  2
## 5     5     0  19.1  6.5  229.  216.   3.95  2.91  15.3   1    5
## 6     5     1  30.4  4     95.1 113    3.77  1.51  16.9   1    2
```

where

NEW in **dplyr** v1.0.0

- You can combine `across` with the selection helper `where`

```
mtcars %>%
  group_by(gear, vs) %>%
  summarise(across(where(function(x) n_distinct(x) > 10), mean))
```

```
## # A tibble: 6 x 8
## # Groups:   gear [3]
##    gear    vs   mpg  disp    hp  drat    wt  qsec
##   <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1     3     0  15.0 358.  194.   3.12  4.10  17.1
## 2     3     1  20.3 201.  104    3.18  3.05  19.9
## 3     4     0  21   160   110    3.9   2.75  16.7
## 4     4     1  25.2 116.   85.4  4.07  2.59  19.4
## 5     5     0  19.1 229.  216.   3.95  2.91  15.3
## 6     5     1  30.4  95.1 113    3.77  1.51  16.9
```

c_across NEW in dplyr v1.0.0

- Remember tidy selection only works with functions that are compatible

```
mtcars %>%
  rowwise() %>%
  summarise(disp = disp, hp = hp, drat = drat, wt = wt,
            score = sum(c_across(disp:wt)))
```

```
## # A tibble: 32 x 5
##     disp    hp  drat    wt score
##    <dbl> <dbl> <dbl> <dbl> <dbl>
##  1   160    110  3.9   2.62  277.
##  2   160    110  3.9   2.88  277.
##  3   108     93  3.85  2.32  207.
##  4   258    110  3.08  3.22  374.
##  5   360    175  3.15  3.44  542.
##  6   225    105  2.76  3.46  336.
##  7   360    245  3.21  3.57  612.
```

rowwise?

- What happens if you omit `rowwise`?

```
mtcars %>%
  #rowwise() %>%
  summarise(disp = disp, hp = hp, drat = drat, wt = wt,
            score = sum(c_across(disp:wt)))
```

```
##     disp  hp drat    wt    score
## 1  160.0 110 3.90 2.620 12295.14
## 2  160.0 110 3.90 2.875 12295.14
## 3  108.0  93 3.85 2.320 12295.14
## 4  258.0 110 3.08 3.215 12295.14
## 5  360.0 175 3.15 3.440 12295.14
## 6  225.0 105 2.76 3.460 12295.14
## 7  360.0 245 3.21 3.570 12295.14
## 8  146.7  62 3.69 3.190 12295.14
```

</> If you installed the `dwexercise` package, run below in your R console

```
learnr::run_tutorial("day1-exercise-02", package = "dwexercise")
```

🔗 If the above doesn't work for you, go here.

? Questions or issues, let us know!

15:00

Session Information

```
devtools::session_info()
```

```
## ─ Session info ─────────────────────────────────────────────────────────────
##  setting  value
##  version  R version 4.0.1 (2020-06-06)
##  os       macOS Catalina 10.15.7
##  system   x86_64, darwin17.0
##  ui       X11
##  language (EN)
##  collate  en_AU.UTF-8
##  ctype    en_AU.UTF-8
##  tz       Australia/Melbourne
##  date     2020-11-30
##
## ─ Packages ─────────────────────────────────────────────────────────────────
##  package     * version    date       lib source
##  anicon        0.1.0      2020-06-21 [1] Github (emitanaka/anicon@0b756df)
##  assertthat    0.2.1      2019-03-21 [2] CRAN (R 4.0.0)
```