

Types, vectors, and functions in R

2022-03-11

Vectors and Types

Vectors

```
c(1, 3, 5)
```

```
c(TRUE, FALSE, TRUE, TRUE)
```

```
c("red", "blue")
```

Vectors

Vectors

Vectors have 1 dimension

Vectors

Vectors have 1 dimension

Vectors have a length.

```
length(c("blue", "red"))
```

Vectors

Vectors have 1 dimension

Vectors have a length.

```
length(c("blue", "red"))
```

Some vectors have names.

```
names(c("x" = 1, "y" = 1))
```

Vectors

Vectors have 1 dimension

Vectors have a length.

```
length(c("blue", "red"))
```

Some vectors have names.

```
names(c("x" = 1, "y" = 1))
```

Vectors have types

Types

Numeric/double

Integer

Factor

Character

Logical

Dates

Packages to work with types:

Strings/character: stringr

Packages to work with types:

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Factors: forcats

Packages to work with types:

Strings/character: stringr

Factors: forcats

Dates: lubridate

Making vectors

```
1:3
```

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

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

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

```
rep(1, 3)
```

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

```
seq(from = 1, to = 3, by = .5)
```

```
## [1] 1.0 1.5 2.0 2.5 3.0
```

Your Turn 1

Create a character vector of colors using `c()`. Use the colors "grey90" and "steelblue". Assign the vector to a name.

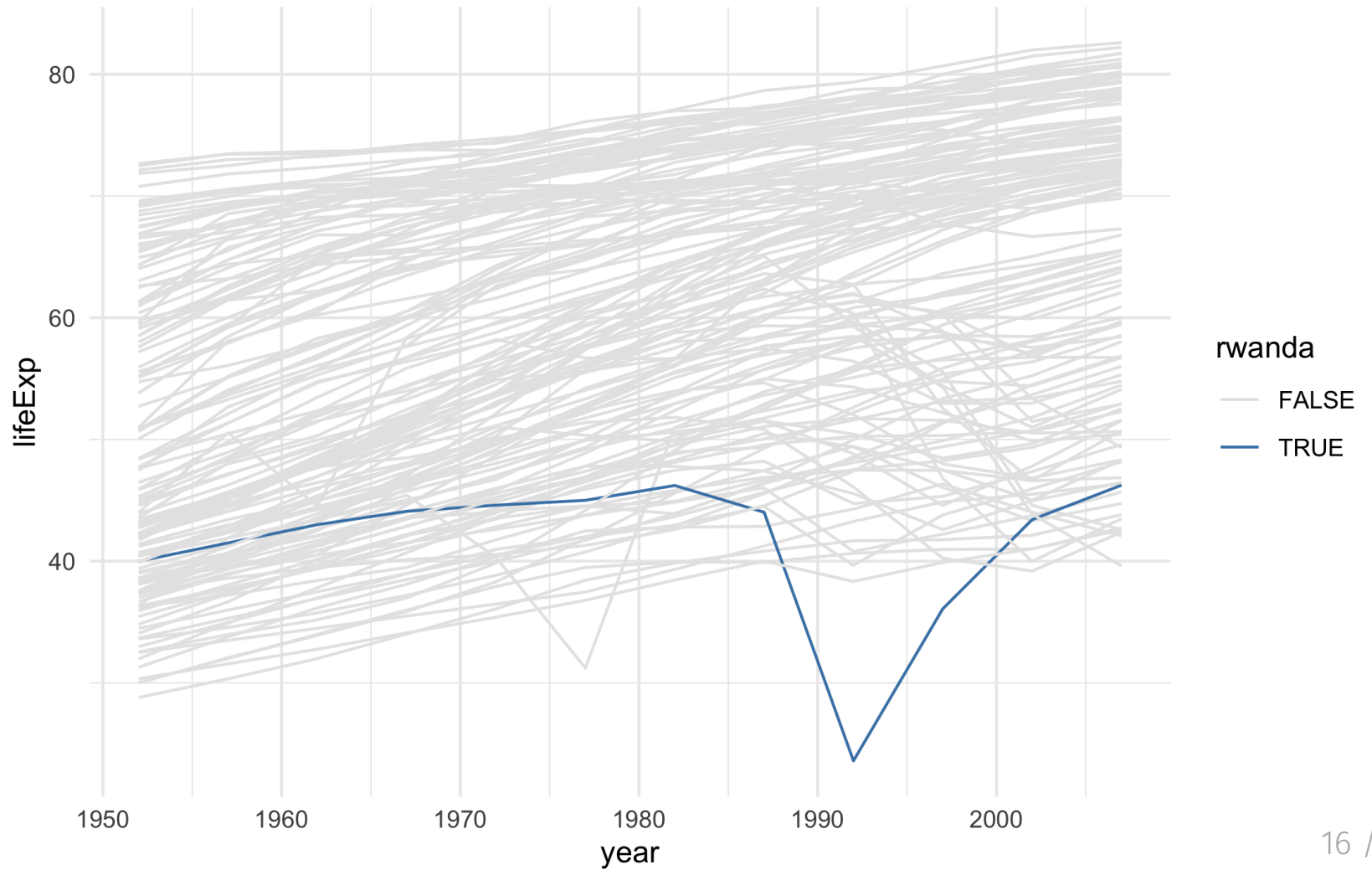
Use the vector you just created to change the colors in the plot below using `scale_color_manual()`. Pass it using the `values` argument.

Your Turn 1

```
cols <- c("grey90", "steelblue")
```

```
gapminder %>%  
  mutate(rwanda = ifelse(country == "Rwanda", TRUE, FALSE)) %>%  
  ggplot(aes(year, lifeExp, color = rwanda, group = country)) +  
  geom_line() +  
  scale_color_manual(values = cols) +  
  theme_minimal()
```

Your Turn 1



Working with vectors

Subset vectors with [] or [[]]

```
x <- c(1, 5, 7)
```

```
x[2]
```

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

```
x[[2]]
```

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

```
x[c(FALSE, TRUE, FALSE)]
```

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

Working with vectors

Modify elements

```
x
```

```
## [1] 1 5 7
```

```
x[2] <- 100
```

```
x
```

```
## [1] 1 100 7
```

Modify elements

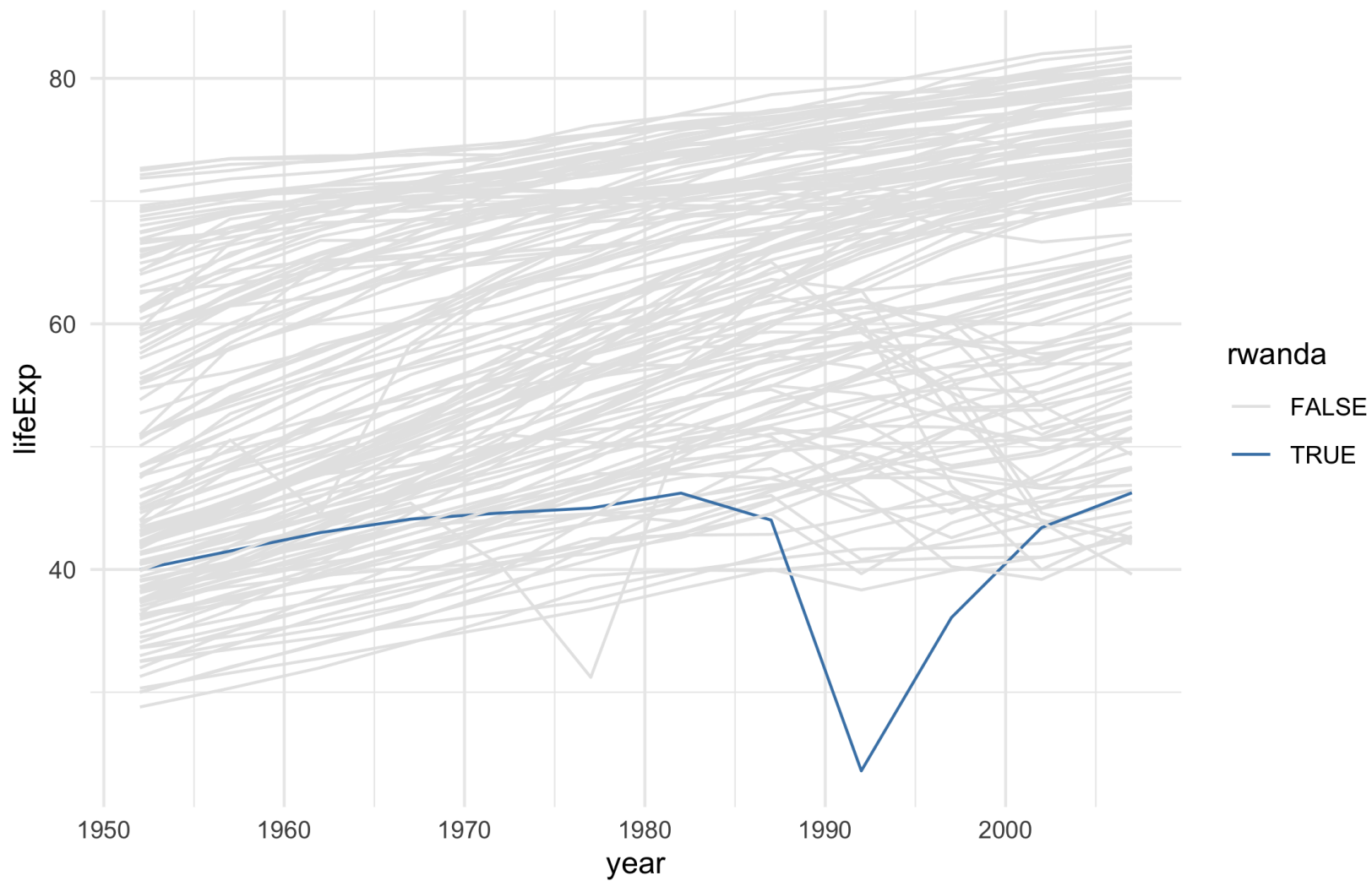
```
x
```

```
## [1] 1 100 7
```

```
x[x > 10] <- NA
```

```
x
```

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



```
cols <- c("grey90", "steelblue")
```

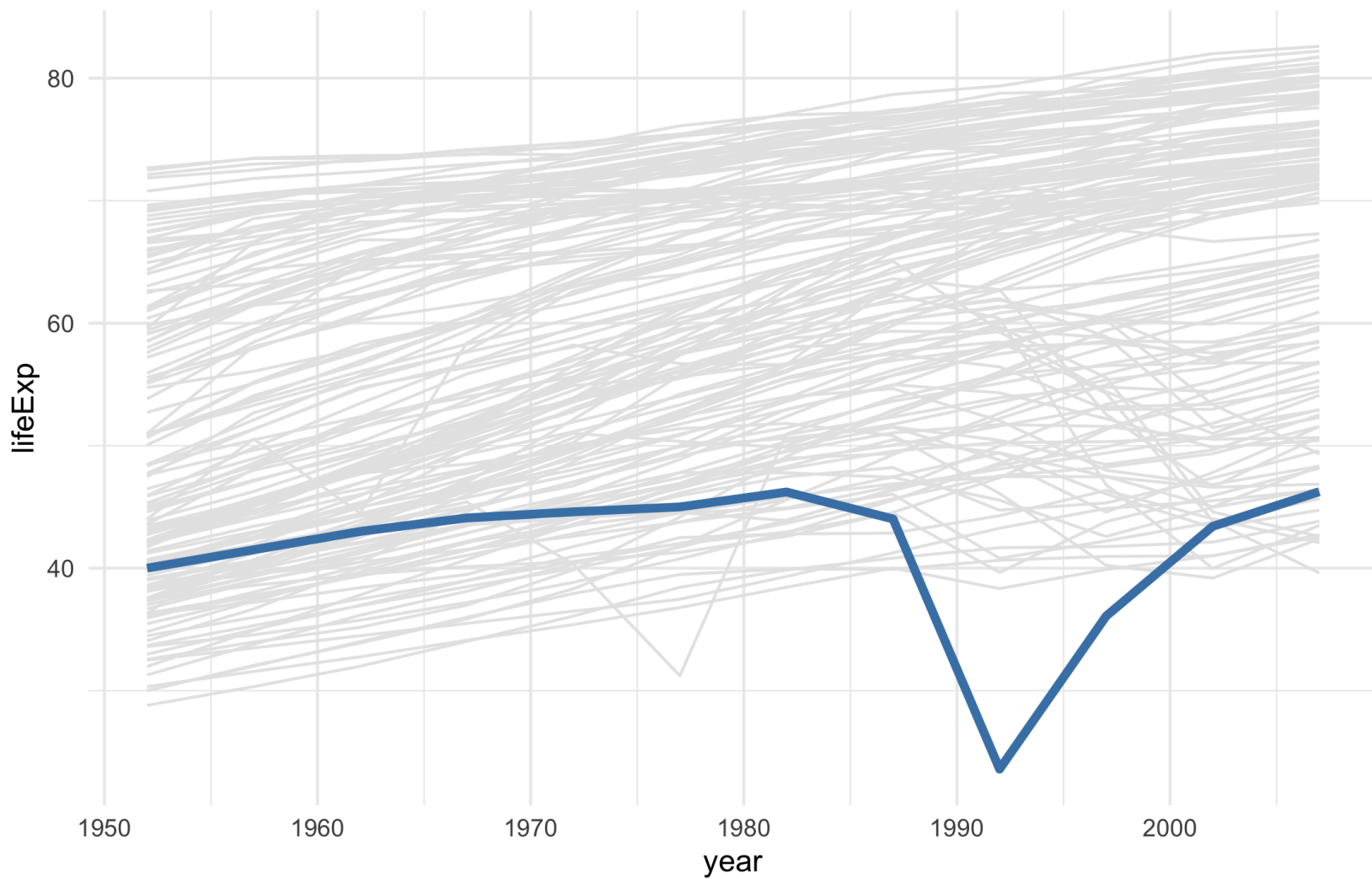
```
gapminder %>%  
  mutate(rwanda = ifelse(country == "Rwanda", TRUE, FALSE)) %>%  
  ggplot(aes(year, lifeExp, color = rwanda, group = country)) +  
  geom_line() +  
  scale_color_manual(values = cols) +  
  theme_minimal()
```

```
cols <- c("grey90", "steelblue")

gapminder %>%
  mutate(rwanda = ifelse(country == "Rwanda", TRUE, FALSE)) %>%
  ggplot(aes(year, lifeExp, group = country)) +
  geom_line(
    data = function(x) filter(x, !rwanda),
    color = cols[1]
  ) +
  theme_minimal()
```

```
cols <- c("grey90", "steelblue")

gapminder %>%
  mutate(rwanda = ifelse(country == "Rwanda", TRUE, FALSE)) %>%
  ggplot(aes(year, lifeExp, color = rwanda, group = country)) +
  geom_line(
    data = function(x) filter(x, !rwanda),
    color = cols[1]
  ) +
  geom_line(
    data = function(x) filter(x, rwanda),
    color = cols[2],
    size = 1.5
  ) +
  theme_minimal()
```



Your Turn 2

Create a numeric vector that has the following values: 3, 5, NA, 2, and NA.

Try using `sum()`. Then add `na.rm = TRUE`.

Check which values are missing with `is.na()`; save the results to a new object and take a look

Change all missing values of `x` to 0

Try `sum()` again without `na.rm = TRUE`.

Your Turn 2

```
x <- c(3, 5, NA, 2, NA)  
sum(x)
```

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

Your Turn 2

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

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

Your Turn 2

```
x_missing <- is.na(x)
x_missing
```

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

```
x[x_missing] <- 0
x
```

```
## [1] 3 5 0 2 0
```

```
sum(x)
```

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

Writing Functions

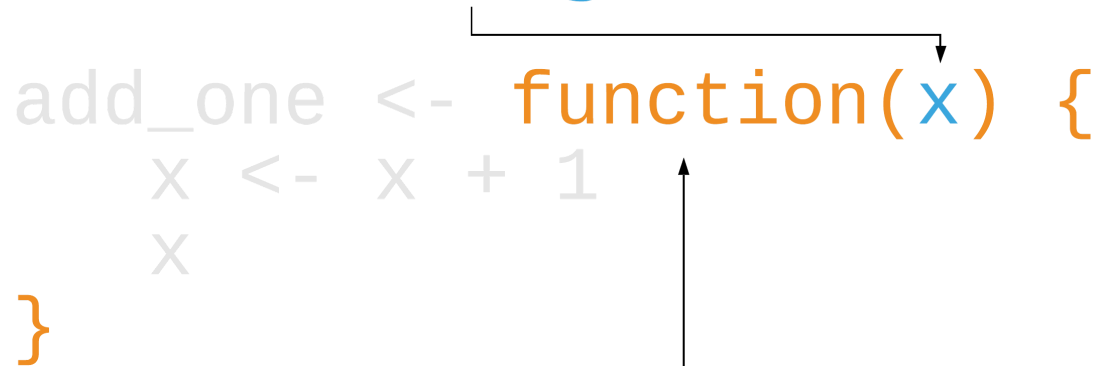
Writing functions

```
add_one <- function(x) {  
  x <- x + 1  
  x  
}
```

```
add_one(1)  
#> 2
```

Writing functions

Function arguments



```
add_one <- function(x) {  
  x <- x + 1  
  x  
}
```

```
add_one(1)  
#> 2
```

Create function

Writing functions

```
function name  
add_one <- function(x) {  
  x <- x + 1  
  x  
}  
  
function body  
add_one(1)  
#> 2
```

The diagram illustrates the syntax of an R function. The label "function name" points to the variable name `add_one` in the assignment `add_one <- function(x) { ... }`. The label "function body" points to the code block between the opening curly brace `{` and the closing curly brace `}`, which contains the function's logic: `x <- x + 1` and `x`. Below the function definition, the function is called with `add_one(1)`, and the output `#> 2` is shown.

Writing functions

```
add_one <- function(x) {  
  x <- x + 1  
  x  
}  
add_one(1)  
#> 2
```

output

input

```
graph LR
    input --> x_param[x]
    subgraph function_body [ ]
        x_var[x]
    end
    output --> x_var
    input --> arg[1]
    arg --> result[2]
```

Your Turn 3

Create a function called `sim_data` that doesn't take any arguments.

In the function body, we'll return a tibble.

For `x`, have `rnorm()` return 50 random numbers.

For `sex`, use `rep()` to create 50 values of "male" and "female". Hint: You'll have to give `rep()` a character vector for the first argument. The `times` argument is how many times `rep()` should repeat the first argument, so make sure you account for that.

For `age()` use the `sample()` function to sample 50 numbers from 25 to 50 with replacement.

Call `sim_data()`

Your Turn 3

```
sim_data <- function() {  
  tibble(  
    x = rnorm(50),  
    sex = rep(c("male", "female"), times = 25),  
    age = sample(25:50, size = 50, replace = TRUE)  
  )  
}  
  
sim_data()
```

Your Turn 3

```
sim_data <- function() {  
  tibble(  
    x = rnorm(50),  
    sex = rep(c("male", "female"), times = 25),  
    age = sample(25:50, size = 50, replace = TRUE)  
  )  
}  
  
sim_data()
```

Your Turn 3

```
sim_data <- function() {  
  tibble(  
    x = rnorm(50),  
    sex = rep(c("male", "female"), times = 25),  
    age = sample(25:50, size = 50, replace = TRUE)  
  )  
}  
  
sim_data()
```

Your Turn 3

```
sim_data <- function() {  
  tibble(  
    x = rnorm(50),  
    sex = rep(c("male", "female"), times = 25),  
    age = sample(25:50, size = 50, replace = TRUE)  
  )  
}  
  
sim_data()
```

Your Turn 3

```
## # A tibble: 50 × 3
##       x sex    age
##   <dbl> <chr> <int>
## 1 -0.208 male    35
## 2 -0.160 female  36
## 3 -0.295 male    44
## 4 -0.204 female  25
## 5  0.830 male    39
## 6 -0.395 female  42
## 7 -0.797 male    28
## 8 -0.245 female  47
## 9  0.733 male    42
## 10 -0.0982 female  46
## # ... with 40 more rows
```

E-Values

The strength of unmeasured confounding required to explain away a value

E-Values

The strength of unmeasured confounding required to explain away a value

Rate ratio: 3.9 = E-value: 7.3

Your Turn 4

Write a function to calculate an E-Value given an RR.

Call the function `evalue` **and give it an argument called** `estimate`. **In the body of the function, calculate the E-Value using** $\text{estimate} + \sqrt{\text{estimate} * (\text{estimate} - 1)}$

Call `evalue()` **for a risk ratio of 3.9**

Your Turn 4

```
evaluate <- function(estimate) {  
  estimate + sqrt(estimate * (estimate - 1))  
}
```

```
evaluate(3.9)
```

```
## [1] 7.263034
```

Control Flow

```
if (PREDICATE) {  
    true_result  
}
```

```
if (PREDICATE) {  
    true_result  
} else {  
    default_result  
}
```

```
if (PREDICATE) {  
    true_result  
} else if (ANOTHER_PREDICATE) {  
    true_result  
} else {  
    default_result  
}
```

Other functions to control flow

```
ifelse(PREDICATE, true_result, false_result)
dplyr::case_when(
  PREDICATE ~ true_result,
  PREDICATE ~ true_result,
  TRUE ~ default_result
)
switch(
  x,
  value1 = result,
  value2 = result
)
```

Validation and stopping

`if (is.numeric(x))`

`stop(), warn()`

```
function(x) {  
  if (is.numeric(x)) stop("x must be a character")  
  # do something with a character  
}
```

Your Turn 5

Use `if ()` together with `is.numeric()` to make sure estimate is a number. Remember to use `!` for not.

If the estimate is less than 1, set estimate to be equal to $1 / \text{estimate}$.

Call `eval` for a risk ratio of 3.9. Then try 0.80. Then try a character value.

Your Turn 5

```
evaluate <- function(estimate) {  
  if (!is.numeric(estimate)) stop("`estimate` must be numeric")  
  if (estimate < 1) estimate <- 1 / estimate  
  estimate + sqrt(estimate * (estimate - 1))  
}
```


Your Turn 5

```
evaluate(3.9)
```

```
## [1] 7.263034
```

```
evaluate(.80)
```

```
## [1] 1.809017
```

```
evaluate("3.9")
```

```
## Error in evaluate("3.9"): `estimate` must be numeric
```

Your Turn 6

Add a new argument called `type`. Set the default value to `"rr"`

Check if `type` is equal to `"or"`. If it is, set the value of `estimate` to be `sqrt(estimate)`

Call `evaluate()` for a risk ratio of 3.9. Then try it again with `type = "or"`.

Your Turn 6

```
evaluate <- function(estimate, type = "rr") {  
  if (!is.numeric(estimate)) stop("`estimate` must be numeric")  
  if (type == "or") estimate <- sqrt(estimate)  
  if (estimate < 1) estimate <- 1 / estimate  
  estimate + sqrt(estimate * (estimate - 1))  
}
```

Your Turn 6

```
evaluate(3.9)
```

```
## [1] 7.263034
```

```
evaluate(3.9, type = "or")
```

```
## [1] 3.362342
```

Your Turn 7: Challenge!

Create a new function called `transform_to_rr` **with arguments** `estimate` **and** `type`.

Use the same code above to check if `type == "or"` **and transform if so. Add another line that checks if** `type == "hr"`. **If it does, transform the estimate using this formula:** $(1 - 0.5^{\sqrt{\text{estimate}}}) / (1 - 0.5^{\sqrt{1 / \text{estimate}}})$.

Move the code that checks if `estimate < 1` **to** `transform_to_rr` **(below the OR and HR transformations)**

Return `estimate`

In `evaluate()`, **change the default argument of** `type` **to be a character vector containing** `"rr"`, `"or"`, **and** `"hr"`.

Get and validate the value of `type` **using** `match.arg()`. **Follow the pattern** `argument_name <- match.arg(argument_name)`

Transform `estimate` **using** `transform_to_rr()`. **Don't forget to pass it both** `estimate` **and** `type`!

Your Turn 7: Challenge!

```
transform_to_rr <- function(estimate, type) {  
  if (type == "or") estimate <- sqrt(estimate)  
  if (type == "hr") {  
    estimate <-  
      (1 - 0.5^sqrt(estimate)) / (1 - 0.5^sqrt(1 / estimate))  
  }  
  if (estimate < 1) estimate <- 1 / estimate  
  
  estimate  
}  
  
evaluate <- function(estimate, type = c("rr", "or", "hr")) {  
  # validate arguments  
  if (!is.numeric(estimate)) stop("`estimate` must be numeric")  
  type <- match.arg(type)  
  
  # calculate evaluate  
  estimate <- transform_to_rr(estimate, type)  
  estimate + sqrt(estimate * (estimate - 1))  
}
```

Your Turn 7: Challenge!

```
transform_to_rr <- function(estimate, type) {  
  if (type == "or") estimate <- sqrt(estimate)  
  if (type == "hr") {  
    estimate <-  
      (1 - 0.5^sqrt(estimate)) / (1 - 0.5^sqrt(1 / estimate))  
  }  
  if (estimate < 1) estimate <- 1 / estimate  
  
  estimate  
}  
  
evaluate <- function(estimate, type = c("rr", "or", "hr")) {  
  # validate arguments  
  if (!is.numeric(estimate)) stop("`estimate` must be numeric")  
  type <- match.arg(type)  
  
  # calculate evaluate  
  estimate <- transform_to_rr(estimate, type)  
  estimate + sqrt(estimate * (estimate - 1))  
}
```

Your Turn 7: Challenge!

```
transform_to_rr <- function(estimate, type) {  
  if (type == "or") estimate <- sqrt(estimate)  
  if (type == "hr") {  
    estimate <-  
      (1 - 0.5^sqrt(estimate)) / (1 - 0.5^sqrt(1 / estimate))  
  }  
  if (estimate < 1) estimate <- 1 / estimate  
  
  estimate  
}  
  
evaluate <- function(estimate, type = c("rr", "or", "hr")) {  
  # validate arguments  
  if (!is.numeric(estimate)) stop("`estimate` must be numeric")  
  type <- match.arg(type)  
  
  # calculate evaluate  
  estimate <- transform_to_rr(estimate, type)  
  estimate + sqrt(estimate * (estimate - 1))  
}
```


Your Turn 7: Challenge!

```
evaluate(3.9)
```

```
## [1] 7.263034
```

```
evaluate(3.9, type = "or")
```

```
## [1] 3.362342
```

```
evaluate(3.9, type = "hr")
```

```
## [1] 4.474815
```

```
evaluate(3.9, type = "rd")
```

```
## Error in match.arg(type): 'arg' should be one of "rr", "or", "hr"
```

Pass the dots: ...

```
select_gapminder <- function(...) {  
  gapminder %>%  
    select(...)  
}
```

```
select_gapminder(pop, year)
```

Pass the dots: ...

```
select_gapminder <- function(...) {  
  gapminder %>%  
    select(...)  
}
```

```
select_gapminder(pop, year)
```

Pass the dots: ...

```
## # A tibble: 1,704 × 2
##       pop    year
##   <int> <int>
## 1  8425333  1952
## 2  9240934  1957
## 3 10267083  1962
## 4 11537966  1967
## 5 13079460  1972
## 6 14880372  1977
## 7 12881816  1982
## 8 13867957  1987
## 9 16317921  1992
## 10 22227415  1997
## # ... with 1,694 more rows
```

Your Turn 8

Use ... to pass the arguments of your function, filter_summarize(), to filter().

In summarize, get the n and mean life expectancy for the data set

Check filter_summarize() with year == 1952.

Try filter_summarize() again for 2002, but also filter countries that have "and" in the country name. Use str_detect() from the stringr package.

Your Turn 8

```
filter_summarize <- function(...) {  
  gapminder %>%  
    filter(...) %>%  
    summarize(n = n(), mean_lifeExp = mean(lifeExp))  
}
```

```
filter_summarize(year == 1952)
```

```
## # A tibble: 1 × 2  
##       n mean_lifeExp  
##   <int>      <dbl>  
## 1    142        49.1
```

```
filter_summarize(year == 2002, str_detect(country, " and "))
```

```
## # A tibble: 1 × 2  
##       n mean_lifeExp  
##   <int>      <dbl>  
## 1      4        69.9
```

Programming with dplyr, ggplot2, and friends

```
plot_hist <- function(x) {  
  ggplot(gapminder, aes(x = x)) + geom_histogram()  
}
```


Programming with dplyr, ggplot2, and friends

```
plot_hist <- function(x) {  
  ggplot(gapminder, aes(x = x)) + geom_histogram()  
}
```

```
plot_hist(lifeExp)
```

```
## Error in FUN(X[[i]], ...): object 'lifeExp' not found
```

Programming with dplyr, ggplot2, and friends

```
plot_hist <- function(x) {  
  ggplot(gapminder, aes(x = x)) + geom_histogram()  
}
```

```
plot_hist("lifeExp")
```

```
## Error in `f()`:  
## ! StatBin requires a continuous x variable: the x variable is discrete
```

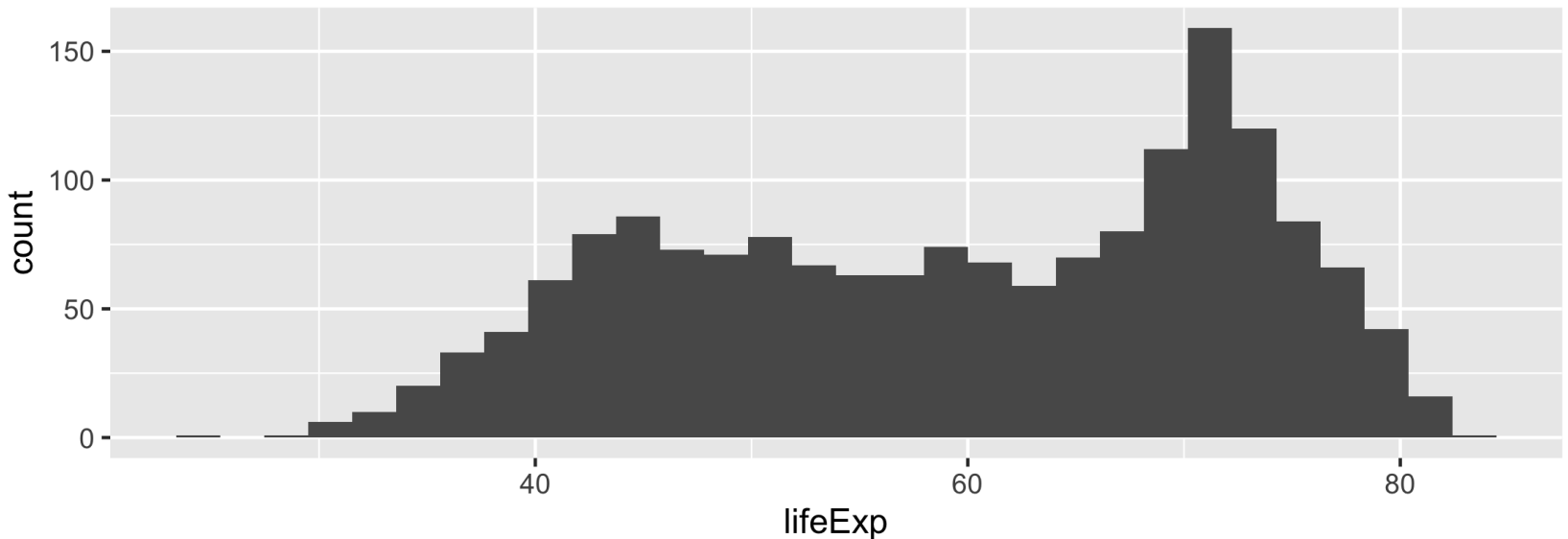
Curly-curly

```
plot_hist <- function(x) {  
  ggplot(gapminder, aes(x = {{x}})) + geom_histogram()  
}
```

Curly-curly

```
plot_hist <- function(x) {  
  ggplot(gapminder, aes(x = {{x}})) + geom_histogram()  
}
```

```
plot_hist(lifeExp)
```



Your turn 9

Filter gapminder by year using the value of .year (notice the period before hand!). You do NOT need curly-curly for this. (Why is that?)

Arrange it by the variable. This time, do wrap it in curly-curly!

Make a scatter plot. Use variable for x. For y, we'll use country, but to keep it in the order we arranged it by, we'll turn it into a factor. Wrap the the factor() call with fct_inorder(). Check the help page if you want to know more about what this is doing.

Your turn 9

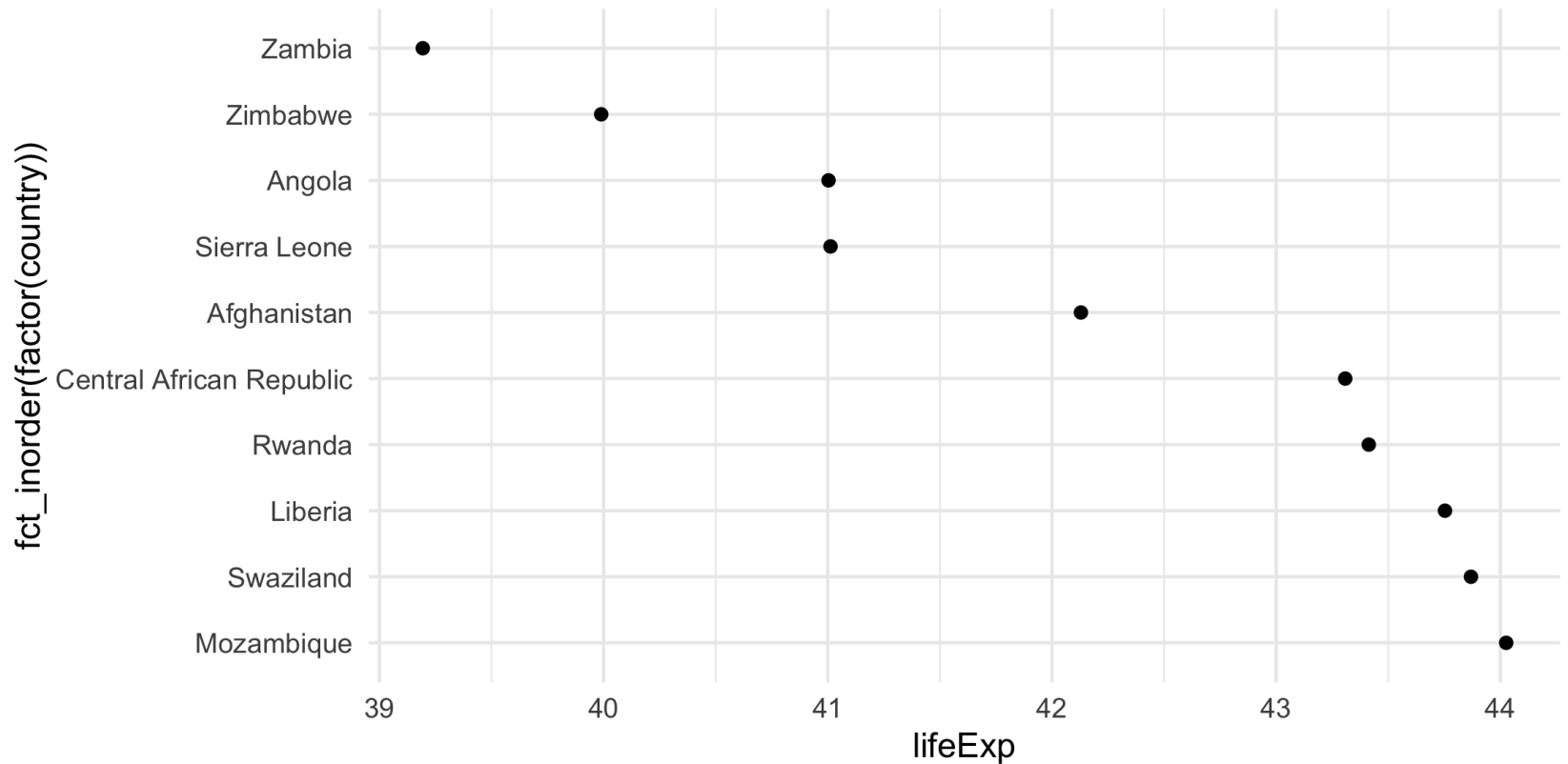
```
top_scatter_plot <- function(variable, .year) {  
  gapminder %>%  
    filter(year == .year) %>%  
    arrange(desc({{variable}})) %>%  
    # take the 10 lowest values  
    tail(10) %>%  
    ggplot(aes(x = {{variable}}, y = fct_inorder(factor(country))))  
    geom_point() +  
    theme_minimal()  
}
```

Your turn 9

```
top_scatter_plot <- function(variable, .year) {  
  gapminder %>%  
    filter(year == .year) %>%  
    arrange(desc({{variable}})) %>%  
    # take the 10 lowest values  
    tail(10) %>%  
    ggplot(aes(x = {{variable}}, y = fct_inorder(factor(country))))  
    geom_point() +  
    theme_minimal()  
}
```

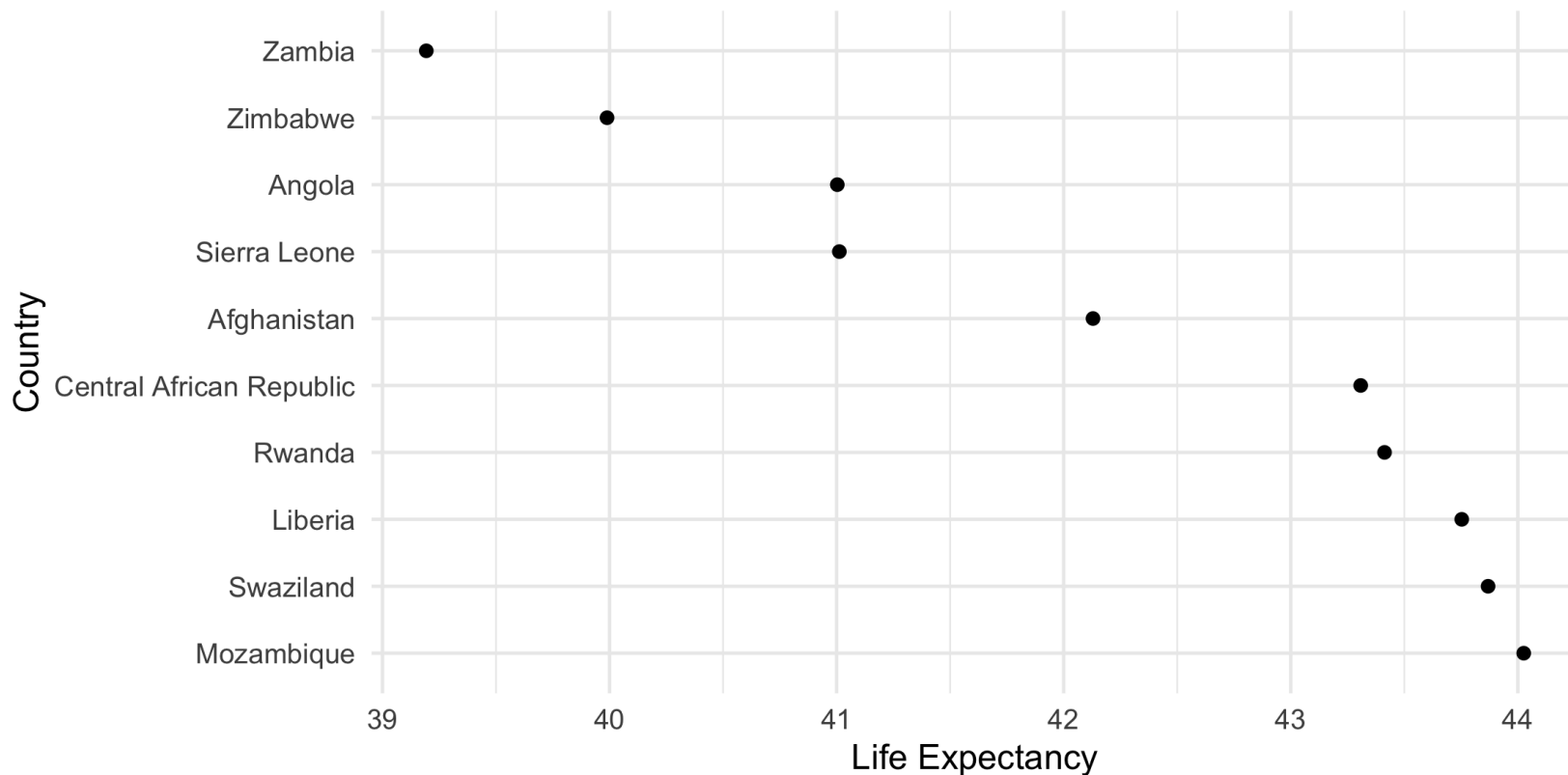
Your turn 9

```
top_scatter_plot(lifeExp, 2002)
```



Your turn 9

```
top_scatter_plot(lifeExp, 2002) +  
  labs(x = "Life Expectancy", y = "Country")
```



Resources

R for Data Science: A comprehensive but friendly introduction to the tidyverse.
Free online.

Advanced R, 2nd ed.: Detailed guide to how R works and how to make your code better. Free online.

RStudio Primers: Free interactive courses in the Tidyverse