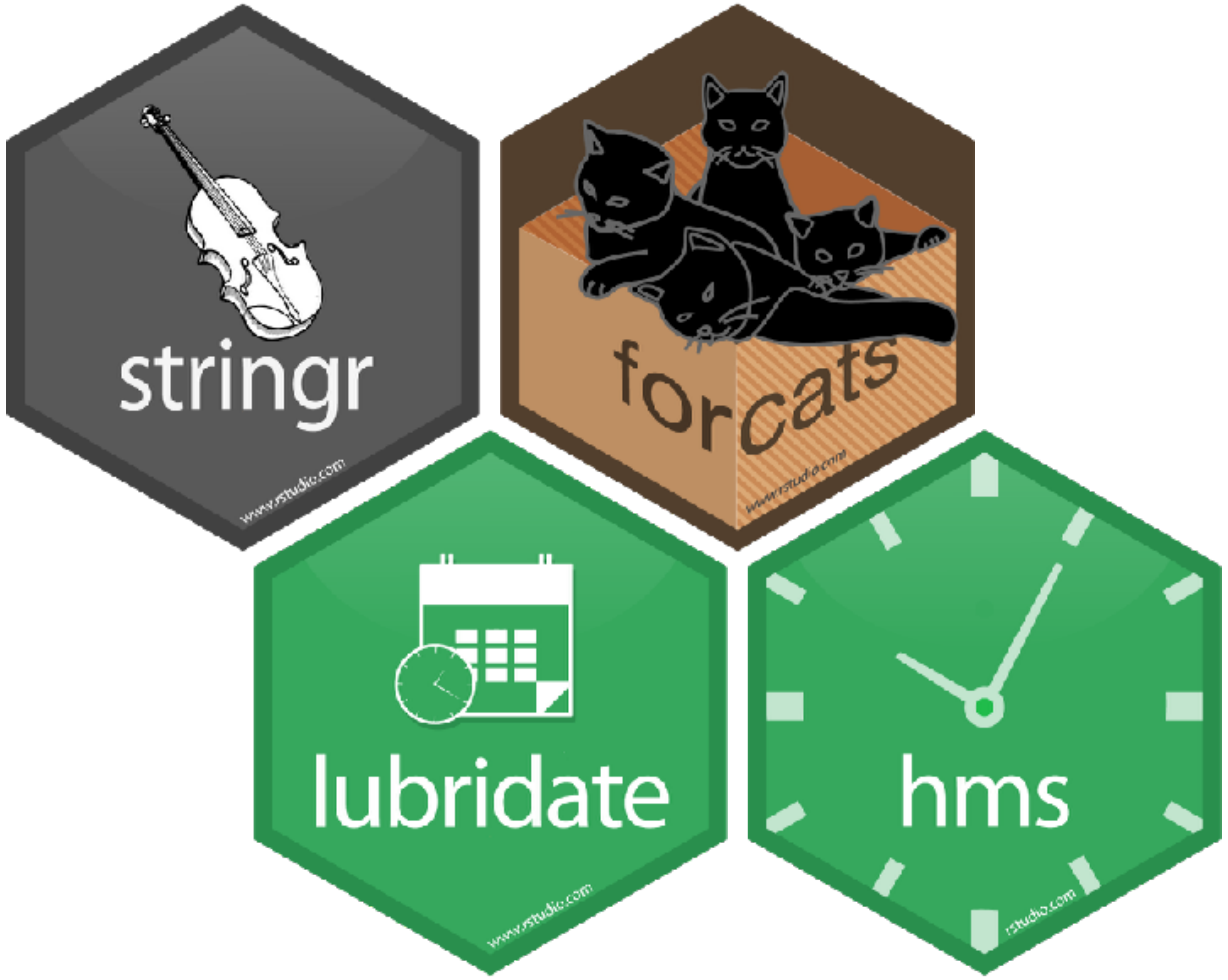
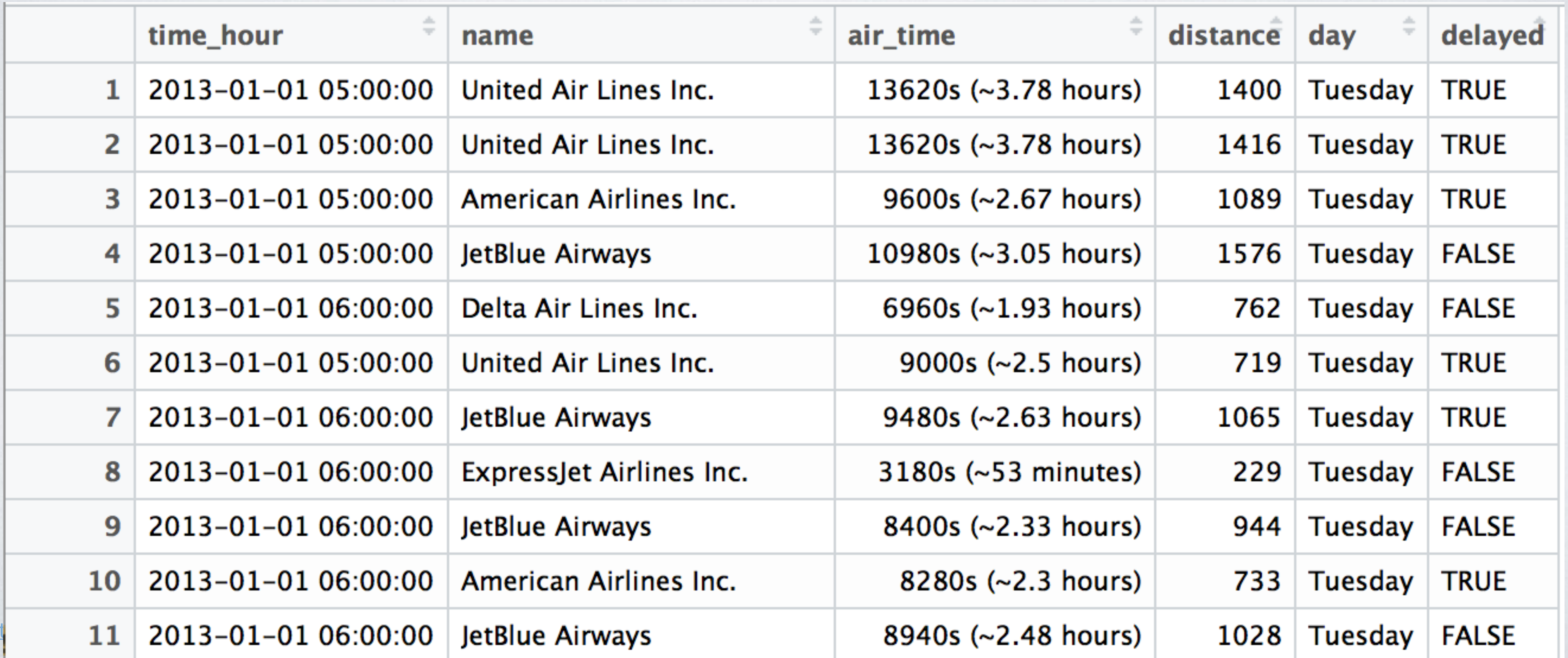
Data types with



Open **05-Data-Types.Rmd**

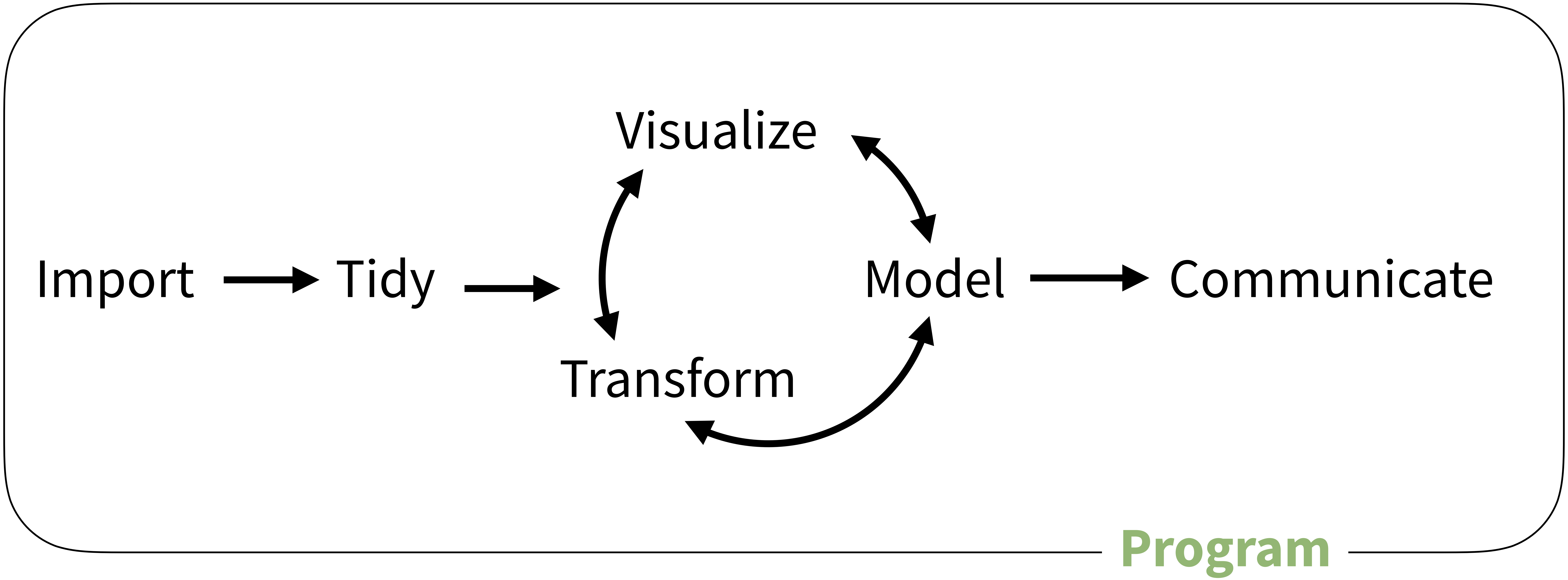
Quiz

What types of data are in this data set?



	time_hour	name	air_time	distance	day	delayed
1	2013-01-01 05:00:00	United Air Lines Inc.	13620s (~3.78 hours)	1400	Tuesday	TRUE
2	2013-01-01 05:00:00	United Air Lines Inc.	13620s (~3.78 hours)	1416	Tuesday	TRUE
3	2013-01-01 05:00:00	American Airlines Inc.	9600s (~2.67 hours)	1089	Tuesday	TRUE
4	2013-01-01 05:00:00	JetBlue Airways	10980s (~3.05 hours)	1576	Tuesday	FALSE
5	2013-01-01 06:00:00	Delta Air Lines Inc.	6960s (~1.93 hours)	762	Tuesday	FALSE
6	2013-01-01 05:00:00	United Air Lines Inc.	9000s (~2.5 hours)	719	Tuesday	TRUE
7	2013-01-01 06:00:00	JetBlue Airways	9480s (~2.63 hours)	1065	Tuesday	TRUE
8	2013-01-01 06:00:00	ExpressJet Airlines Inc.	3180s (~53 minutes)	229	Tuesday	FALSE
9	2013-01-01 06:00:00	JetBlue Airways	8400s (~2.33 hours)	944	Tuesday	FALSE
10	2013-01-01 06:00:00	American Airlines Inc.	8280s (~2.3 hours)	733	Tuesday	TRUE
11	2013-01-01 06:00:00	JetBlue Airways	8940s (~2.48 hours)	1028	Tuesday	FALSE

(Applied) Data Science



Import

Tidy

Visualize

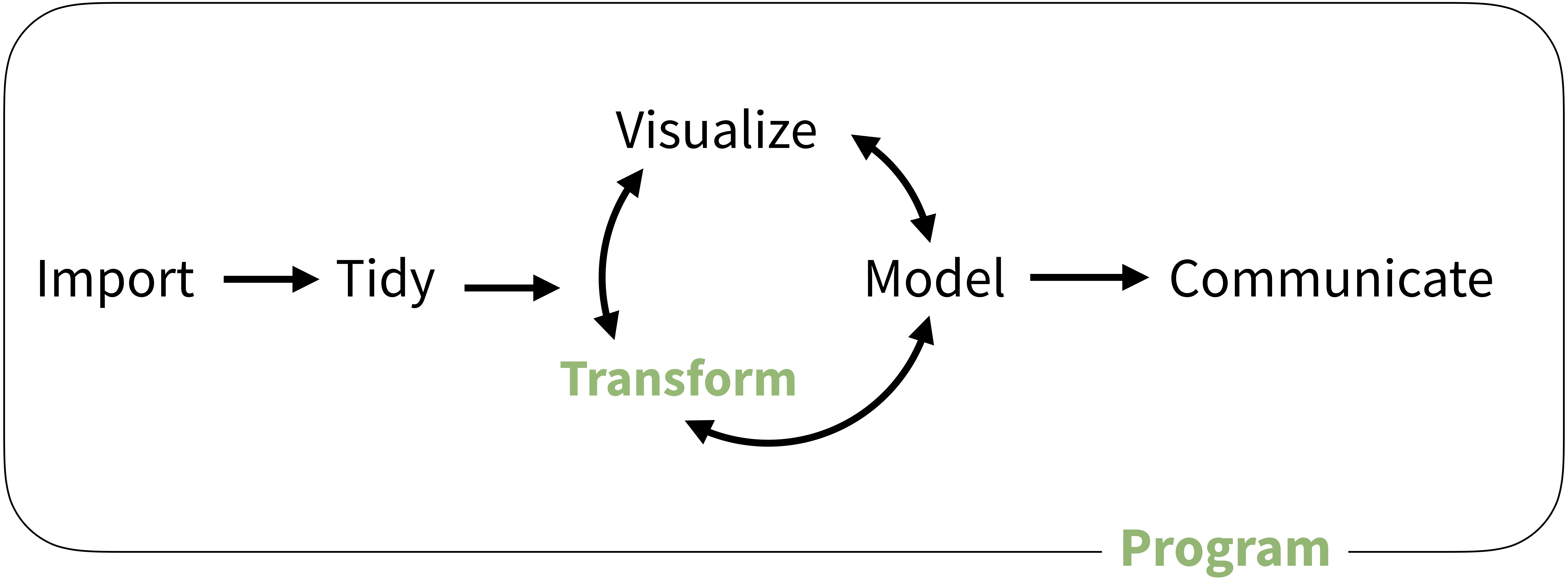
Transform

Model

Communicate

Program

(Applied) Data Science



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Logicals

Most useful skills

1. Math with logicals

Math

When you do math with logicals, **TRUE becomes 1** and **FALSE becomes 0**.

Math

When you do math with logicals, **TRUE becomes 1** and **FALSE becomes 0**.

- The **sum** of a logical vector is the **count of TRUEs**

```
sum(c(TRUE, FALSE, TRUE, TRUE))
##  3
```

Math

When you do math with logicals, **TRUE becomes 1** and **FALSE becomes 0**.

- The **sum** of a logical vector is the **count of TRUEs**

```
sum(c(TRUE, FALSE, TRUE, TRUE))
##  3
```

- The **mean** of a logical vector is the **proportion of TRUEs**

```
mean(c(1, 2, 3, 4) < 4)
##  0.75
```

Warm Up

Did you fly here?

Did your flight arrive late?

Your Turn 1

Create a logical variable in flights that displays whether a flight was delayed (arr_delay > 0). Remove all NAs in the variable.

Then create a summary table that shows:

1. How many flights were delayed
2. What proportion of flights were delayed

04:00

```
flights %>%
  mutate(delayed = arr_delay > 0) %>%
  drop_na(delayed) %>%
  summarise(total = sum(delayed), prop = mean(delayed))
## # A tibble: 1 × 2
##   total      prop
##   <int>     <dbl>
## 1 133004 0.4063101
```

Strings

Warm Up

Decide in your group:

Are boys names or girls names more likely to end in a vowel?

02:00

(character) **strings**

Anything surrounded by quotes(") or single quotes(').

```
> "one"
> "1"
> "one’s"
> '"Hello World"'
> "foo
+
+
+ oops. I’m stuck in a string."
```

Most useful skills

1. How to extract/ replace substrings
2. How to find matches for patterns
3. Regular expressions

stringr

Simple, consistent functions for working with strings.

```
# install.packages("tidyverse")
library(stringr)
```

```
install.packages("tidyverse")
```

does the equivalent of

```
install.packages("ggplot2")
install.packages("dplyr")
install.packages("tidyr")
install.packages("readr")
install.packages("purrr")
install.packages("tibble")
install.packages("hms")
install.packages("stringr")
install.packages("lubridate")
install.packages("forcats")
install.packages("DBI")
install.packages("haven")
install.packages("httr")
install.packages("jsonlite")
install.packages("readxl")
install.packages("rvest")
install.packages("xml2")
install.packages("modelr")
install.packages("broom")
```

```
library("tidyverse")
```

does the equivalent of

```
library("ggplot2")
library("dplyr")
library("tidyr")
library("readr")
library("purrr")
library("tibble")
```

```r
install.packages("tidyverse")
```

does the equivalent of

```r
install.packages("ggplot2")
install.packages("dplyr")
install.packages("tidyr")
install.packages("readr")
install.packages("purrr")
install.packages("tibble")
install.packages("hms")
install.packages("stringr")
install.packages("lubridate")
install.packages("forcats")
install.packages("DBI")
install.packages("haven")
install.packages("httr")
install.packages("jsonlite")
install.packages("readxl")
install.packages("rvest")
install.packages("xml2")
install.packages("modelr")
install.packages("broom")
```

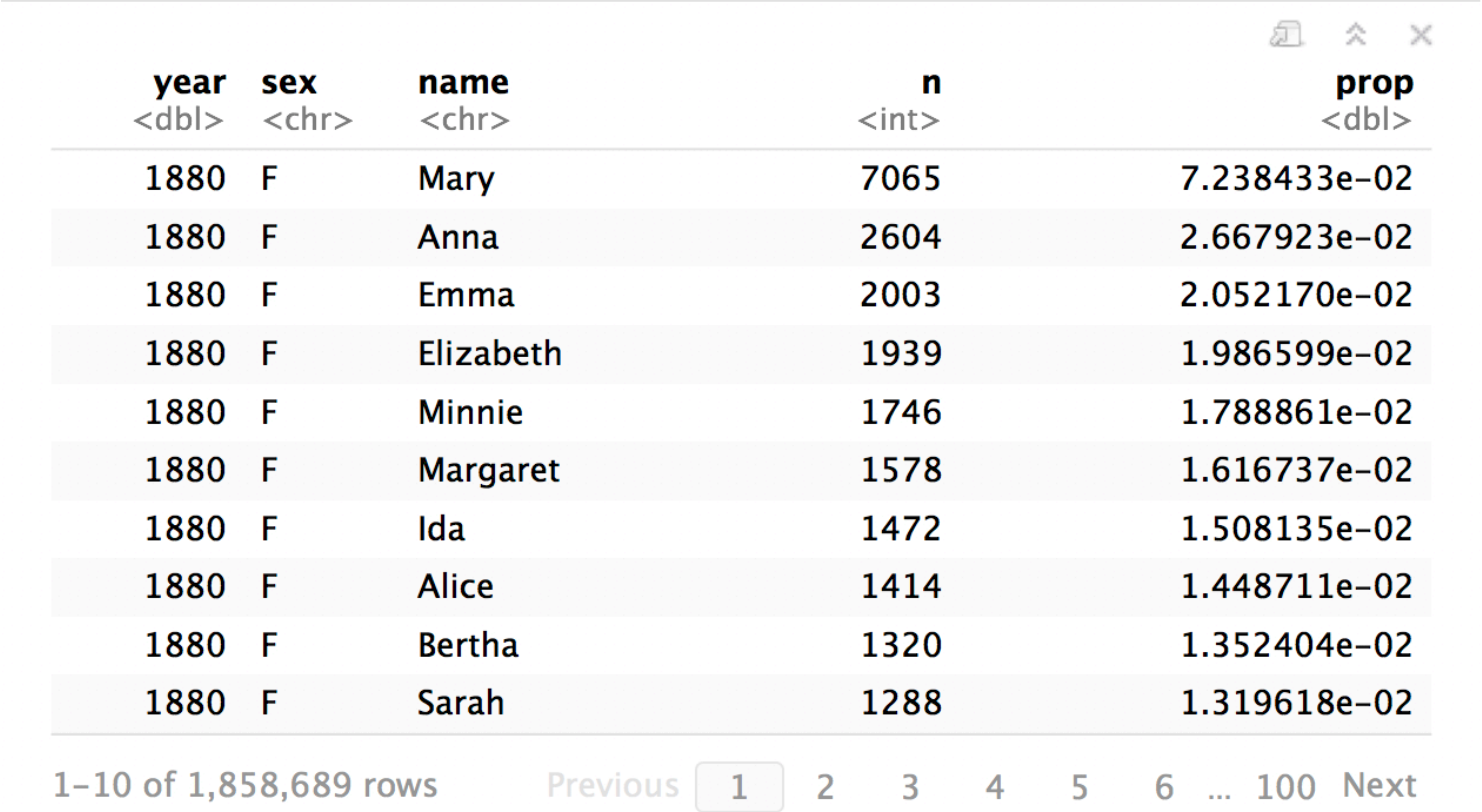
```r
library("tidyverse")
```

does the equivalent of

```r
library("ggplot2")
library("dplyr")
library("tidyr")
library("readr")
library("purrr")
library("tibble")
```

CC by RStudio

```
babynames
```

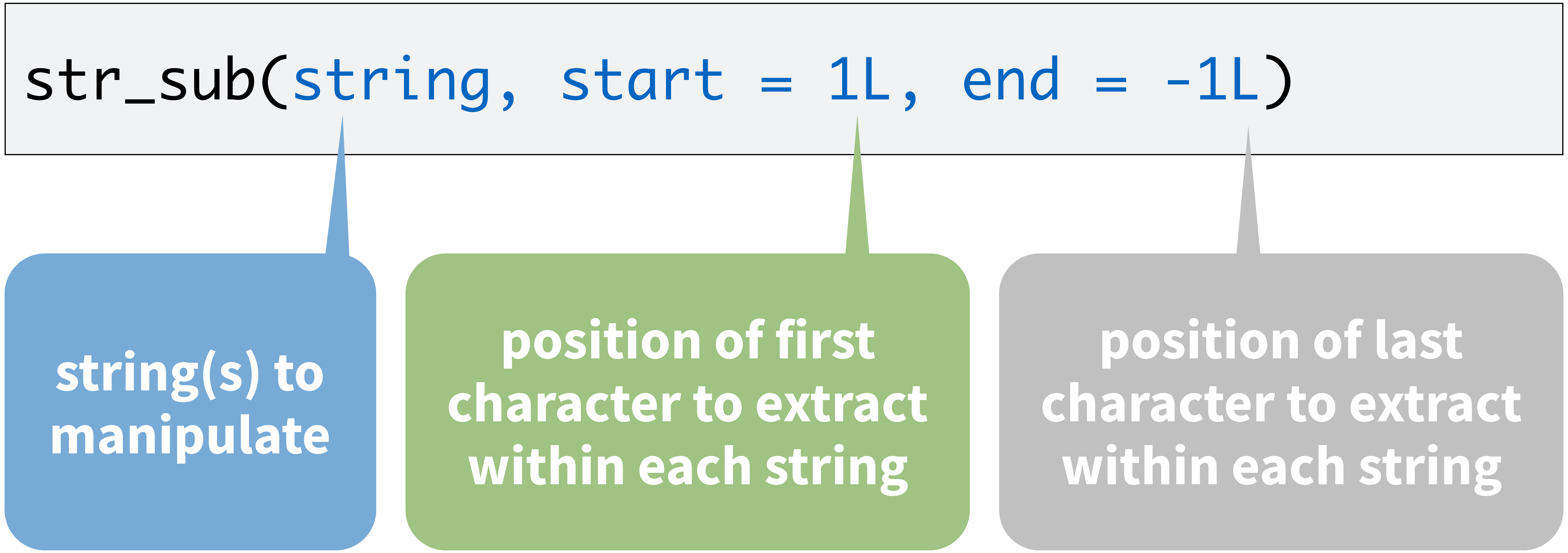


year <dbl>	sex <chr>	name <chr>	n <int>	prop <dbl>
1880	F	Mary	7065	7.238433e-02
1880	F	Anna	2604	2.667923e-02
1880	F	Emma	2003	2.052170e-02
1880	F	Elizabeth	1939	1.986599e-02
1880	F	Minnie	1746	1.788861e-02
1880	F	Margaret	1578	1.616737e-02
1880	F	Ida	1472	1.508135e-02
1880	F	Alice	1414	1.448711e-02
1880	F	Bertha	1320	1.352404e-02
1880	F	Sarah	1288	1.319618e-02

1–10 of 1,858,689 rows

str_sub()

Extract or replace portions of a string with **str_sub()**



```
str_sub(string, start = 1L, end = -1L)
```

string(s) to manipulate

position of first character to extract within each string

position of last character to extract within each string

Quiz

What will this return?

```
str_sub("Garrett", 1, 2)
```

Quiz

What will this return?

```
str_sub("Garrett", 1, 2)
```

```
"Ga"
```

Quiz

What will this return?

```
str_sub("Garrett", 1, 1)
```

Quiz

What will this return?

```
str_sub("Garrett", 1, 1)
```

```
"G"
```

Quiz

What will this return?

```
str_sub("Garrett", 2)
```

Quiz

What will this return?

```
str_sub("Garrett", 2)
```

```
"arrett"
```

Quiz

What will this return?

```
str_sub("Garrett", -3)
```

Quiz

What will this return?

```
str_sub("Garrett", -3)
```

```
"ett"
```

Quiz

What will this return?

```
g <- "Garrett"
str_sub(g, -3) <- "eth"
g
```

Quiz

What will this return?

```
g <- "Garrett"
str_sub(g, -3) <- "eth"
g
```

```
"Garreth"
```

Your Turn 2

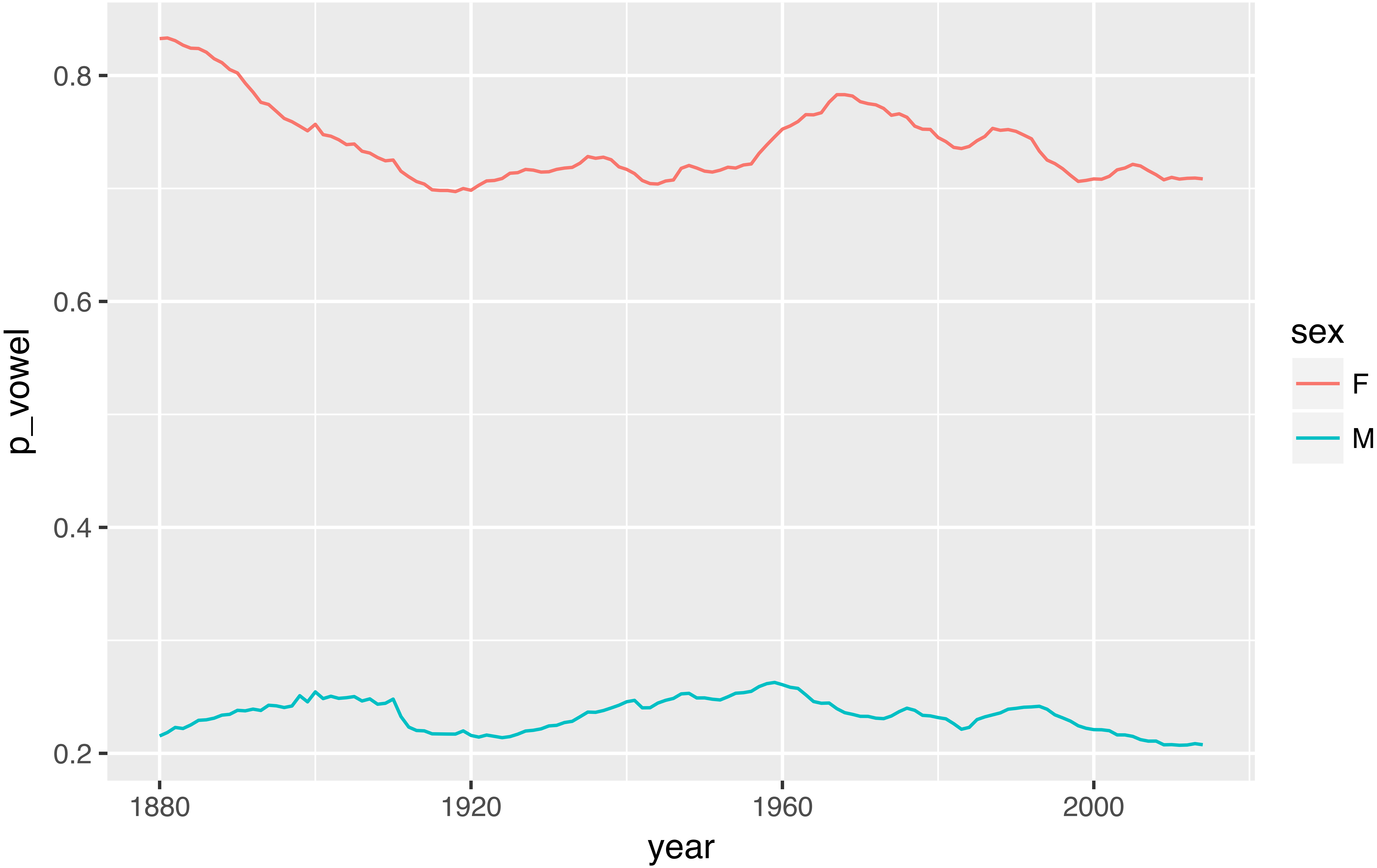
In your group, fill in the blanks to:

1. Isolate the last letter of every name
2. and create a logical variable that displays whether the last letter is one of "a", "e", "i", "o", "u", or "y".
3. Use a weighted mean to calculate the proportion of children whose name ends in a vowel (by year and sex)
4. and then display the results as a line plot.

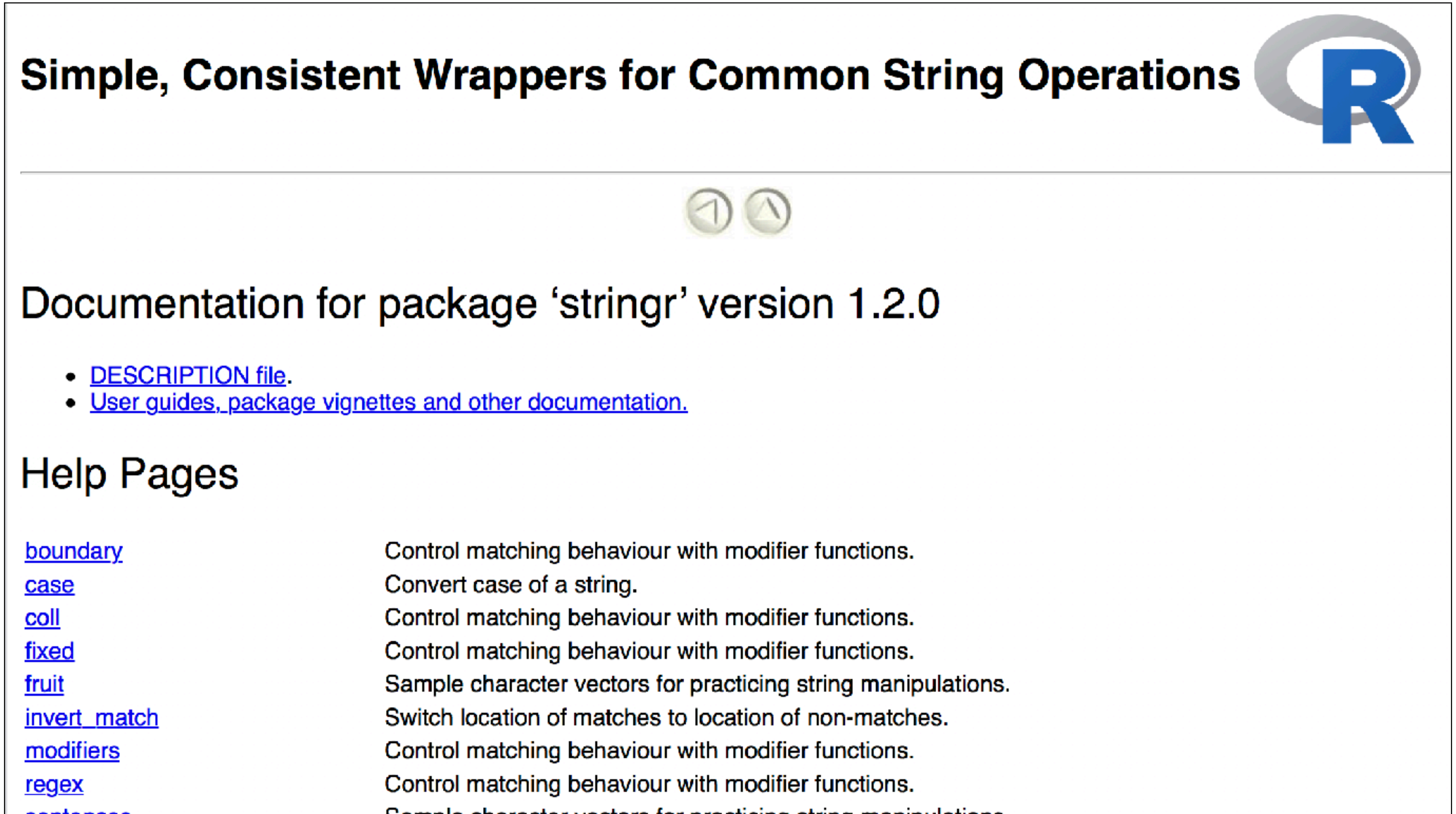
05:00

```r
babynames %>%
  mutate(last = str_sub(name, -1),
    vowel = last %in% c("a", "e", "i", "o", "u", "y")) %>%
  group_by(year, sex) %>%
  summarise(p_vowel = weighted.mean(vowel, n)) %>%
  ggplot(aes(year, p_vowel, color = sex)) +
    geom_line()
```

Proportion of names that end in a vowel



```r
help(package = stringr)
```



Simple, Consistent Wrappers for Common String Operations

Documentation for package ‘stringr’ version 1.2.0

- DESCRIPTION file.
- User guides, package vignettes and other documentation.

Help Pages

boundary	Control matching behaviour with modifier functions.
case	Convert case of a string.
coll	Control matching behaviour with modifier functions.
fixed	Control matching behaviour with modifier functions.
fruit	Sample character vectors for practicing string manipulations.
invert_match	Switch location of matches to location of non-matches.
modifiers	Control matching behaviour with modifier functions.
regex	Control matching behaviour with modifier functions.
sentences	Sample character vectors for practicing string manipulations.

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Factors

Warm Up

Decide in your group:

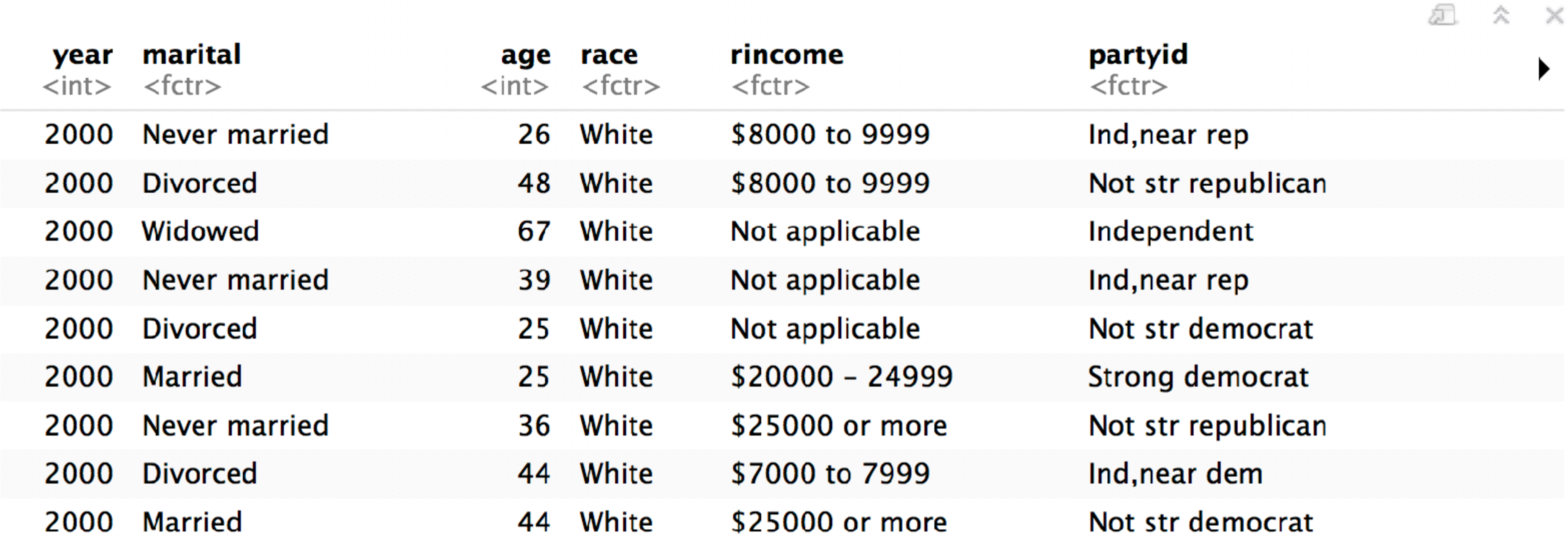
Do married people watch more or less TV than single people?

02:00

gss_cat

```
library(forcats)
gss_cat
```

A sample of data from the General Social Survey, a long-running US survey conducted by NORC at the University of Chicago.



year	marital	age	race	rincome	partyid
<int>	<fctr>	<int>	<fctr>	<fctr>	<fctr>
2000	Never married	26	White	$8000 to 9999	Ind,near rep
2000	Divorced	48	White	$8000 to 9999	Not str republican
2000	Widowed	67	White	Not applicable	Independent
2000	Never married	39	White	Not applicable	Ind,near rep
2000	Divorced	25	White	Not applicable	Not str democrat
2000	Married	25	White	$20000 - 24999	Strong democrat
2000	Never married	36	White	$25000 or more	Not str republican
2000	Divorced	44	White	$7000 to 7999	Ind,near dem
2000	Married	44	White	$25000 or more	Not str democrat

factors

R’s representation of categorical data. Consists of:

1. A set of **values**
2. An ordered set of **valid levels**

```
eyes <- factor(x = c("blue", "green", "green"),
               levels = c("blue", "brown", "green"))
eyes
## [1] blue  green green
## Levels: blue brown green
```

factors

Stored as an integer vector with a levels attribute

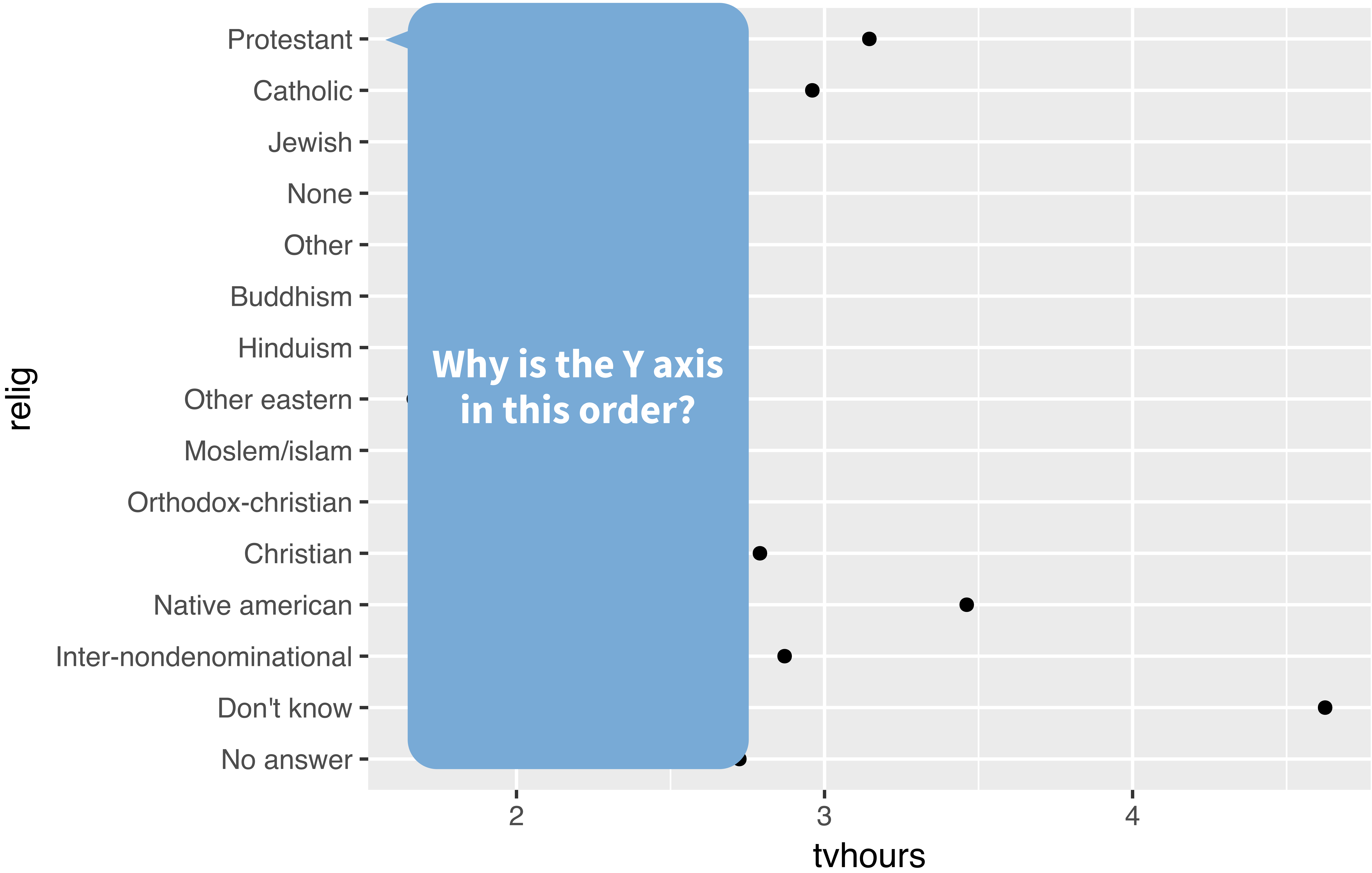
```
unclass(eyes)
## 1 2 2
## attr(,"levels")
## "blue"  "brown" "green"
```

Most useful skills

1. Reorder the levels
2. Recode the levels
3. Collapse levels

Which religions watch the most TV?

```
gss_cat %>%
  drop_na(tvhours) %>%
  group_by(relig) %>%
  summarise(tvhours = mean(tvhours)) %>%
  ggplot(aes(tvhours, relig)) +
    geom_point()
```



Why is the Y axis in this order?

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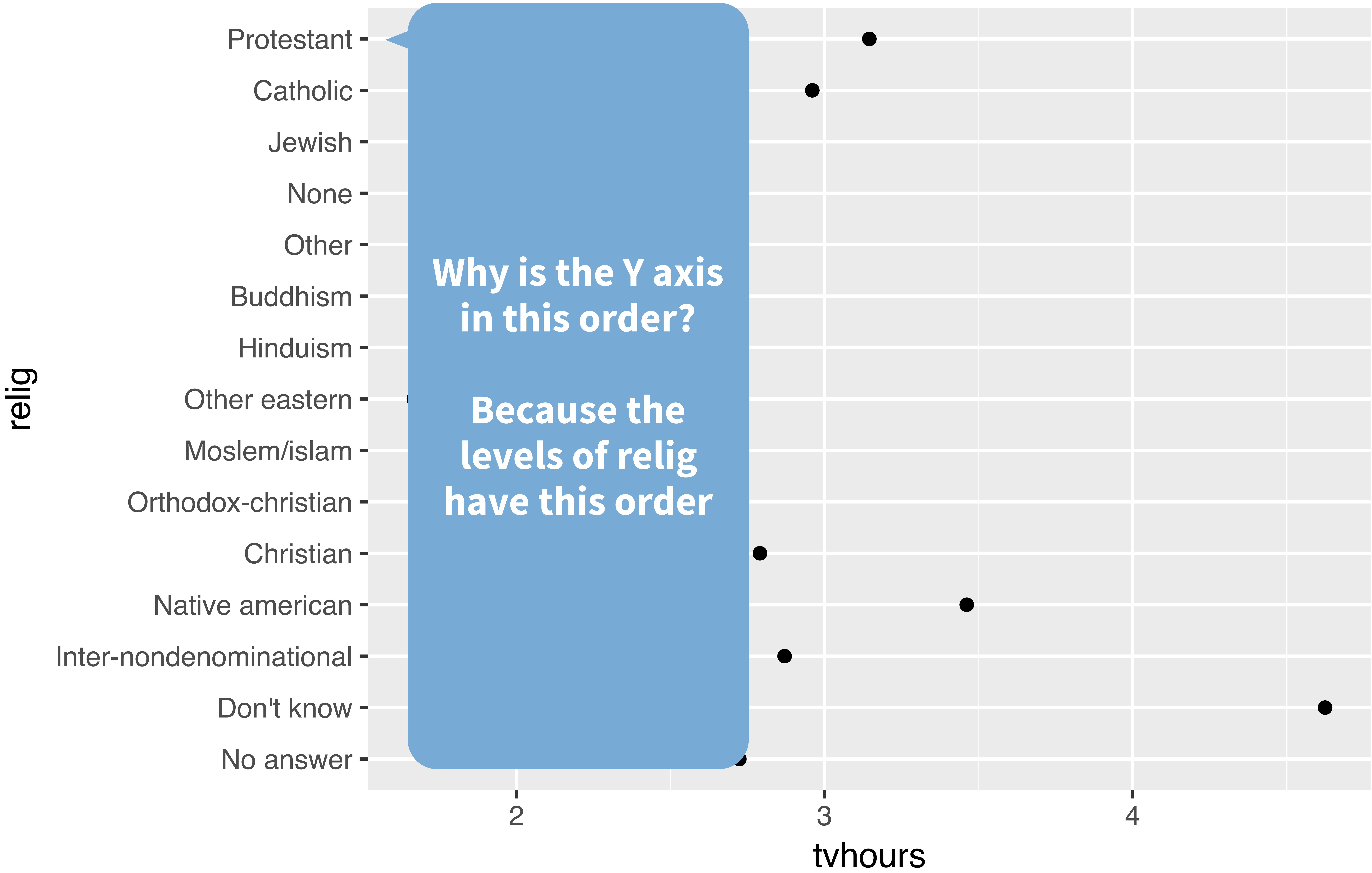
levels()

Use **levels()** to access a factor’s levels

```
levels(gss_cat$relig)
##  [1] "No answer"               "Don't know"
## [3] "Inter-nondenominational" "Native american"
## [5] "Christian"               "Orthodox-christian"
## [7] "Moslem/islam"            "Other eastern"
## [9] "Hinduism"                "Buddhism"
## [11] "Other"                   "None"
## [13] "Jewish"                  "Catholic"
## [15] "Protestant"              "Not applicable"
```



Why is the Y axis in this order?

Because the levels of relig have this order

Reordering levels

forcats

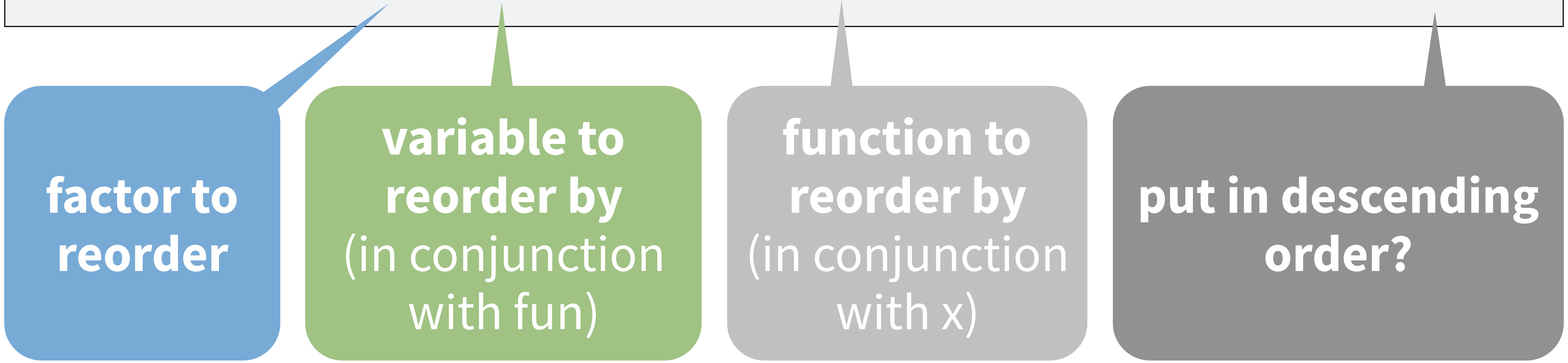
Simple functions for working with factors.

```r
# install.packages("tidyverse")
library(forcats)
```

fct_reorder()

Reorders the levels of a factor based on the result of fun(x) applied to each group of cases (grouped by level).

```
fct_reorder(f, x, fun = median, …, .desc = FALSE)
```



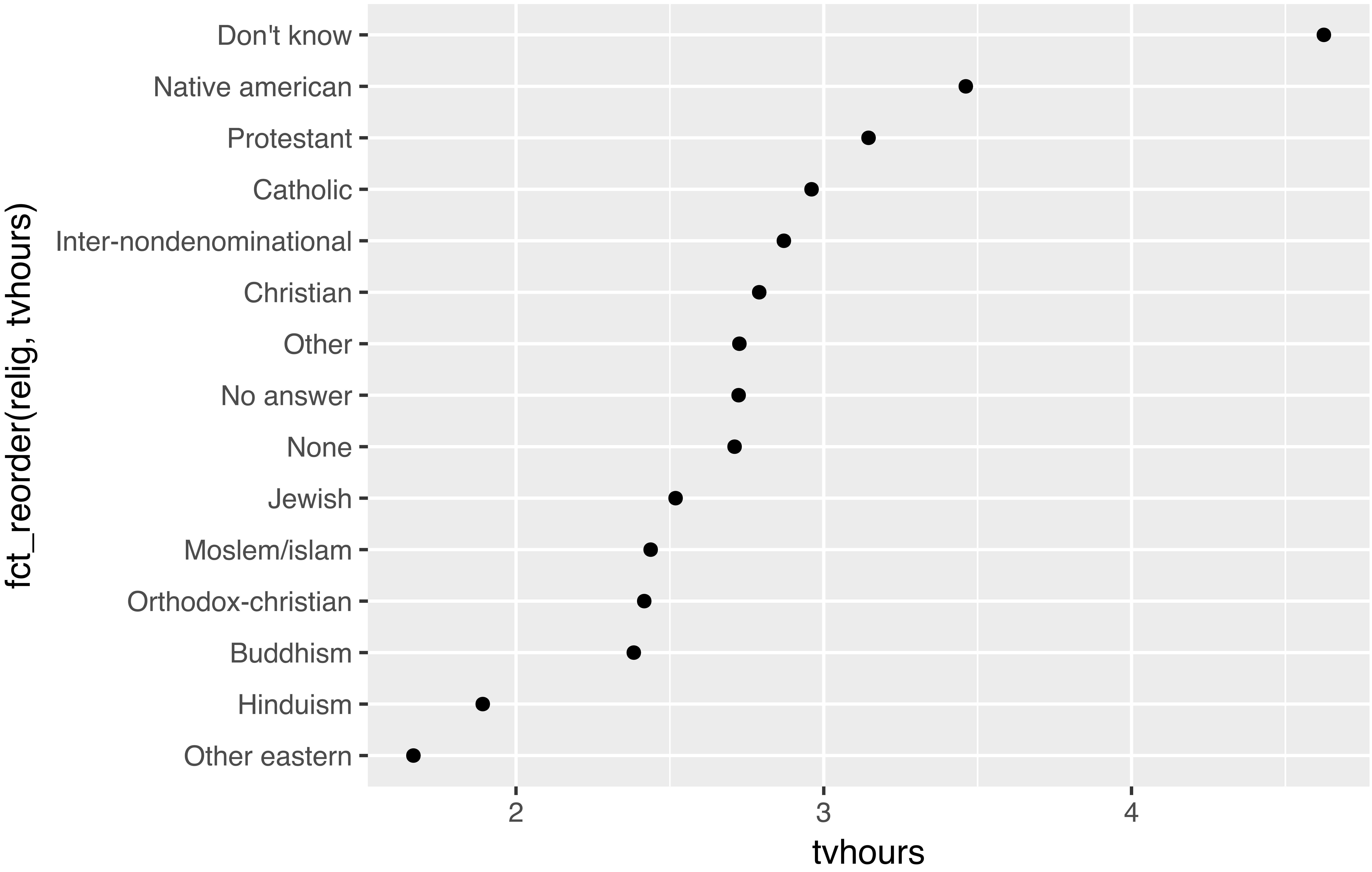
factor to reorder

variable to reorder by (in conjunction with fun)

function to reorder by (in conjunction with x)

put in descending order?

```
gss_cat %>%
  drop_na(tvhours) %>%
  group_by(relig) %>%
  summarise(tvhours = mean(tvhours)) %>%
  ggplot(aes(tvhours, fct_reorder(relig, tvhours))) +
    geom_point()
```



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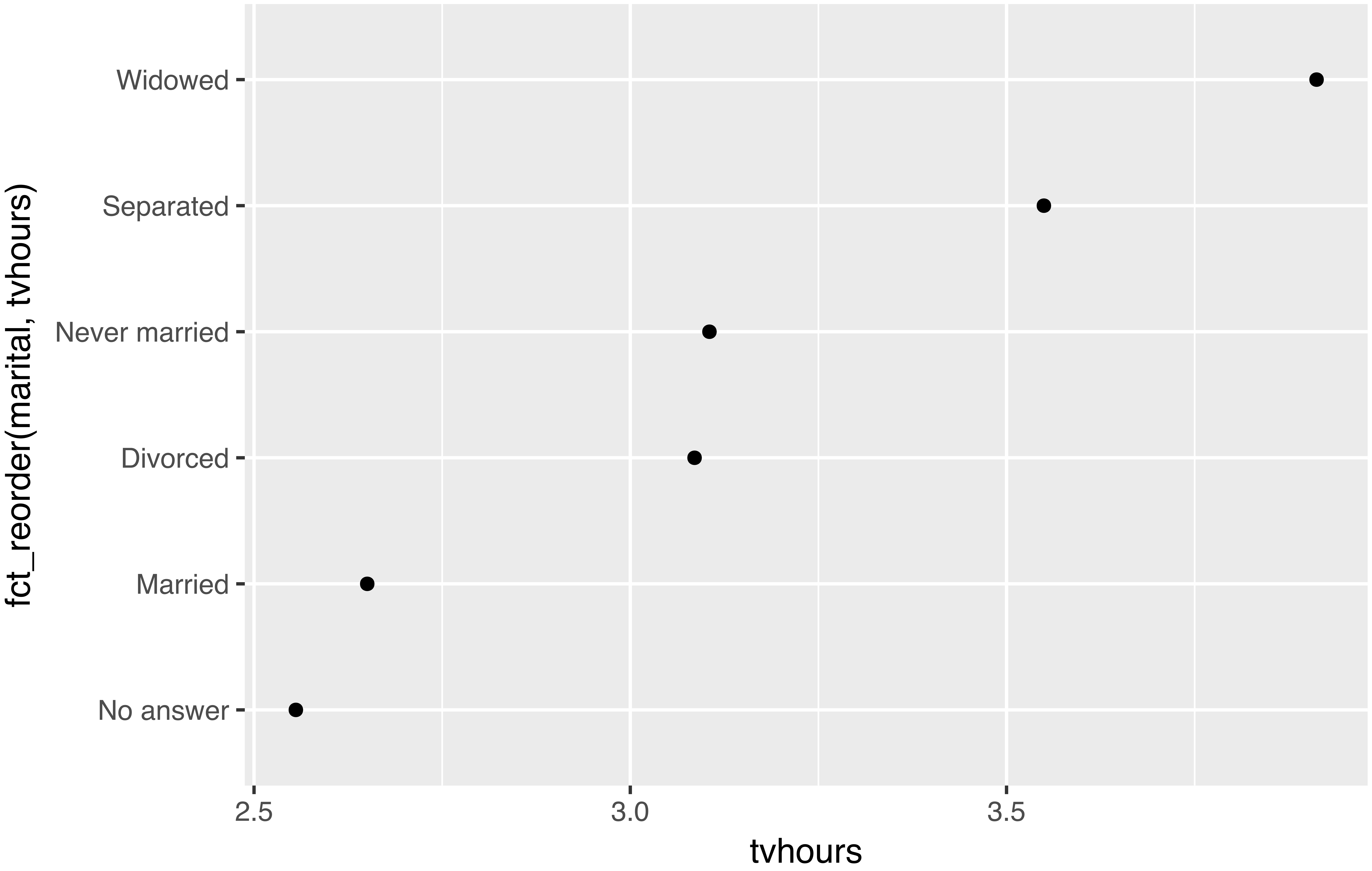
Your Turn 3

Repeat the previous exercise, some of whose code is in your notebook, to make a sensible graph of average TV consumption by marital status.

05:00

```
gss_cat %>%
  drop_na(tvhours) %>%
  group_by(marital) %>%
  summarise(tvhours = mean(tvhours)) %>%
  ggplot(aes(tvhours, fct_reorder(marital, tvhours))) +
    geom_point()
```



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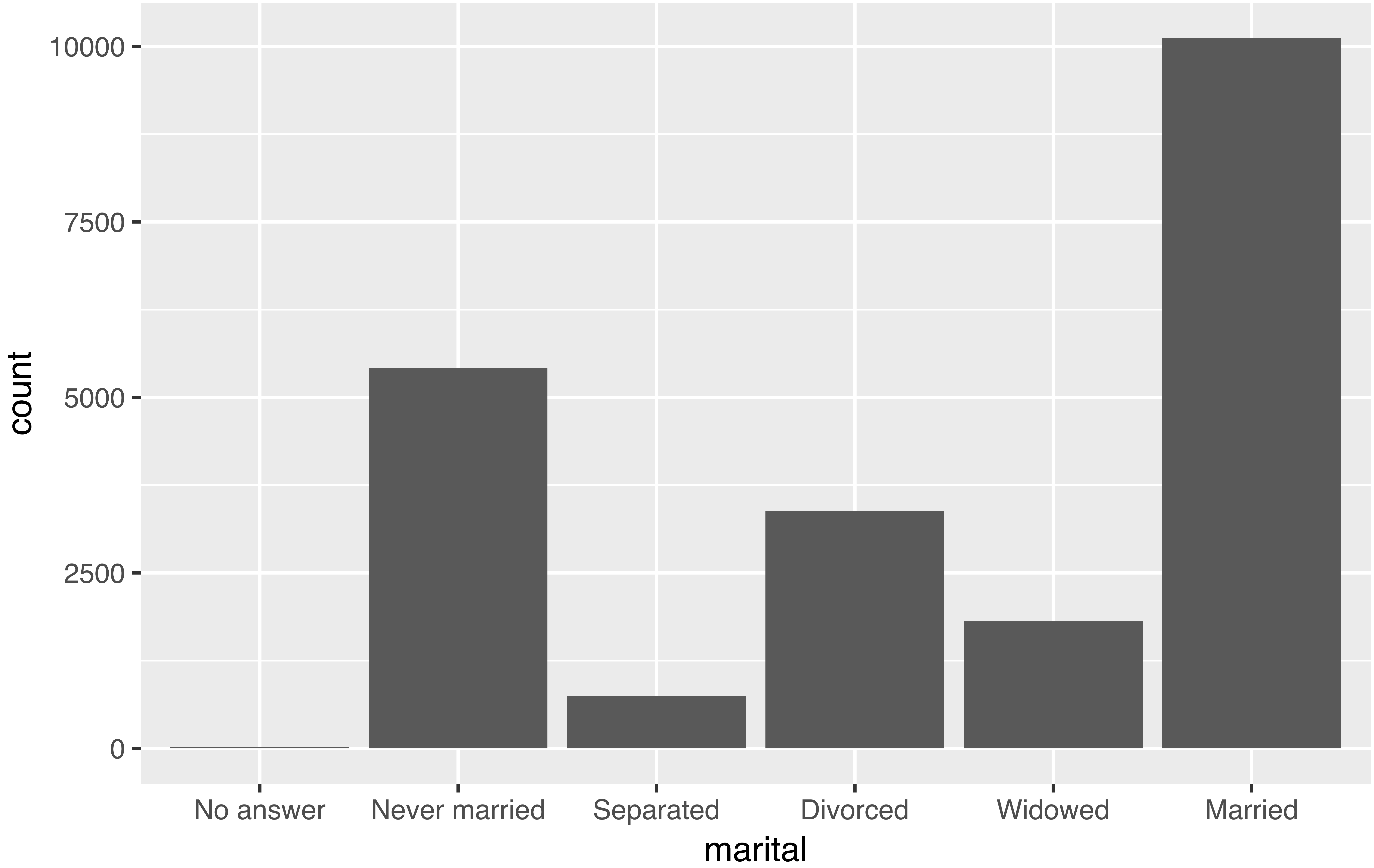
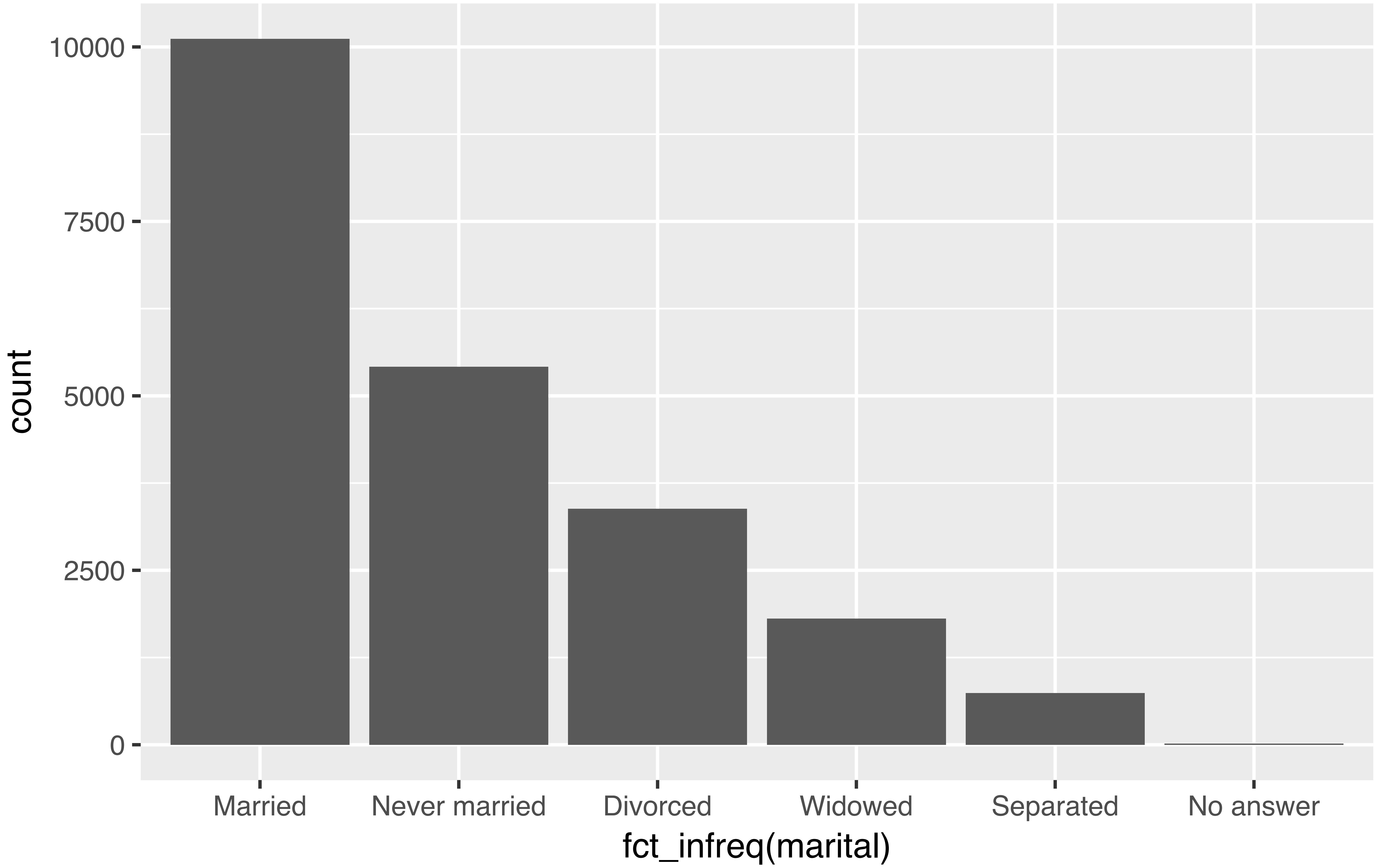


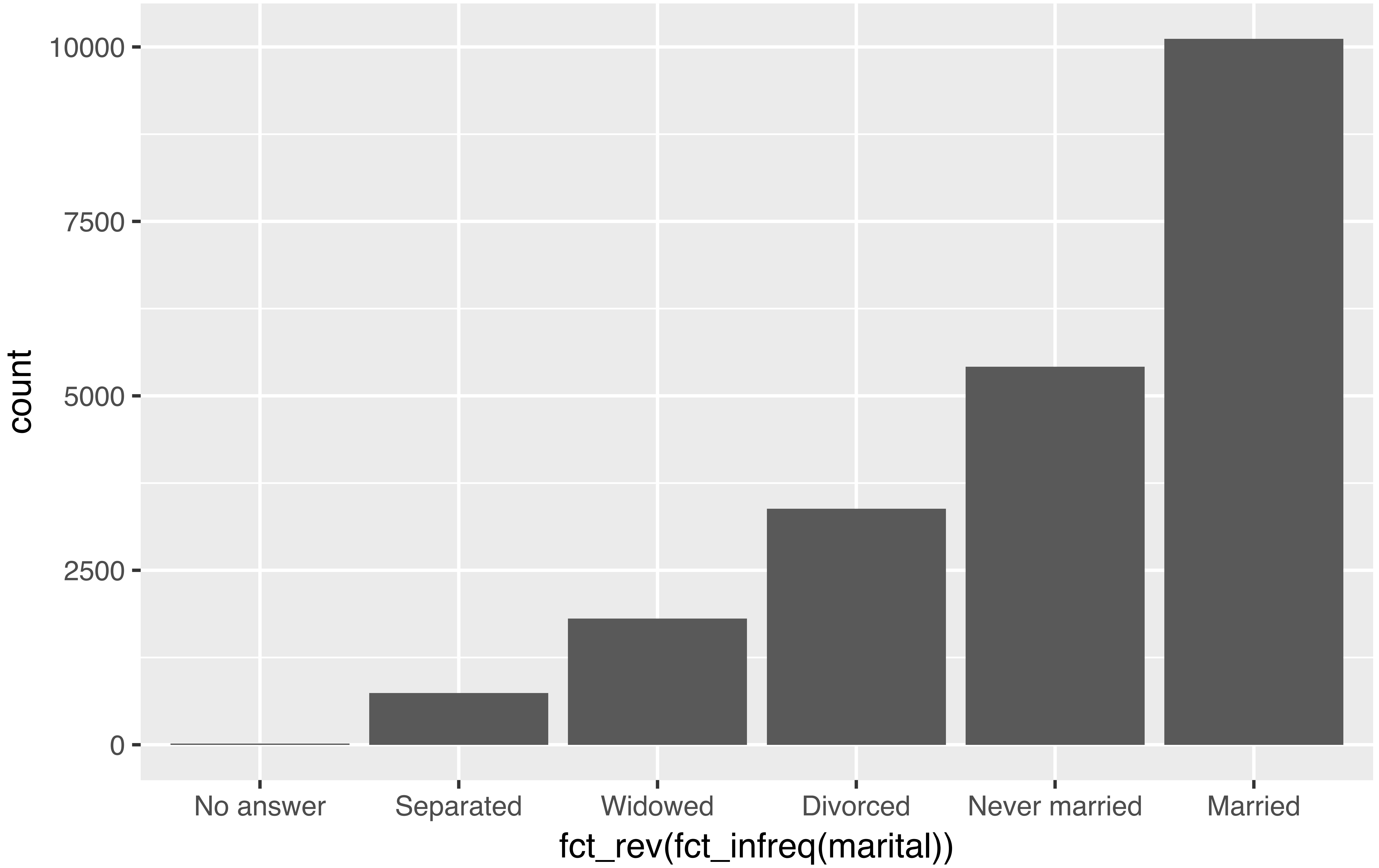
```
gss_cat %>%
  ggplot(aes(marital)) + geom_bar()
```

fct_infreq



```
gss_cat %>%
  ggplot(aes(fct_infreq(marital))) + geom_bar()
```

fct_rev



```
gss_cat %>%
  ggplot(aes(fct_rev(fct_infreq(marital))) + geom_bar()
```

Changing level values

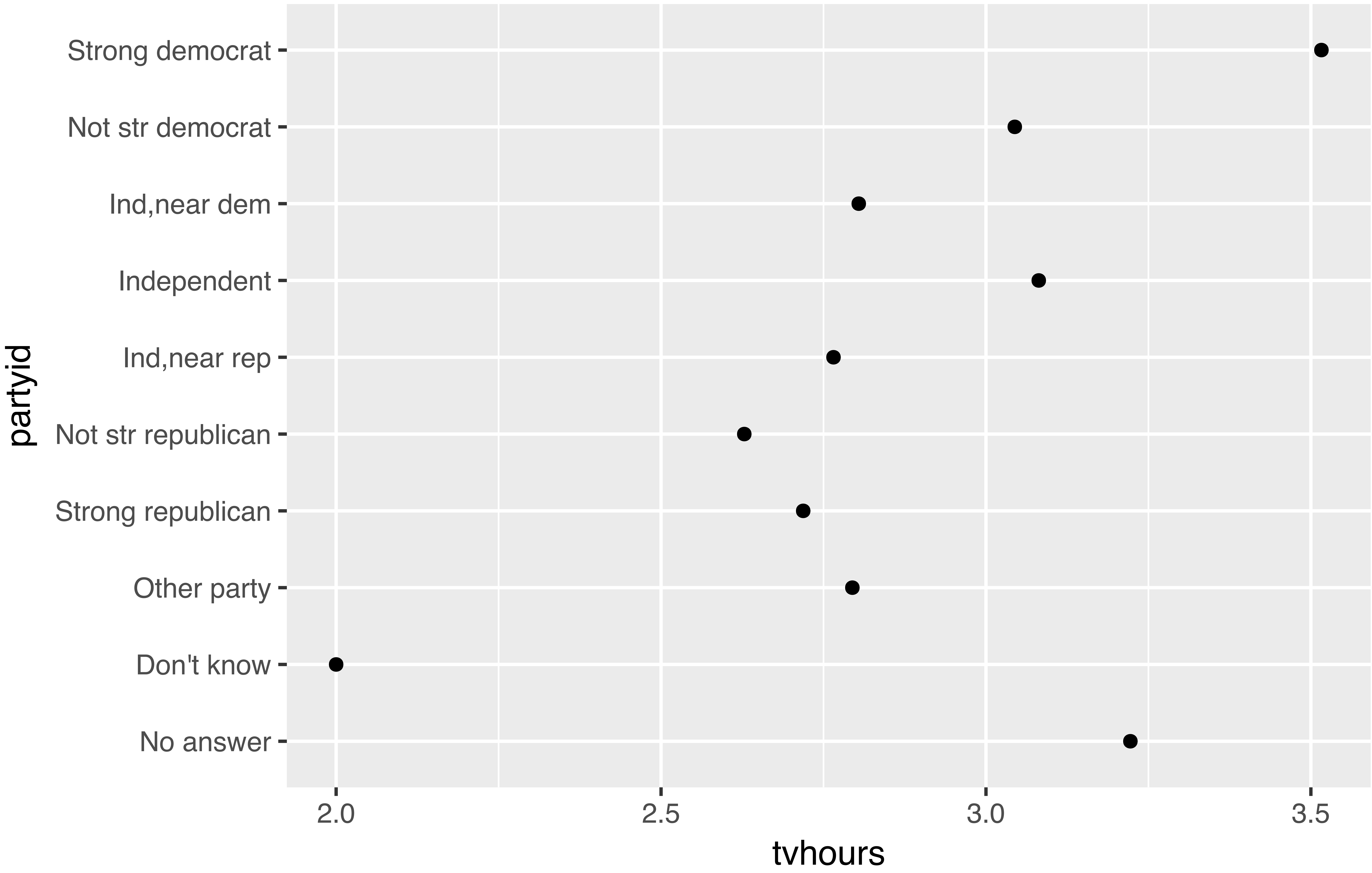
Your Turn 4

Do you think liberals or conservatives watch more TV?

Compute average tv hours by party ID an then plot the results.

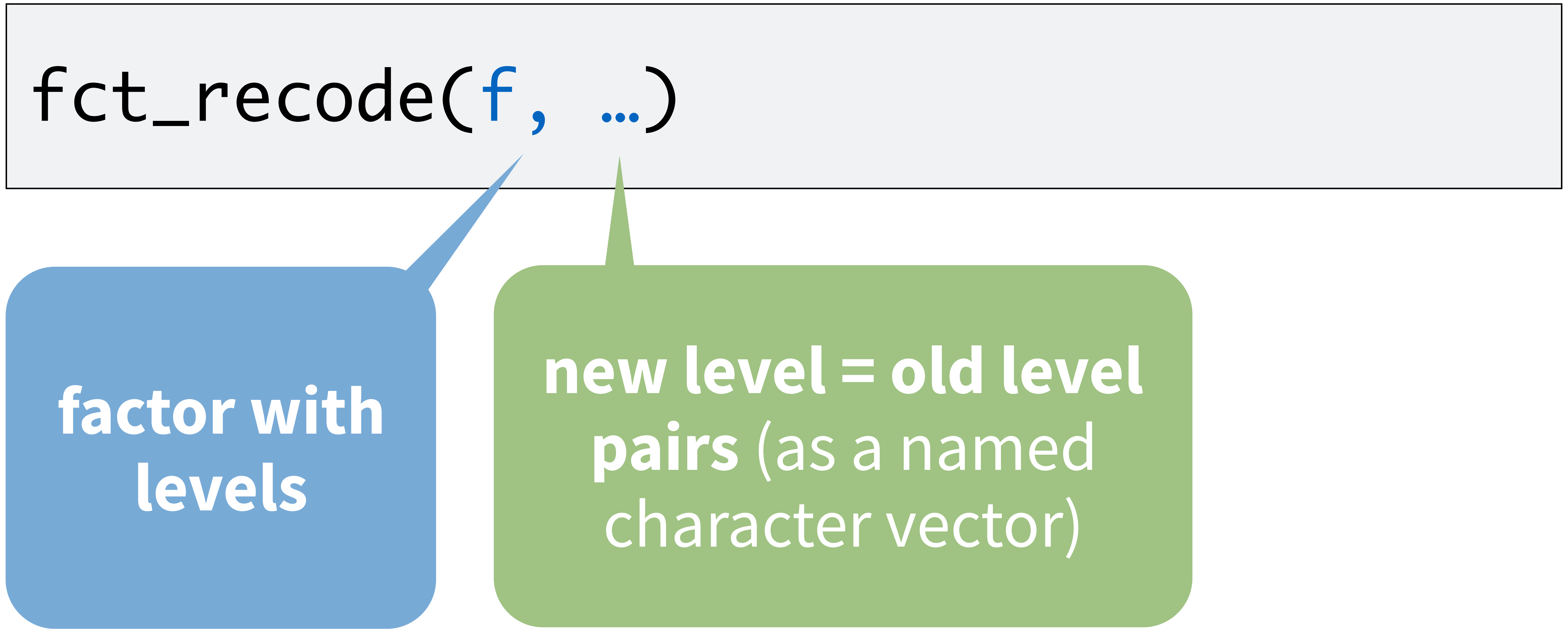
04:00

```
gss_cat %>%
   drop_na(tvhours) %>%
   group_by(partyid) %>%
   summarise(tvhours = mean(tvhours)) %>%
   ggplot(aes(tvhours, partyid)) +
     geom_point()
```


Strong democrat
Not str democrat
Ind,near dem
Independent
Ind,near rep
Not str republican
Strong republican
Other party
Don't know
No answer
partyid
2.0
2.5
3.0
3.5
tvhours

fct_recode()

Changes values of levels

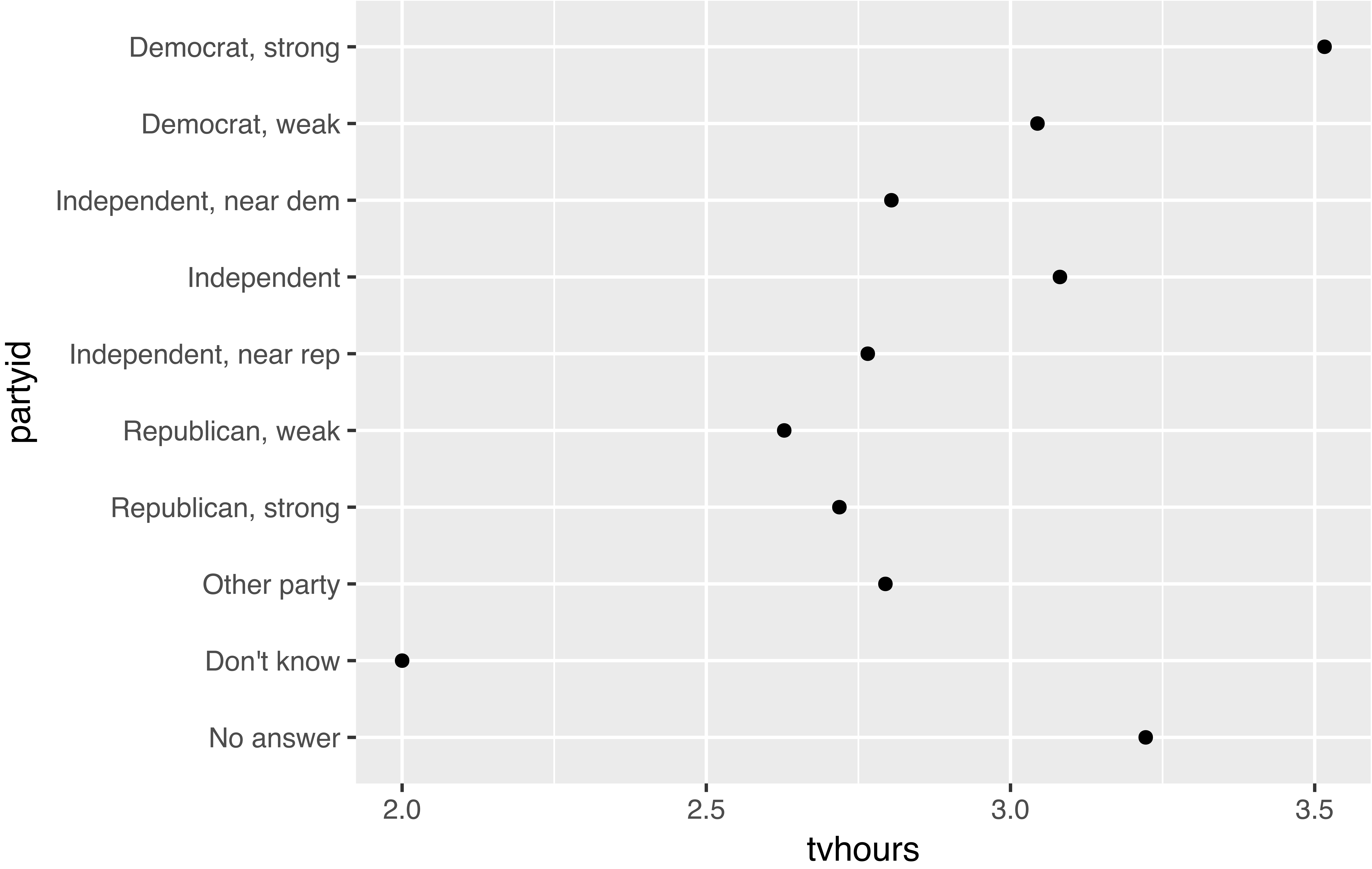


```
fct_recode(f, …)
```

factor with levels

new level = old level pairs (as a named character vector)

```
gss_cat %>%
   drop_na(tvhours) %>%
    mutate(partyid = fct_recode(partyid,
    "Republican, strong"    = "Strong republican",
    "Republican, weak"      = "Not str republican",
    "Independent, near rep" = "Ind,near rep",
    "Independent, near dem" = "Ind,near dem",
    "Democrat, weak"        = "Not str democrat",
    "Democrat, strong"      = "Strong democrat")) %>%
   group_by(partyid) %>%
   summarise(tvhours = mean(tvhours)) %>%
   ggplot(aes(tvhours, partyid)) +
     geom_point()
```



CC by RStudio

Collapsing levels

fct_collapse()

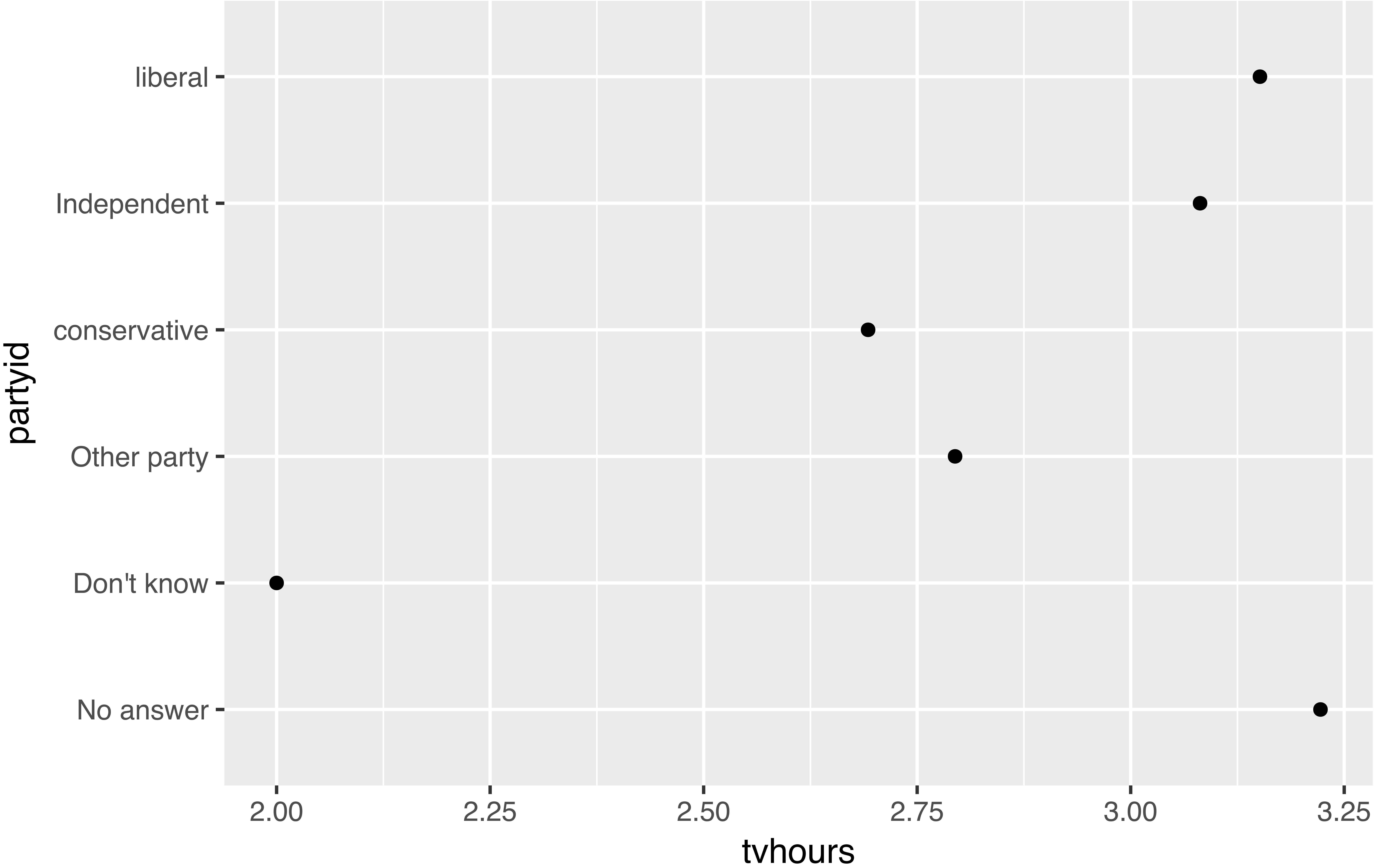
Changes multiple levels into single levels

```
fct_collapse(f, …)
```

factor with levels

named arguments set to a character vector (levels in the vector will be collapsed to the name of the argument)

```r
gss_cat %>%
   drop_na(tvhours) %>%
    mutate(partyid = fct_collapse(partyid,
      conservative = c("Strong republican",
                       "Not str republican",
                       "Ind,near rep"),
      liberal = c("Strong democrat",
                  "Not str democrat",
                  "Ind,near dem"))) %>%
   group_by(partyid) %>%
   summarise(tvhours = mean(tvhours)) %>%
   ggplot(aes(tvhours, partyid)) +
     geom_point()
```

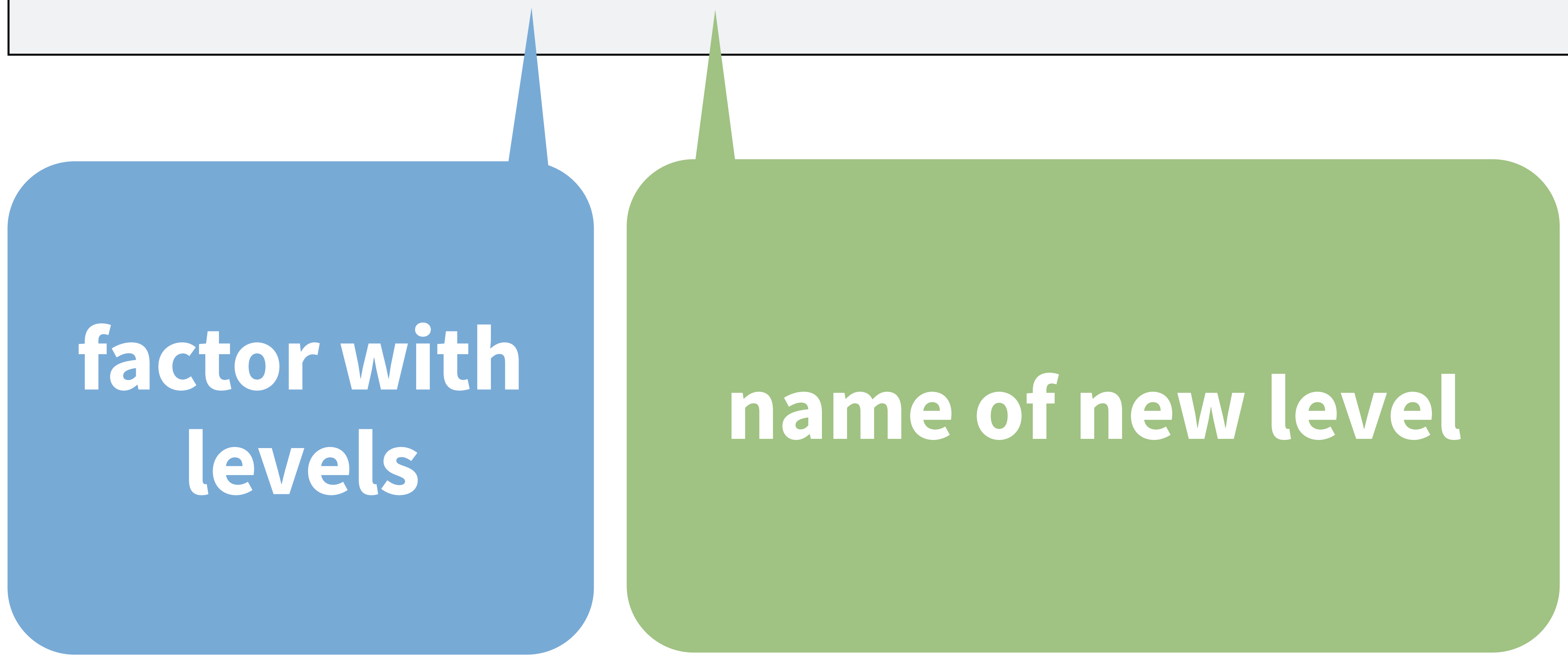


CC by RStudio

fct_lump()

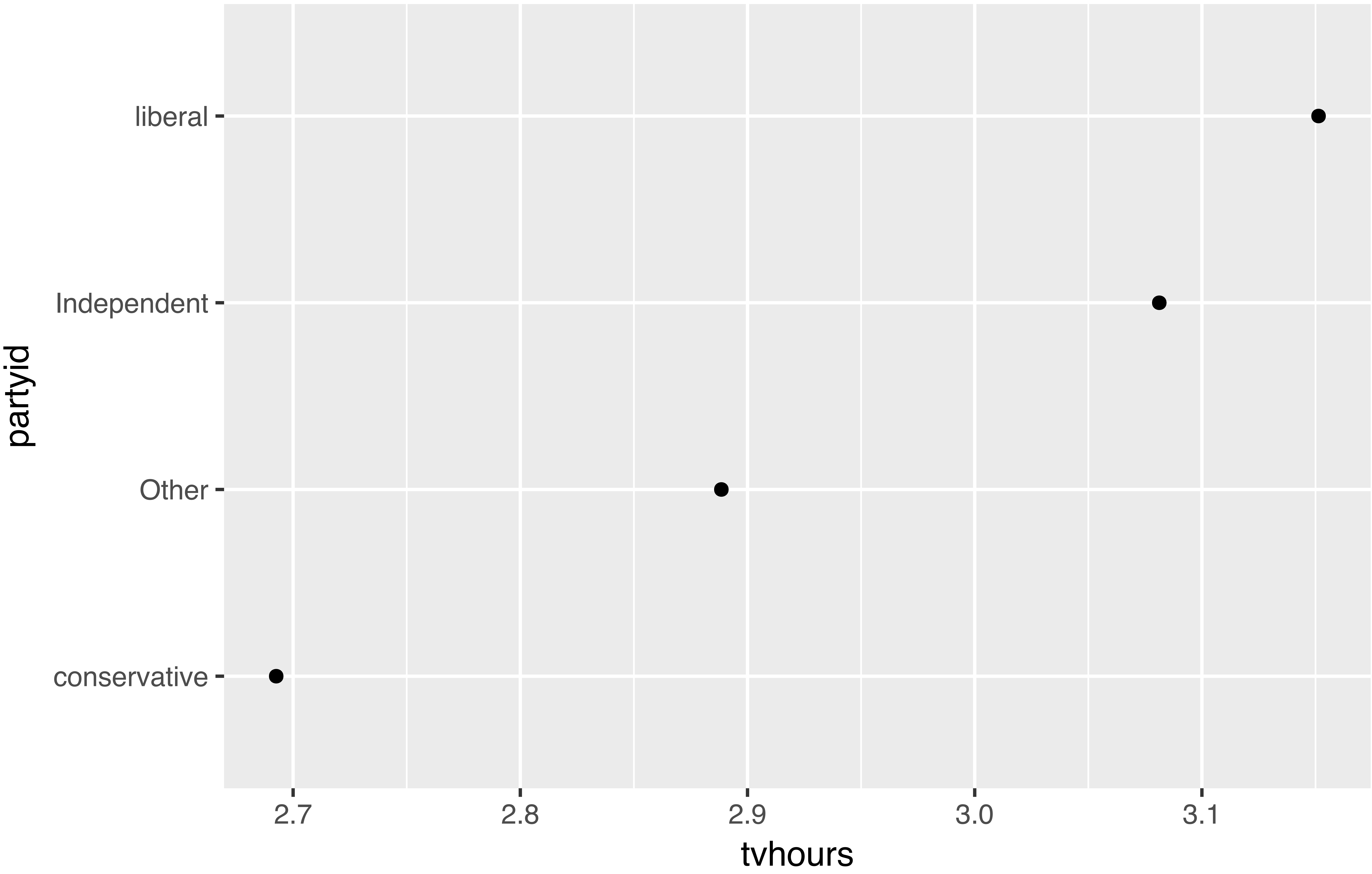
Collapses levels with fewest values into a single level. By default collapses as many levels as possible such that the new level is still the smallest.

```
fct_lump(f, other_level = "Other", …)
```



factor with levels

name of new level



CC by RStudio

```
gss_cat %>%
  drop_na(tvhours) %>%
  mutate(partyid = partyid %>%
    fct_lump() %>%
    fct_collapse(
      conservative = c("Strong republican",
                       "Not str republican", "Ind,near rep"),
      liberal = c("Strong democrat", "Not str democrat",
                  "Ind,near dem")) %>%
    fct_reorder(tvhours, mean)
  ) %>%
  group_by(partyid) %>%
  summarise(tvhours = mean(tvhours)) %>%
  ggplot(aes(tvhours, partyid)) +
    geom_point()
```

Date times

Quiz

Does every year have 365 days?

Quiz

Does every day have 24 hours?

Quiz

Does every minute have 60 seconds?

Quiz

What does a month measure?

Most useful skills

1. Parse a string into a date time class
2. Access and change parts of a date
3. Deal with time zones
4. Do math with instants and time spans

Warm Up

Decide in your group:

- What is the best time of day to fly?
- What is the best day of the week to fly?

02:00

Parsing dates and times

hms

A class for representing just clock times.

```
# install.packages("tidyverse")
library(hms)
```

hms

2017-01-01 12:34:56

Stored as the number of seconds since 00:00:00.*

```
library(hms)
hms(seconds = 56, min = 34, hour = 12)
## 12:34:56

unclass(hms(56, 34, 12))
## 45296
```

* on a typical day

hms()

2017-01-01 12:34:56

```
library(hms)
hms(seconds, minutes, hours, days)
```

* on a typical day

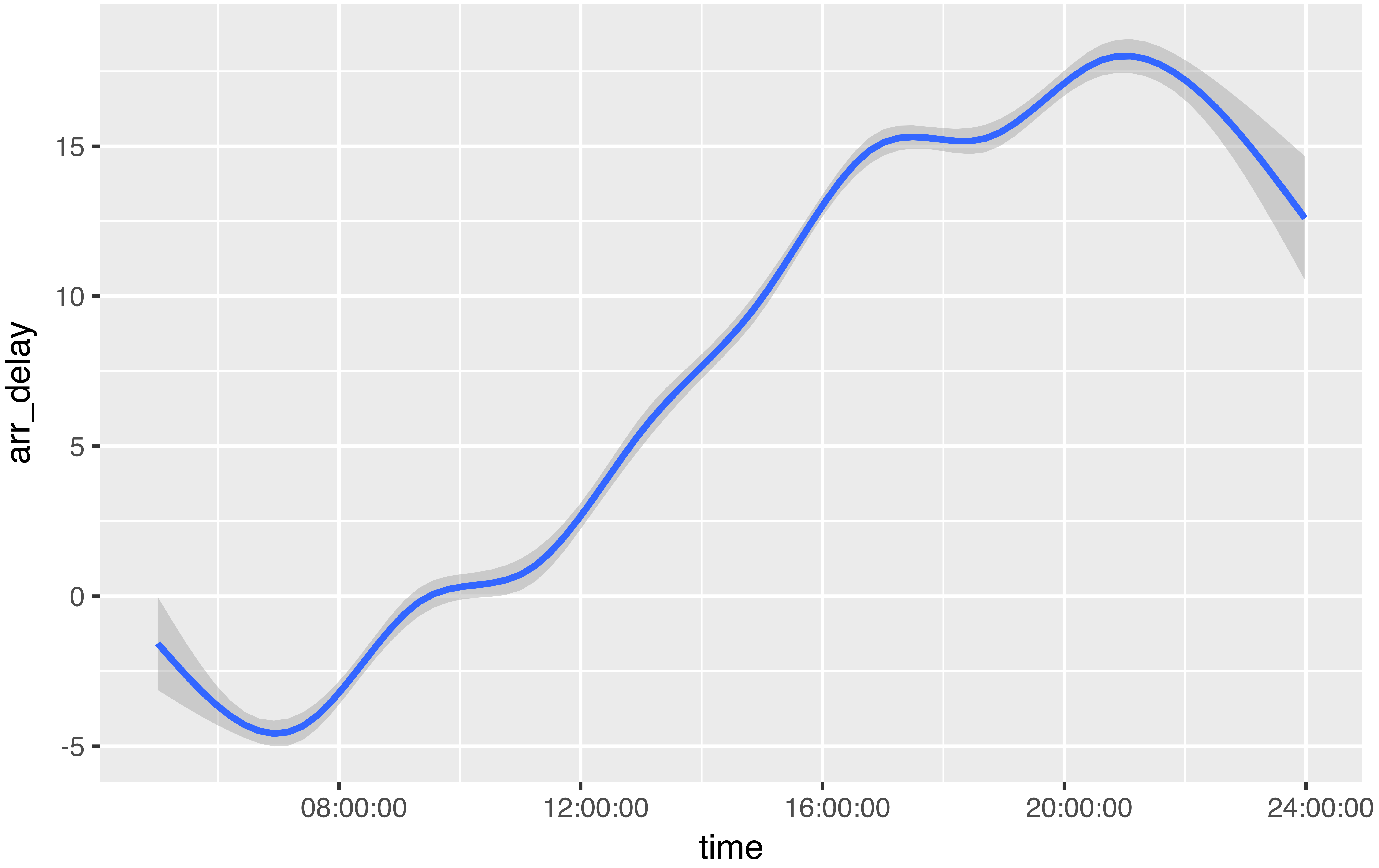
Your Turn 5

What is the best time of day to fly?

Use the **hour** and **minute** variables in flights to compute the time of day for each flight as an hms. Then use a smooth line to plot the relationship between time of day and **arr_delay**.

05:00

```
flights %>%
  mutate(time = hms(hour = hour, minute = minute)) %>%
  ggplot(aes(time, arr_delay)) + geom_smooth()
```



lubridate

Functions for working with dates and time spans

```
# install.packages("tidyverse")
library(lubridate)
```

ymd() family

To parse strings as dates, use a y, m, d, h, m, s combo

```
ymd("2017/01/11")
mdy("January 11, 2017")
ymd_hms("2017-01-11  01:30:55")
```

Parsing functions

function	parses to
ymd_hms(), ymd_hm(), ymd_h()	POSIXct
ydm_hms(), ydm_hm(), ydm_h()	
dmy_hms(), dmy_hm(), dmy_h()	
mdy_hms(), mdy_hm(), mdy_h()	
ymd(), ydm(), mdy()	Date (POSIXct if tz specified)
myd(), dmy(), dym(), yq()	
hms(), hm(), ms()	Period

Accessing and changing components

Accessing components

Extract components by name with a **singular** name

```
date <- ymd("2017-01-11")
year(date)
## 2017
```

Setting components

Use the same function to set components

```
date
## "2017-01-11"
year(date) <- 1999
date
## "1999-01-11"
```

Accessing date time components

function	extracts	extra arguments
year()	year	
month()	month	label = FALSE, abbr = TRUE
week()	week	
day()	day of month	
wday()	day of week	label = FALSE, abbr = TRUE
qday()	day of quarter	
yday()	day of year	
hour()	hour	
minute()	minute	
second()	second	

Accessing components

```
wday(ymd("2017-01-11"))
## 2017
wday(ymd("2017-01-11"), label = TRUE)
## [1] Wed
## 7 Levels: Sun < Mon < Tues < Wed < Thurs < ... < Sat
wday(ymd("2017-01-11"), label = TRUE, abbr = FALSE)
## [1] Sunday
## 7 Levels: Sunday < Monday < Tuesday < ... < Saturday
```

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Your Turn 6

Fill in the blanks to:

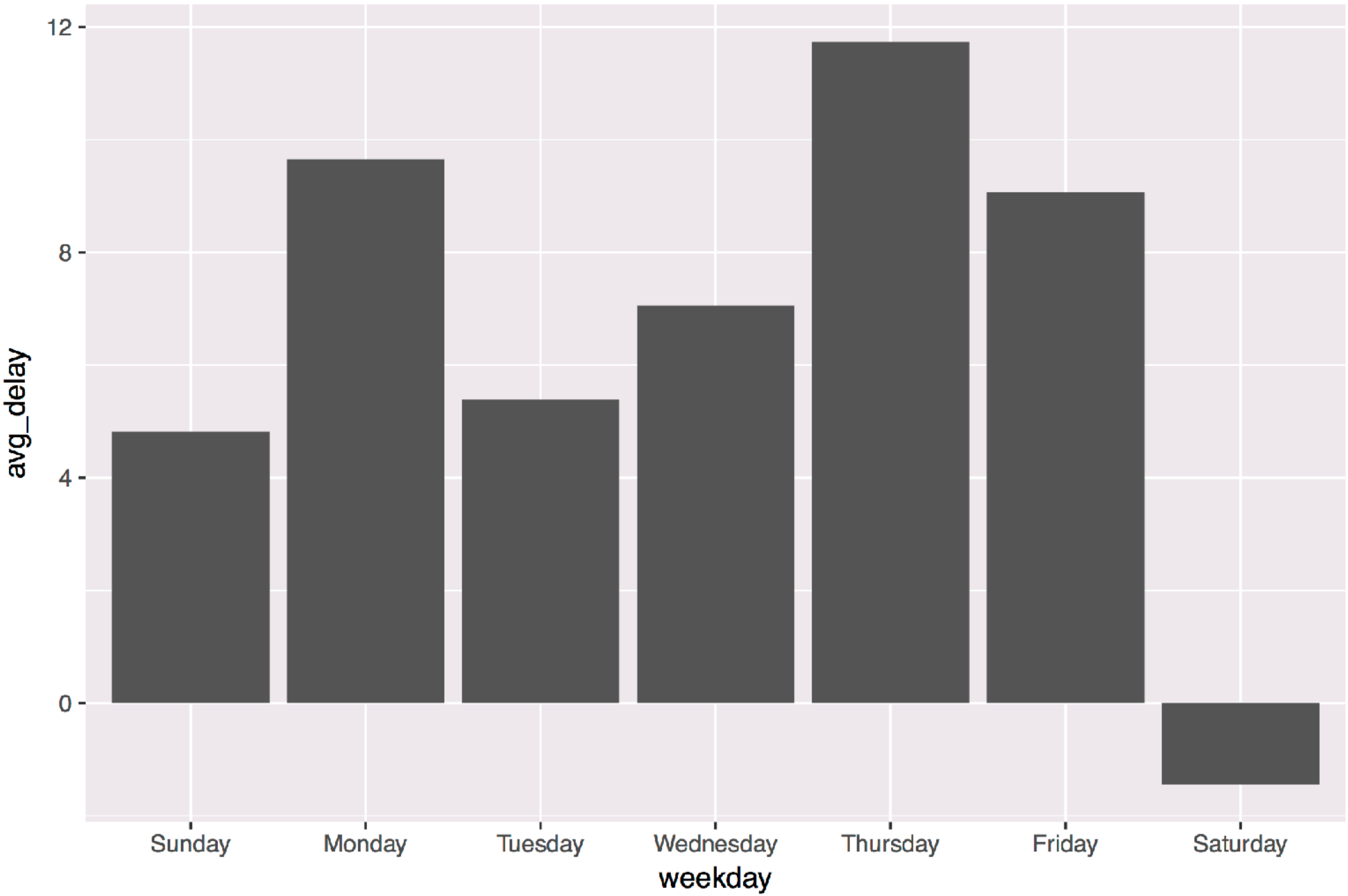
Extract the day of the week of each flight (as a full name) from **time_hour**.

Calculate the average **dep_delay** by day of the week.

Plot the results as a column chart (bar chart) with **geom_col()**.

05:00

```r
flights %>%
  mutate(weekday = wday(time_hour, label = TRUE, abbr = FALSE)) %>%
  group_by(weekday) %>%
  drop_na(dep_delay) %>%
  summarise(avg_delay = mean(dep_delay)) %>%
  ggplot() +
    geom_col(mapping = aes(x = weekday, y = avg_delay))
```



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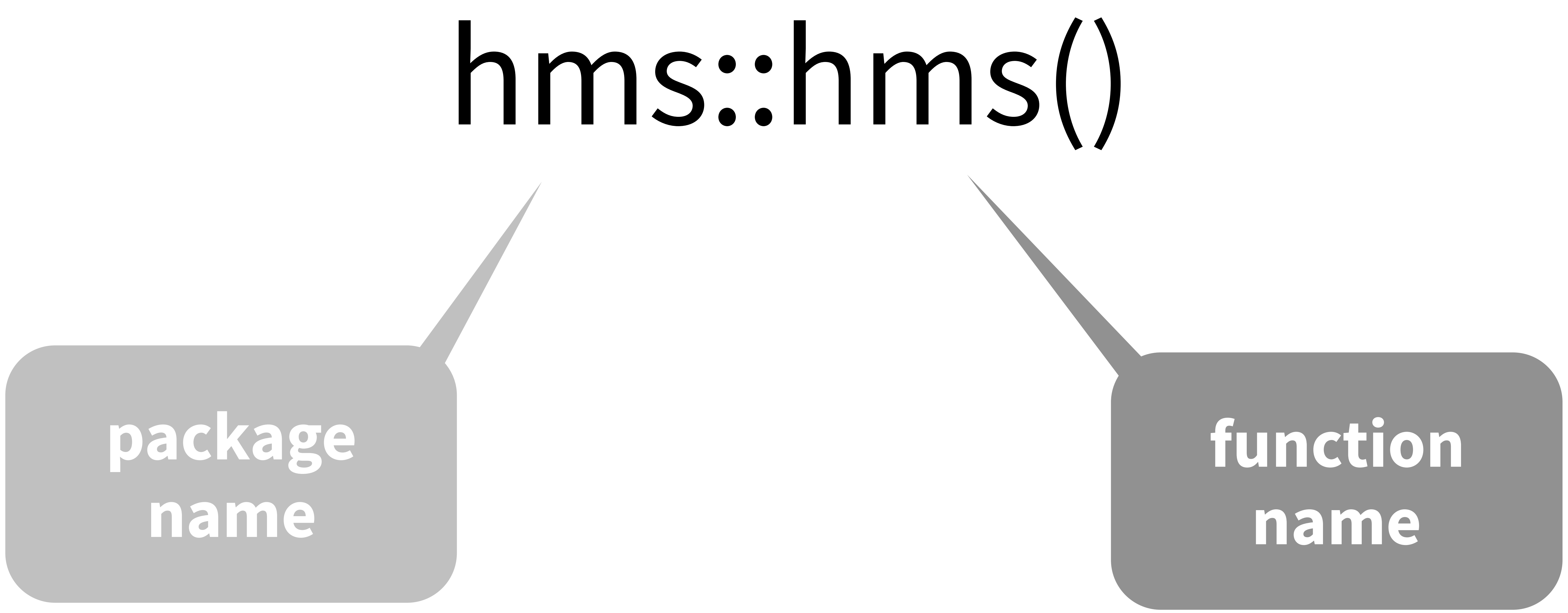
Parsing functions

function	parses to
ymd_hms(), ymd_hm(), ymd_h()	POSIXct
ydm_hms(), ydm_hm(), ydm_h()	
dmy_hms(), dmy_hm(), dmy_h()	
mdy_hms(), mdy_hm(), mdy_h()	
ymd(), ydm(), mdy()	Date (POSIXct if tz specified)
myd(), dmy(), dym(), yq()	
hms(), hm(), ms()	Period

Parsing functions

function	parses to
ymd_hms(), ymd_hm(), ymd_h()	POSIXct
ydm_hms(), ydm_hm(), ydm_h()	
dmy_hms(), dmy_hm(), dmy_h()	
mdy_hms(), mdy_hm(), mdy_h()	
ymd(), ydm(), mdy()	Date (POSIXct if tz specified)
myd(), dmy(), dym(), yq()	
hms(), hm(), ms()	Period

Same name as hms() in hms



hms::hms()

package name

function name

* on a typical day

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```
hms::hms()

lubridate::hms()
```

* on a typical day

hms()

```
hms::hms(seconds = 3, hours = 5)
```

Use the hms() function in the hms package

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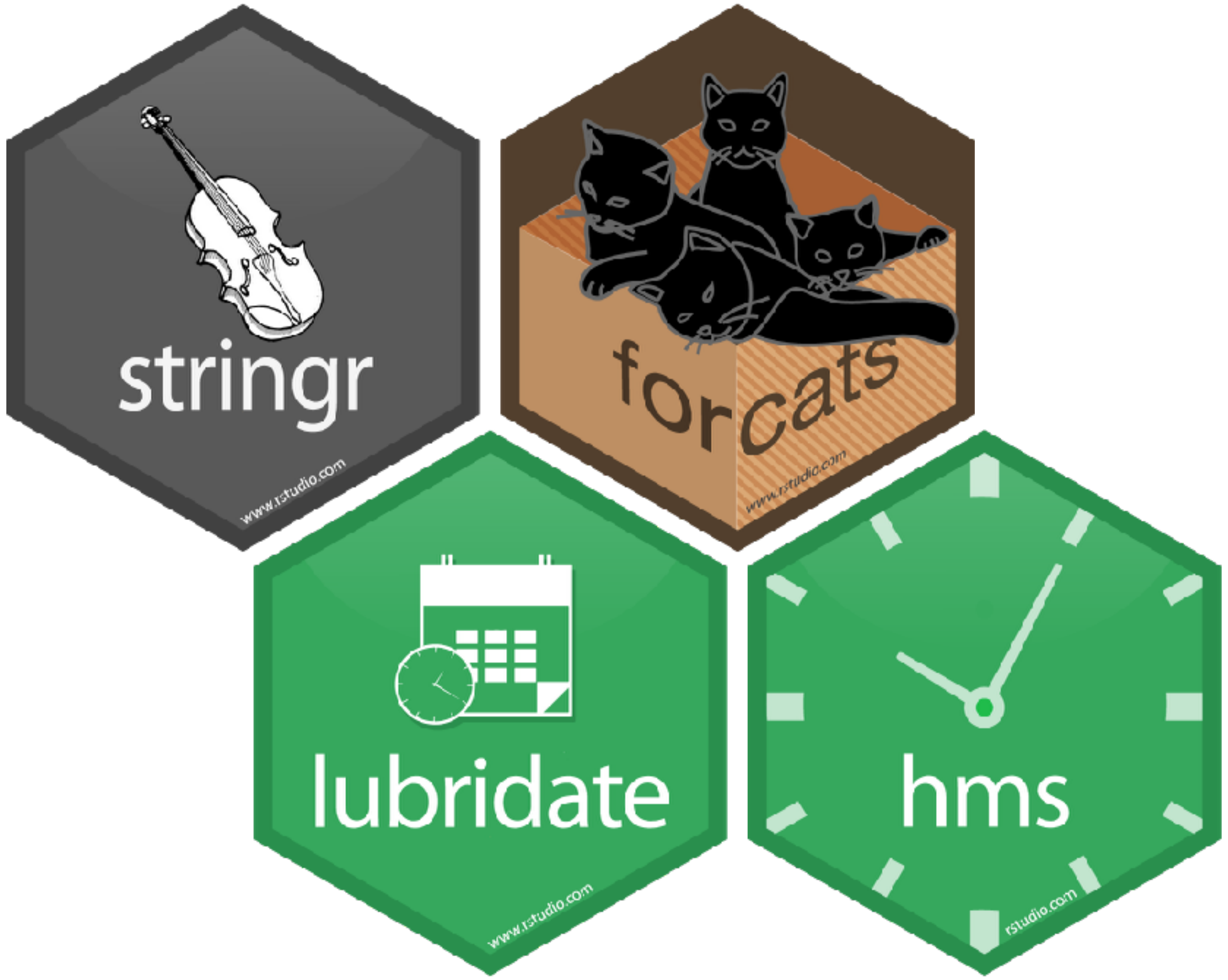
* on a typical day

Data types with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