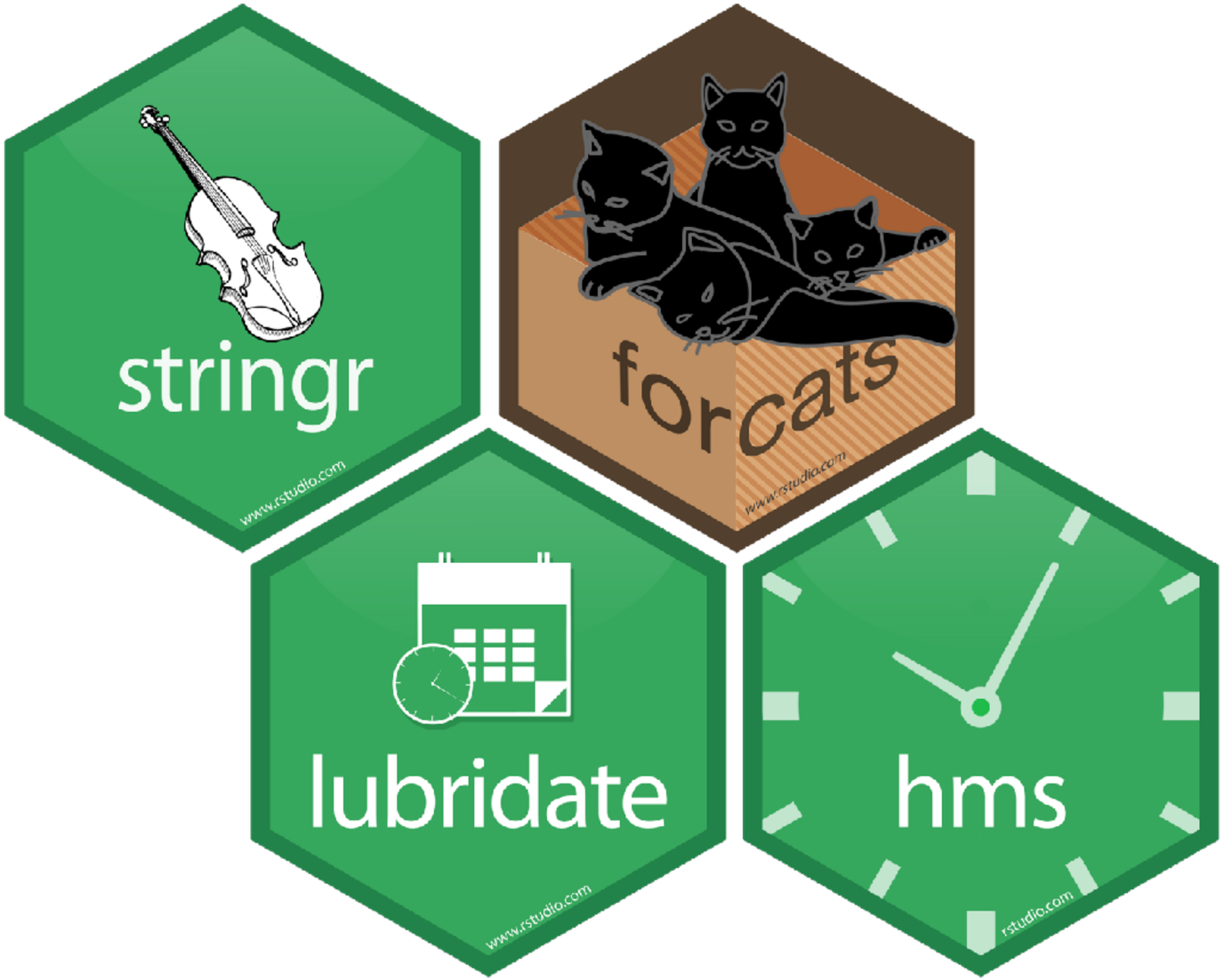
Data Types

Jake Thompson
wjakethompson.com
@wjakethompson

ATLAS
Accessible Teaching, Learning, and Assessment Systems



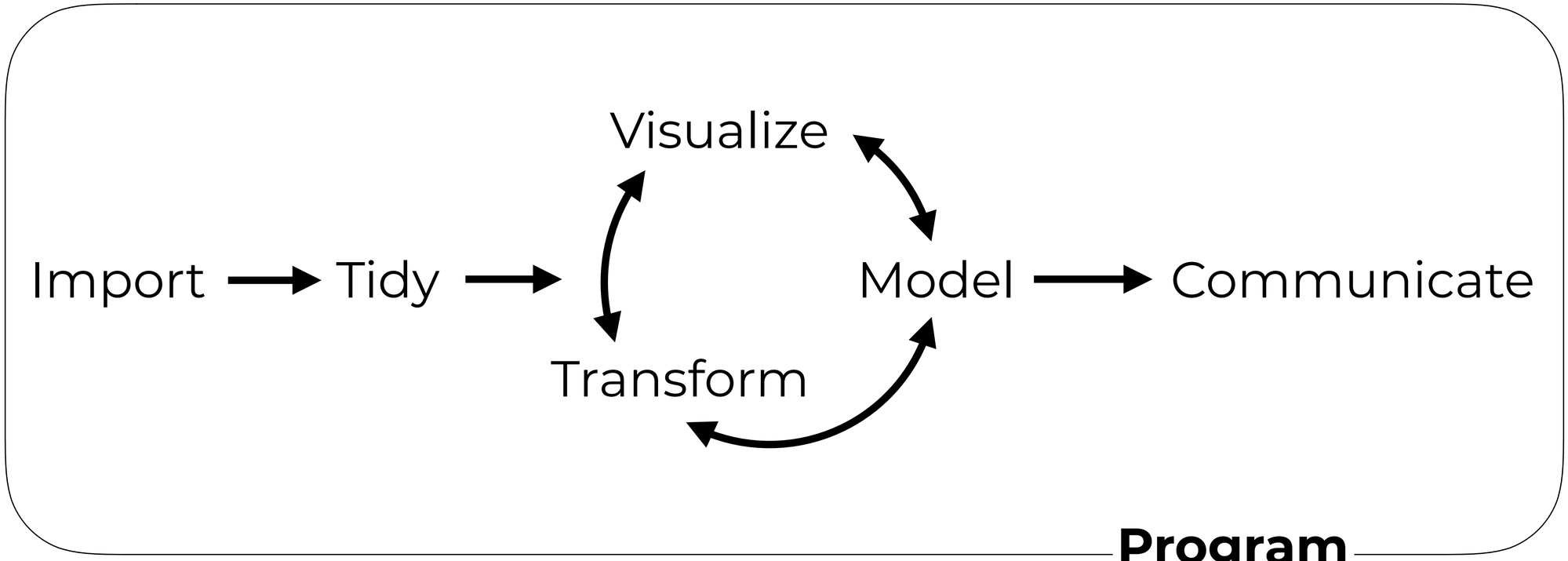
Your Turn 0

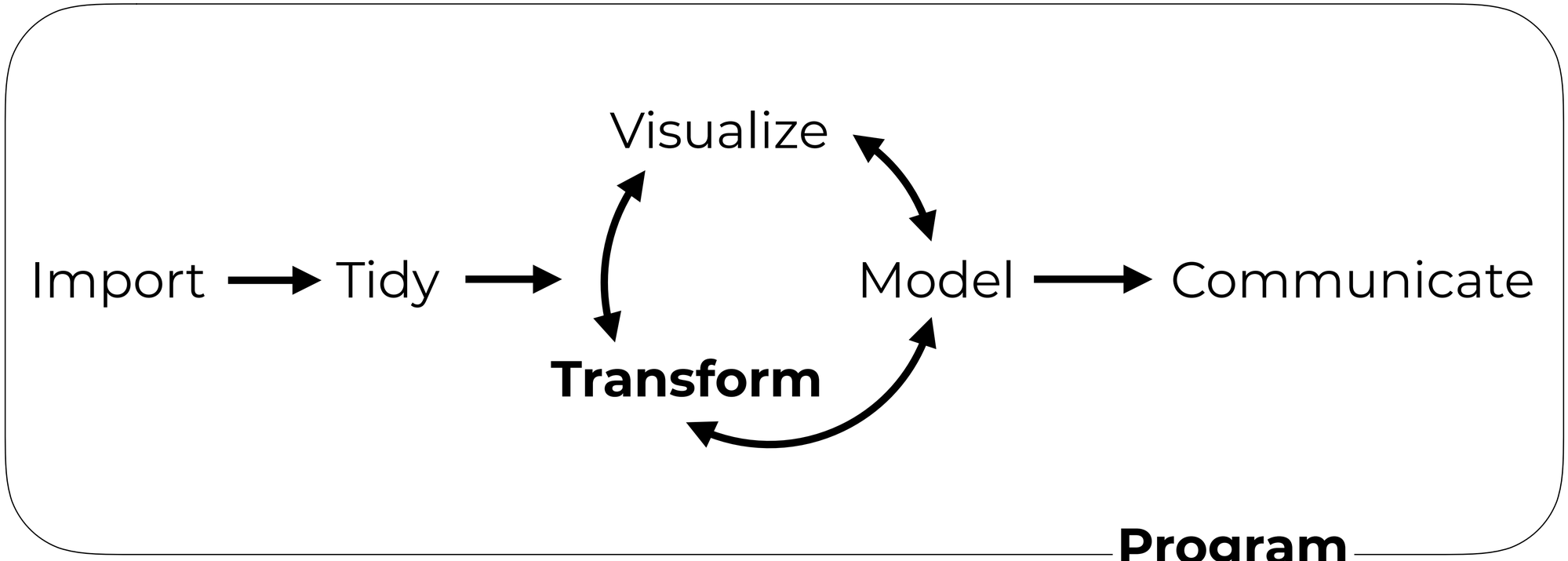
- Open **03-Data-Types.Rmd**
- Run the setup chunk

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





Logicals

Logicals

R's data type for boolean values (i.e., TRUE and FALSE)

```
typeof(TRUE)
# "logical"

typeof(FALSE)
# "logical"

typeof(c(TRUE, TRUE, FALSE))
# "logical"
```

```
flights %>%
  mutate(delayed = arr_delay > 0) %>%
  select(arr_delay, delayed)
# A tibble: 336,776 x 2
#    arr_delay delayed
#        <dbl> <lgl>
#  1        11 TRUE
#  2        20 TRUE
#  3        33 TRUE
#  4       -18 FALSE
#  5       -25 FALSE
#  6        12 TRUE
#  7        19 TRUE
#  8       -14 FALSE
#  9        -8 FALSE
# 10         8 TRUE
# ... with 336,766 more rows
```

Can we compute the proportion of flights that arrived late?

ATLAS

Most useful skills

- Math with logicals
  - 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
```

Your Turn 1

Use flights to create **delayed**, a variable that displays whether a flight was delayed (**arr_delay > 0**).

Then, remove all rows that contain an NA in **delayed**.

Finally, create a summary table that shows:

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

04 : 00

ATLAS

```
flights %>%
  mutate(delayed = arr_delay > 0) %>%
  drop_na(delayed) %>%
  summarize(total = sum(delayed), prop = mean(delayed))
# A tibble: 1 x 2
#    total  prop
#    <int> <dbl>
# 1 133004 0.406
```

Strings

(character) **strings**

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

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

Warm Up

Decide in your group:

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

ATLAS

```
babynames
# A tibble: 1,924,665 x 5
#     year sex   name           n   prop
#    <dbl> <chr> <chr>      <int>  <dbl>
#  1  1880 F     Mary        7065 0.07
#  2  1880 F     Anna        2604 0.0
#  3  1880 F     Emma        2003 0.0
#  4  1880 F     Elizabeth   1939 0.0
#  5  1880 F     Minnie      1746 0.0
#  6  1880 F     Margaret    1578 0.0
#  7  1880 F     Ida         1472 0.01
#  8  1880 F     Alice       1414 0.0145
#  9  1880 F     Bertha      1320 0.0135
# 10  1880 F     Sarah       1288 0.0132
# … with 1,924,655 more rows
```

How can we build the proportion of boys and girls whose name ends in a vowel?

ATLAS

Most useful skills

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

ATLAS

str_sub()

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

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

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)
```

```
"Ga"
```

Quiz

What will this return?

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

```
"G"
```

Quiz

What will this return?

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

```
"arrett"
```

Quiz

What will this return?

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

```
"ett"
```

Quiz

What will this return?

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

```
"Garreth"
```

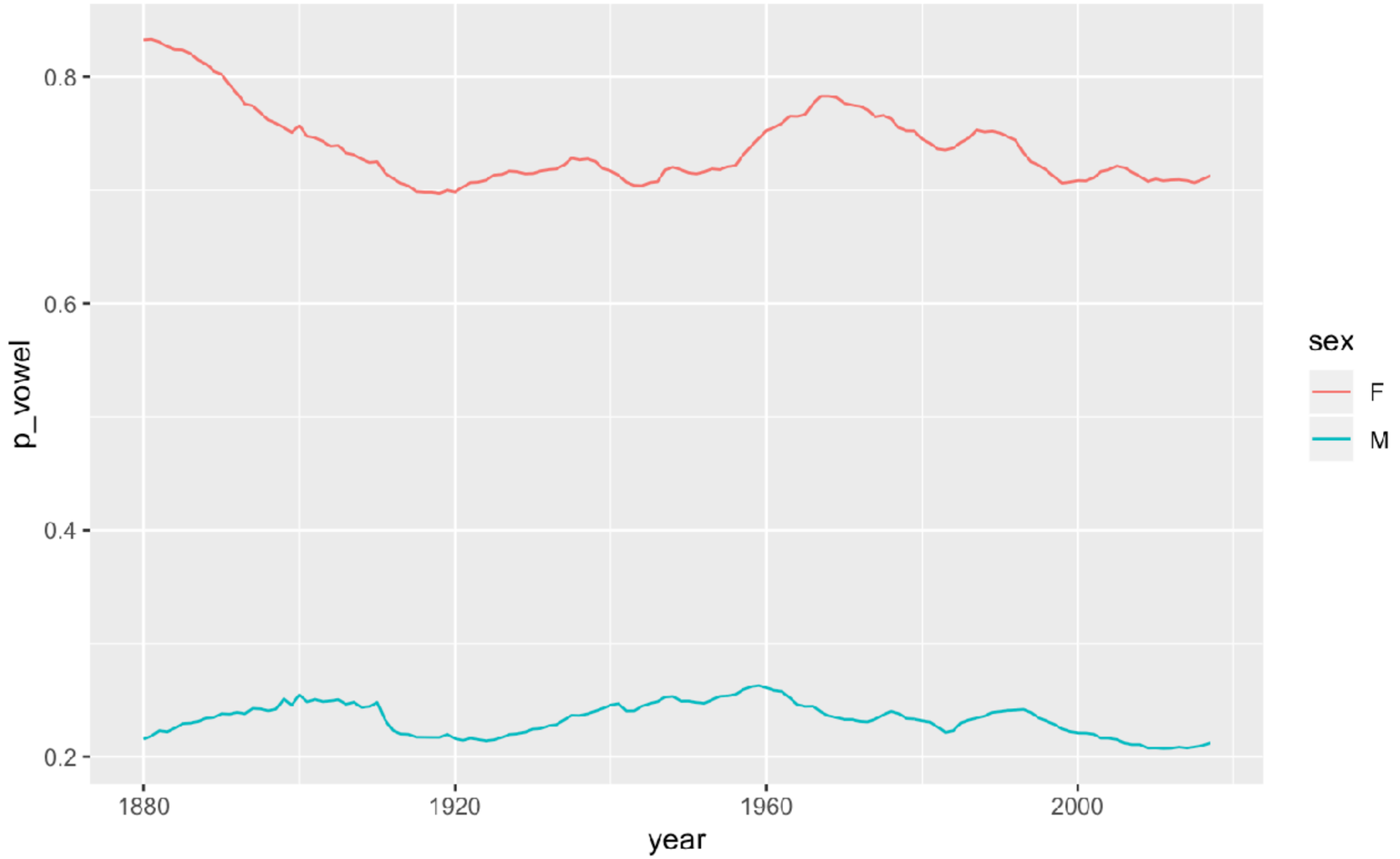
Your Turn 2

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

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



Factors

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] 1 3 3
# attr(,"levels")
# [1] "blue"  "brown" "green"
```

In R4DS

Factors

ATLAS

Warm Up

Decide in your group:

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

gss_cat

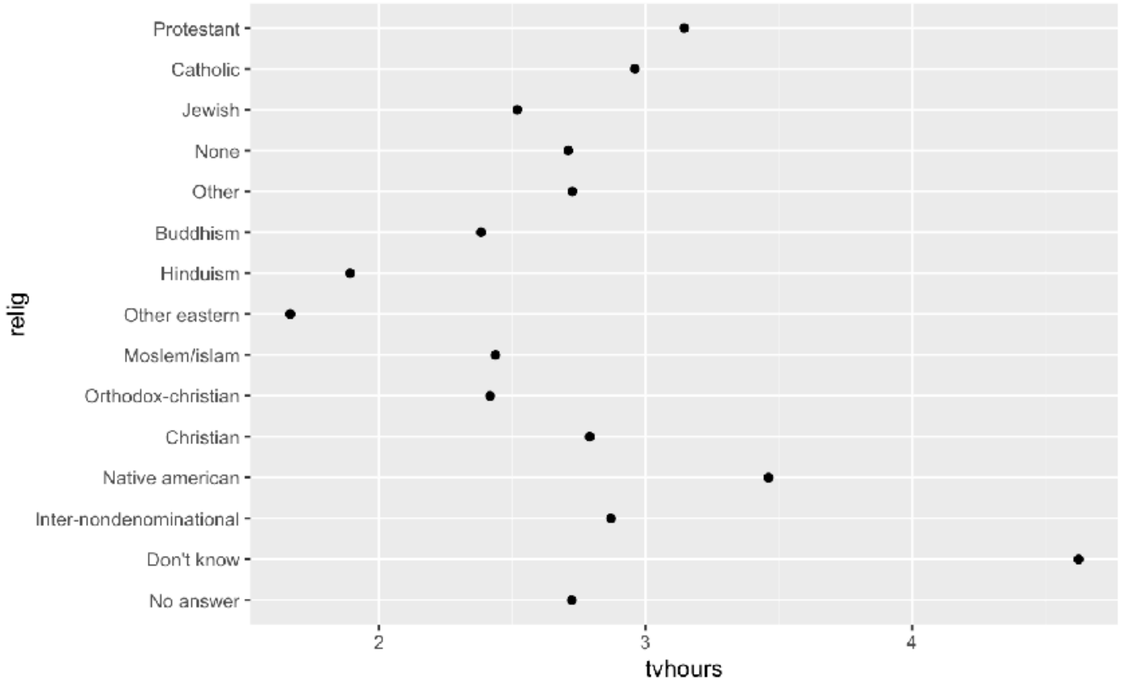
A sample of data from the General Social Survey, a long-running US survey conducted by NORC at the University of Chicago.

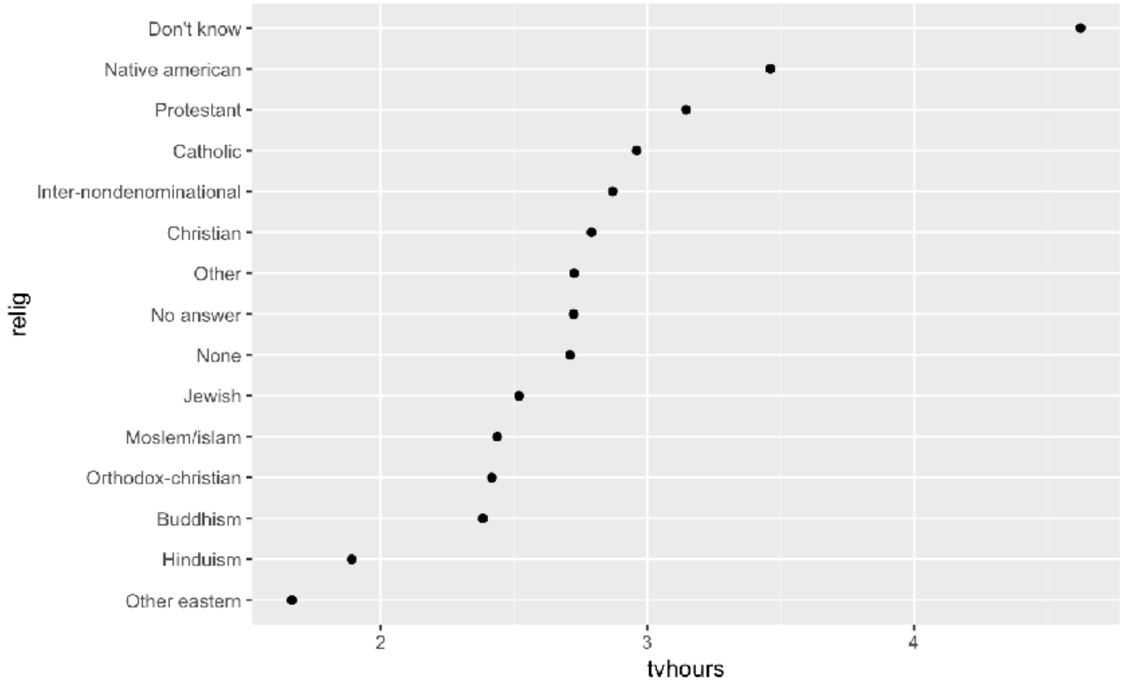
	tvhours	marital	age	race	partyid	relig
1	12	Never married	26	White	Ind,near rep	Protestant
2	*NA*	Divorced	48	White	Not str republican	Protestant
3	2	Widowed	67	White	Independent	Protestant
4	4	Never married	39	White	Ind,near rep	Orthodox-christian
5	1	Divorced	25	White	Not str democrat	None
6	*NA*	Married	25	White	Strong democrat	Protestant
7	3	Never married	36	White	Not str republican	Christian
8	*NA*	Divorced	44	White	Ind,near dem	Protestant

Which religions watch the least TV?

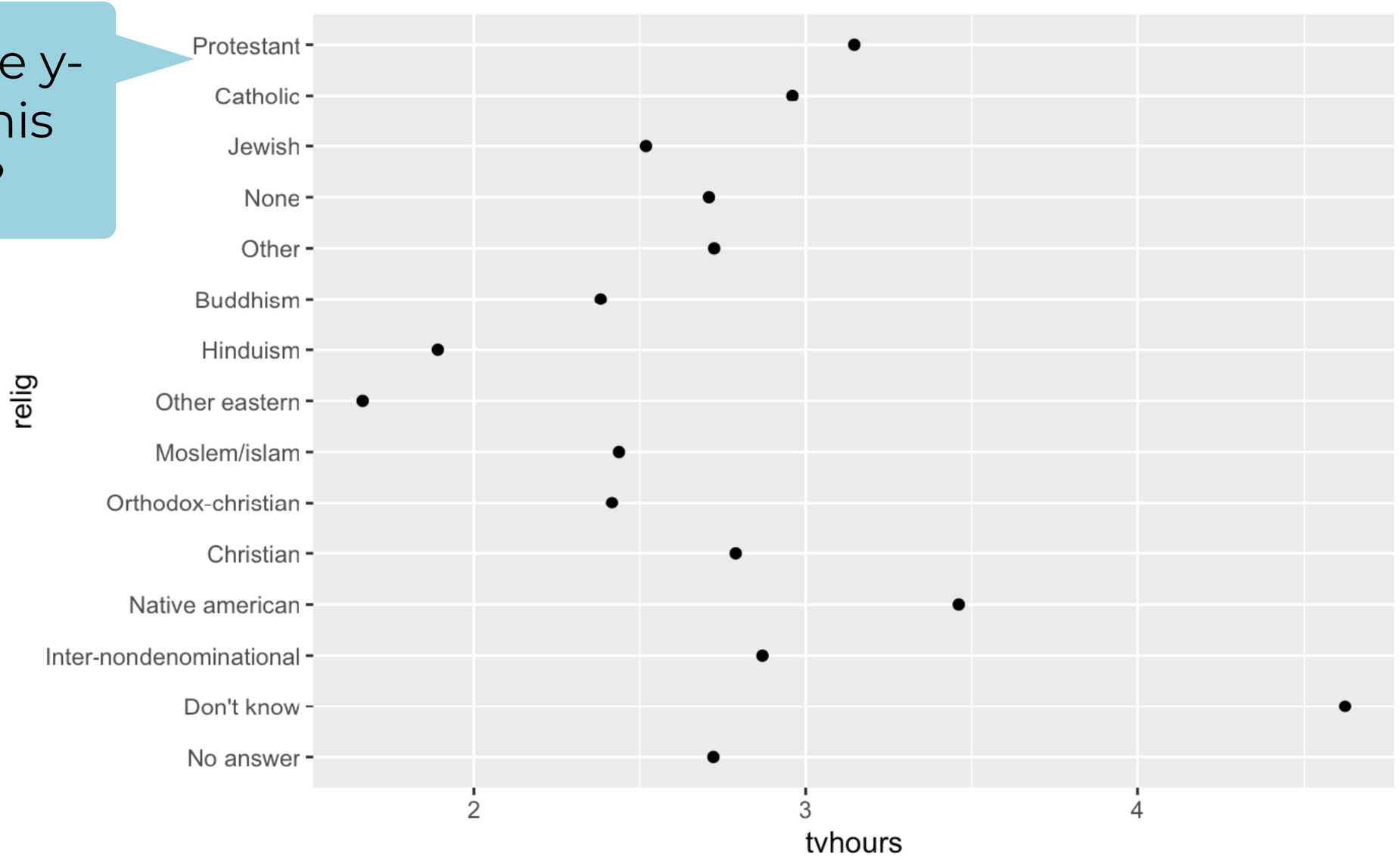
```
gss_cat %>%
  drop_na(tvhours) %>%
  group_by(relig) %>%
  summarize(tvhours = mean(tvhours)) %>%
  ggplot(mapping = aes(x = tvhours, y = relig)) +
    geom_point()
```

Which do you prefer?





Why is the y-axis in this order?



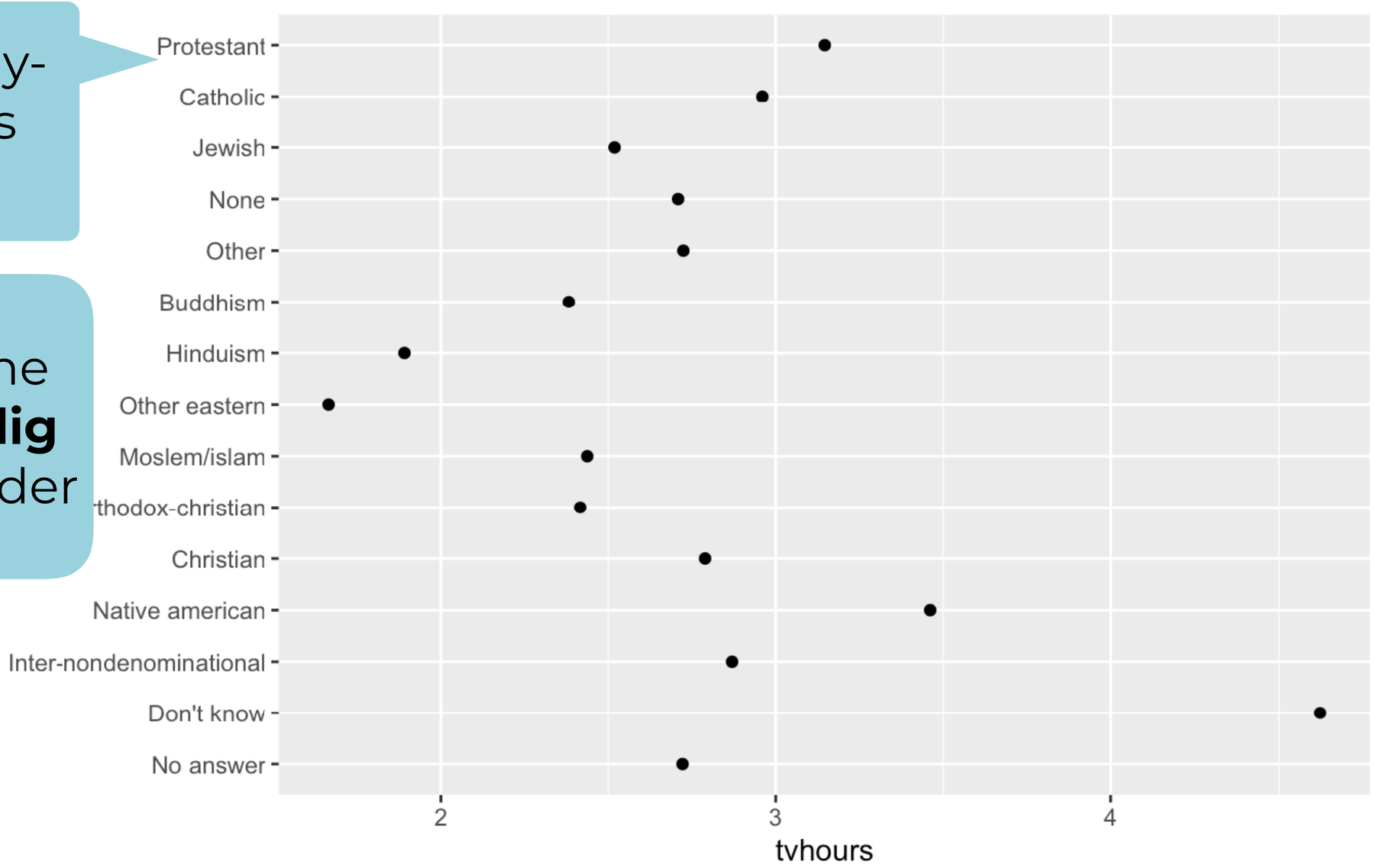
levels()

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



Most useful skills

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

Reordering levels

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)
```

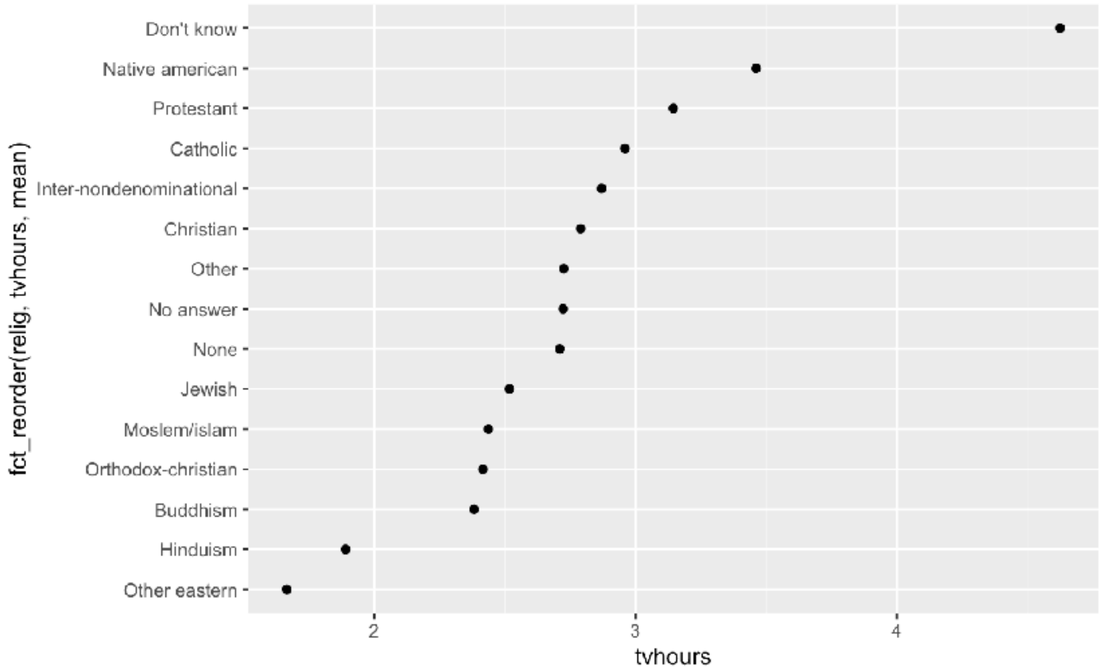
factor to reorder

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) %>%
  summarize(tvhours = mean(tvhours)) %>%
  ggplot(mapping = aes(x = tvhours,y = fct_reorder(relig, tvhours, mean))) +
    geom_point()
```

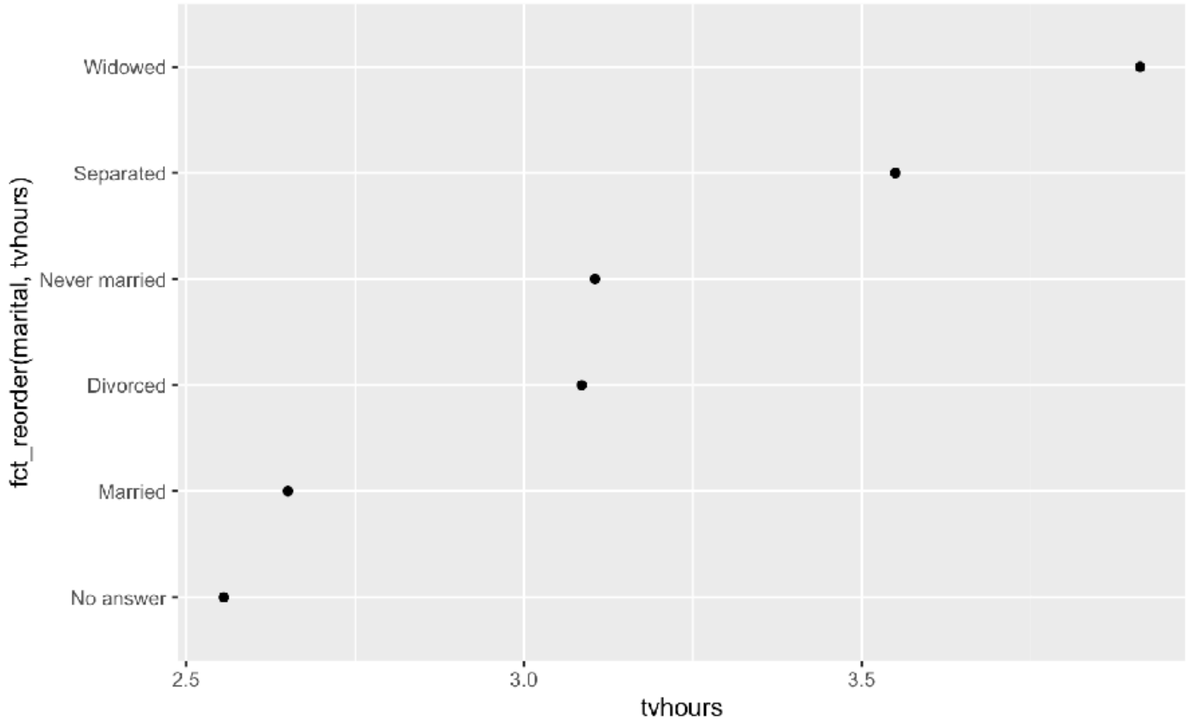


Your Turn 3

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

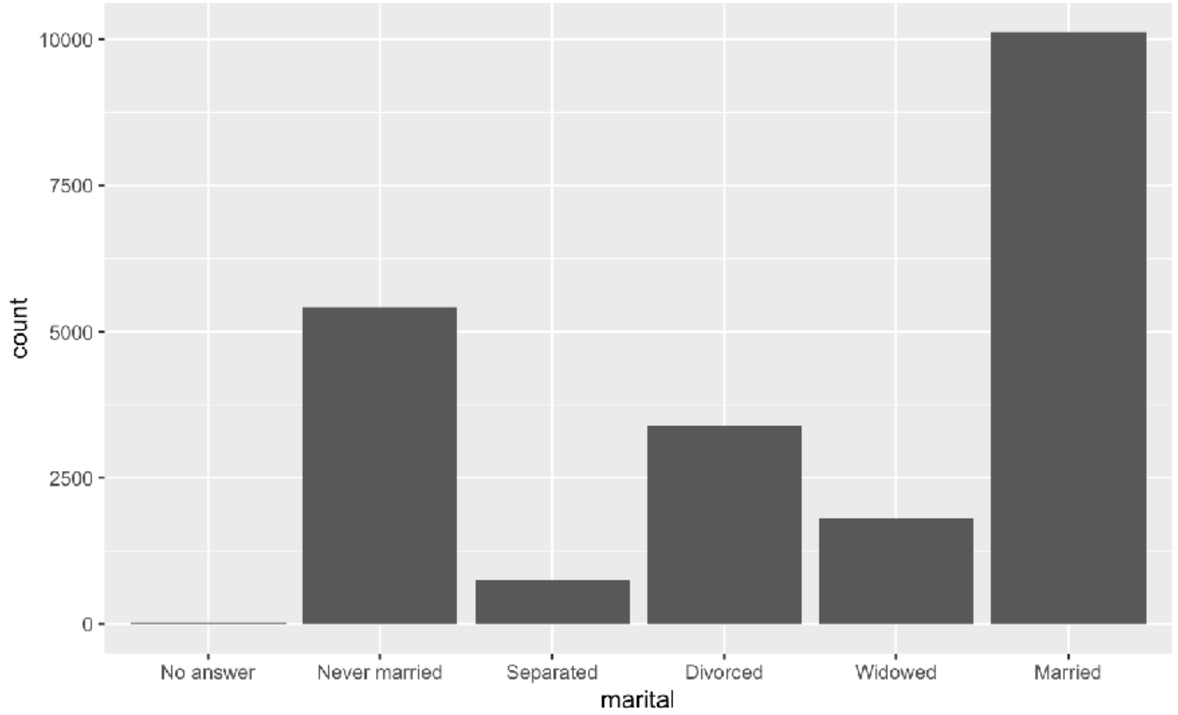
05 : 00

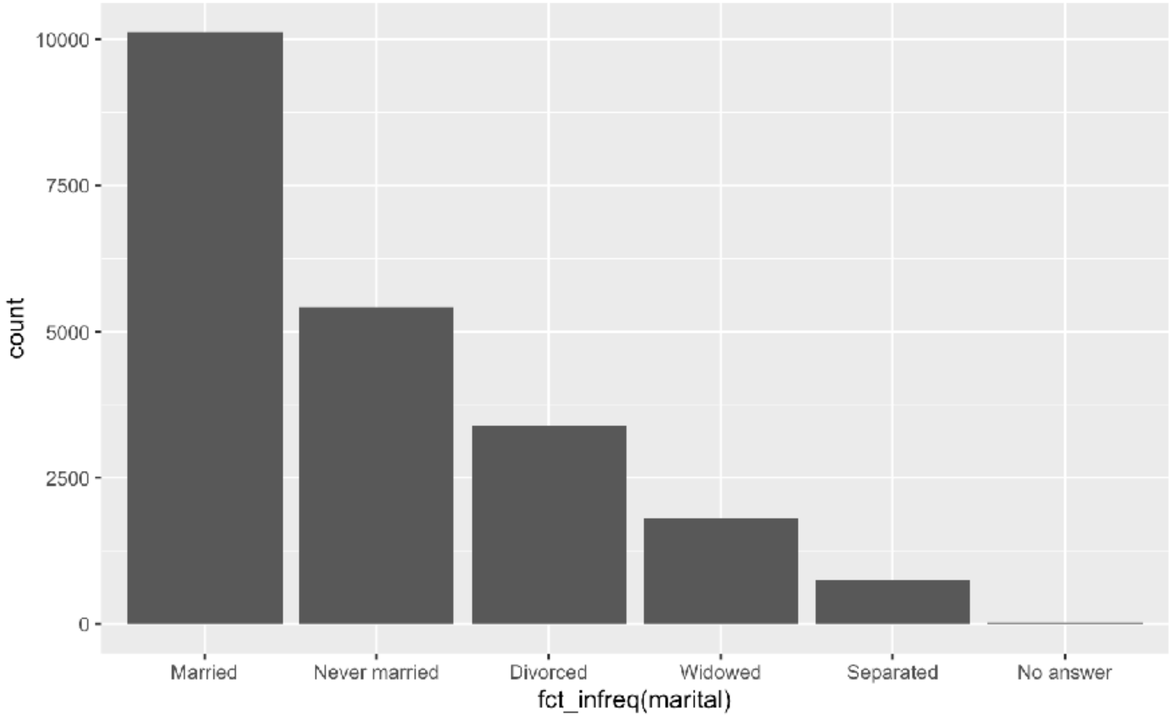
```
gss_cat %>%
  drop_na(tvhours) %>%
  group_by(marital) %>%
  summarize(tvhours = mean(tvhours)) %>%
  ggplot(mapping = aes(x = tvhours,y = fct_reorder(marital, tvhours, mean))) +
    geom_point()
```



fct_infreq()

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



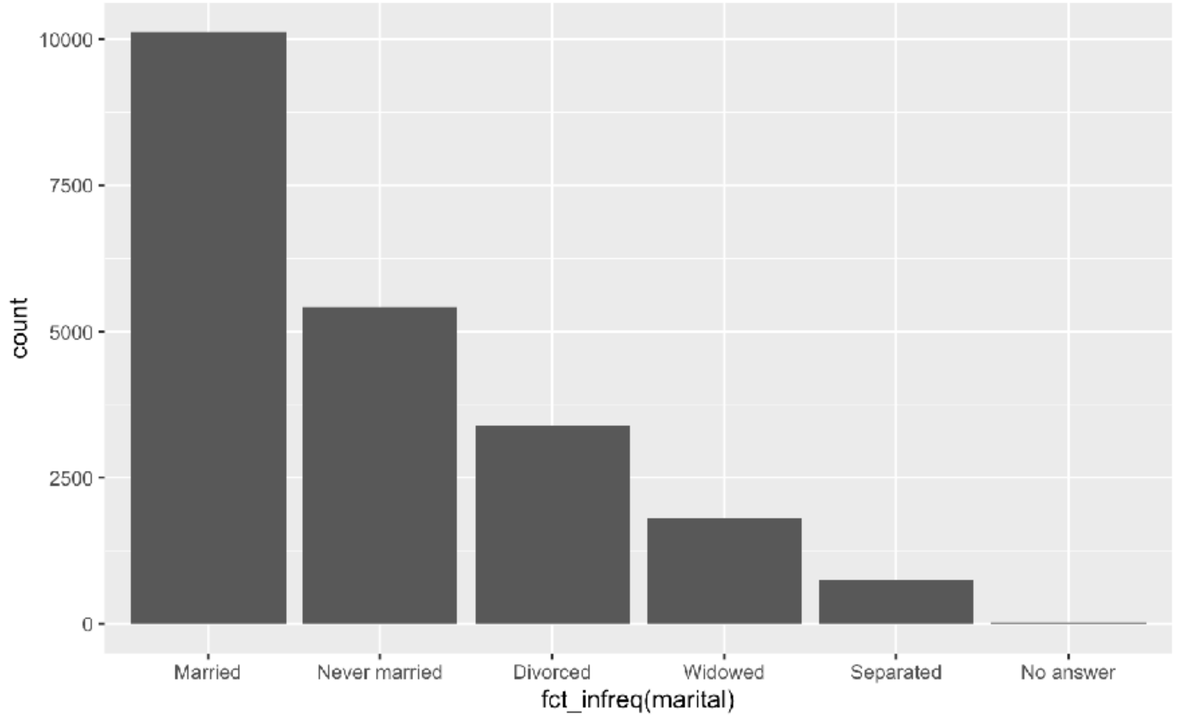


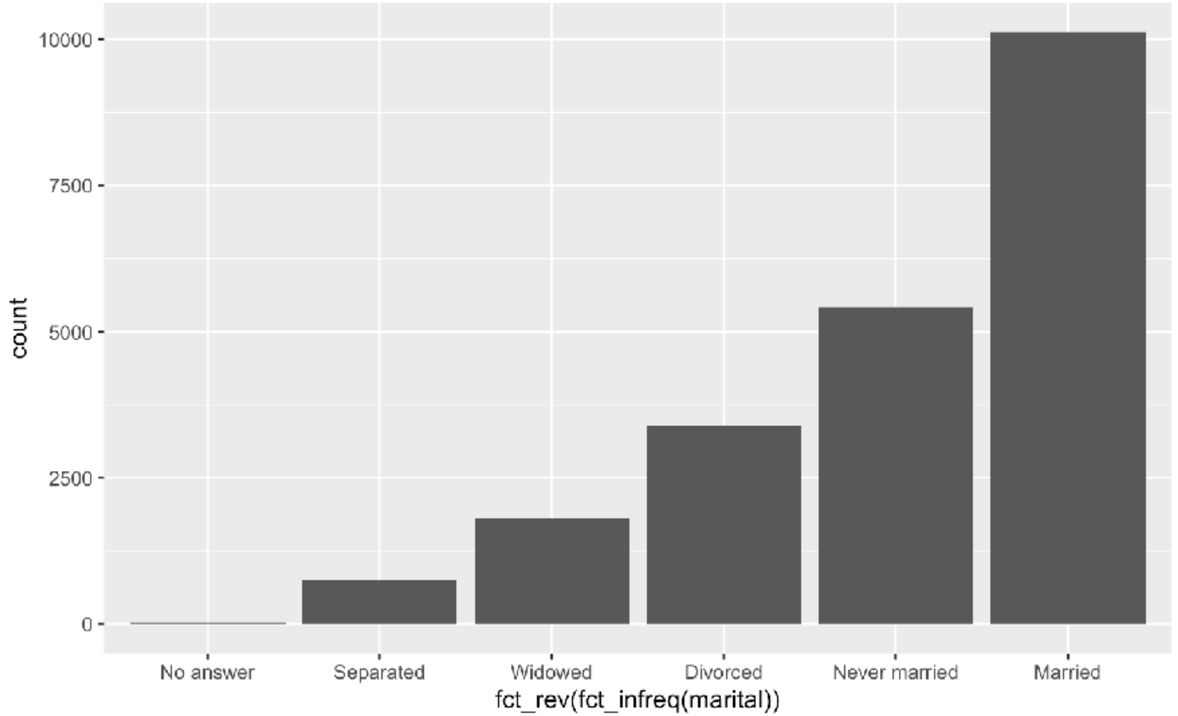
ATLAS

forcats

fct_rev()

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





Changing level values

Your Turn 4

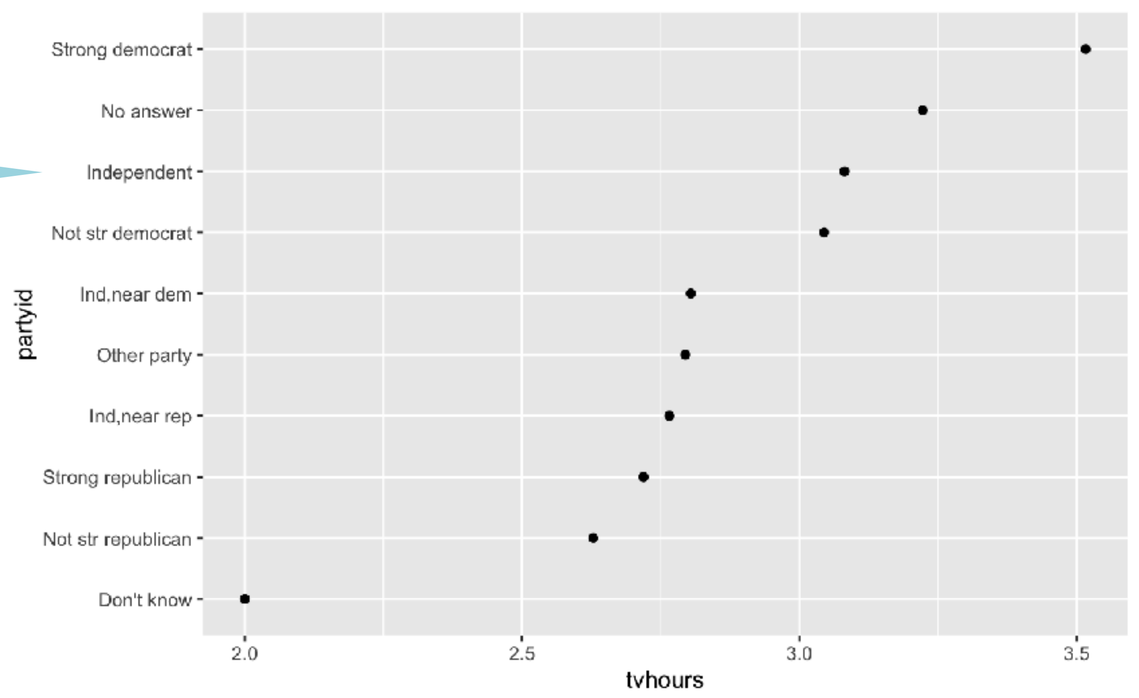
Do you think liberals or conservatives watch more TV?

Compute the average TV hours by party ID and then plot the results.

04 : 00

```
gss_cat %>%
  drop_na(tvhours) %>%
  group_by(partyid) %>%
  summarize(tvhours = mean(tvhours)) %>%
  ggplot(mapping = aes(x = tvhours,y = fct_reorder(marital, tvhours, mean))) +
    geom_point() +
    labs(y = "partyid")
```

1. How can we improve these labels?



fct_recode()

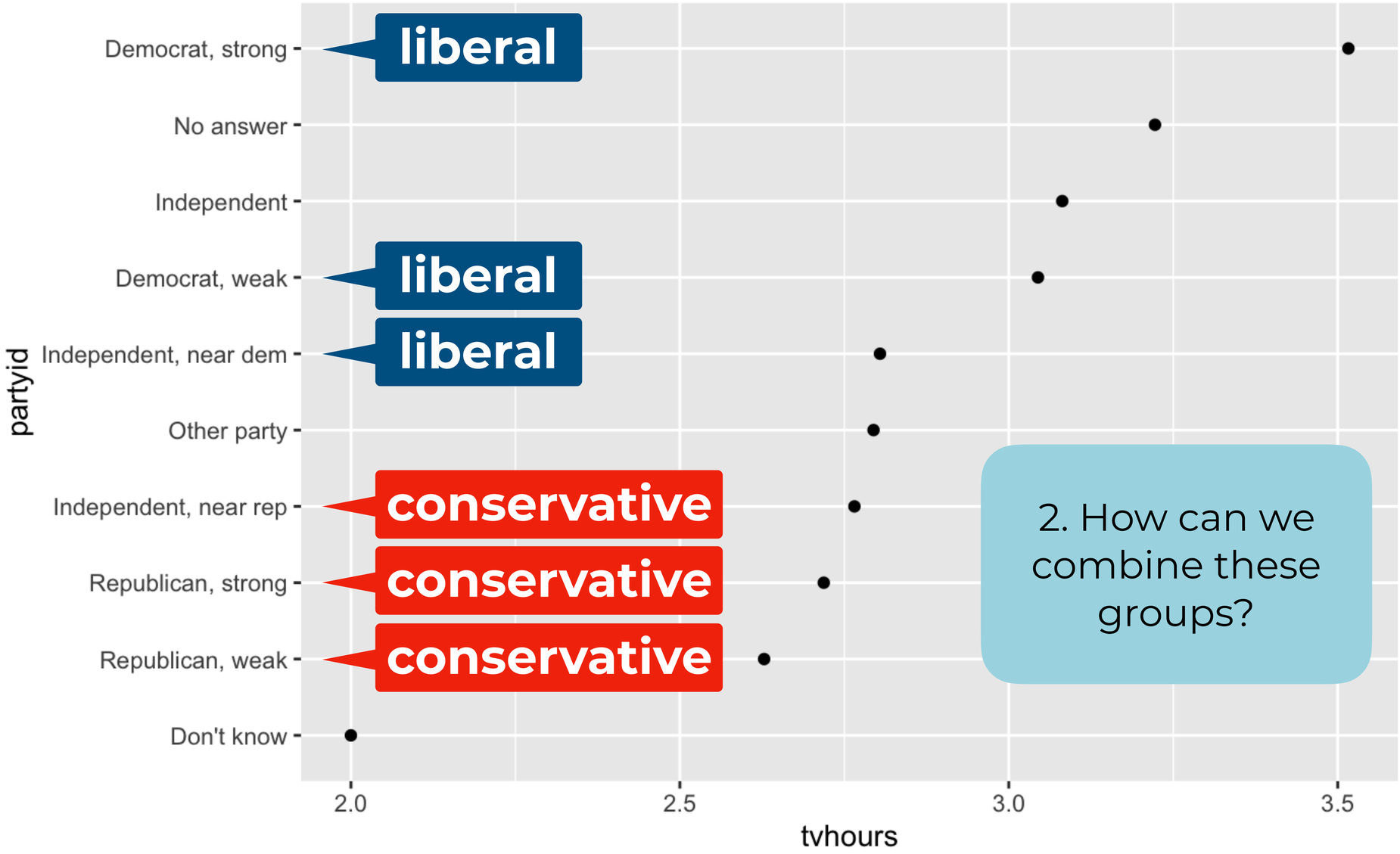
Change values of levels

```
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) %>%
  summarize(tvhours = mean(tvhours)) %>%
  ggplot(mapping = aes(x = tvhours,y = fct_reorder(partyid, tvhours, mean))) +
    geom_point() +
    labs(y = "partyid")
```



2. How can we combine these groups?

Collapsing levels

fct_collapse()

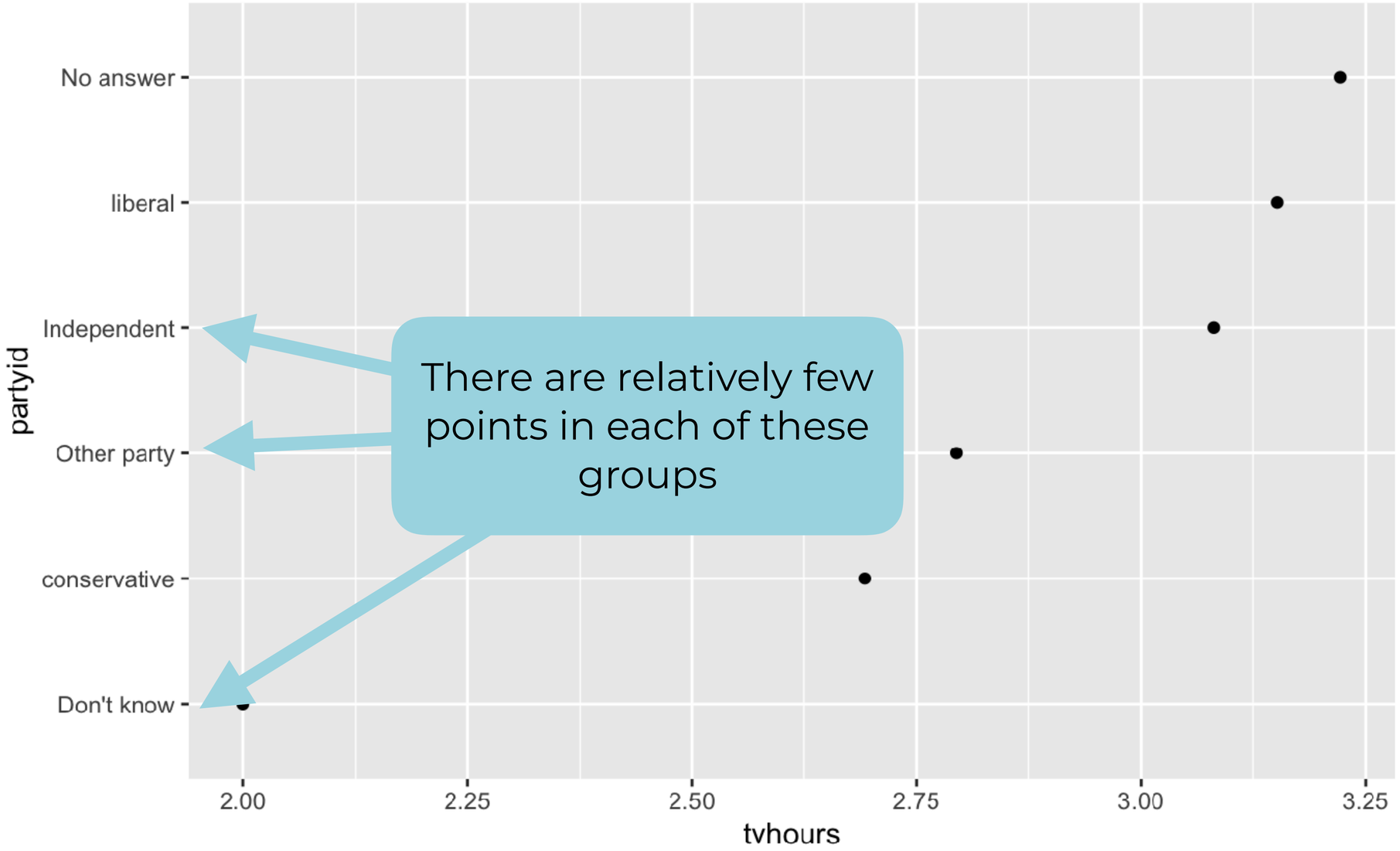
Changes multiple levels into single level

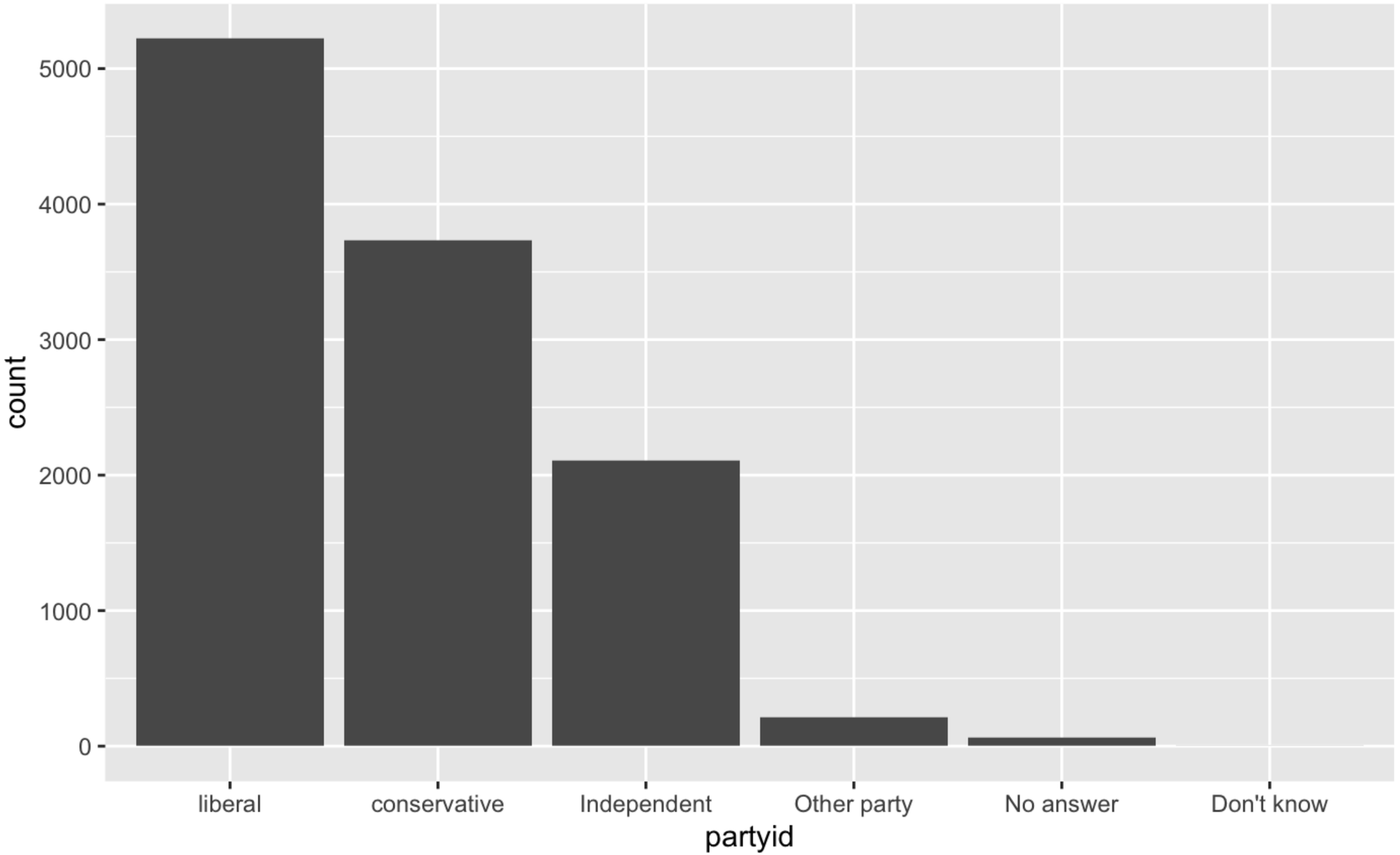
```
fct_collapse(f, ...)
```

factor with levels

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

```
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) %>%
  summarize(tvhours = mean(tvhours)) %>%
  ggplot(mapping = aes(x = tvhours,y = fct_reorder(partyid, tvhours, mean))) +
    geom_point() +
    labs(y = "partyid")
```





fct_lump()

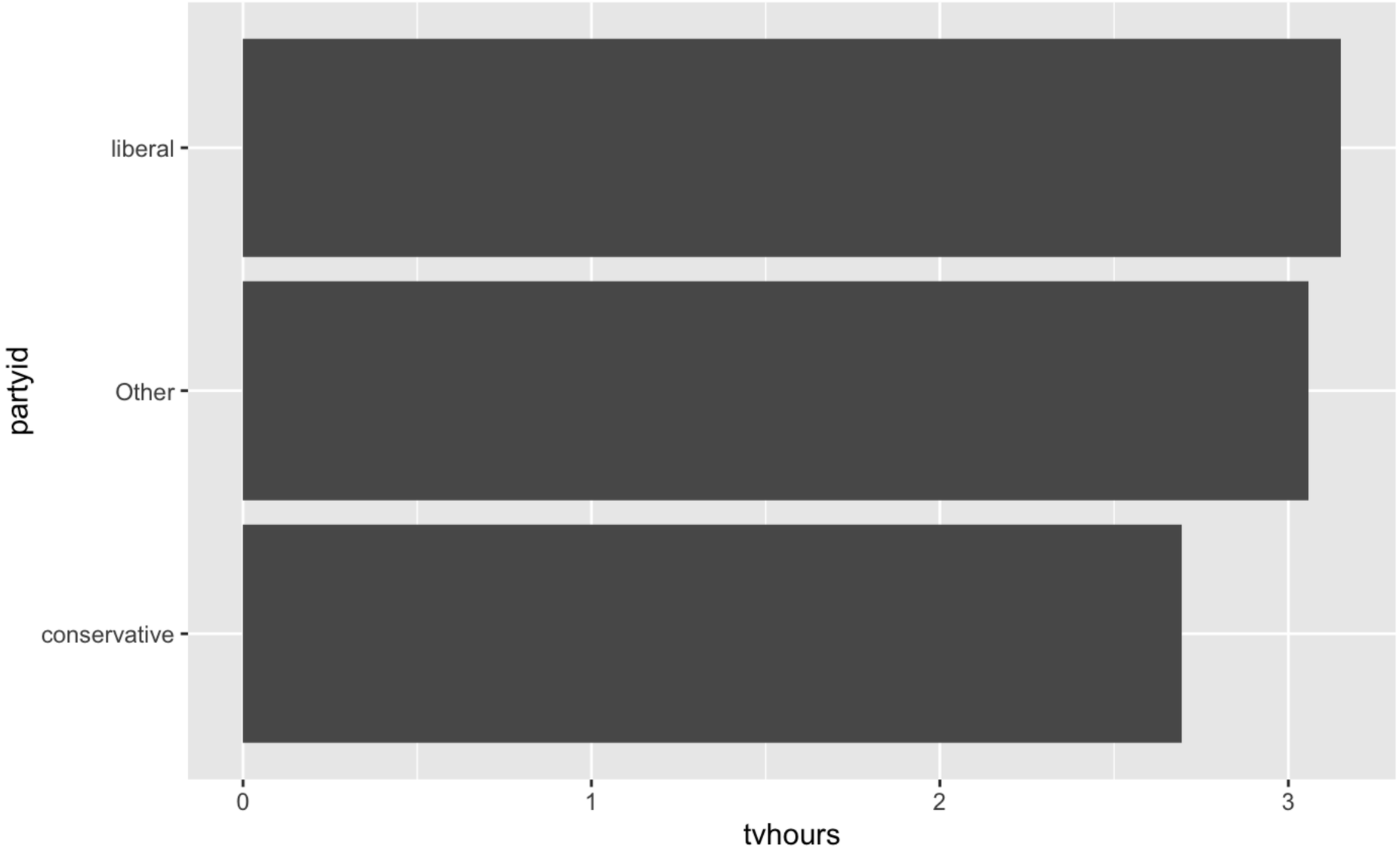
Collapses levels with fewest values into a single level. By default collapses as many levels as possible such that the new level is still the smallest.

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

factor with levels

name of new level

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



Date times

Quiz

Does every year have 365 days?

Does every day have 24 hours?

Does every minute have 60 seconds?

What does a month measure?

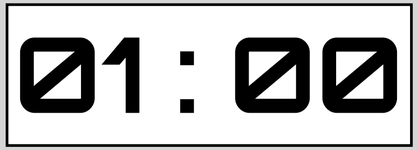
Most useful skills

1. Creating dates/times (i.e., *parsing*)
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?



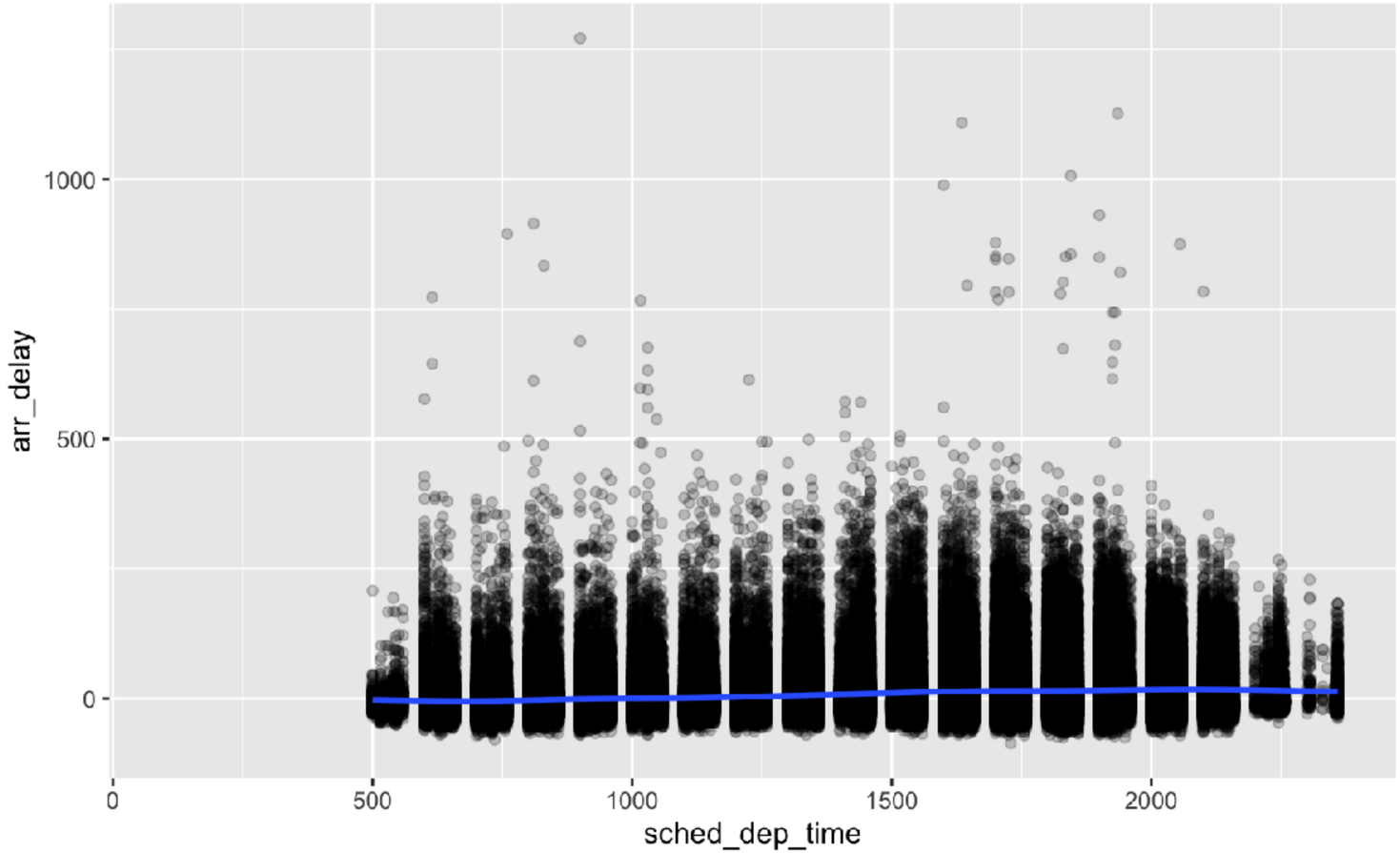
```
flights %>% select(year, month, day, hour, minute, sched_dep_time, time_hour)
```

year <int>	month <int>	day <int>	hour <dbl>	minute <dbl>	sched_dep_time <int>	time_hour <S3: POSIXct>
2013	1	1	5	15	515	2013-01-01 05:00:00
2013	1	1	5	29	529	2013-01-01 05:00:00
2013	1	1	5	40	540	2013-01-01 05:00:00
2013	1	1	5	45	545	2013-01-01 05:00:00
2013	1	1	6	0	600	2013-01-01 06:00:00
2013	1	1	5	58	558	2013-01-01 05:00:00
2013	1	1	6	0	600	2013-01-01 06:00:00
2013	1	1	6	0	600	2013-01-01 06:00:00
2013	1	1	6	0	600	2013-01-01 06:00:00
2013	1	1	6	0	600	2013-01-01 06:00:00

1–10 of 336,776 rows

Previous 1 2 3 4 5 6 ... 100 Next

```
flights %>%
  ggplot(mapping = aes(x = sched_dep_time, y = arr_delay)) +
    geom_point(alpha = 0.2) + geom_smooth()
```



Creating dates and times

In R4DS

Dates and times

hms

2019-01-01 **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()

2019-01-01 12:34:56

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

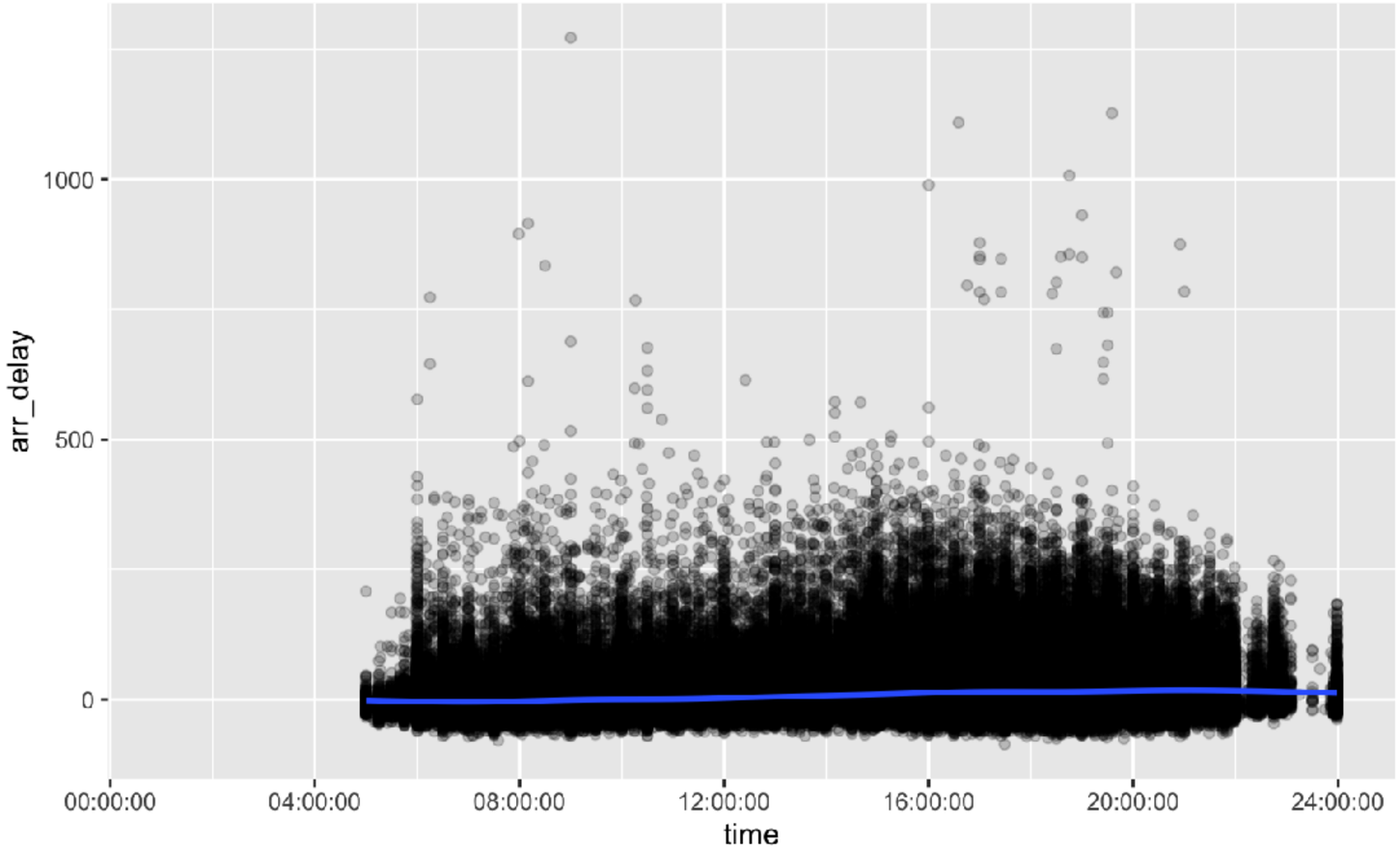

Your Turn 5

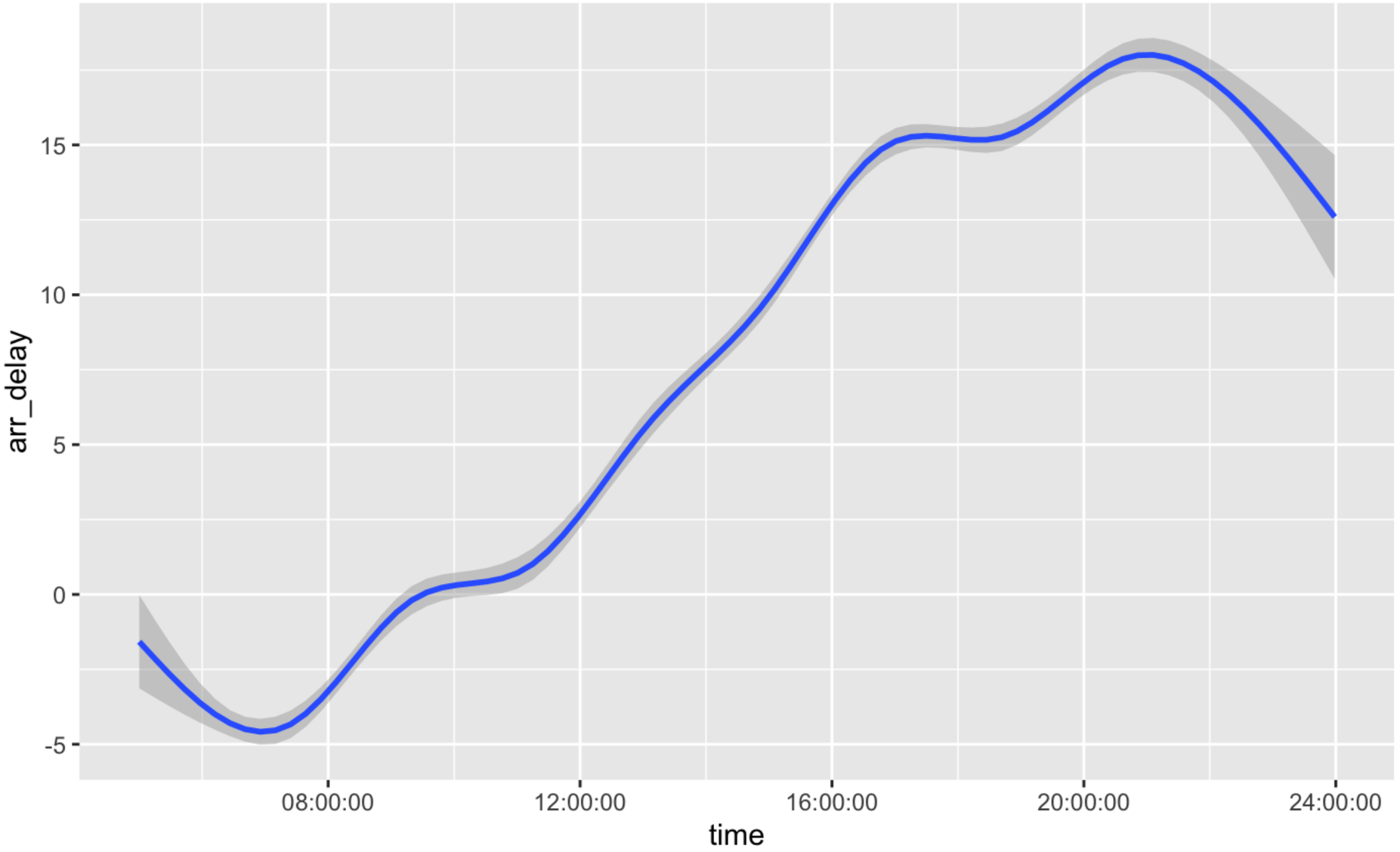
What is the best time of day to fly?

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**.

04 : 00

```
flights %>%
  mutate(time = hms(hour = hour, minute = minute)) %>%
  ggplot(mapping = aes(x = time, y = arr_delay)) +
    geom_point(alpha = 0.2) + geom_smooth()
```





lubridate

In R4DS

Dates and times

ymd() family

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

```
ymd("2019/01/09")
# [1] "2019-01-09"

mdy("January 9, 2019")
# [1] "2019-01-09"

ymd_hms("2019-01-09 13:42:32")
# [1] "2019-01-09 13:42:32 UTC"
```

Parsing functions

function	parses to

`ymd_hms()`, `ymd_hm()`, `ymd_h()`
`ydm_hms()`, `ydm_hm()`, `ydm_h()`
`dmy_hms()`, `dmy_hm()`, `dmy_h()`
`mdy_hms()`, `mdy_hm()`, `mdy_h()`
	POSIXct

`ymd()`, `ydm()`, `mdy()` `myd()`, `dmy()`, `dym()`, `yq()`	Date (POSIXct if `tz` specified)
`hms()`, `hm()`, `ms()`	Period

Accessing and changing components

Accessing components

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

```
date <- ymd("2019-01-09")
year(date)
# 2019
```

Setting components

Use the same function to set components

```
date
# "2019-01-09"

year(date) <- 1999
date
# "1999-01-09"
```

Accessing date time components

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

Accessing components

```
wday(ymd("2019-01-09"))
# [1] 4

wday(ymd("2019-01-09"), label = TRUE)
# [1] Wed
# 7 Levels: Sun < Mon < Tues < Wed < Thurs < ... < Sat

wday(ymd("2019-01-09"), label = TRUE, abbr = FALSE)
# [1] Wednesday
# 7 Levels: Sunday < Monday < Tuesday < ... < Saturday
```

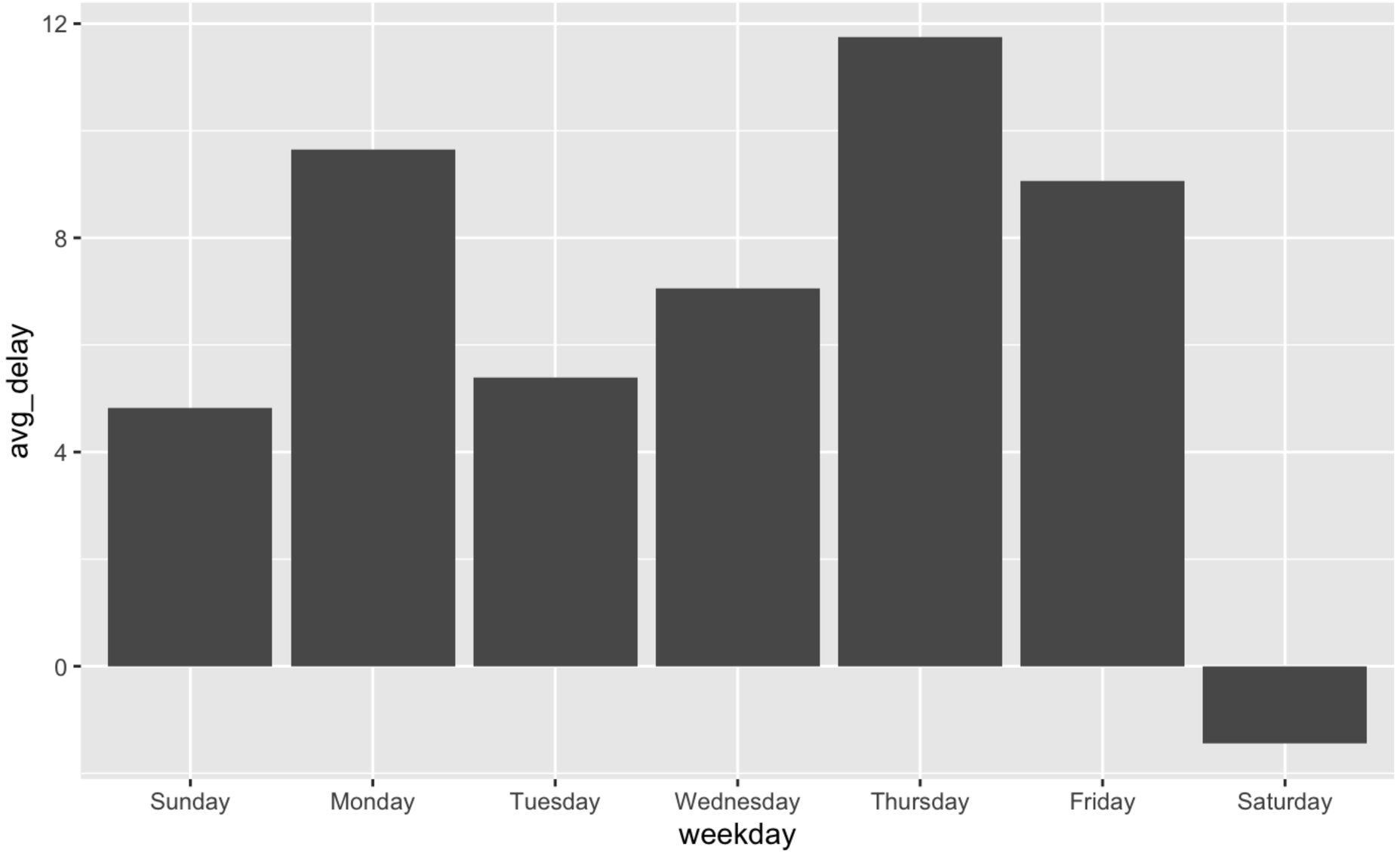
Your Turn 6

Fill in the blanks to:

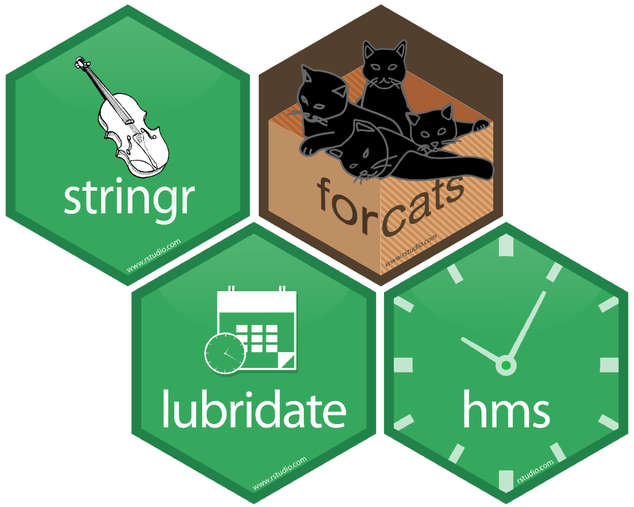
1. Extract the day of the week of each flight (as a full name) from **time_hour**.
2. Calculate the average **arr_delay** by day of the week.
3. Plot the results as a column chart (bar chart) with **geom_col()**.

05 : 00

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



Data Types



ATLAS
Accessible Teaching, Learning, and Assessment Systems

wjakethompson.com wjakethompson@ku.edu @wjakethompson @wjakethompson