

Data types with



Navigate to the **03-Types** folder.
Open **03-Types-Exercises.Rmd**

Recall

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

Common data types

1. Logicals
2. Strings
3. Factors
4. Dates and Times

Logicals



Logicals

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

```
TRUE
```

```
## TRUE
```

```
typeof(TRUE)
```

```
## "logical"
```

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

```
## "logical"
```

Details



⚠ The class of service you searched may not be available on one or more flights

BNA - ORD

Flight 1 of 2

ORD - YVR

Flight 2 of 2

Nashville, TN to Chicago, IL

Thursday, July 26, 2018

4:10 PM → 6:03 PM

AA 3246 ■ CRJ-900 RJ 700
Operated by SkyWest Airlines As American Eagle

Travel info

Travel time: 1h 53m
Connection time: 2h 33m

Performance

On time: 52%
Late: 43%

Performance*

On time: 52%**
Late: 43%

Main Cabin

Meals: Beverage service
Booking code: V
Class: Economy

Business

Meals: Beverage service
Booking code: I
Class: First

* This is based on information from the month of May 2018

** The on-time arrival percentage for the selected flight is based on arrival within 14 minutes after

**** The on-time arrival percentage for the selected flight is based on arrival within 14 minutes after the scheduled arrival as reported monthly to the U.S. Department of Transportation.**

Warm Up

Did you fly here?

Did your flight arrive late?

```
flights %>%  
  mutate(delayed = arr_delay > 0) %>%  
  select(arr_delay, delayed)
```

arr_delay <dbl>	delayed <lgl>
11	TRUE
20	TRUE
33	TRUE
-18	FALSE
-25	FALSE
12	TRUE
19	TRUE
-14	FALSE
-8	FALSE
8	TRUE

```
flights %>%  
  mutate(delayed = arr_delay > 0) %>%  
  select(arr_delay, delayed)
```

arr_delay <dbl>	delayed <lgl>
11	TRUE
20	TRUE
33	TRUE
-18	FALSE
-25	FALSE
12	TRUE
19	TRUE
-14	FALSE
-8	FALSE
8	TRUE

Can we compute
the proportion of
NYC flights that
arrived late?

Most useful skills

1. Logical tests
2. Math with logicals

Quiz

What does this return?

TRUE + 0

NOT AN ERROR!

Quiz

What does this return?

TRUE + 0

1

Math with logicals

TRUE = 1

FALSE = 0

Quiz

What will this return?

sum(c(FALSE, FALSE, TRUE, FALSE))

THE NUMBER OF TRUES

Quiz

What will this tell us?

```
sum(flights$arr_delay > 0)
```

THE NUMBER OF DELAYED
FLIGHTS

Quiz

What will this tell us?

`mean(flights$arr_delay > 0)`

THE PROPORTION OF
DELAYED FLIGHTS

TRUE = 1

FALSE = 0

sum() = **number** that pass

mean() = **proportion** that pass

Your Turn 1

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

Then, filter to rows where **delayed** does not equal NA.

Finally, create a summary table that shows:

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



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

Strings

A faint watermark of the R logo is visible in the bottom right corner, consisting of two overlapping circles and the letter 'R'.

(character) strings

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

```
"one"  
##  "one"  
  
typeof("one")  
##  "character"  
  
typeof("oops. I'm stuck in a string")  
+ ")"  
##  "character"
```

Warm Up

Decide in your group:

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



babynames



Names of male and female babies born
in the US from 1880 to 2017. 1.9M rows.

```
# install.packages("babynames")
library(babynames)
```



babynames

year	sex	name	n	prop
<dbl>	<chr>	<chr>	<int>	<dbl>
1880	F	Mary	7065	7.238433e-02
1880	F	Anna	2604	2.667923e-02
1880	F	Emma		
1880	F	Elizabeth		
1880	F	Minnie		
1880	F	Margaret		
1880	F	Ida		
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

Previous

1

2

3

4

5

6

...

100 Next

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



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(tidyverse)
```



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)
```

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

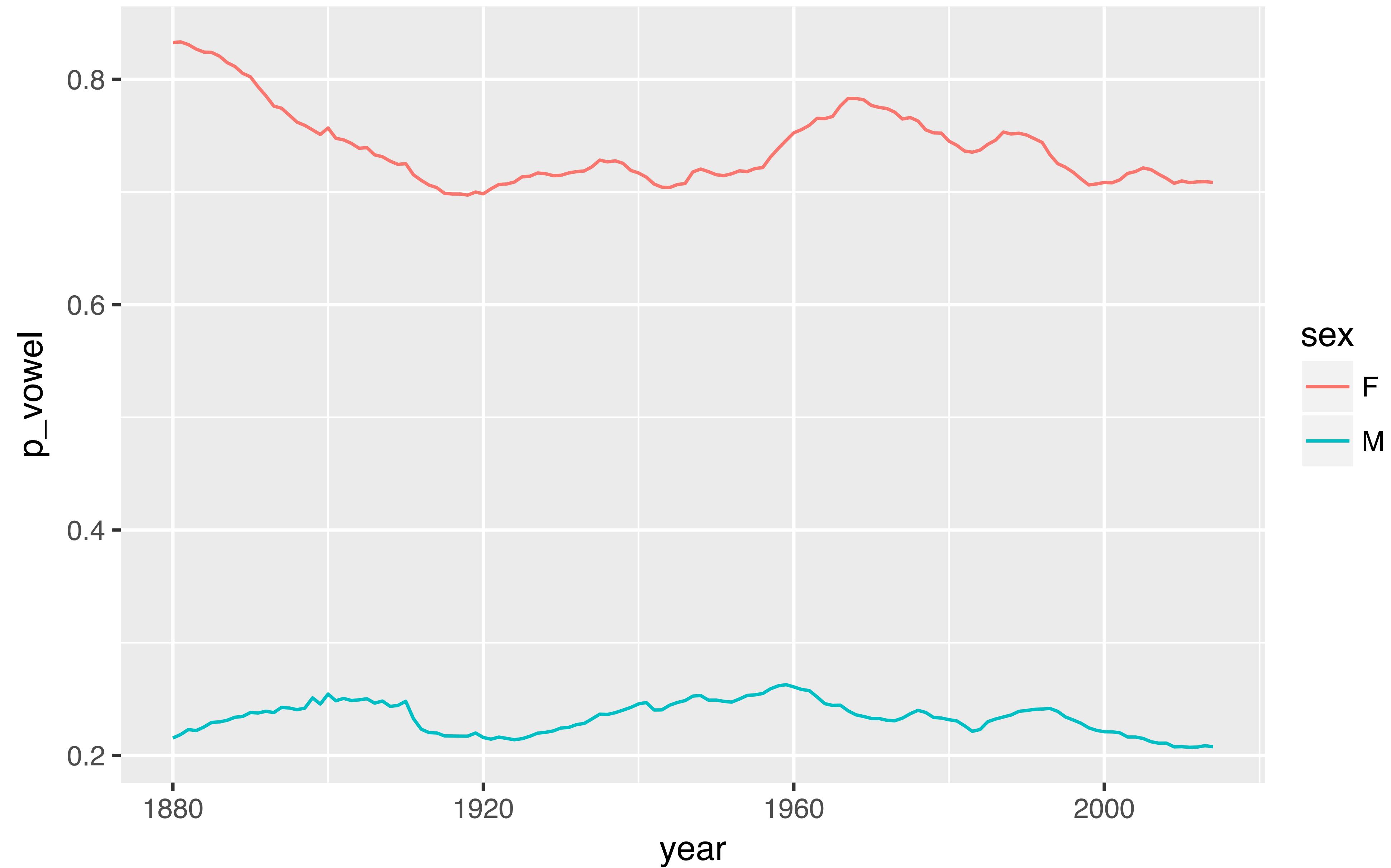
In your group, fill in the blanks to:

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.



```
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() +  
    geom_line(mapping = aes(year, p_vowel, color = sex))
```

Proportion of names that end in a vowel



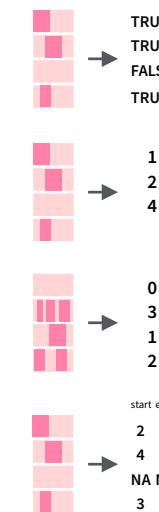
strings

String manipulation with stringr :: CHEAT SHEET

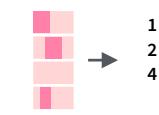
The `stringr` package provides a set of internally consistent tools for working with character strings, i.e. sequences of characters surrounded by quotation marks.



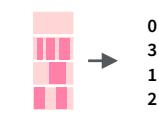
Detect Matches



`str_detect(string, pattern)` Detect the presence of a pattern match in a string.
`str_detect(fruit, "a")`



`str_which(string, pattern)` Find the indexes of strings that contain a pattern match.
`str_which(fruit, "a")`

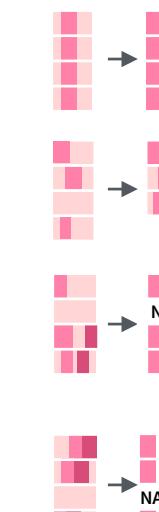


`str_count(string, pattern)` Count the number of matches in a string.
`str_count(fruit, "a")`

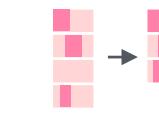


`str_locate(string, pattern)` Locate the positions of pattern matches in a string. Also
`str_locate_all`. `str_locate(fruit, "a")`

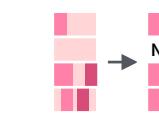
Subset Strings



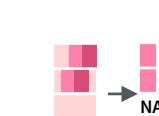
`str_sub(string, start = 1L, end = -1L)` Extract substrings from a character vector.
`str_sub(fruit, 1, 3); str_sub(fruit, -2)`



`str_subset(string, pattern)` Return only the strings that contain a pattern match.
`str_subset(fruit, "b")`

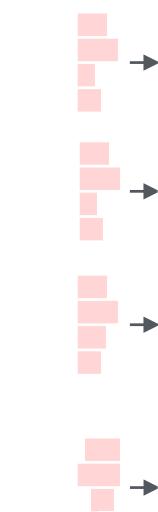


`str_extract(string, pattern)` Return the first pattern match found in each string, as a vector. Also `str_extract_all` to return every pattern match. `str_extract(fruit, "[aeiou]")`



`str_match(string, pattern)` Return the first pattern match found in each string, as a matrix with a column for each () group in pattern. Also `str_match_all`.
`str_match(sentences, "(a|the) ([^]+)")`

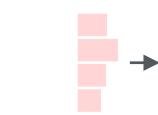
Manage Lengths



`str_length(string)` The width of strings (i.e. number of code points, which generally equals the number of characters). `str_length(fruit)`



`str_pad(string, width, side = c("left", "right", "both"), pad = " ")` Pad strings to constant width. `str_pad(fruit, 17)`

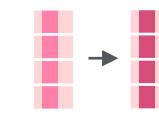


`str_trunc(string, width, side = c("right", "left", "center"), ellipsis = "...")` Truncate the width of strings, replacing content with ellipsis.
`str_trunc(fruit, 3)`

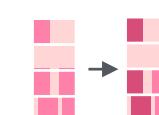


`str_trim(string, side = c("both", "left", "right"))` Trim whitespace from the start and/or end of a string. `str_trim(fruit)`

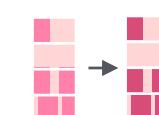
Mutate Strings



`str_sub() <- value`. Replace substrings by identifying the substrings with `str_sub()` and assigning into the results.
`str_sub(fruit, 1, 3) <- "str"`



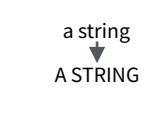
`str_replace(string, pattern, replacement)` Replace the first matched pattern in each string. `str_replace(fruit, "a", "-")`



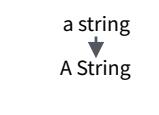
`str_replace_all(string, pattern, replacement)` Replace all matched patterns in each string. `str_replace_all(fruit, "a", "-")`



`str_to_lower(string, locale = "en")1` Convert strings to lower case.
`str_to_lower(sentences)`

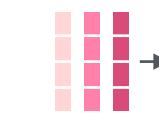


`str_to_upper(string, locale = "en")1` Convert strings to upper case.
`str_to_upper(sentences)`



`str_to_title(string, locale = "en")1` Convert strings to title case. `str_to_title(sentences)`

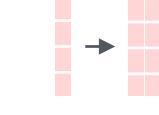
Join and Split



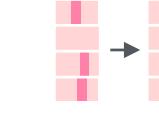
`str_c(..., sep = "", collapse = NULL)` Join multiple strings into a single string.
`str_c(letters, LETTERS)`



`str_c(..., sep = "", collapse = NULL)` Collapse a vector of strings into a single string.
`str_c(letters, collapse = "")`



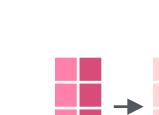
`str_dup(string, times)` Repeat strings times times. `str_dup(fruit, times = 2)`



`str_split_fixed(string, pattern, n)` Split a vector of strings into a matrix of substrings (splitting at occurrences of a pattern match). Also `str_split` to return a list of substrings.
`str_split_fixed(fruit, " ", n=2)`



`str_glue(..., .sep = "", .envir = parent.frame())` Create a string from strings and {expressions} to evaluate. `str_glue("Pi is {pi}")`



`str_glue_data(x, ..., .sep = "", .envir = parent.frame(), .na = "NA")` Use a data frame, list, or environment to create a string from strings and {expressions} to evaluate.
`str_glue_data(mtcars, "{rownames(mtcars)} has {hp} hp")`

Order Strings

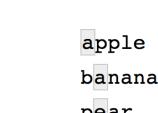


`str_order(x, decreasing = FALSE, na_last = TRUE, locale = "en", numeric = FALSE, ...)` Return the vector of indexes that sorts a character vector. `x[str_order(x)]`

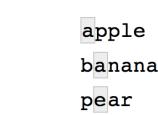


`str_sort(x, decreasing = FALSE, na_last = TRUE, locale = "en", numeric = FALSE, ...)` Sort a character vector.
`str_sort(x)`

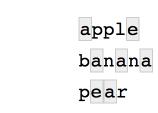
Helpers



`str_conv(string, encoding)` Override the encoding of a string. `str_conv(fruit, "ISO-8859-1")`



`str_view(string, pattern, match = NA)` View HTML rendering of first regex match in each string. `str_view(fruit, "[aeiou]")`



`str_view_all(string, pattern, match = NA)` View HTML rendering of all regex matches.
`str_view_all(fruit, "[aeiou]")`



`str_wrap(string, width = 80, indent = 0, exdent = 0)` Wrap strings into nicely formatted paragraphs. `str_wrap(sentences, 20)`

¹ See bit.ly/ISO639-1 for a complete list of locales.



Atomic types

R recognizes six elemental data types.

```
typeof(1)      ## double  
typeof(1L)     ## integer  
typeof(TRUE)    ## logical  
typeof("one")   ## character  
typeof(raw(1))  ## raw  
typeof(1i)      ## complex
```

So what are dates
and factors?



Classes

You can use atomic types to build new classes.

```
x <- 1560139200
```

```
x
```

```
## 1560139200
```

```
typeof(x)
```

```
## double
```

Classes

You can use atomic types to build new classes.

```
x <- 1560139200  
class(x) <- "POSIXct"
```

```
x                      ## "2019-06-10 EDT"  
typeof(x)               ## double
```

Classes

You can use atomic types to build new classes.

```
x <- 1560139200  
class(x) <- "POSIXct"
```

```
x                      ## "2019-06-10 EDT"  
typeof(x)               ## double  
class(x)                ## POSIXct
```

Classes

```
eyes <- c(1L, 3L, 3L)
```

```
eyes          ## 1 3 3
```

```
typeof(eyes)  ## integer
```

Classes

```
eyes <- c(1L, 3L, 3L)  
levels(eyes) <- c("blue", "brown", "green")
```

```
eyes          ## 1 3 3  
typeof(eyes) ## integer
```

Classes

```
eyes <- c(1L, 3L, 3L)
levels(eyes) <- c("blue", "brown", "green")
class(eyes) <- "factor"
```

```
eyes          ## blue  green green
              Levels: blue brown green
typeof(eyes) ## integer
```

Classes

```
eyes <- c(1L, 3L, 3L)
levels(eyes) <- c("blue", "brown", "green")
class(eyes) <- "factor"
```

```
eyes                      ## blue  green green
                           Levels: blue brown green
typeof(eyes)               ## integer
class(eyes)                ## factor
```

Factors

R

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"))
```

Stored as an integer vector with a levels attribute

```
eyes
## [1] blue green green
## Levels: blue brown green

unclass(eyes)
## 1 3 3
## attr(,"levels")
## "blue" "brown" "green"
```

forcats



Simple functions for working with factors.

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



Warm Up

Decide in your group:

Which religions watch the least TV?

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



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.

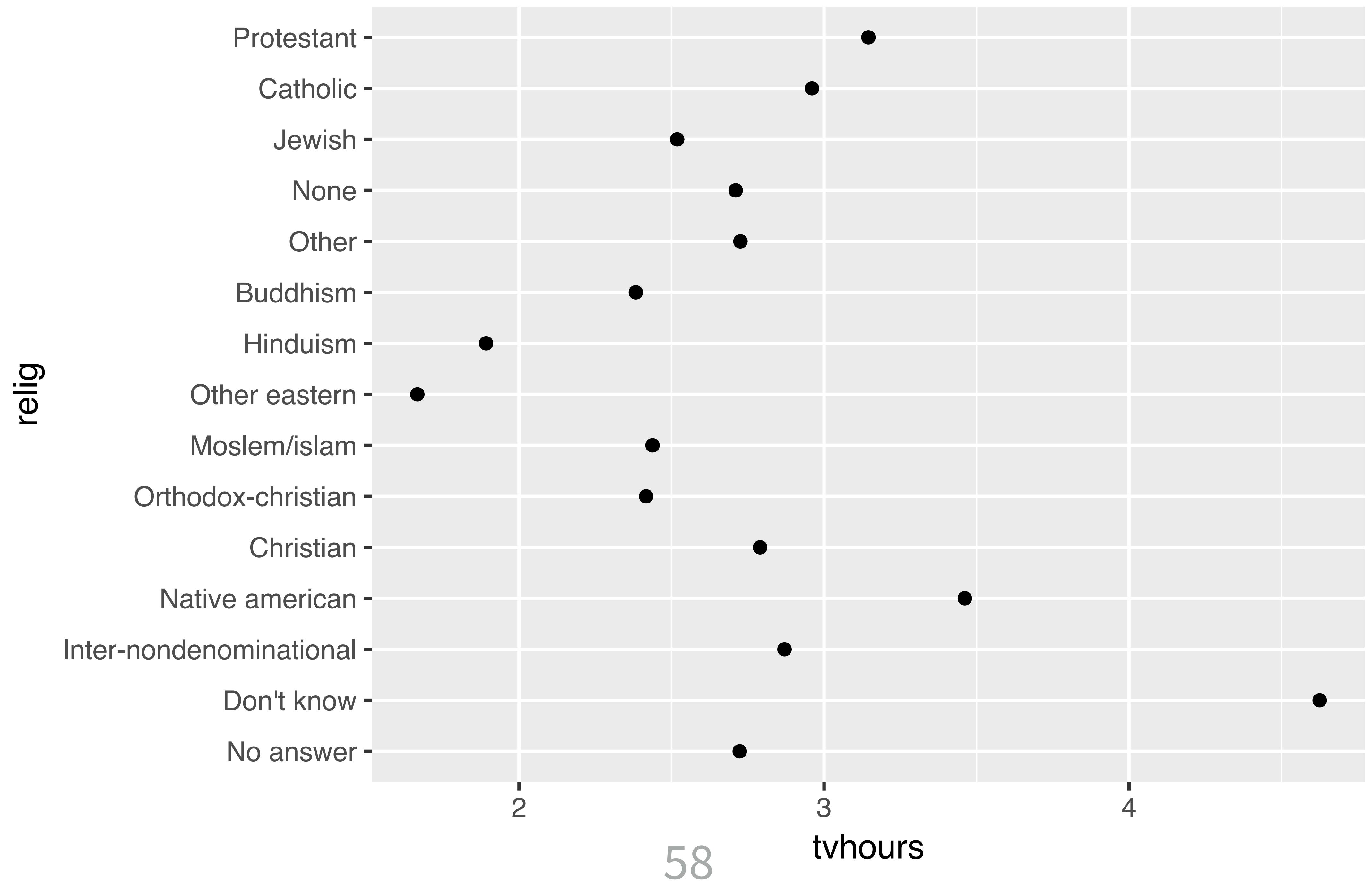
tvhours	marital	age	race	partyid	relig
		<int>	<fctr>	<fctr>	<fctr>
12	Never married	26	White	Ind,near rep	Protestant
NA	Divorced	48	White	Not str republican	Protestant
2	Widowed	67	White	Independent	Protestant
4	Never married	39	White	Ind,near rep	Orthodox-christian
1	Divorced	25	White	Not str democrat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

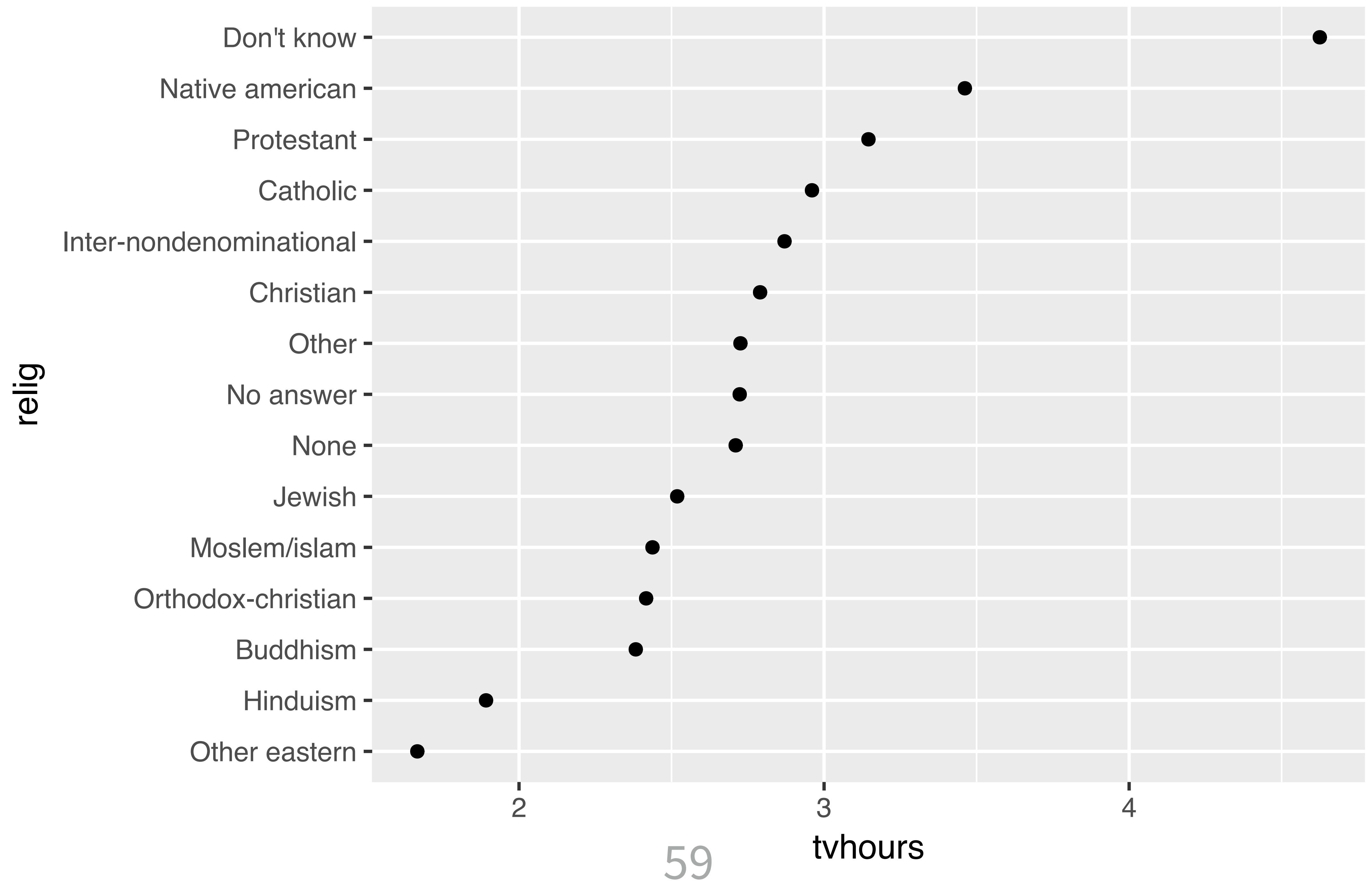


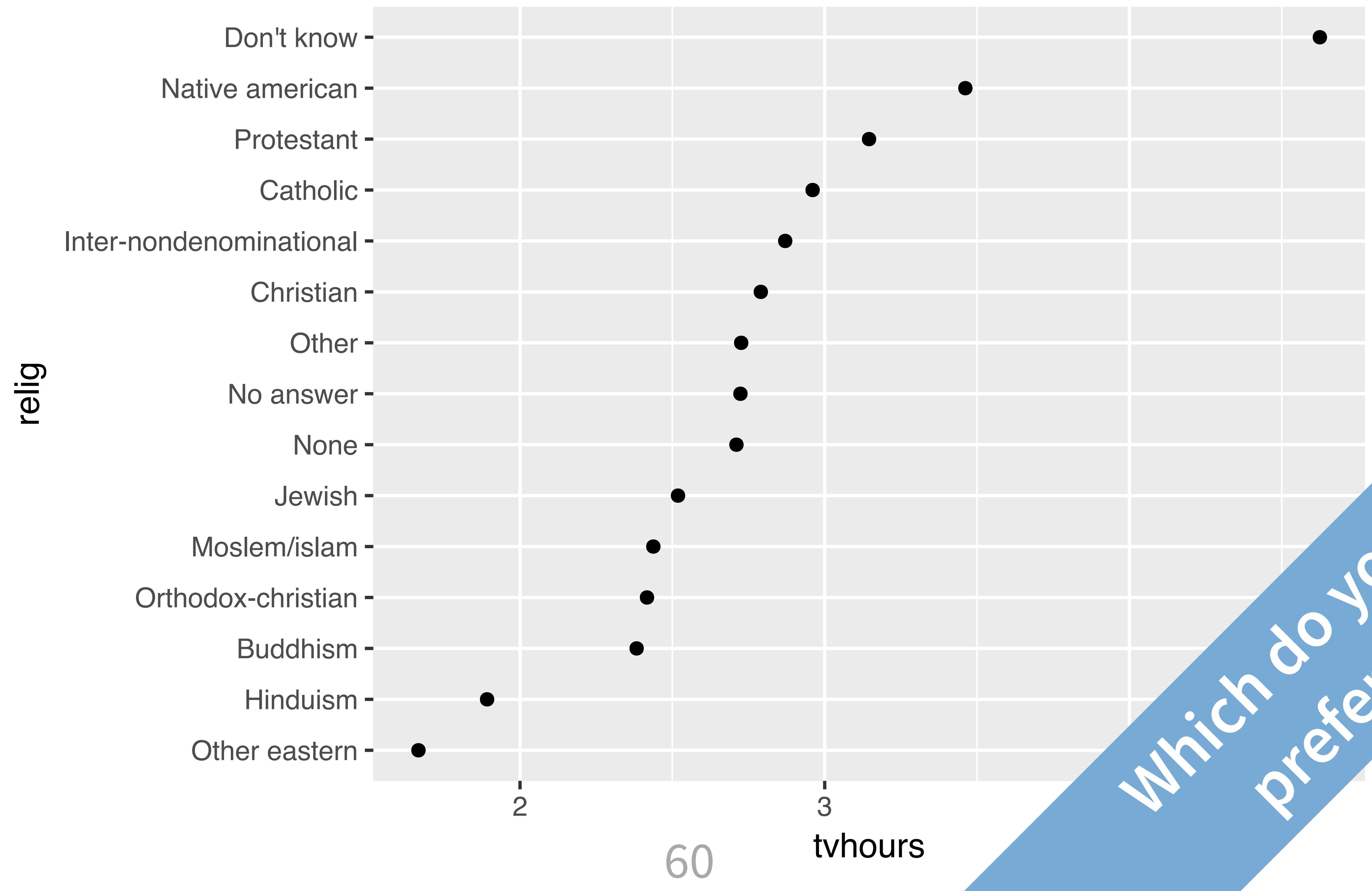
Which religions watch the least TV?

```
gss_cat %>%  
  filter(!is.na(tvhours)) %>%  
  group_by(relig) %>%  
  summarise(tvhours = mean(tvhours)) %>%  
  ggplot(aes(tvhours, relig)) +  
  geom_point()
```



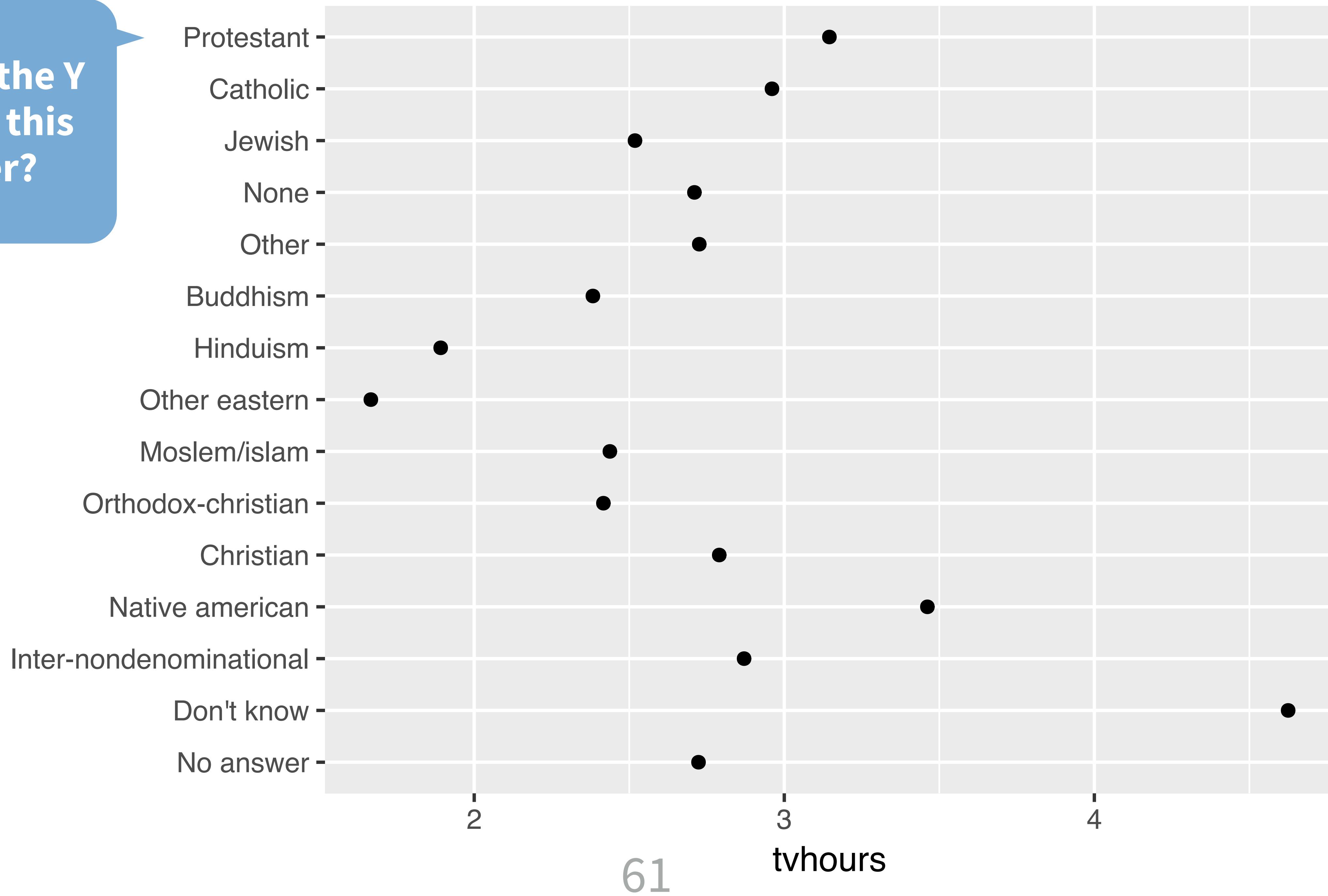






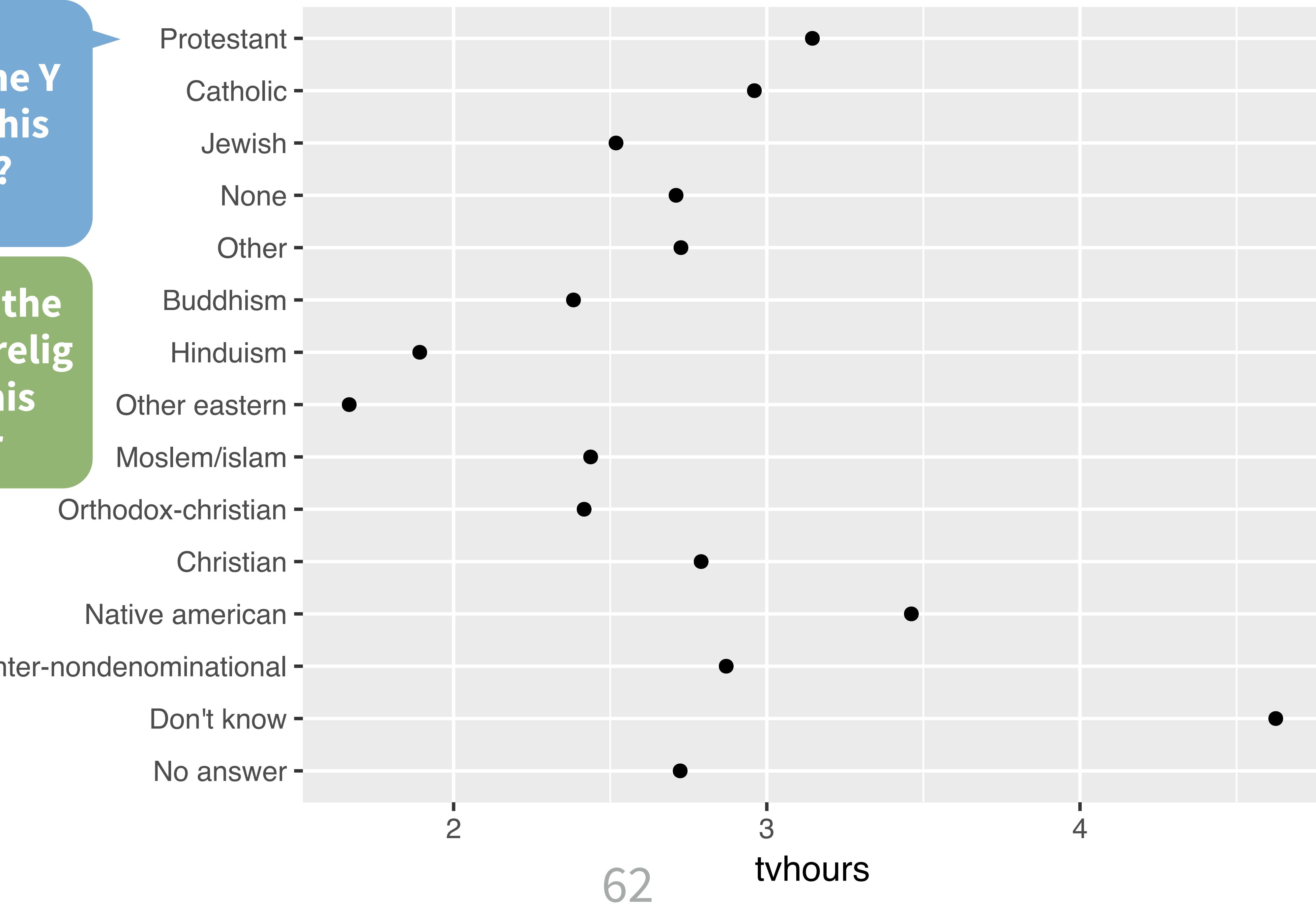
Why is the Y axis in this order?

relig



Why is the Y axis in this order?

Because the levels of relig have 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"
```



Most useful skills

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



Reordering levels

A large, semi-transparent watermark of the R logo is positioned in the bottom right corner of the slide. The logo consists of a circular arrow with the letter 'R' inside.

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)

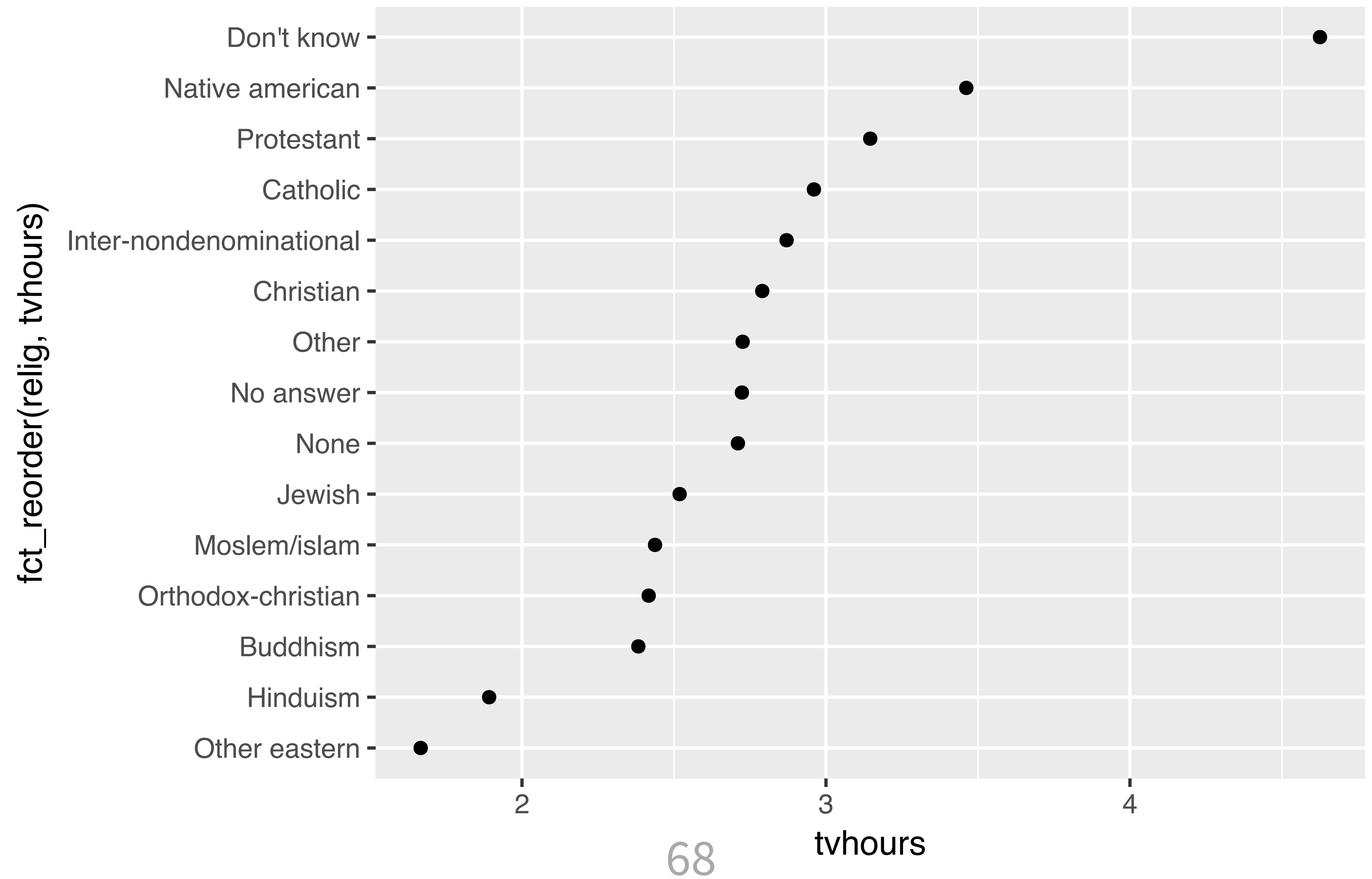
function to
reorder by
(in conjunction
with x)

put in descending
order?



```
gss_cat %>%  
  filter(!is.na(tvhours)) %>%  
  group_by(relig) %>%  
  summarise(tvhours = mean(tvhours)) %>%  
  ggplot(aes(tvhours, fct_reorder(relig, tvhours))) +  
  geom_point()
```





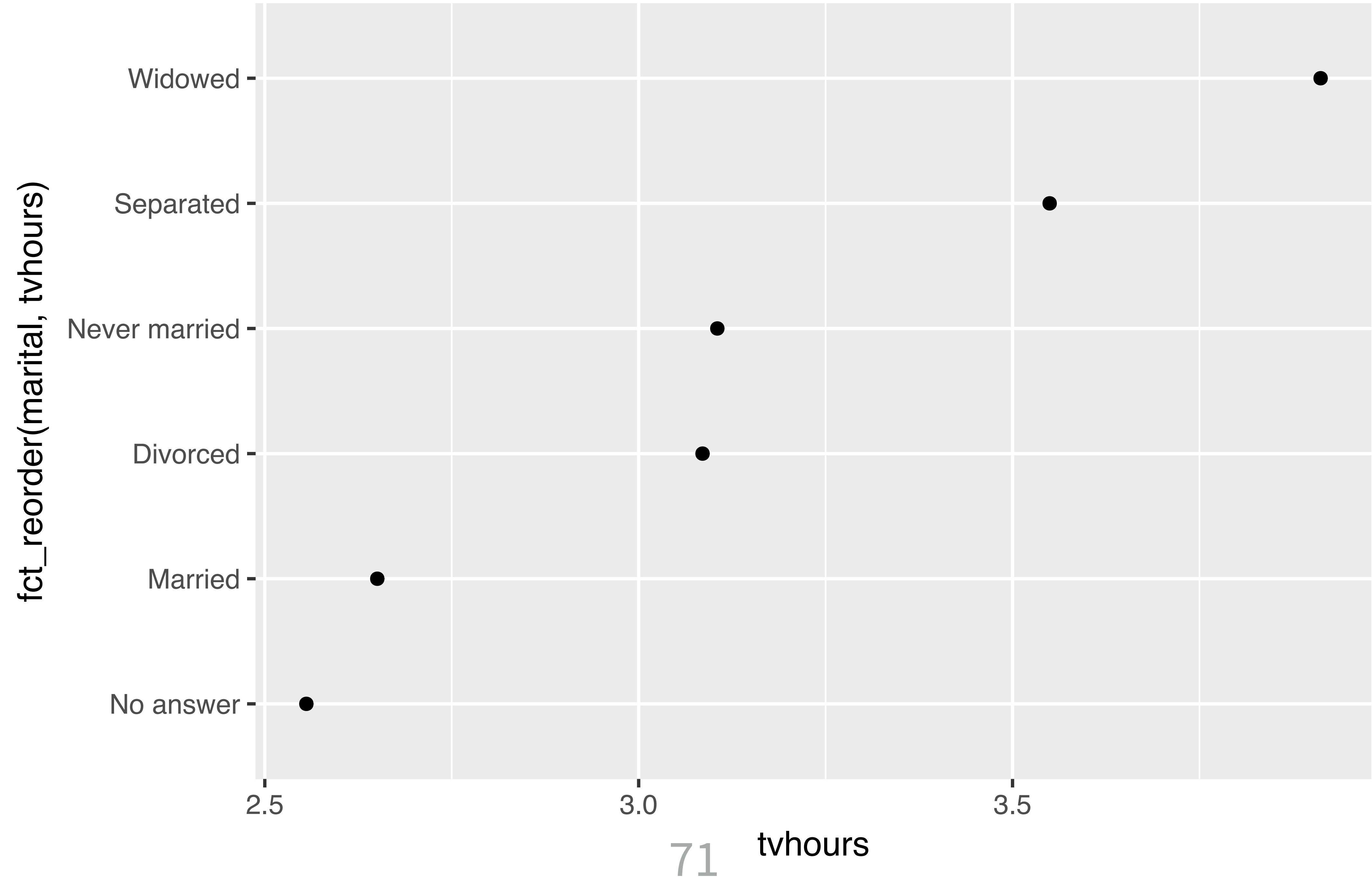
Your Turn 3

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



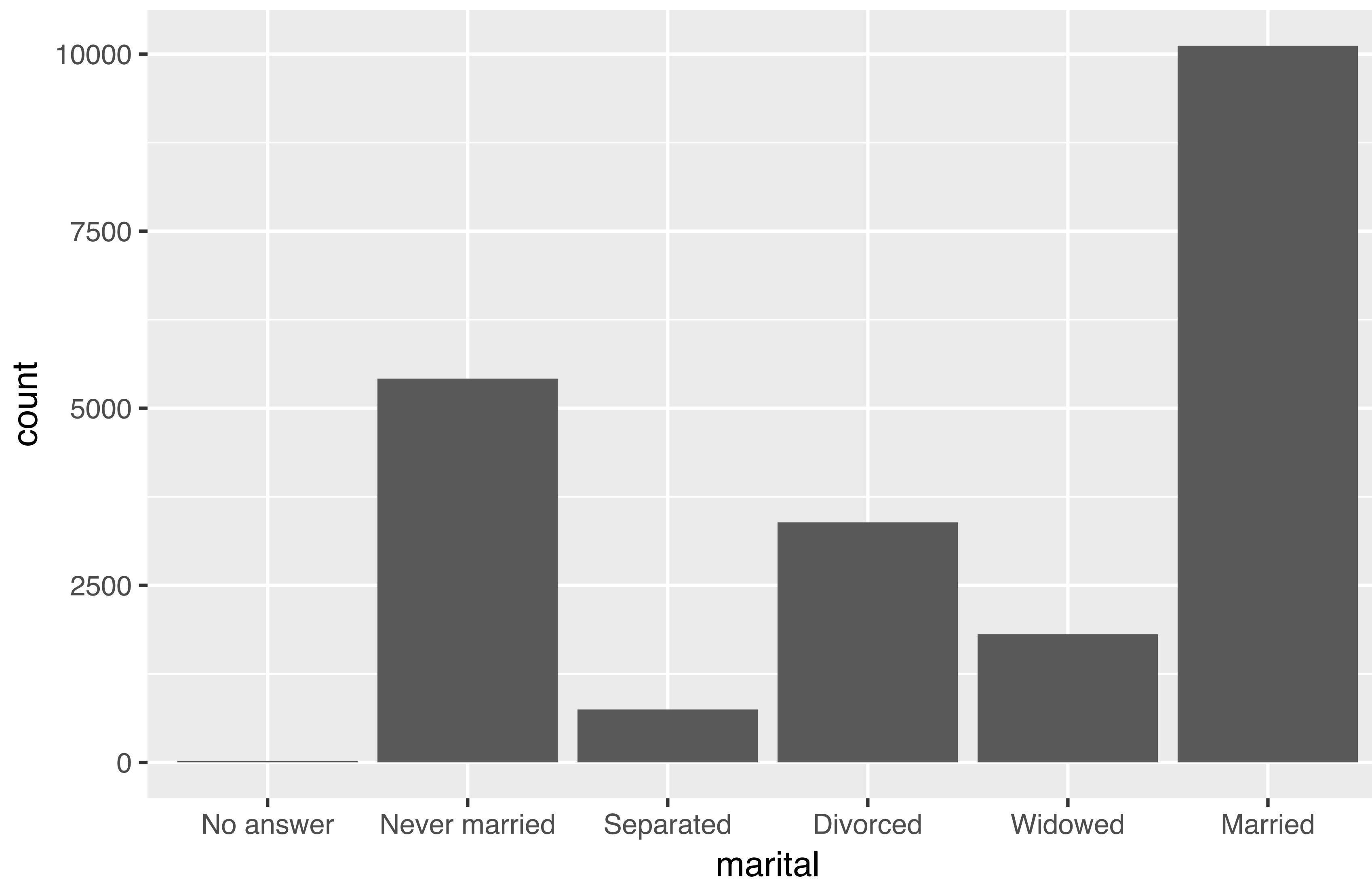
```
gss_cat %>%  
  filter(!is.na(tvhours)) %>%  
  group_by(marital) %>%  
  summarise(tvhours = mean(tvhours)) %>%  
  ggplot(aes(tvhours, fct_reorder(marital, tvhours))) +  
  geom_point()
```





Similar reordering functions

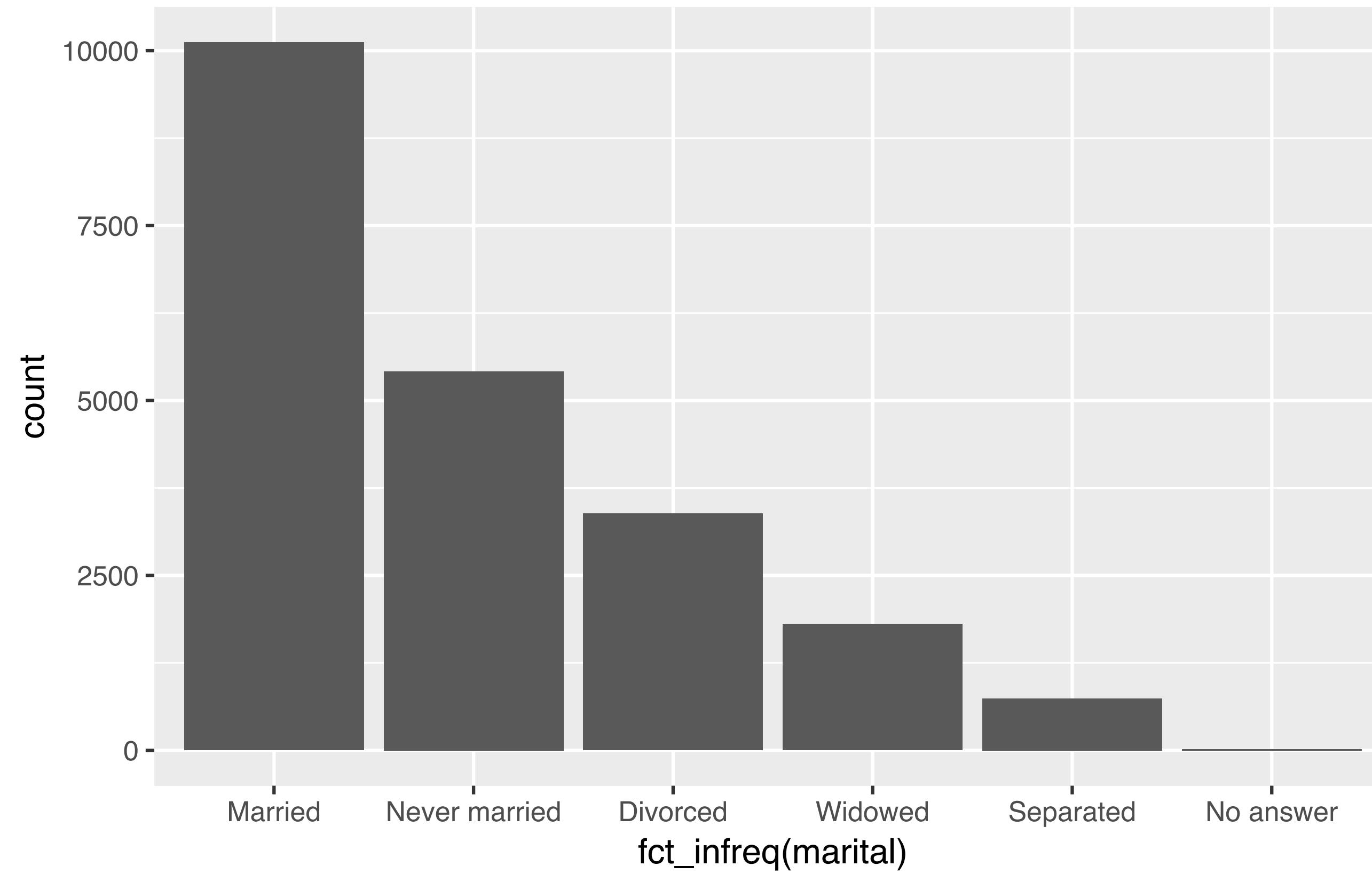




```
gss_cat %>%  
  ggplot(aes(marital)) + geom_bar()
```



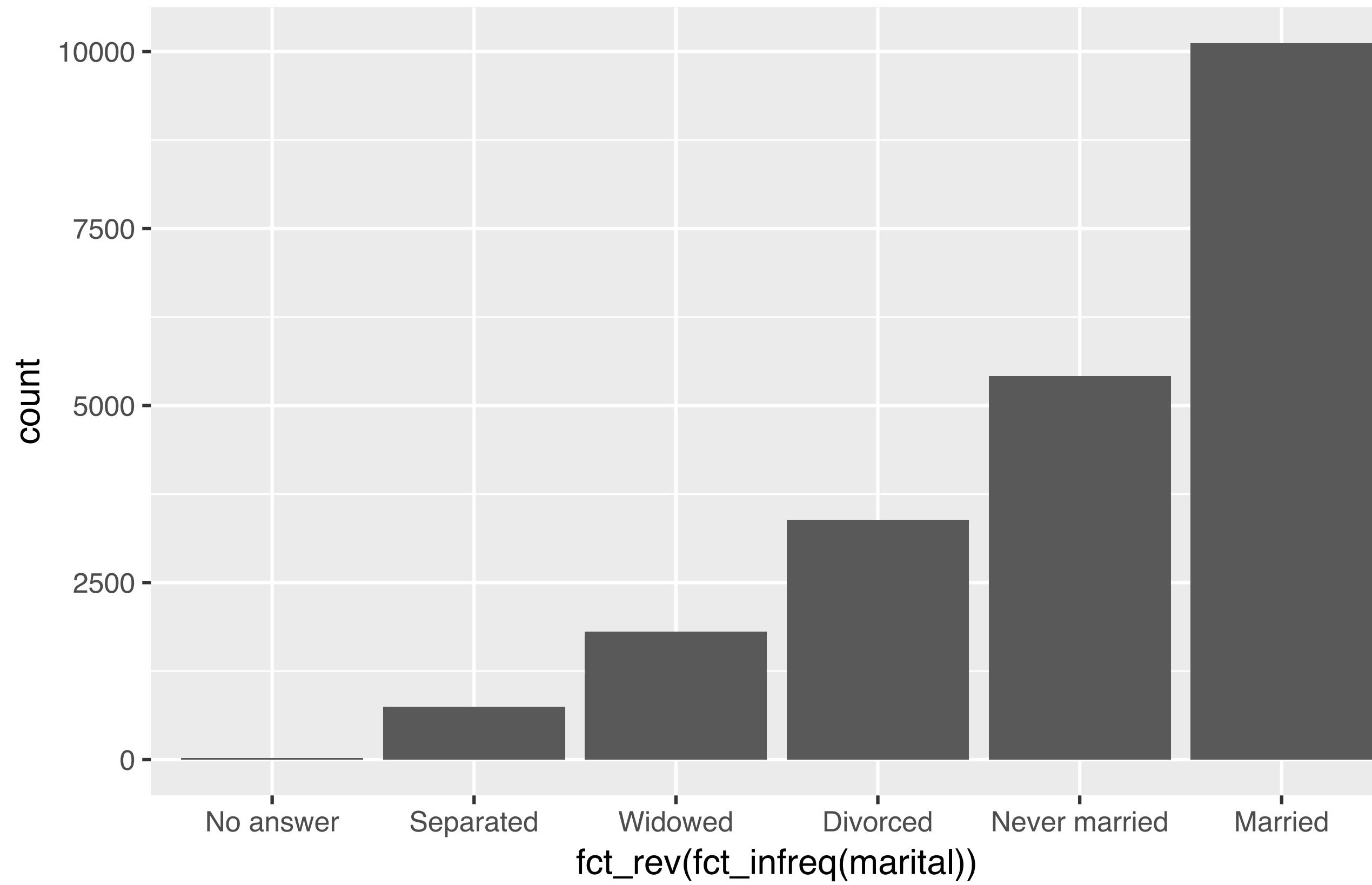
fct_infreq



```
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

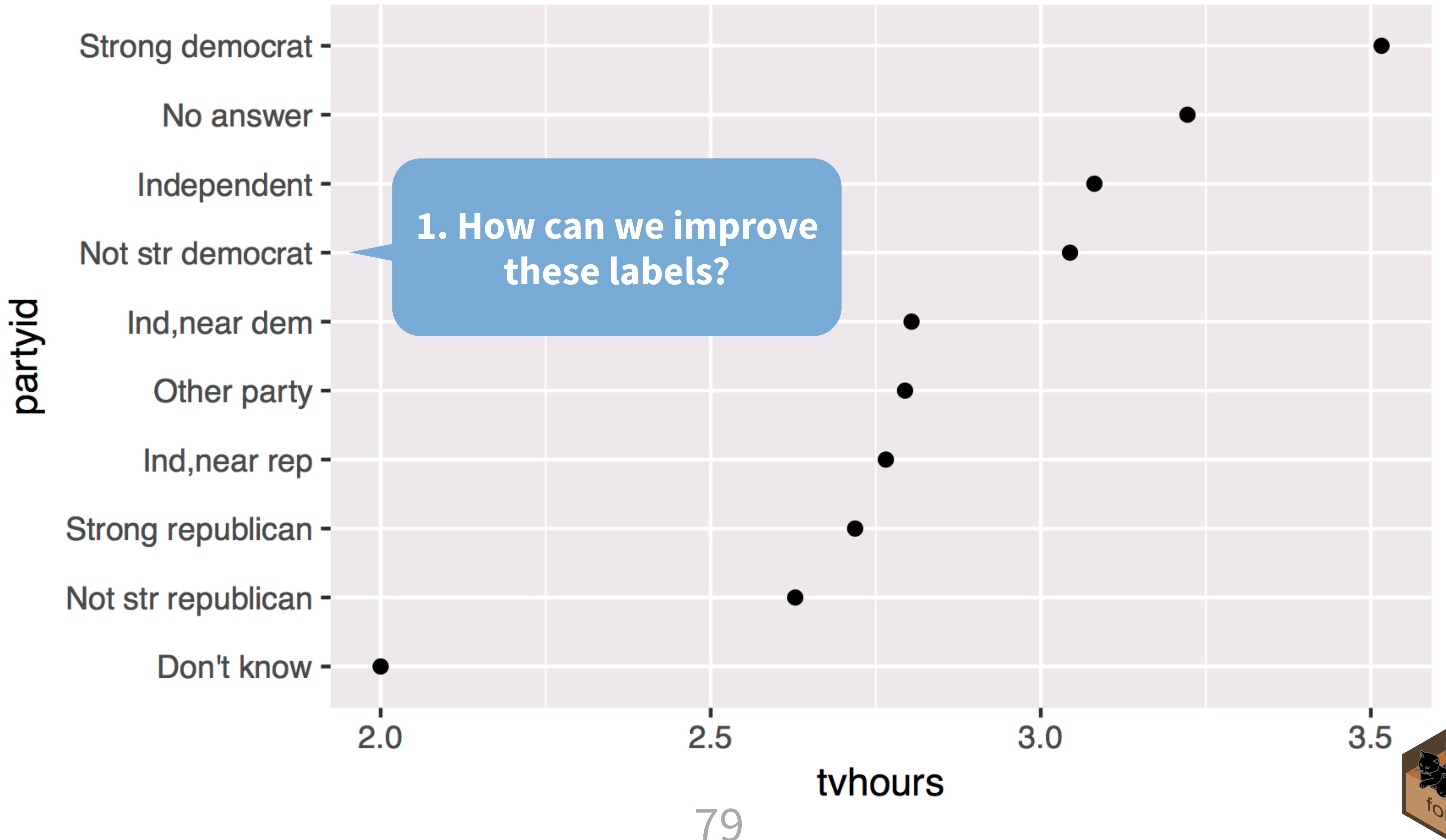
Do you think liberals or conservatives watch more TV?

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



```
gss_cat %>%  
  filter(!is.na(tvhours)) %>%  
  group_by(partyid) %>%  
  summarise(tvhours = mean(tvhours)) %>%  
  ggplot(aes(tvhours, fct_reorder(partyid, tvhours))) +  
    geom_point() +  
    labs(y = "partyid")
```





fct_recode()

Changes values of levels

```
fct_recode(f, Independent = "Ind,near dem")
```

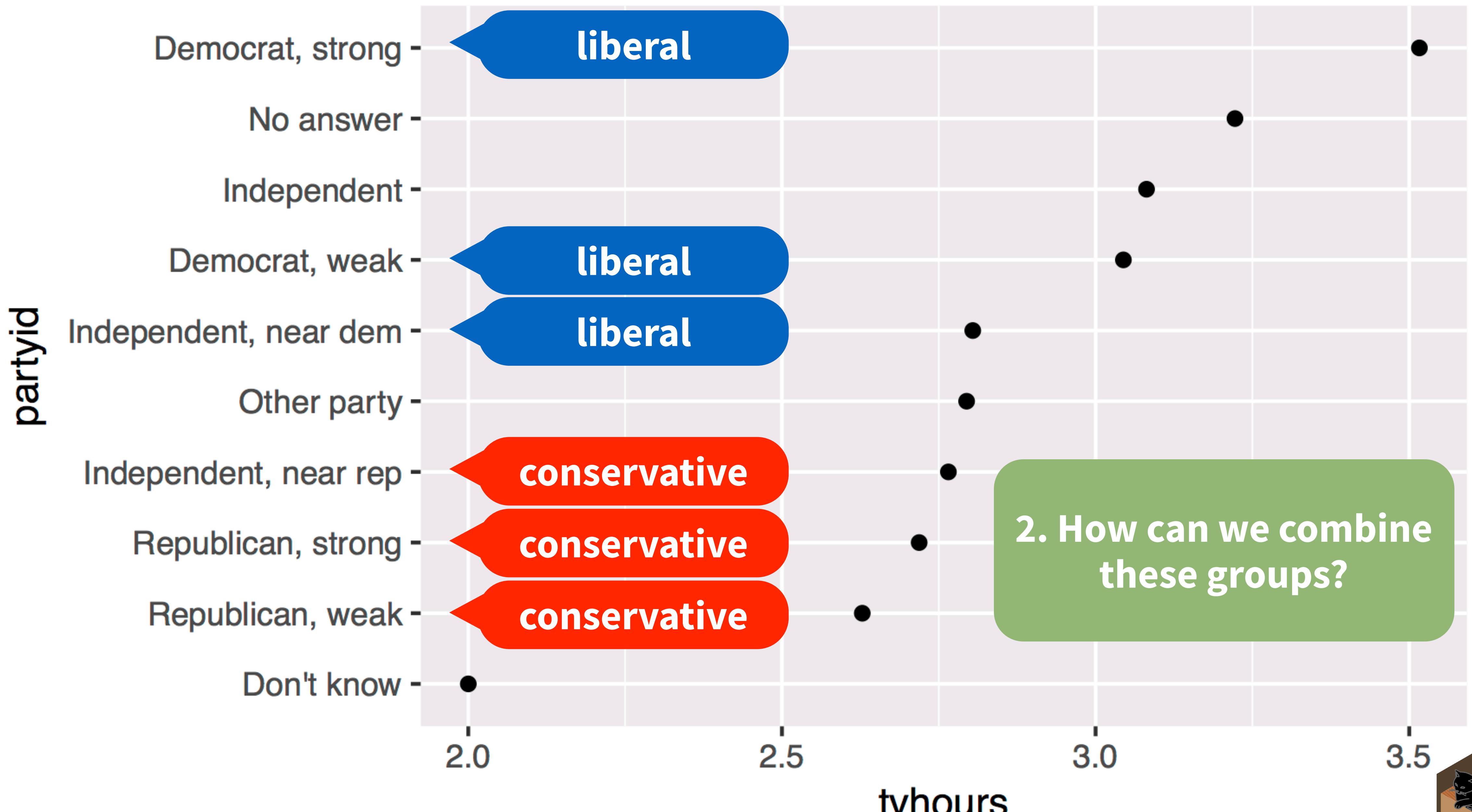
factor with
levels

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



```
gss_cat %>%  
  filter(!is.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, fct_reorder(partyid, tvhours))) +  
  geom_point() + labs(y = "partyid")
```





Collapsing levels

A large, semi-transparent watermark of the R logo is positioned in the bottom right corner of the slide. The logo consists of a circular arrow with the letters "R" inside.

fct_collapse()

Collapses multiple levels into single levels

```
fct_collapse(f, Liberal = c("Democrat, strong",  
                           "Democrat, weak"))
```

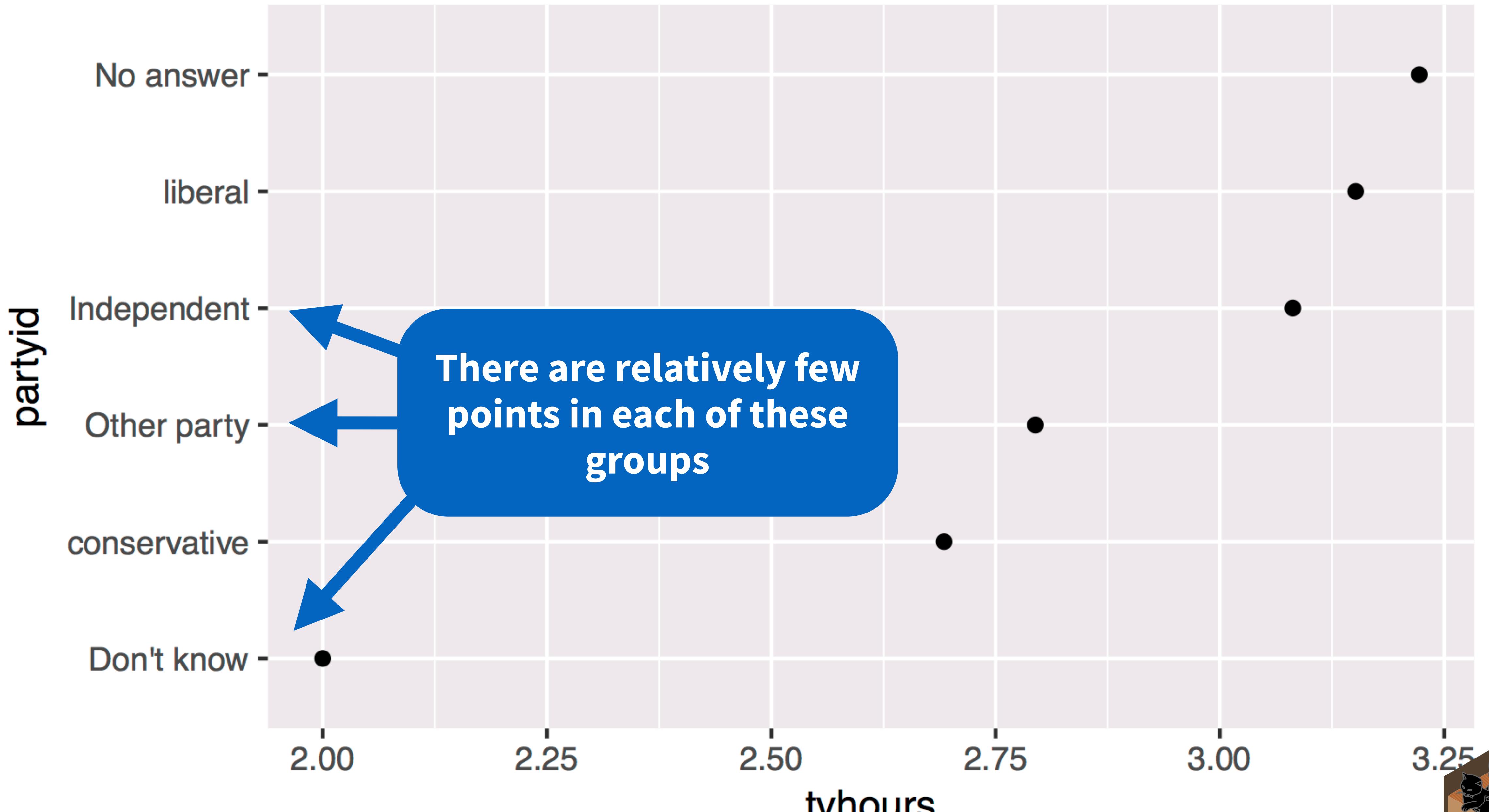
factor with
levels

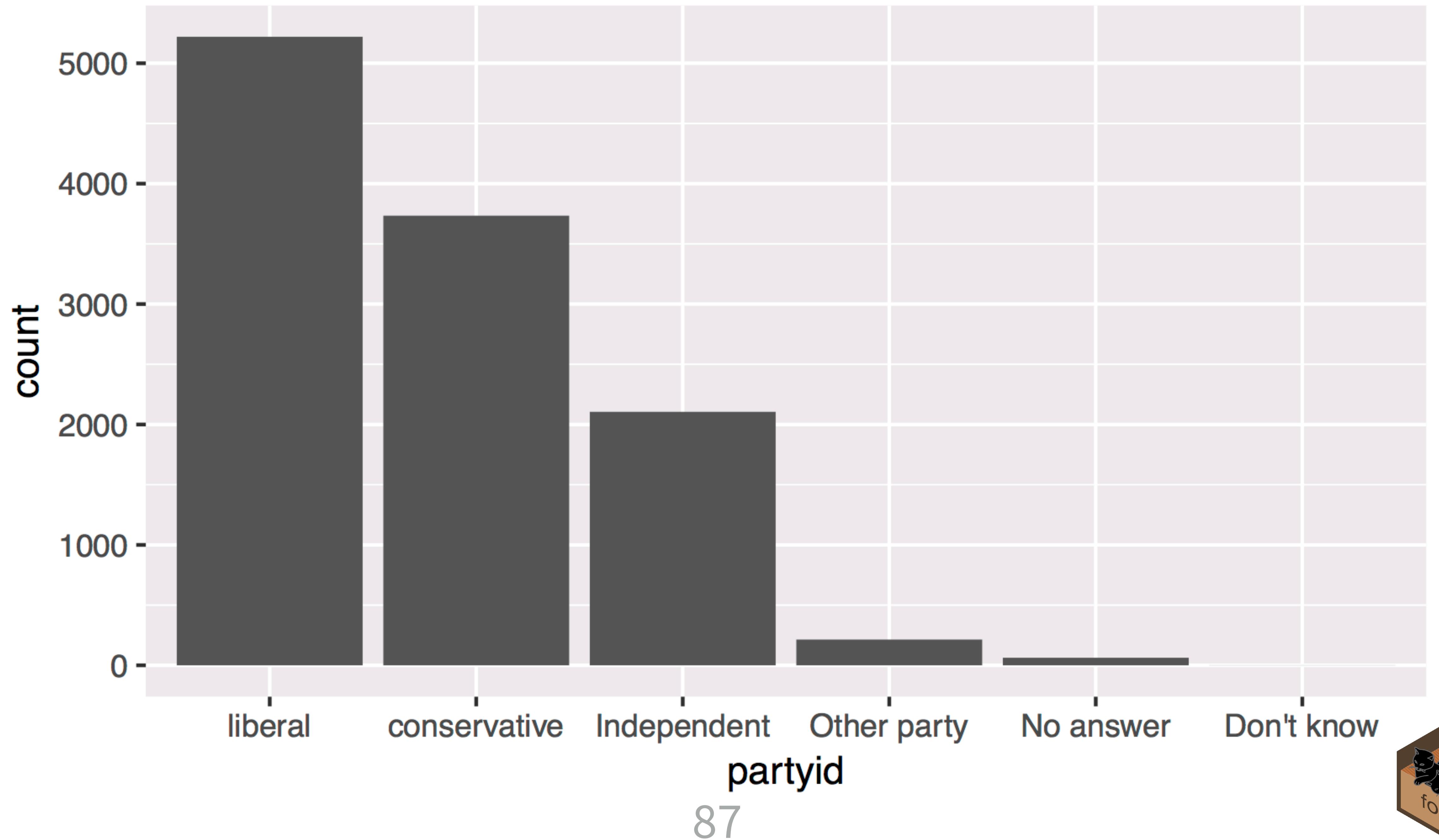
named arguments set to a
character vector (levels in the
vector will be collapsed to the name
of the argument)



```
gss_cat %>%  
  filter(!is.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, fct_reorder(partyid, tvhours))) +  
  geom_point() + labs(y = "partyid")
```







fct_lump()

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

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

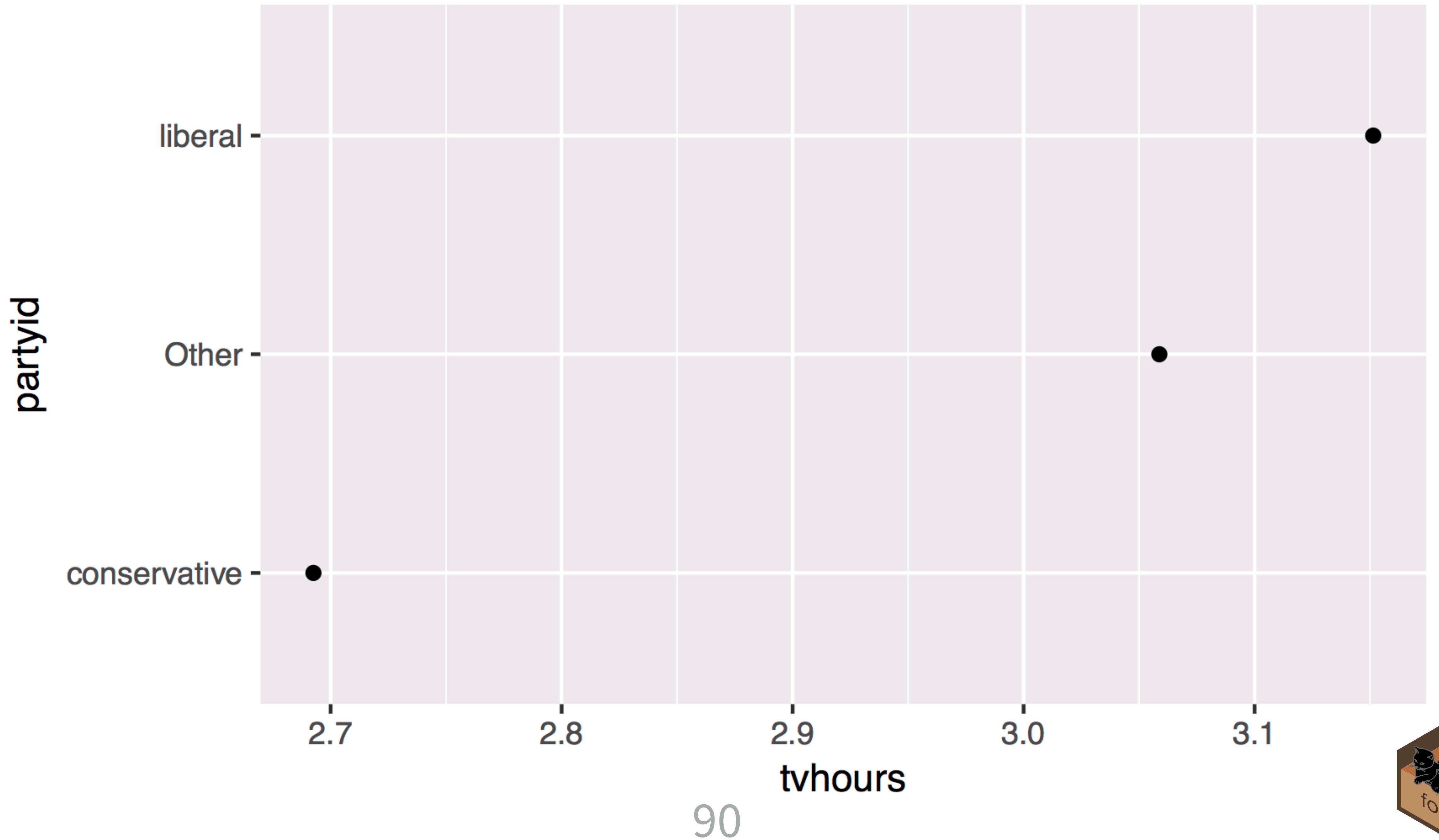
factor with
levels

name of new level



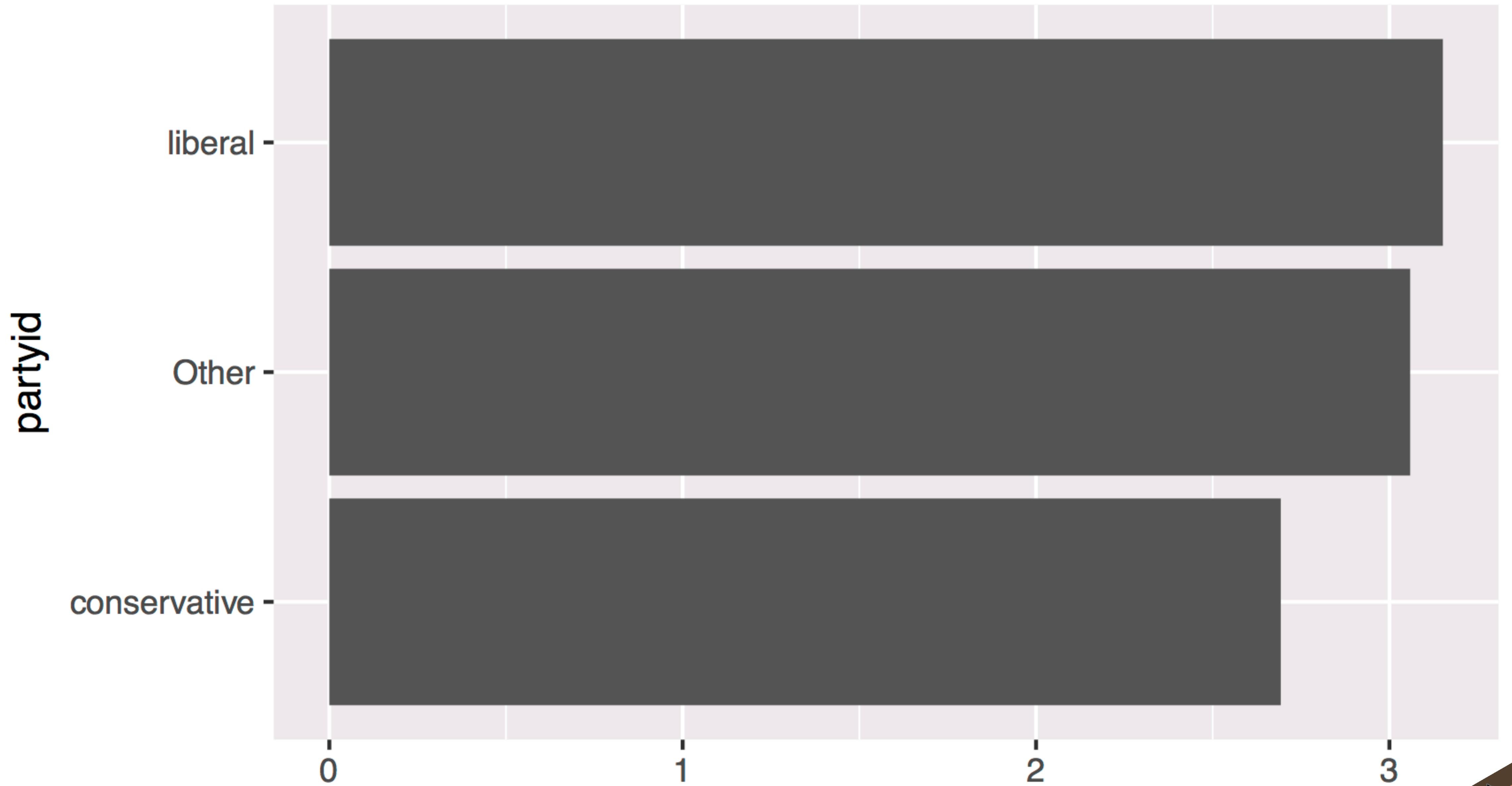
```
gss_cat %>%  
  filter(!is.na(tvhours)) %>%  
  mutate(partyid = partyid %>%  
    fct_collapse(  
      conservative = c("Strong republican",  
                        "Not str republican", "Ind,near rep"),  
      liberal = c("Strong democrat", "Not str democrat",  
                  "Ind,near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





```
gss_cat %>%  
  filter(!is.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) %>%  
  summarise(tvhours = mean(tvhours)) %>%  
  ggplot(aes(fct_reorder(partyid, tvhours), tvhours)) +  
    geom_col() + labs(x = "partyid") + coord_flip()
```





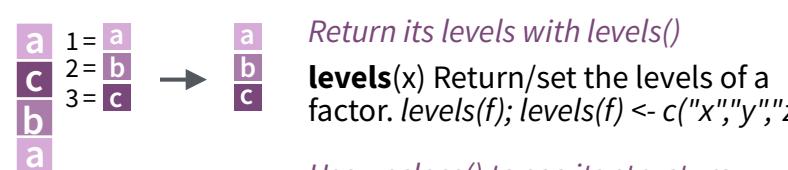
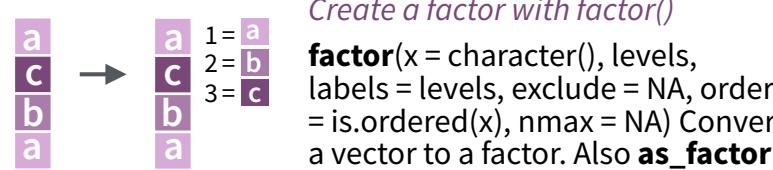
forcats

Factors with forcats :: CHEAT SHEET

The **forcats** package provides tools for working with factors, which are R's data structure for categorical data.

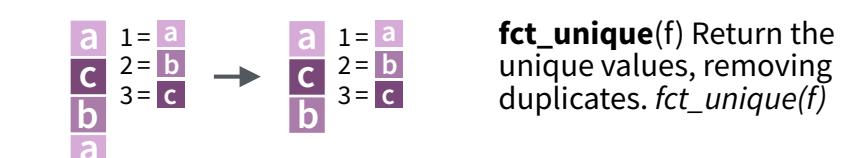
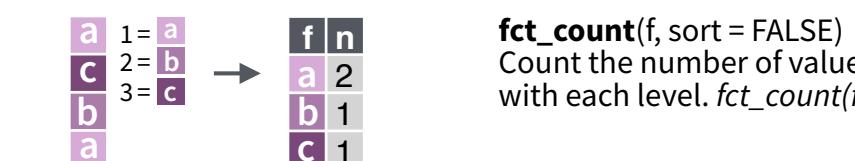
Factors

R represents categorical data with factors. A **factor** is an integer vector with a **levels** attribute that stores a set of mappings between integers and categorical values. When you view a factor, R displays not the integers, but the values associated with them.

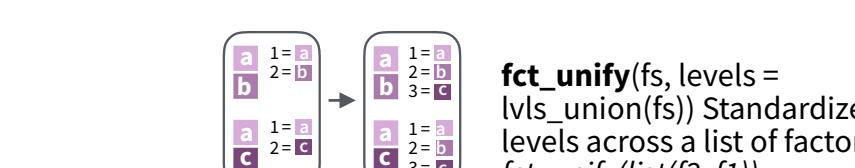
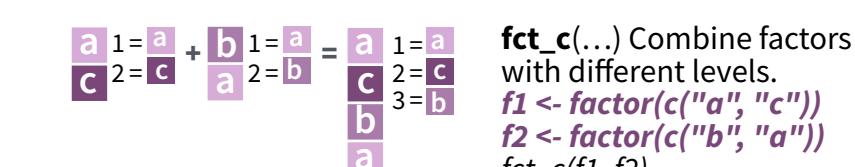


Use `unclass()` to see its structure

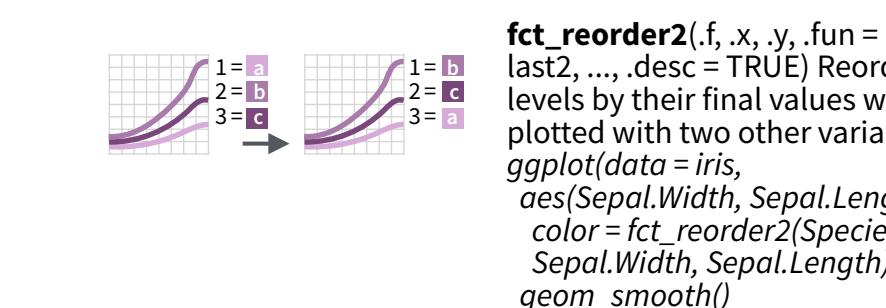
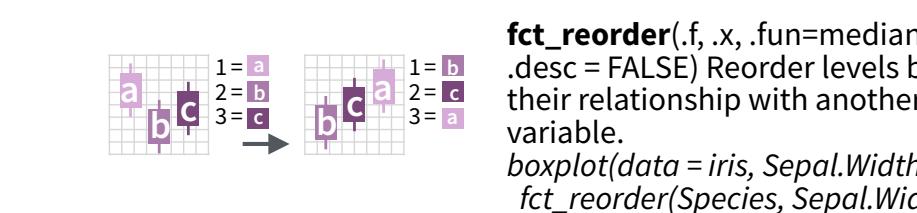
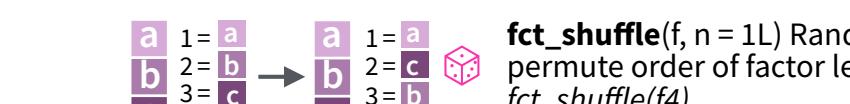
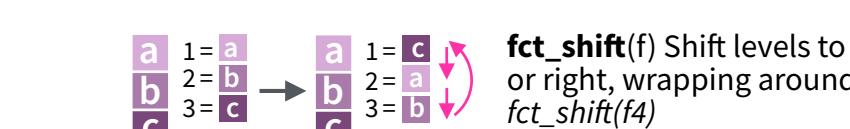
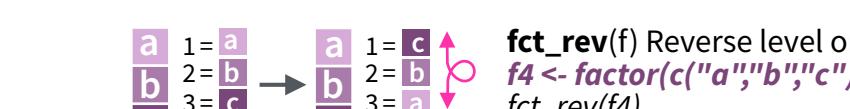
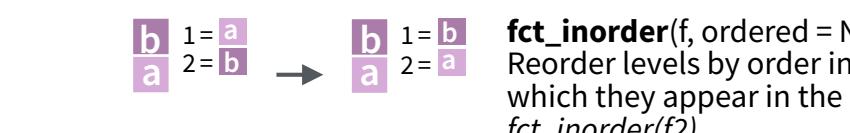
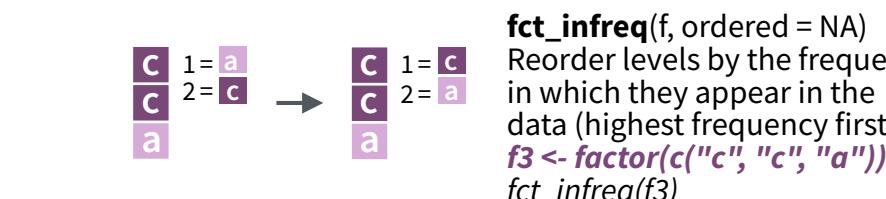
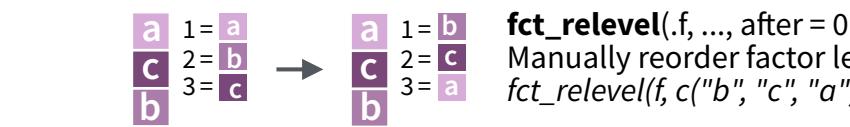
Inspect Factors



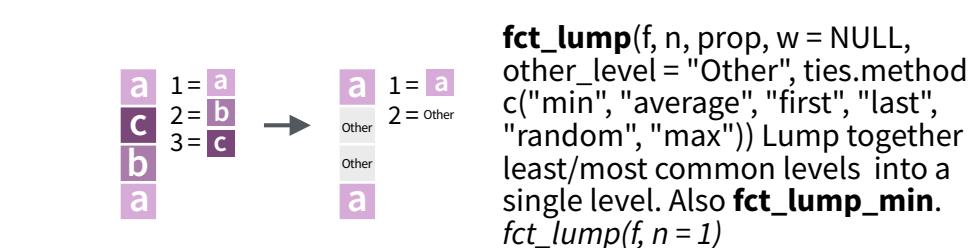
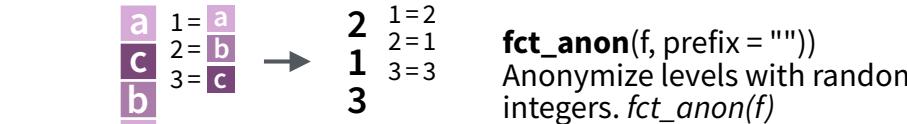
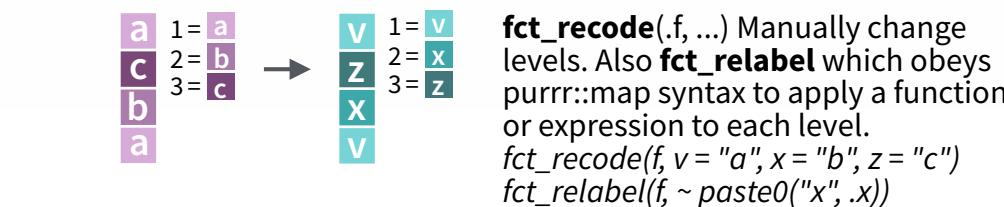
Combine Factors



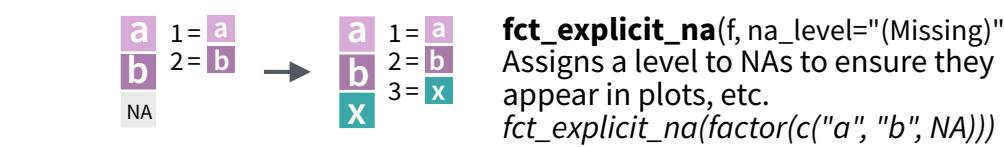
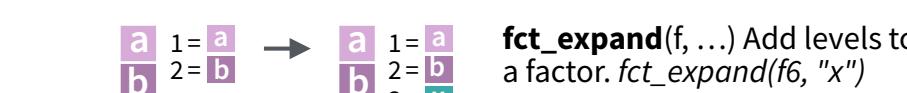
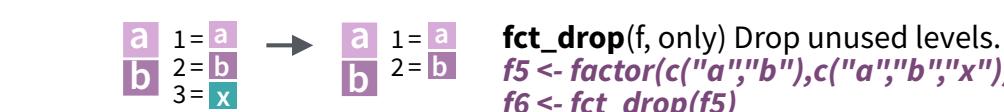
Change the order of levels



Change the value of levels



Add or drop levels



Date times

R

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. 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?



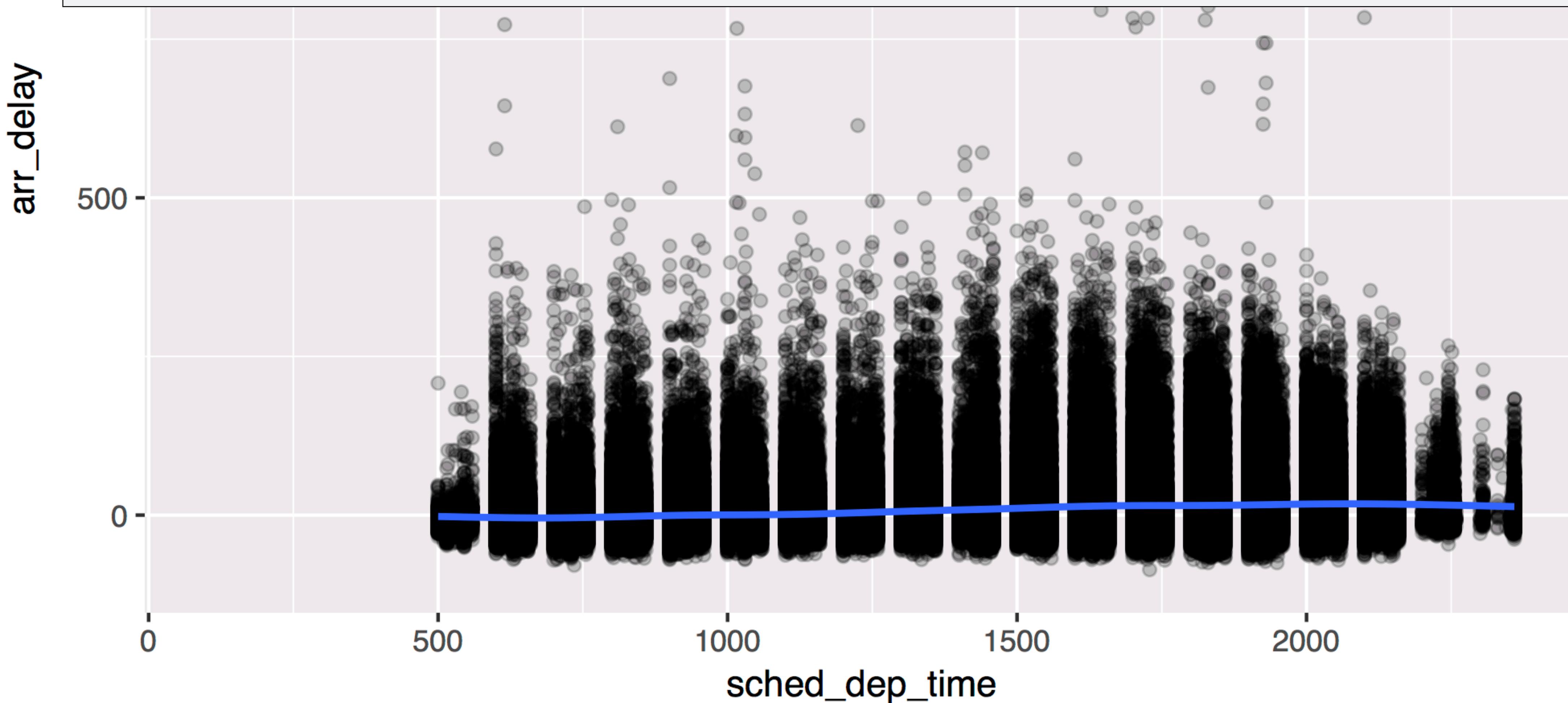
```
flights %>% select(c(1, 2, 3, 17, 18, 5, 19))
```

year	month	day	hour	minute	sched_dep_time	time_hour
<int>	<int>	<int>	<dbl>	<dbl>	<int>	<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()
```



```
flights %>% select(c(1, 2, 3, 17, 18, 5, 19))
```

year	month	day	hour	minute	sched_dep_time	time_hour
<int>	<int>	<int>	<dbl>	<dbl>	<int>	<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

Creating dates and times



hms



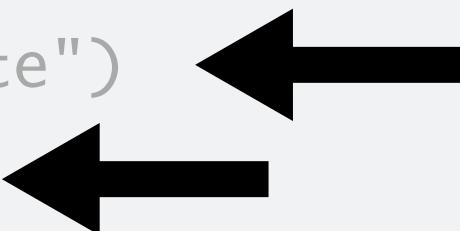
A class for representing just clock times.

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



```
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("stringr")
install.packages("forcats")
install.packages("lubridate")
install.packages("hms")
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")
library("stringr")
library("forcats")
```

hms()

2017-01-01 12:34:56

hms(seconds, minutes, hours, days)

numbers of each unit to
add to the time



hms

2017-01-01 12:34:56

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

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

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



Your Turn 5

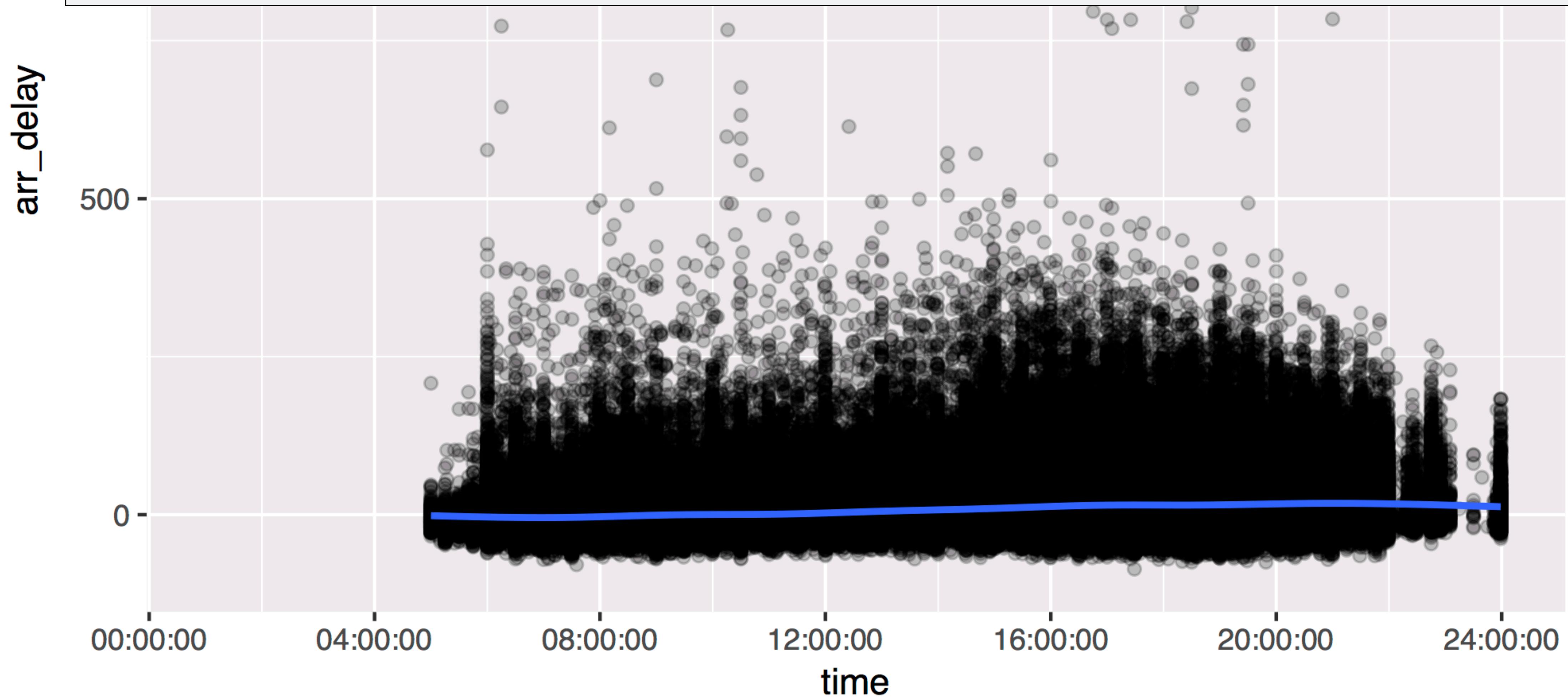
What is the best time of day to fly?

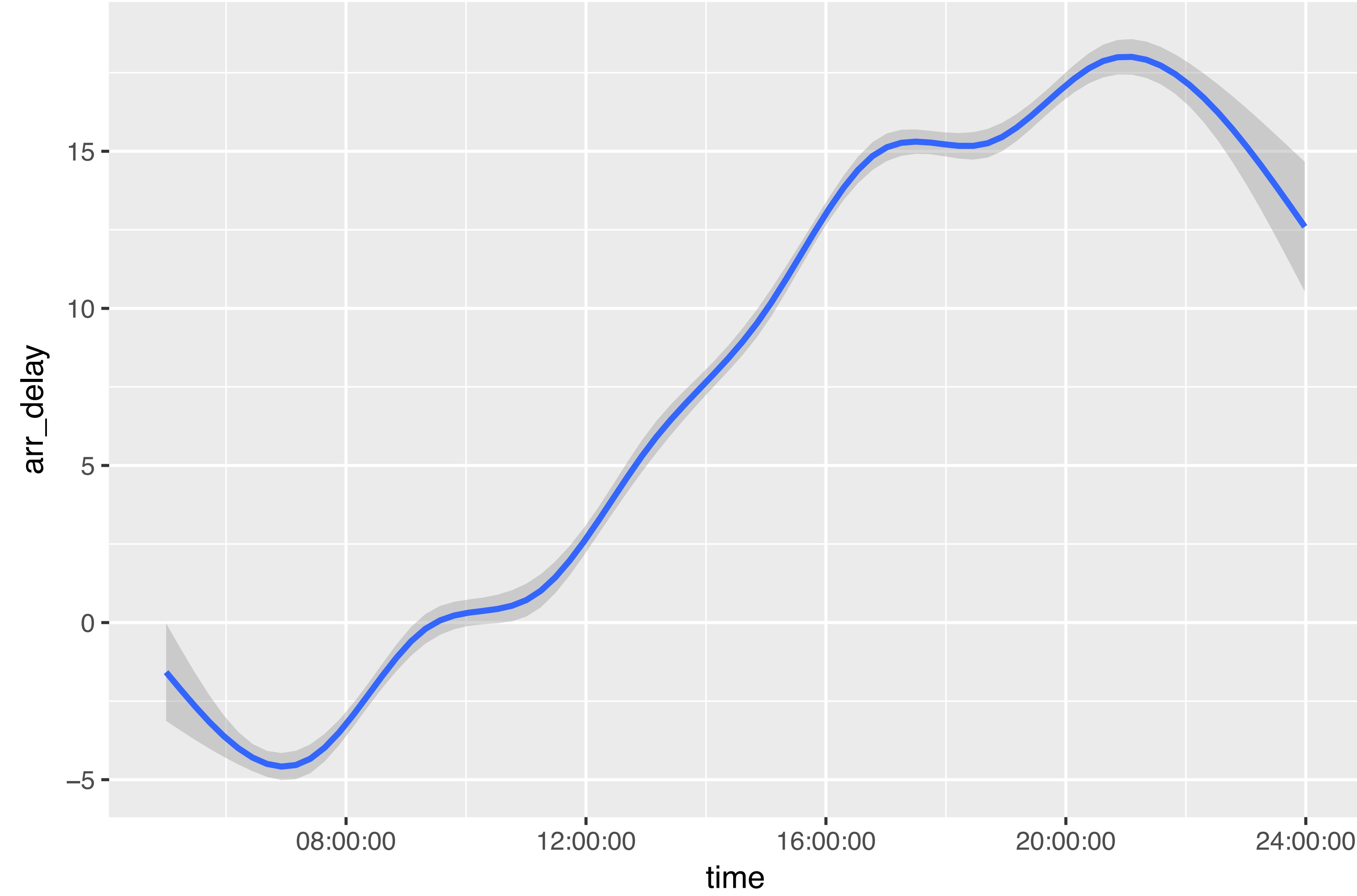
Use the **hour** and **minute** variables in flights to make a new variable that shows the **time** of each flight as an hms.

Then use a smooth line to plot the relationship between time of day and **arr_delay**.



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





What is the best day of the week to fly?

Your Turn 6

Look at the code skeleton for Your Turn 7. Discuss with your neighbor:

- What does each line do?
- What will the missing parts need to do?



lubridate



Functions for working with dates and time spans

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



ymd() family

```
2017-01-01 12:34:56
```

To parse strings as dates, use the function whose name is y, m, d, h, m, s in the correct order.

```
ymd("2012/01/11")  
mdy("January 11, 2012")  
ymd_hms("2012-01-11 01:30:55")
```

Parsing functions

function	parses to
ymd_hms(), ymd_hm(), ymd_h()	
ydm_hms(), ydm_hm(), ydm_h()	POSIXct
dmy_hms(), dmy_hm(), dmy_h()	
mdy_hms(), mdy_hm(), mdy_h()	
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("2019-01-11")
year(date)
## 2019
```

Setting components

Use the same function to set components

```
date  
## "2019-01-11"  
  
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("2019-01-11"))

## 6

wday(ymd("2019-01-11"), label = TRUE)

## [1] Fri

## 7 Levels: Sun < Mon < Tues < Wed < Thurs < ... < Sat

wday(ymd("2019-01-11"), label = TRUE, abbr = FALSE)

## [1] Friday

## 7 Levels: Sunday < Monday < Tuesday < ... < Saturday
```

Your Turn 7

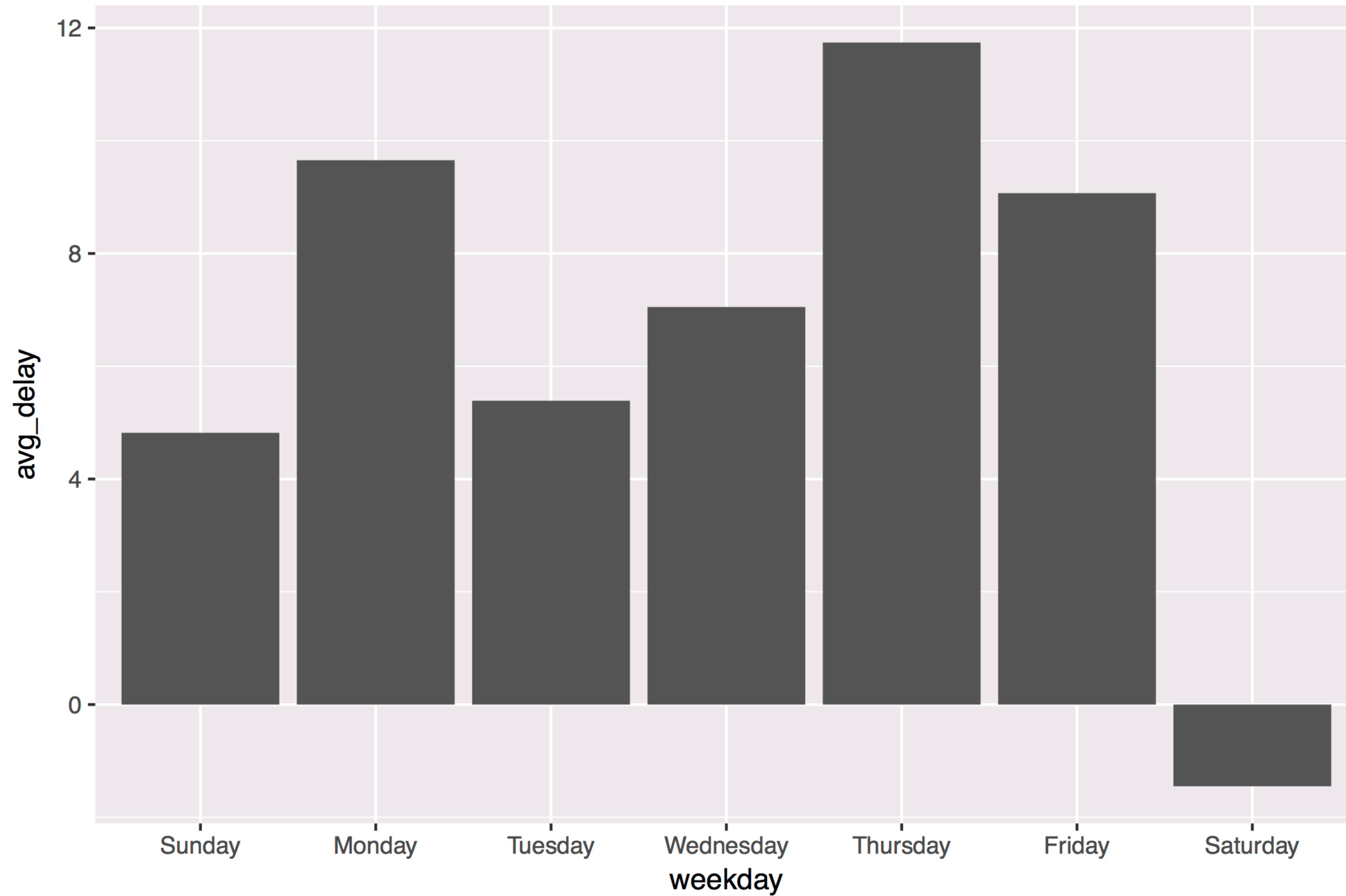
Fill in the blank to:

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

Plot the average arrival delay by day as a column chart (bar chart).



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



Parsing functions

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

Parsing functions

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

Same name as
hms() in hms



`hms::hms()`

package
name

function
name



`hms::hms()`

`lubridate::hms()`



`hms()`

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

Use the
`hms()` function in
the `hms` package

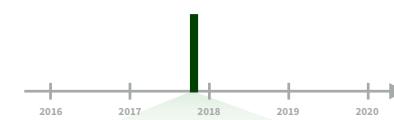


Dates and Times

Dates and times with lubridate :: CHEAT SHEET



Date-times



2017-11-28 12:00:00

2017-11-28 12:00:00
A **date-time** is a point on the timeline, stored as the number of seconds since 1970-01-01 00:00:00 UTC

```
dt <- as_datetime(1511870400)
## "2017-11-28 12:00:00 UTC"
```

PARSE DATE-TIMES

1. Identify the order of the year (**y**), month (**m**), day (**d**), hour (**h**), minute (**m**) and second (**s**) elements in your data.
2. Use the function below whose name replicates the order. Each accepts a wide variety of input formats.

2017-11-28T14:02:00

ymd_hms(), ymd_hm(), ymd_h().
ymd_hms("2017-11-28T14:02:00")

2017-22-12 10:00:00

ydm_hms(), ydm_hm(), ydm_h().
ydm_hms("2017-22-12 10:00:00")

11/28/2017 1:02:03

mdy_hms(), mdy_hm(), mdy_h().
mdy_hms("11/28/2017 1:02:03")

1 Jan 2017 23:59:59

dmy_hms(), dmy_hm(), dmy_h().
dmy_hms("1 Jan 2017 23:59:59")

20170131

ymd(), ydm(). ymd(20170131)

July 4th, 2000

mdy(), myd(). mdy("July 4th, 2000")

4th of July '99

dmy(), dym(). dmy("4th of July '99")

2001: Q3

yq() Q for quarter. yq("2001: Q3")

2:01

hms::hms() Also lubridate::hms(), hm() and ms(), which return periods.* hms::hms(sec = 0, min = 1, hours = 2)

2017.5

date_decimal(decimal, tz = "UTC")
date_decimal(2017.5)

now(zone = "") Current time in tz
(defaults to system tz). now()

today(zone = "") Current date in a
tz (defaults to system tz). today()

fast.strptime() Faster strftime.
fast.strptime('9/1/01', '%y/%m/%d')

parse_date_time() Easier strftime.
parse_date_time("9/1/01", "ymd")



2017-11-28

A **date** is a day stored as
the number of days since
1970-01-01

```
d <- as_date(17498)
## "2017-11-28"
```

12:00:00

An **hms** is a **time** stored as
the number of seconds since
00:00:00

```
t <- hms::as.hms(85)
## 00:01:25
```

GET AND SET COMPONENTS

Use an accessor function to get a component.
Assign into an accessor function to change a
component in place.

2018-01-31 11:59:59

date(x) Date component. date(dt)

2018-01-31 11:59:59

year(x) Year. year(dt)
isoyear(x) The ISO 8601 year.
epiyear(x) Epidemiological year.

2018-01-31 11:59:59

month(x, label, abbr) Month.
month(dt)

2018-01-31 11:59:59

day(x) Day of month. day(dt)
wday(x, label, abbr) Day of week.
qday(x) Day of quarter.

2018-01-31 11:59:59

hour(x) Hour. hour(dt)

2018-01-31 11:59:59

minute(x) Minutes. minute(dt)

2018-01-31 11:59:59

second(x) Seconds. second(dt)

2018-01-31 11:59:59

week(x) Week of the year. week(dt)
isoweek() ISO 8601 week.
epiweek() Epidemiological week.

2018-01-31 11:59:59

quarter(x, with_year = FALSE)
Quarter. quarter(dt)

2018-01-31 11:59:59

semester(x, with_year = FALSE)
Semester. semester(dt)

2018-01-31 11:59:59

am(x) Is it in the am? am(dt)
pm(x) Is it in the pm? pm(dt)

2018-01-31 11:59:59

dst(x) Is it daylight savings? dst(dt)

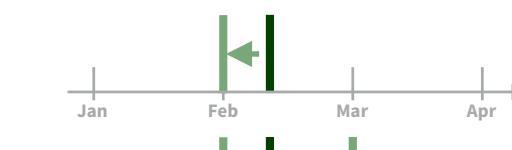
2018-01-31 11:59:59

leap_year(x) Is it a leap year?
leap_year(dt)

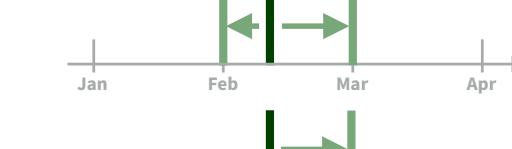
2018-01-31 11:59:59

update(object, ..., simple = FALSE)
update(dt, mday = 2, hour = 1)

Round Date-times



floor_date(x, unit = "second")
Round down to nearest unit.
floor_date(dt, unit = "month")



round_date(x, unit = "second")
Round to nearest unit.
round_date(dt, unit = "month")

ceiling_date(x, unit = "second",
change_on_boundary = NULL)
Round up to nearest unit.
ceiling_date(dt, unit = "month")

rollback(dates, roll_to_first =
FALSE, preserve_hms = TRUE)
Roll back to last day of previous
month. rollback(dt)

Stamp Date-times

stamp() Derive a template from an example string and return a new
function that will apply the template to date-times. Also
stamp_date() and stamp_time().

1. Derive a template, create a function
`sf <- stamp("Created Sunday, Jan 17, 1999 3:34")`
2. Apply the template to dates
`sfymd("2010-04-05")`
`## [1] "Created Monday, Apr 05, 2010 00:00"`

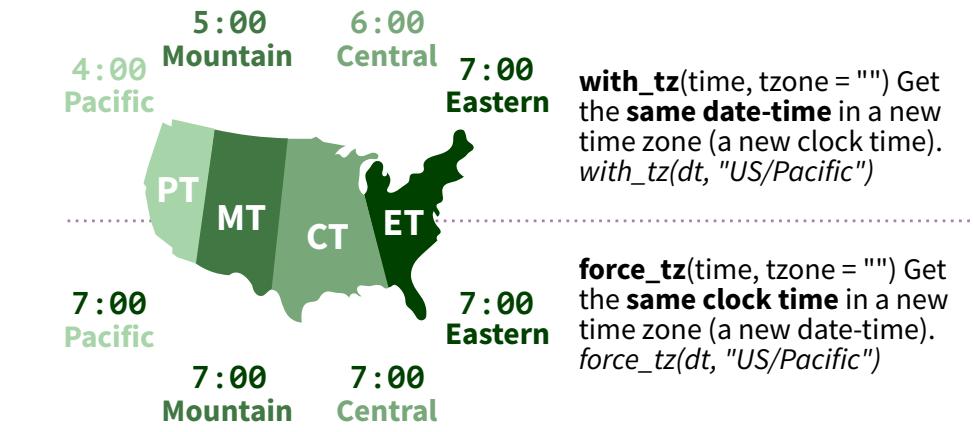
Tip: use a
date with
day > 12

Time Zones

R recognizes ~600 time zones. Each encodes the time zone, Daylight
Savings Time, and historical calendar variations for an area. R assigns
one time zone per vector.

Use the **UTC** time zone to avoid Daylight Savings.

OlsonNames() Returns a list of valid time zone names. OlsonNames()



* on a typical day



Data types with

