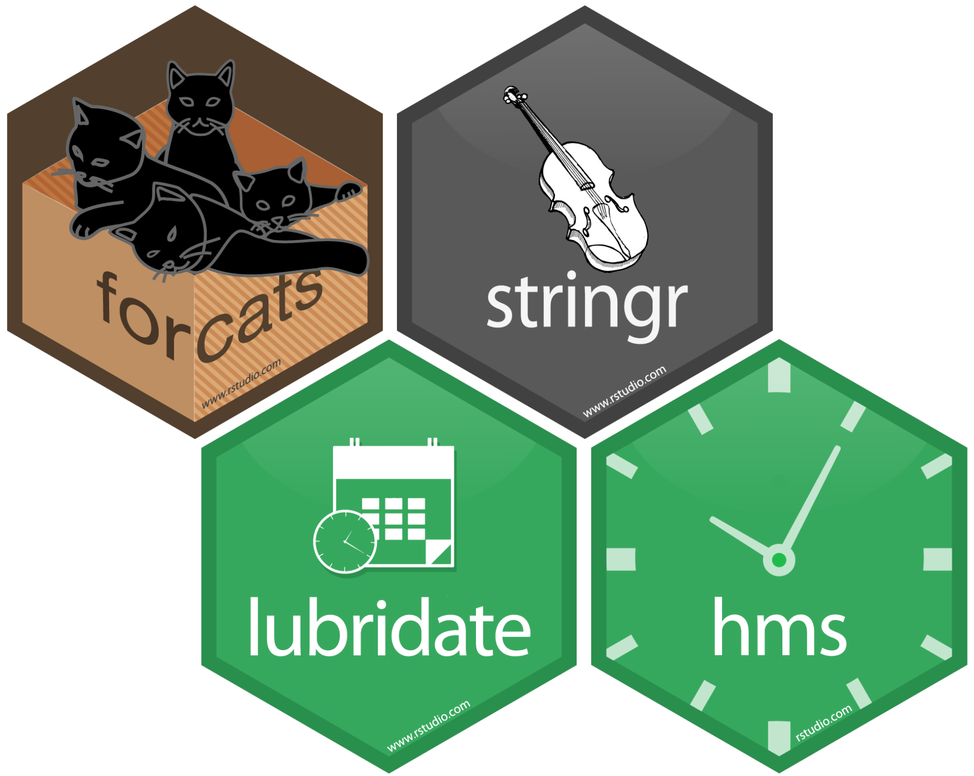
Data Types


forcats
www.rstudio.com
stringr
www.rstudio.com
lubridate
www.rstudio.com
hms
rstudio.com

gss_cat

```
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 <int>	marital <fctr>	age <int>	race <fctr>	rincome <fctr>	partyid <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

Warm-up/Review

Using the data `gss_cat`, find the average hours of tv watched (`tvhours`) for each category of marital status (`marital`). What's the problem?

```
gss_cat %>%
  group_by(marital) %>%
  summarise(avg_tv = mean(tvhours))
```

marital <fctr>	avg_tv <dbl>
No answer	*NA*
Never married	*NA*
Separated	*NA*
Divorced	*NA*
Widowed	*NA*
Married	*NA*

6 rows

??

Missing values

Missing values propagate

```
NA + 2
## [1] NA

mean(c(1, NA, 2))
## [1] NA

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

NA == NA == WHAT?

```
# Are Amelia and Hadley the same age?
amelia_age <- NA
hadley_age <- NA

amelia_age == hadley_age
```

is.na()

Returns TRUE if the value is NA

```
filter(gss_cat, tvhours == NA)     # Nope!
## # A tibble: 0 x 9
```

```
filter(gss_cat, is.na(tvhours))    # Yes!
```

```
# A tibble: 10,146 x 9
    year marital    age race   rincome partyid  relig  denom   tvho…
   <int> <fctr>   <int> <fctr> <fctr>  <fctr>   <fctr> <fctr>  <int>
 1  2000 Divorced    48 White  $8000 … Not str… Prote… Baptis…    NA
 2  2000 Married     25 White  $20000… Strong … Prote… Southe…    NA
```

drop_na()

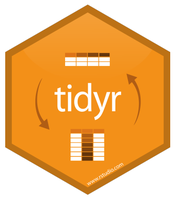
Drops rows that contain NA's in the specified columns.

```
drop_na(df, x2)
```

data frame to transform

column(s) to screen for NA's

```
filter(df, !is.na(x2))
```



drop_na()

Drops rows that contain NA's in the specified columns.

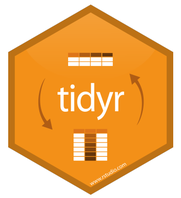
```
drop_na(df, x2)
```

x

x1	x2
A	1
B	NA
C	NA
D	3
E	NA

x1	x2
A	1
D	3

```
filter(df, !is.na(x2))
```



```
gss_cat %>%
  group_by(marital) %>%
  drop_na(tvhours) %>%
  summarise(avg_tv = mean(tvhours))
```

marital <fctr>	avg_tv <dbl>
No answer	2.555556
Never married	3.105175
Separated	3.549618
Divorced	3.085407
Widowed	3.912000
Married	2.650425

6 rows

OR

```
gss_cat %>%
  group_by(marital) %>%
  summarise(avg_tv = mean(tvhours, na.rm = TRUE))
```

marital <fctr>	avg_tv <dbl>
No answer	2.555556
Never married	3.105175
Separated	3.549618
Divorced	3.085407
Widowed	3.912000
Married	2.650425

6 rows

Your Turn 1

What kind of object is the `marital` variable?

Brainstorm with your neighbor, all the things you know about that kind of object.

Factors

In R4DS

Factors

factors

R's representation of categorical data. Consists of:

1. A set of **values**
2. An ordered set of **possible 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 3 3
## attr(,"levels")
## "blue"  "brown" "green"
```

factors

Stored as an integer vector with a levels attribute

```
x <- factor(c("characters", "in", "the", "streets"))
y <- factor(c("integers", "in", "the", "sheets"))


c(x, y)
#> [1] 1 2 4 3 2 1 4 3
```

forcats

Simple functions for working with factors.

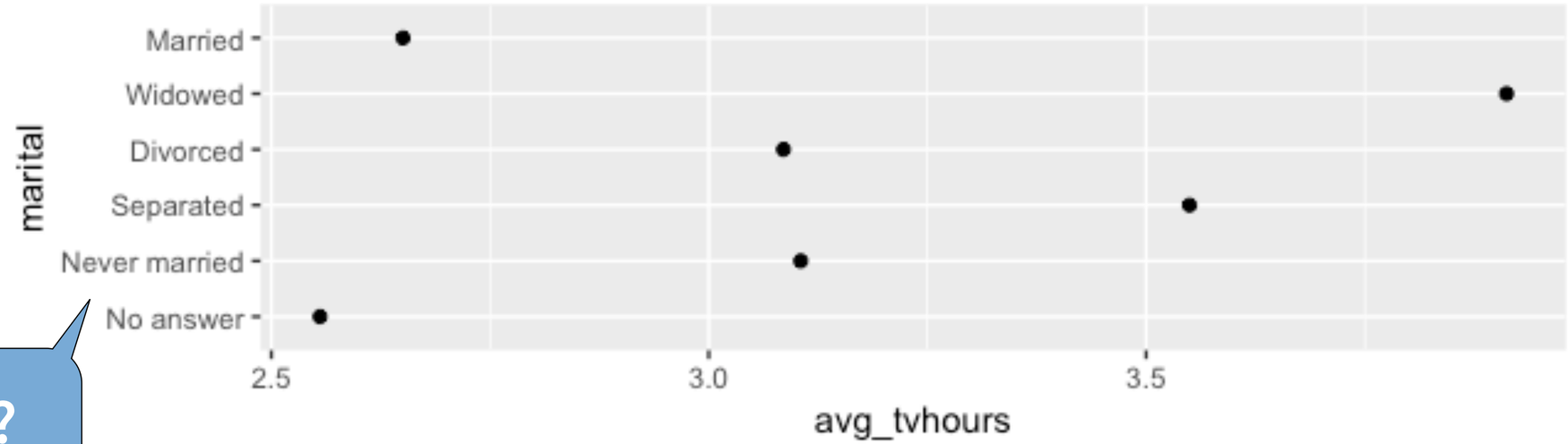
```
library(forcats)
```

Your Turn 2

Fix your summary of average hours of tv watched (`tvhours`) by marital status (`marital`), to ignore missing values,

then create a **plot** to examine the results.

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



Why this order?

levels()

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

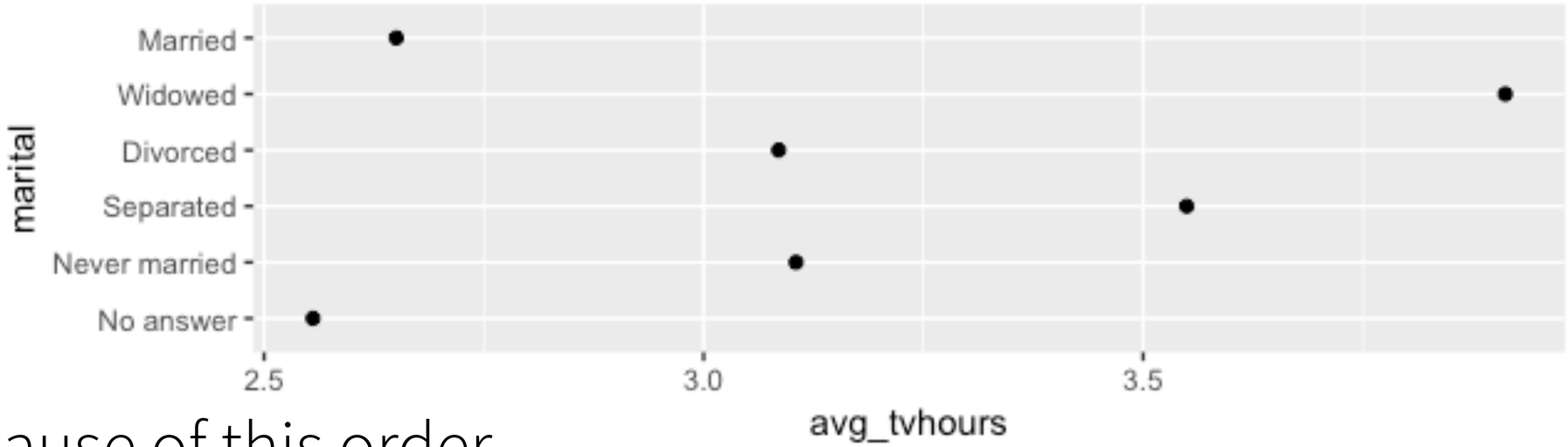
```
levels(eyes)
# [1] "blue"  "brown" "green"


gss_cat %>% pull(marital) %>% levels()
# [1] "No answer"     "Never married" "Separated"
# [4] "Divorced"      "Widowed"       "Married"
```

x %>% pull(y)

same as

x$y

Why this order?



Because of this order

```
gss_cat %>% pull(marital) %>% levels()
# [1] "No answer"     "Never married" "Separated"
# [4] "Divorced"      "Widowed"       "Married"
```

Most useful skills

1. Reorder the levels
2. Manipulate the 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)
```

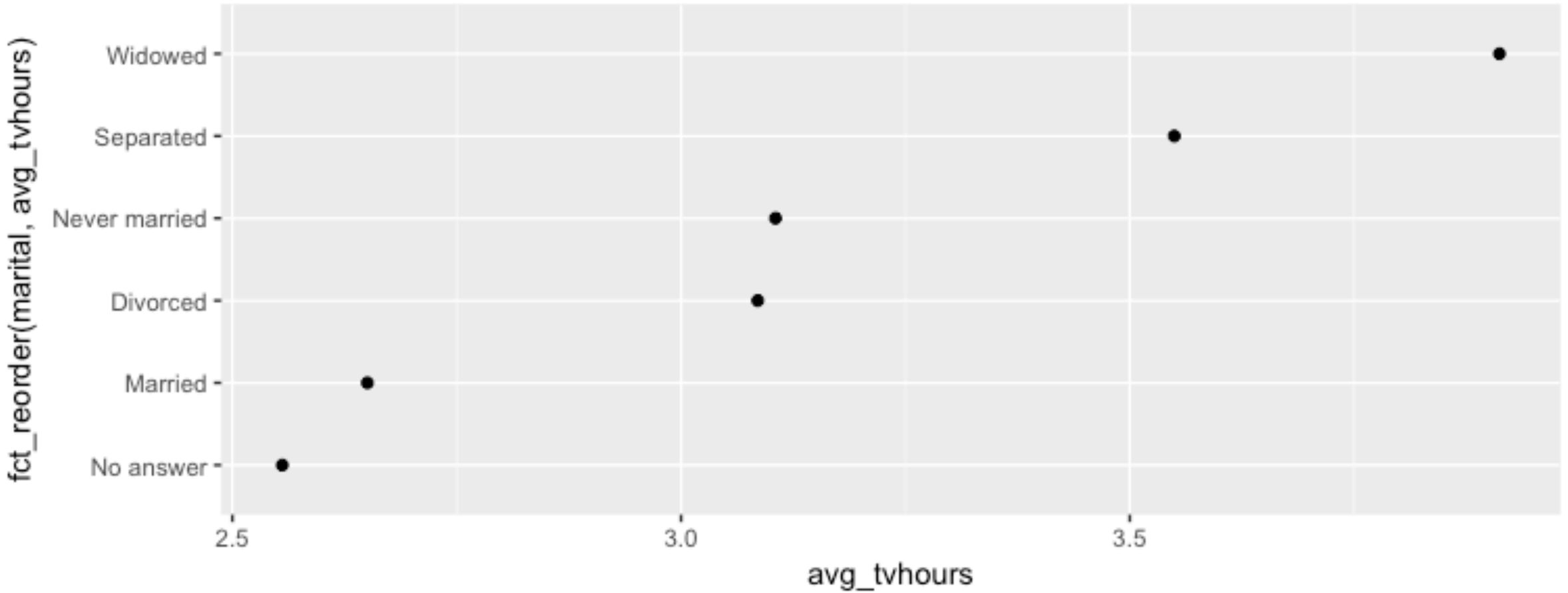
factor to reorder

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(marital) %>%
  summarise(avg_tvhours = mean(tvhours)) %>%
  ggplot() +
    geom_point(aes(x = avg_tvhours,
                   y = fct_reorder(marital, avg_tvhours)))
```

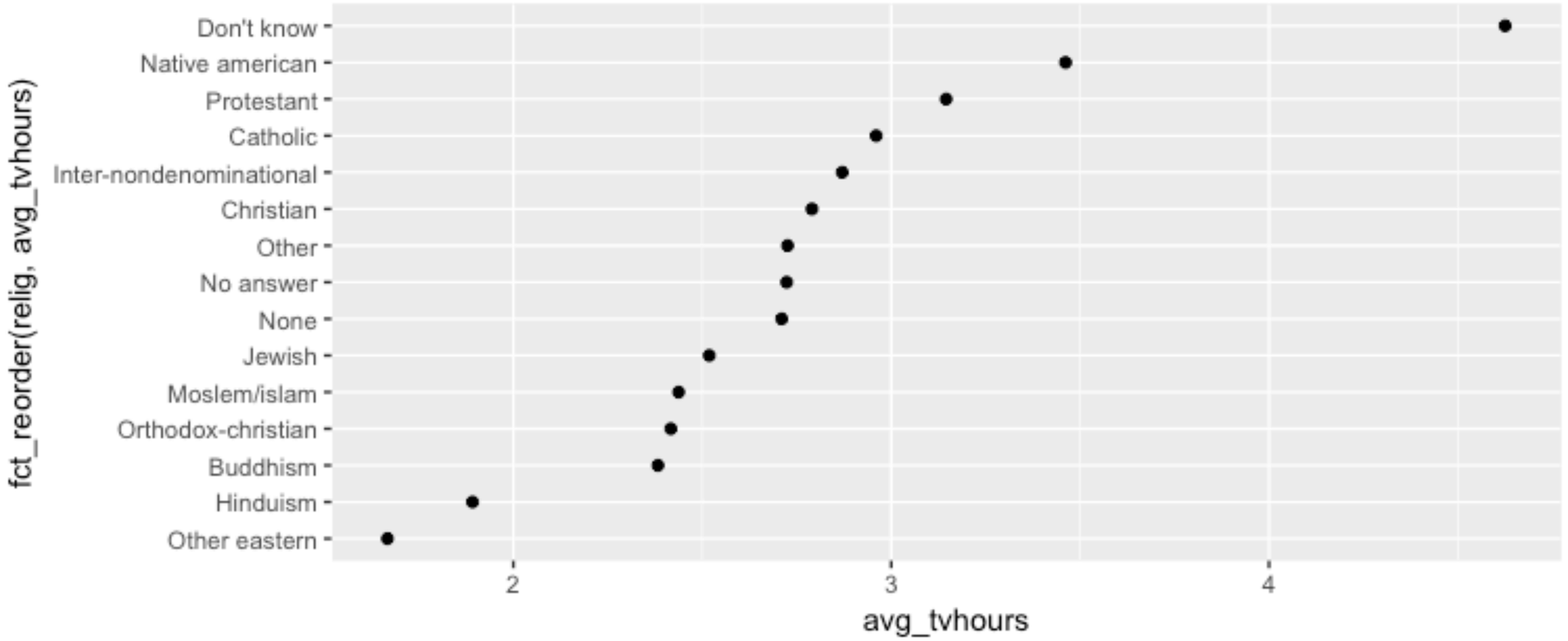

fct_reorder(marital, avg_tvhours)
Widowed
Separated
Never married
Divorced
Married
No answer
2.5
3.0
3.5
avg_tvhours

Your Turn 3

Fill in the blanks (___) to explore the average hours of tv watched by religion.

```
gss_cat %>%
  drop_na(___) %>%
  group_by(___) %>%
  summarise(___) %>%
  ggplot() +
  geom_point(mapping = aes(x = ___, y = ___))
```

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


fct_reorder(relig, avg_tvhours)
Don't know
Native american
Protestant
Catholic
Inter-nondenominational
Christian
Other
No answer
None
Jewish
Moslem/islam
Orthodox-christian
Buddhism
Hinduism
Other eastern
2
3
4
avg_tvhours

Other reordering functions

Values and level labels are unchanged

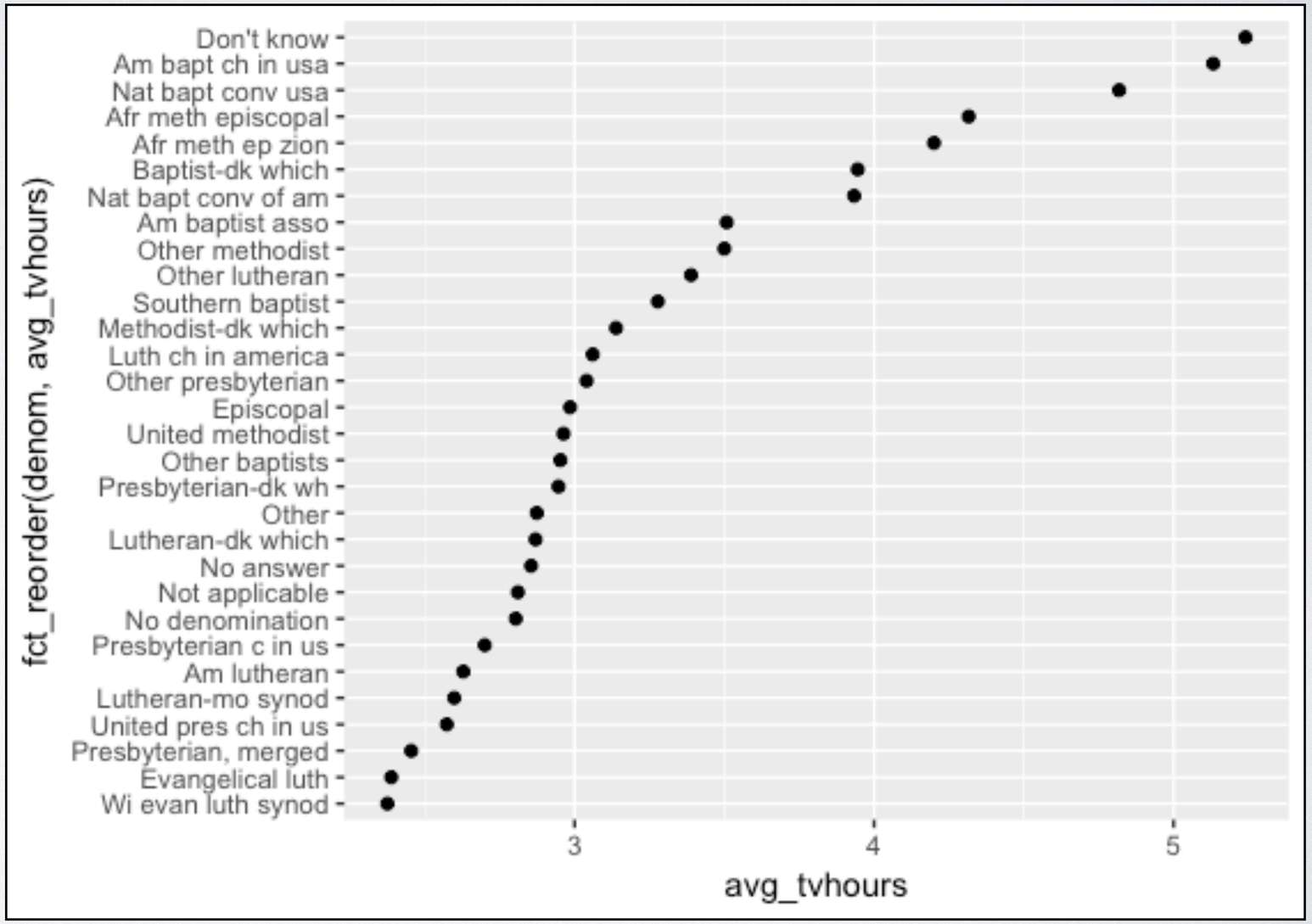
`fct_shuffle()`	Randomize order
`fct_relevel()`	Order "by hand"
`fct_infreq()`	Order from most to least frequent
`fct_inorder()`	Order from first to last observed
`fct_rev()`	Reverse the current order
`fct_shift()`	Shift the order by 1

Key forcats functions start with `fct_`

manipulating levels

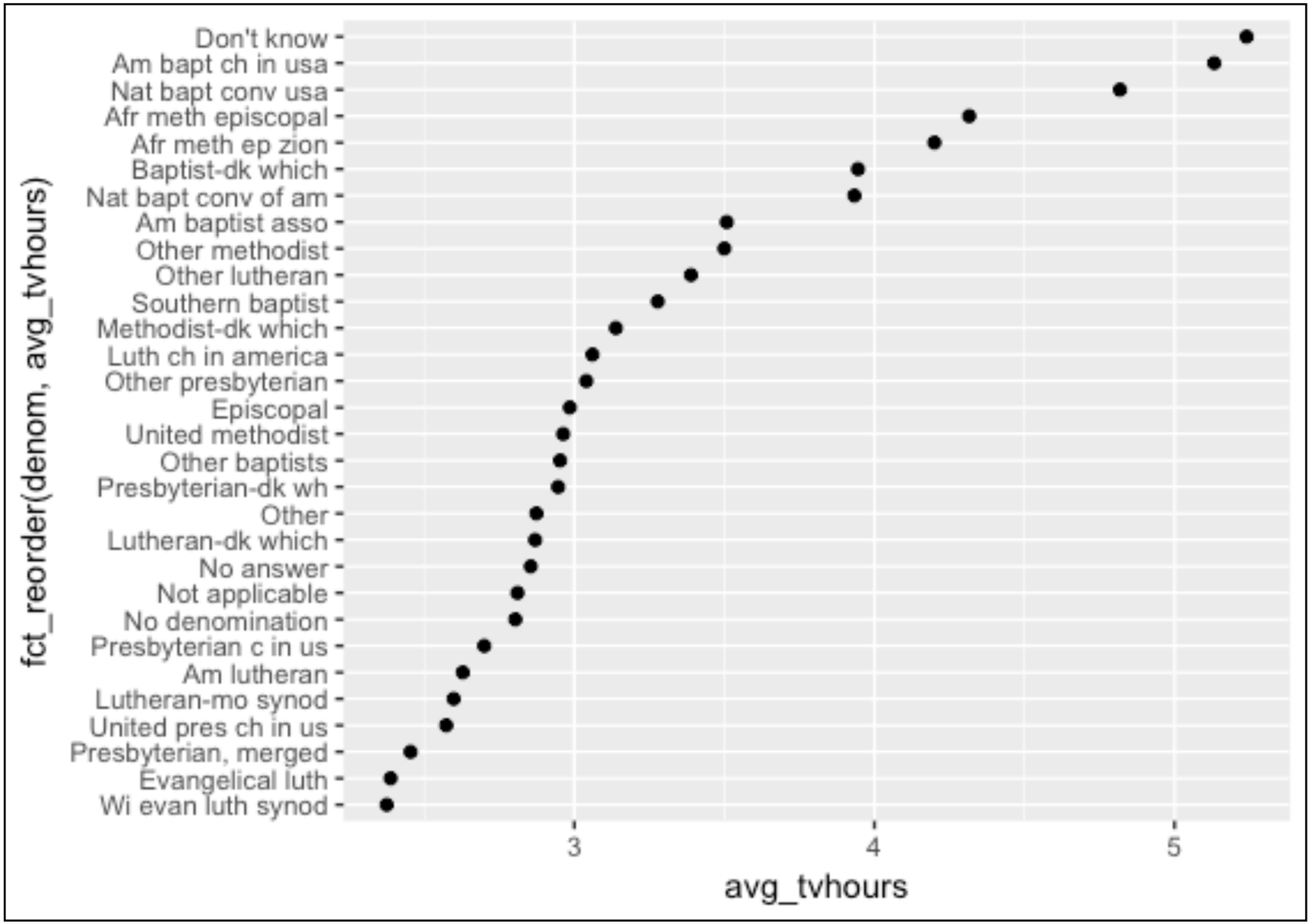
Quiz

Why is this plot not very useful?



Too many categories

Poorly labelled



First 10 rows

Obs.	denom	Relabel levels denom	Reduce levels denom
1	Southern baptist	Baptist - Southern	Baptist
2	Baptist-dk which	Baptist - Don't know	Baptist
3	No denomination	No denomination	None
4	Not applicable	Not applicable	None
5	Not applicable	Not applicable	None
6	Southern baptist	Baptist - Southern	Baptist
7	Not applicable	Not applicable	None
8	Lutheran-mo synod	Lutheran - Missouri Synod	Lutheran
9	Other	Other	Other
10	Southern baptist	Baptist - Southern	Baptist
…	…	…	…

Level manipulation functions

Values change to match levels

Relabel

- `fct_recode()` — Relabel levels "by hand"
- `fct_anon()` — Anonymize levels
- `fct_relabel()` — Relabel using a function

Reduce

- `fct_collapse()` — Collapse levels "by hand"
- `fct_lump()` — Lump levels with small counts together
- `fct_other()` — Replace levels with "Other"

fct_recode()

Changes values of levels

```
fct_recode(f, ...)
```

factor with levels

new level = old level pairs

```
gss_cat %>%
  pull(denom) %>%
  levels()
```

```
 [1] "No answer"              "Don't know"
 [3] "No denomination"        "Other"
 [5] "Episcopal"              "Presbyterian-dk wh"
 [7] "Presbyterian, merged"   "Other presbyterian"
 [9] "United pres ch in us"   "Presbyterian c in us"
[11] "Lutheran-dk which"      "Evangelical luth"
[13] "Other lutheran"         "Wi evan luth synod"
[15] "Lutheran-mo synod"      "Luth ch in america"
[17] "Am lutheran"            "Methodist-dk which"
[19] "Other methodist"        "United methodist"
[21] "Afr meth ep zion"       "Afr meth episcopal"
[23] "Baptist-dk which"       "Other baptists"
[25] "Southern baptist"       "Nat bapt conv usa"
[27] "Nat bapt conv of am"    "Am bapt ch in usa"
[29] "Am baptist asso"        "Not applicable"
```

```r
gss_cat %>%
  mutate(denom = fct_recode(denom,
    "Baptist - Southern" = "Southern baptist")
  ) %>%
  pull(denom) %>%
  levels()
```

```
 [1] "No answer"              "Don't know"
 [3] "No denomination"        "Other"
 [5] "Episcopal"              "Presbyterian-dk wh"
 [7] "Presbyterian, merged"   "Other presbyterian"
 [9] "United pres ch in us"   "Presbyterian c in us"
[11] "Lutheran-dk which"      "Evangelical luth"
[13] "Other lutheran"         "Wi evan luth synod"
[15] "Lutheran-mo synod"      "Luth ch in america"
[17] "Am lutheran"            "Methodist-dk which"
[19] "Other methodist"        "United methodist"
[21] "Afr meth ep zion"       "Afr meth episcopal"
[23] "Baptist-dk which"       "Other baptists"
[25] "Baptist - Southern"     "Nat bapt conv usa"
[27] "Nat bapt conv of am"    "Am bapt ch in usa"
[29] "Am baptist asso"        "Not applicable"
```

factor with levels

```
gss_cat %>%
  mutate(denom = fct_recode(denom,
    "Baptist - Southern" = "Southern baptist")
  ) %>%
  pull(denom) %>%
  levels()
```

new level = old level pairs

```
 [1] "No answer"              "Don't know"
 [3] "No denomination"        "Other"
 [5] "Episcopal"              "Presbyterian-dk wh"
 [7] "Presbyterian, merged"   "Other presbyterian"
 [9] "United pres ch in us"   "Presbyterian c in us"
[11] "Lutheran-dk which"      "Evangelical luth"
[13] "Other lutheran"         "Wi evan luth synod"
[15] "Lutheran-mo synod"      "Luth ch in america"
[17] "Am lutheran"            "Methodist-dk which"
[19] "Other methodist"        "United methodist"
[21] "Afr meth ep zion"       "Afr meth episcopal"
[23] "Baptist-dk which"       "Other baptists"
[25] "Baptist - Southern"     "Nat bapt conv usa"
[27] "Nat bapt conv of am"    "Am bapt ch in usa"
[29] "Am baptist asso"        "Not applicable"
```

Your Turn 4

Edit the code to also relabel some other Baptist denominations:

- "Baptist-dk which"
- "Other baptists"

```
gss_cat %>%
  mutate(denom = fct_recode(denom,
    "Baptist - Southern" = "Southern baptist",
    "Baptist - Don't know" = "Baptist-dk which",
    "Baptist - Other" = "Other baptists")
  ) %>%
  pull(denom) %>%
  levels()
```

```
gss_cat %>%
  mutate(denom = fct_recode(denom,
    "Baptist - Southern" = "Southern baptist",
    "Baptist-dk which" = "Baptist - Don't know",
    "Baptist - Other" = "Other baptists")
  )
# Unknown levels in `f`: Baptist - Don't know
```

Common mistake

Whoops, around the wrong way!

Message, but no warning or error!

Your Turn 5

What does the function `detect_denom()` do?

```
gss_cat %>% pull(denom) %>% levels()
```

```
 [1] "No answer"             "Don't know"
 [3] "No denomination"       "Other"
 [5] "Episcopal"             "Presbyterian-dk wh"
 [7] "Presbyterian, merged"  "Other presbyterian"
 [9] "United pres ch in us"  "Presbyterian c in us"
[11] "Lutheran-dk which"     "Evangelical luth"
[13] "Other lutheran"        "Wi evan luth synod"
[15] "Lutheran-mo synod"     "Luth ch in america"
[17] "Am lutheran"           "Methodist-dk which"
[19] "Other methodist"       "United methodist"
[21] "Afr meth ep zion"      "Afr meth episcopal"
[23] "Baptist-dk which"      "Other baptists"
[25] "Southern baptist"      "Nat bapt conv usa"
[27] "Nat bapt conv of am"   "Am bapt ch in usa"
[29] "Am baptist asso"       "Not applicable"
```

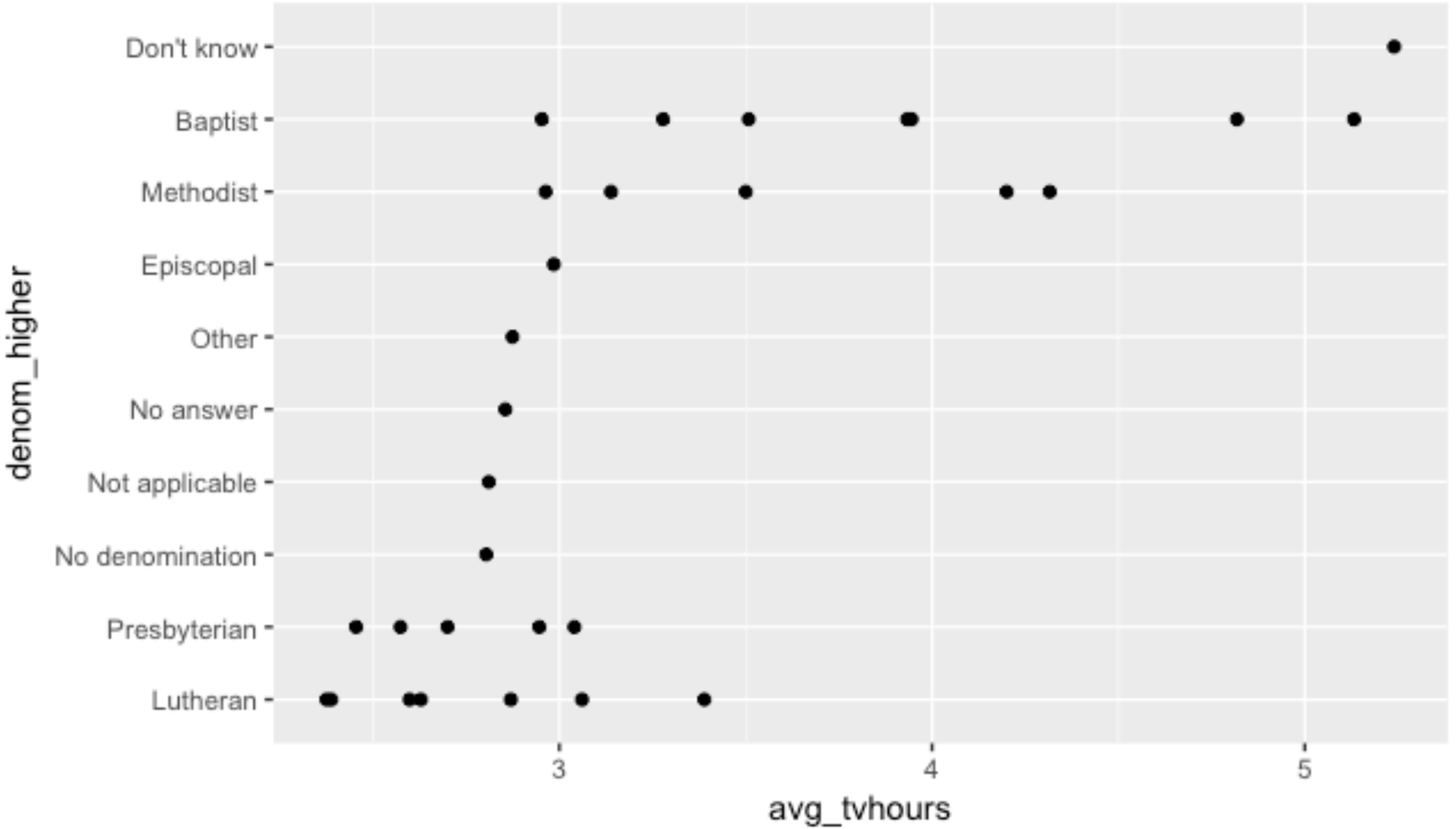
```
gss_cat %>% pull(denom) %>% levels() %>% detect_denom()
```

```
 [1] "No answer"             "Don't know"
 [3] "No denomination"       "Other"
 [5] "Episcopal"             "Presbyterian"
 [7] "Presbyterian"          "Presbyterian"
 [9] "Presbyterian"          "Presbyterian"
[11] "Lutheran"              "Lutheran"
[13] "Lutheran"              "Lutheran"
[15] "Lutheran"              "Lutheran"
[17] "Lutheran"              "Methodist"
[19] "Methodist"             "Methodist"
[21] "Methodist"             "Methodist"
[23] "Baptist"               "Baptist"
[25] "Baptist"               "Baptist"
[27] "Baptist"               "Baptist"
[29] "Baptist"               "Not applicable"
```

converts to a higher level grouping

Use with `fct_relabel()` to collapse levels

```
gss_cat %>%
  drop_na(tvhours) %>%
  mutate(denom_higher = denom %>%
      fct_relabel(detect_denom) %>%
      fct_reorder(tvhours, mean)
  ) %>%
  group_by(denom_higher, denom) %>%
  summarise(avg_tvhours = mean(tvhours)) %>%
  ggplot() +
    geom_point(mapping = aes(x = avg_tvhours,
      y = denom_higher))
```


Don't know
Baptist
Methodist
Episcopal
Other
No answer
Not applicable
No denomination
Presbyterian
Lutheran
denom_higher
3
4
5
avg_tvhours

strings

In R4DS

Strings

(character) **strings**

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

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

stringr

Simple functions for working with character **strings**.

```
library(stringr)
```

Most useful skills

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

```
detect_denom <- function(x){
  case_when(
    str_detect(x, "[Bb]ap") ~ "Baptist",
    str_detect(x, "[Pp]res") ~ "Presbyterian",
    str_detect(x, "[Ll]uth") ~ "Lutheran",
    str_detect(x, "[Mm]eth") ~ "Methodist",
    TRUE ~ x
  )
}
```

```
detect_denom <- function(x){
  case_when(
    str_detect(x, "[Bb]ap") ~ "Baptist",
    str_detect(x, "[Pp]res") ~ "Presbyterian",
    str_detect(x, "[Ll]uth") ~ "Lutheran",
    str_detect(x, "[Mm]eth") ~ "Methodist",
    TRUE ~ x
  )
}
```

str_detect()

Test whether a pattern appears within a string.

```
str_detect(string, pattern)
```

stringr functions start with str_

vector of strings to find patterns in

a string that represents a regular expression

Returns **TRUE** or **FALSE**

Your Turn 6

```
strings <- c("Apple", "Pineapple", "Orange")
```

With your neighbor, **predict** what these might return:

```
str_detect(strings, pattern = "pp")
str_detect(strings, pattern =  "apple")
str_detect(strings, pattern = "[Aa]pple")
```

Then **run** them!

```
str_detect(strings, pattern = "pp")
# [1]  TRUE  TRUE FALSE
```

A**pp**le
Pinea**pp**le
Orange

```
str_detect(strings, pattern =  "apple")
# [1] FALSE  TRUE FALSE
```

Apple
Pine**apple**
Orange

```
str_detect(strings, pattern = "[Aa]pple")
# [1]  TRUE  TRUE FALSE
```

"A" or "a"
(regular expression)

Apple
Pine**apple**
Orange

```
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.

Date times

In R4DS

Dates and Times

Most useful skills

1. Creating dates/times (i.e. *parsing*)
2. Access parts of a date
3. Deal with time zones
4. Do math with instants and time spans

creating dates and times

lubridate

Functions for working with dates and time spans

```
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() 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

Your Turn 7

For each of the following formats (of the same date), pick the right `ymd()` function to parse them:

- "2018 Feb 02"
- "2-1-18"
- "01/02/2018"

```
ymd("2018 Feb 02")
# [1] "2018-02-02"

mdy("2-1-18")
# [1] "2018-02-01"

dmy("01/02/2018")
# [1] "2018-02-01"
```

accessing components

Accessing components

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

```
date <- ymd("2018-02-01")
year(date)
## 2018
```

Accessing 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("2018-02-01"))
## 5
wday(ymd("2018-02-01"), label = TRUE)
# [1] Thu
# Levels: Sun < Mon < Tue < Wed < Thu < Fri < Sat
wday(ymd("2018-02-01"), label = TRUE, abbr = FALSE)
# [1] Thursday
# 7 Levels: Sunday < Monday < Tuesday < Wednesday < ... < Saturday
```

births

Two variables from yesterday's data

date <date>	births <int>
1994-01-01	8096
1994-01-02	7772
1994-01-03	10142
1994-01-04	11248
1994-01-05	11053
1994-01-06	11406
1994-01-07	11251
1994-01-08	8653
1994-01-09	7910
1994-01-10	10498

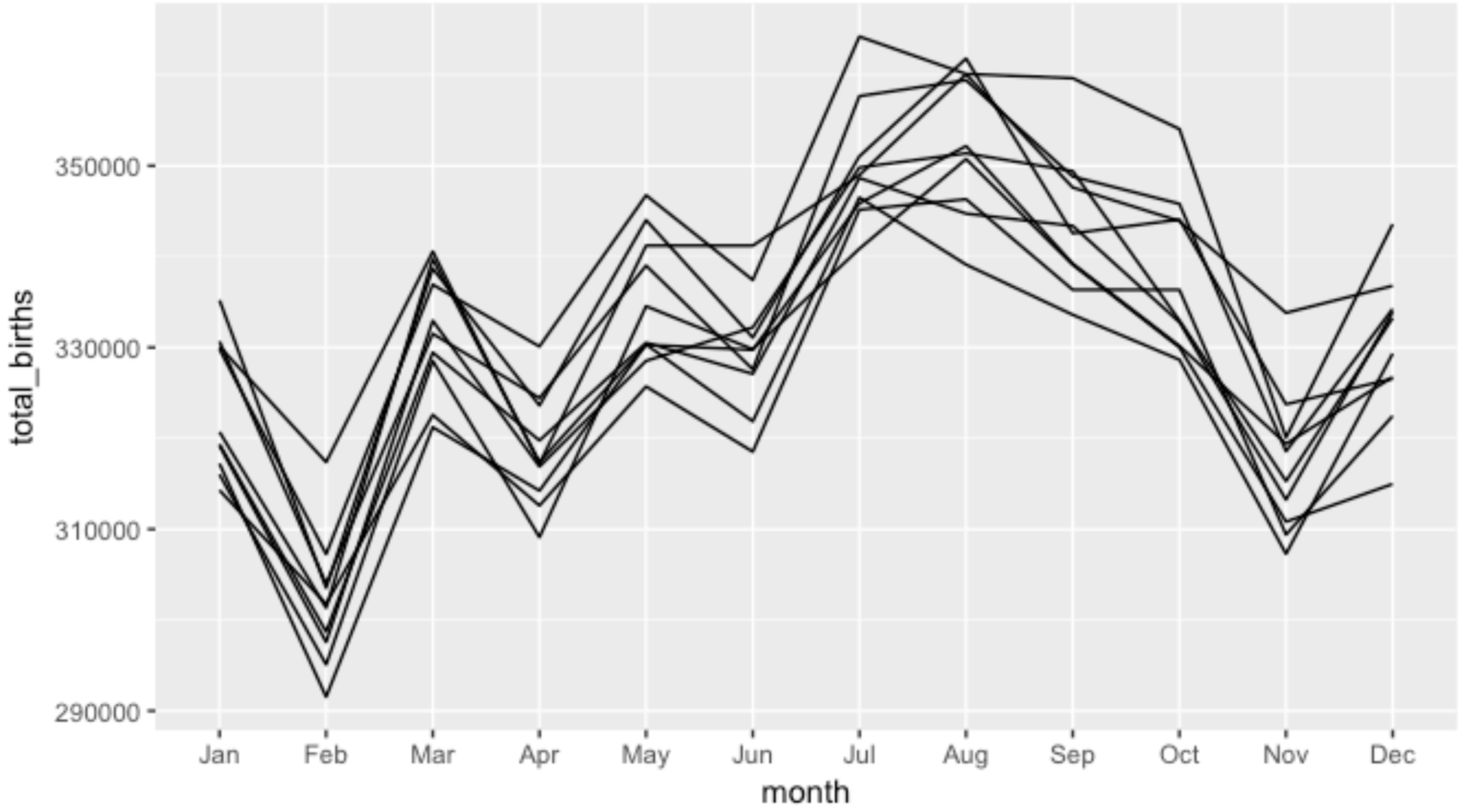
1-10 of 3,652 rows

Your Turn 8

Fill in the blanks to:

- Extract the month from **date**.
- Extract the year from **date**.
- Find the total births for each year/month.
- Plot the results as a line chart.

```
births %>%
  mutate(year = year(date),
    month = month(date, label = TRUE)) %>%
  group_by(year, month) %>%
  summarise(total_births = sum(births)) %>%
  ggplot() +
    geom_line(aes(x = month, y = total_births, group = year))
```


total_births
350000
330000
310000
290000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month


lubridate

hms

A class for representing just clock times.

```
library(hms)
```

hms

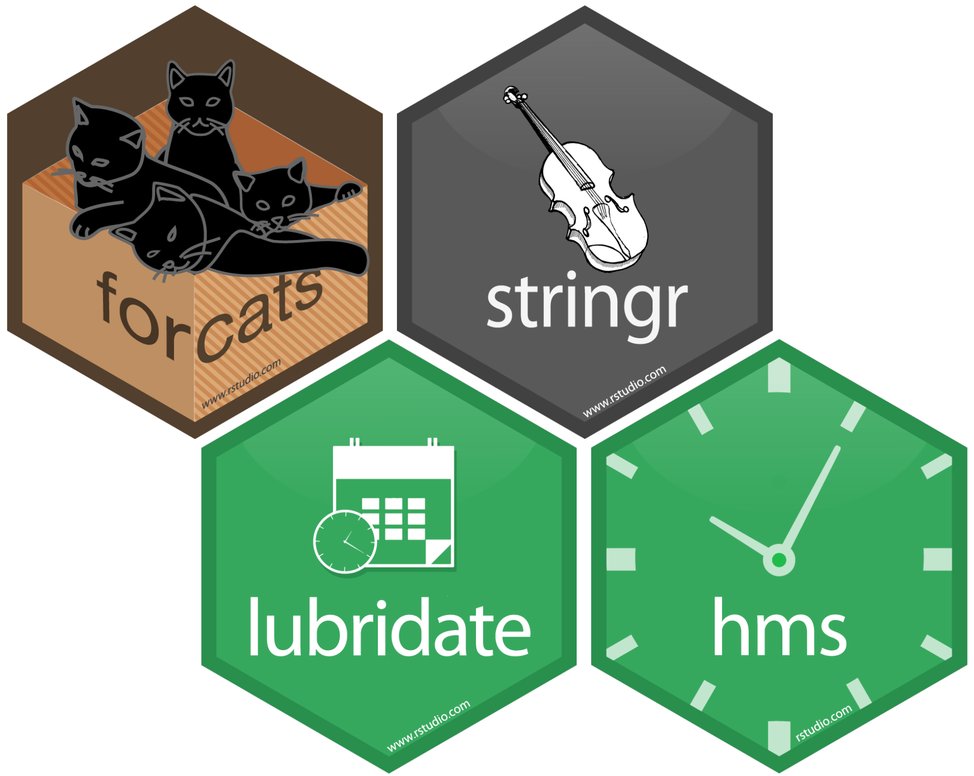
2017-01-01 **12:34:56**

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

Data Types


forcats
www.rstudio.com
stringr
www.rstudio.com
lubridate
www.rstudio.com
hms
rstudio.com