Categorical Variable How-to

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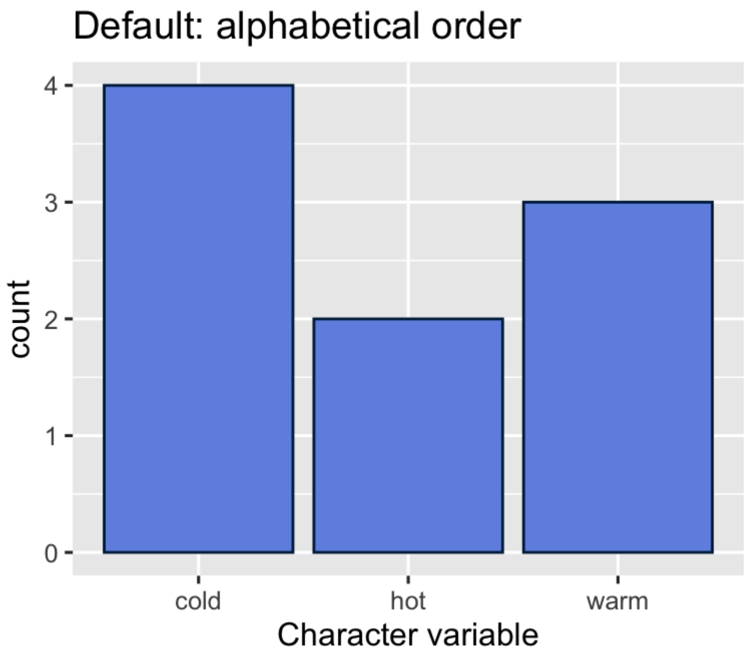
Character vs factor data

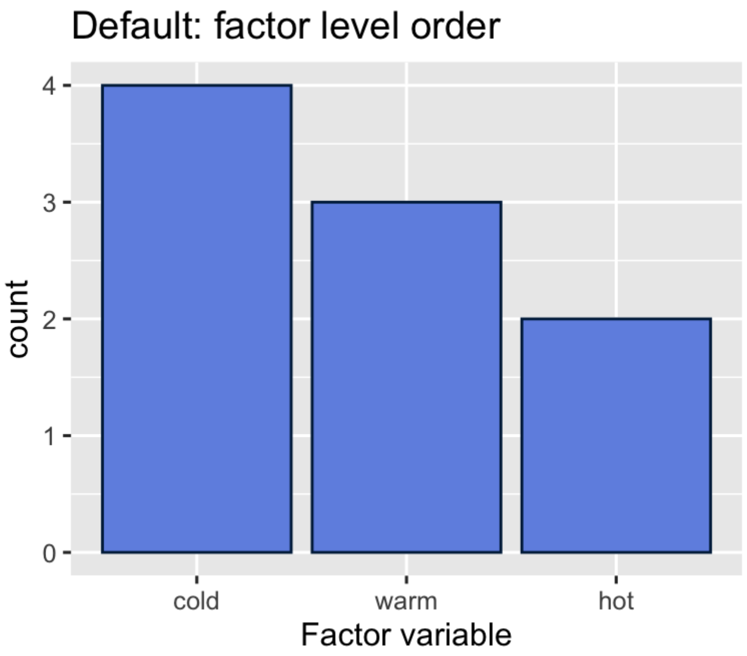
character data: plotted alphabetically

factor data: plotted in order of factor levels

```r
df <- tibble(chardata = c("cold", "warm", "hot", "hot", "warm", "warm", "cold", "cold", "cold"),
    factordata = factor(c("cold", "warm", "hot", "hot", "warm", "warm", "cold", "cold", "cold"),
                                 levels = c("cold", "warm", "hot")))
```



Default: alphabetical order



Default: factor level order

Recoding factor levels: don’t assign levels with `levels()`

Not the best approach

```
x <- factor(c("G234", "G452", "G136"))
levels(x)
```

```
## [1] "G136" "G234" "G452"
```

```
levels(x) <- c("Physics", "Math", "Chemistry")
x
```

```
## [1] Math      Chemistry Physics
## Levels: Physics Math Chemistry
```

Recoding factor levels

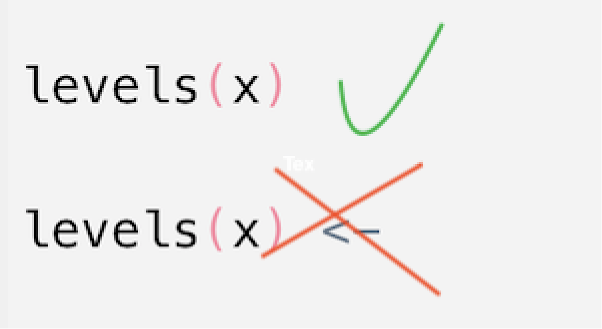
Not the best approach

```
x <- factor(c("G234", "G452", "G136"))
levels(x)
```

```
## [1] "G136" "G234" "G452"
```

```
levels(x) <- c("Physics", "Math", "Chemistry")
x
```

```
## [1] Math      Chemistry Physics
## Levels: Physics Math Chemistry
```



```
levels(x)
levels(x) <-
```

Recoding factor levels: `fct_recode()`

A better approach: Keep a trail of breadcrumbs

```r
x <- factor(c("G234", "G452", "G136"))
y <- fct_recode(x, Physics = "G234", Math = "G452", Chemistry = "G136")
y
```

```
## [1] Physics   Math      Chemistry
## Levels: Chemistry Physics Math
```

Binned data

```
df <- data.frame(quarter = factor(c("Q1", "Q2", "Q3", "Q4")),
                 sales = c(213, 125, 421, 315))
df
```

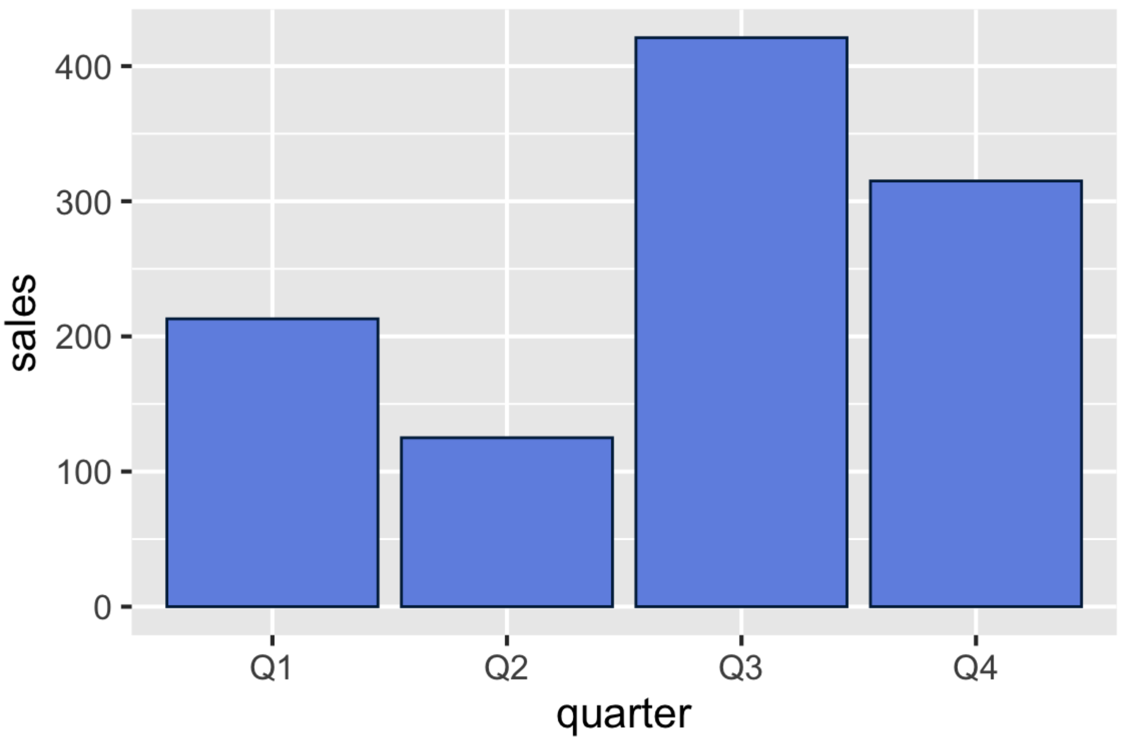
```
##   quarter sales
## 1      Q1   213
## 2      Q2   125
## 3      Q3   421
## 4      Q4   315
```

```
levels(df$quarter)
```

```
## [1] "Q1" "Q2" "Q3" "Q4"
```

Binned, ordinal data, correct level order

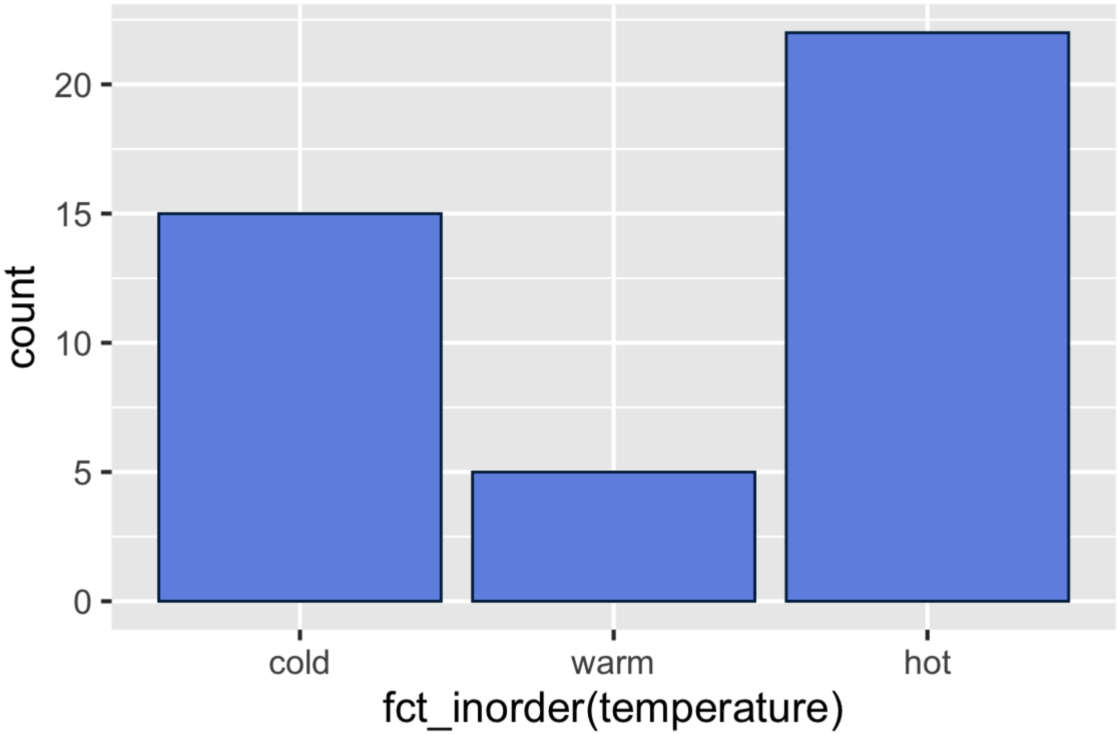
```
# reordering is not necessary
ggplot(df, aes(x = quarter, y = sales)) +
  geom_col(color = mycolor, fill= myfill) +
  theme_grey(16)
```



Binned, ordinal data, levels out of order

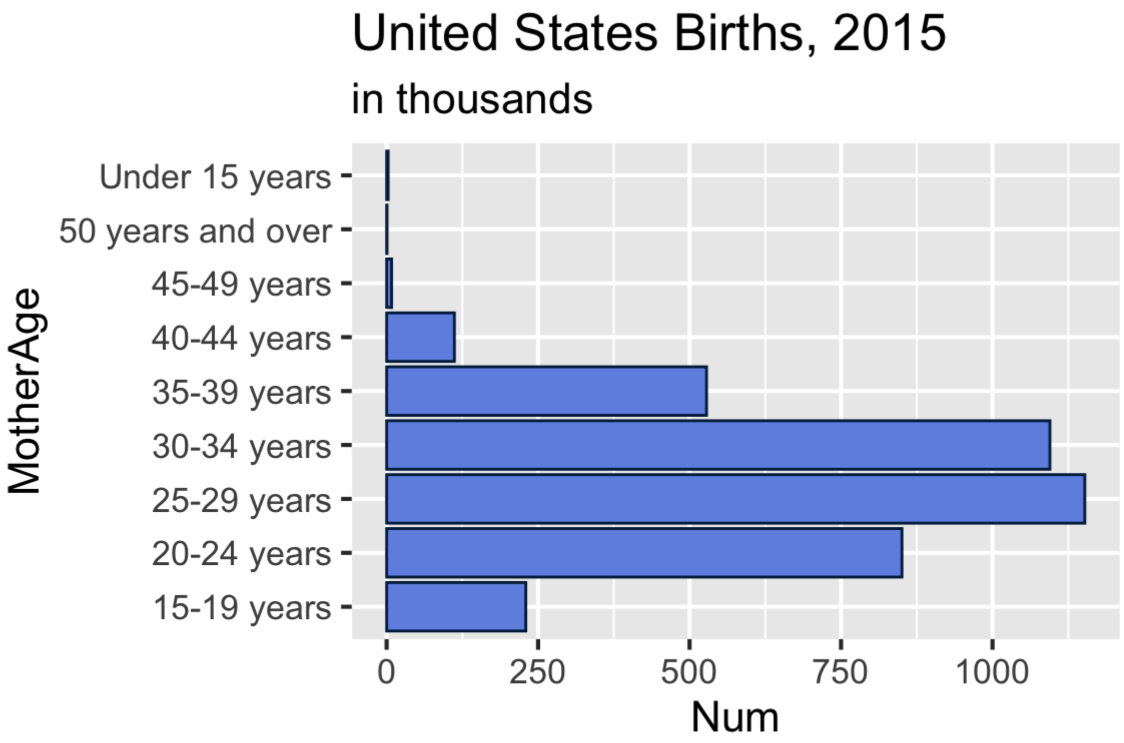
If the row order is correct, use `fct_inorder()`

```r
df <- data.frame(temperature = factor(c("cold", "warm", "hot")),
                 count = c(15, 5, 22))

# row order is correct (think: factor in ROW order)
ggplot(df, aes(x = fct_inorder(temperature), y = count)) +
  geom_col(color = mycolor, fill = myfill) +
  theme_grey(16)
```



Binned, ordinal data, levels out of order

```r
Births2015 <- tibble(MotherAge = c("15-19 years", "20-24 years", "25-29 years", "30-34 years", "35-39 years",
                                   "40-44 years", "45-49 years", "50 years and over", "Under 15 years"),
                     Num = c(229.715, 850.509, 1152.311, 1094.693, 527.996, 111.848, 8.171, .754, 2.5))

ggplot(Births2015, aes(MotherAge, Num)) +
  geom_col(color = mycolor, fill = myfill) +
  ggtitle("United States Births, 2015", subtitle = "in thousands") +
  scale_y_continuous(breaks = seq(0, 1250, 250)) +
  coord_flip() +
  theme_grey(16)
```

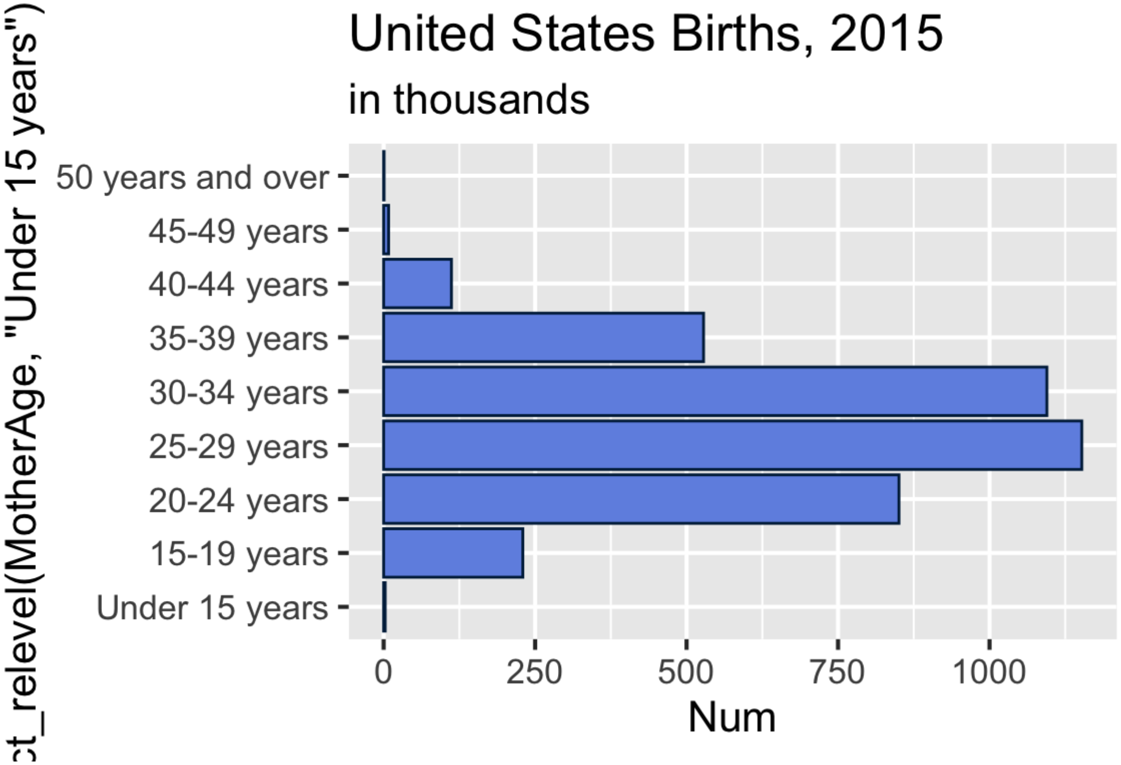


What’s the problem?

Binned, ordinal data, levels out of order

`fct_relevel()` can be used to set the correct order

```
ggplot(Births2015, aes(fct_relevel(MotherAge, "Under 15 years"), Num)) +
  ggtitle("United States Births, 2015", subtitle = "in thousands") +
  scale_y_continuous(breaks = seq(0, 1250, 250)) +
  geom_col(color = mycolor, fill = myfill) +
  coord_flip() +
  theme_grey(16)
```



Using `fct_relevel()` to move levels to the beginning

```r
x <- c("A", "B", "C", "move1", "D", "E", "move2", "F")

fct_relevel(x, "move1", "move2")
```

```
## [1] A      B      C      move1 D      E      move2 F
## Levels: move1 move2 A B C D E F
```

Using `fct_relevel()` to move levels after an item (by position)

```r
x <- c("A", "B", "C", "move1", "D", "E", "move2", "F")

fct_relevel(x, "move1", "move2", after = 4) # move after the fourth item
```

```
## [1] A     B     C     move1 D     E     move2 F    
## Levels: A B C D move1 move2 E F
```

Using `fct_relevel()` to move levels to the end

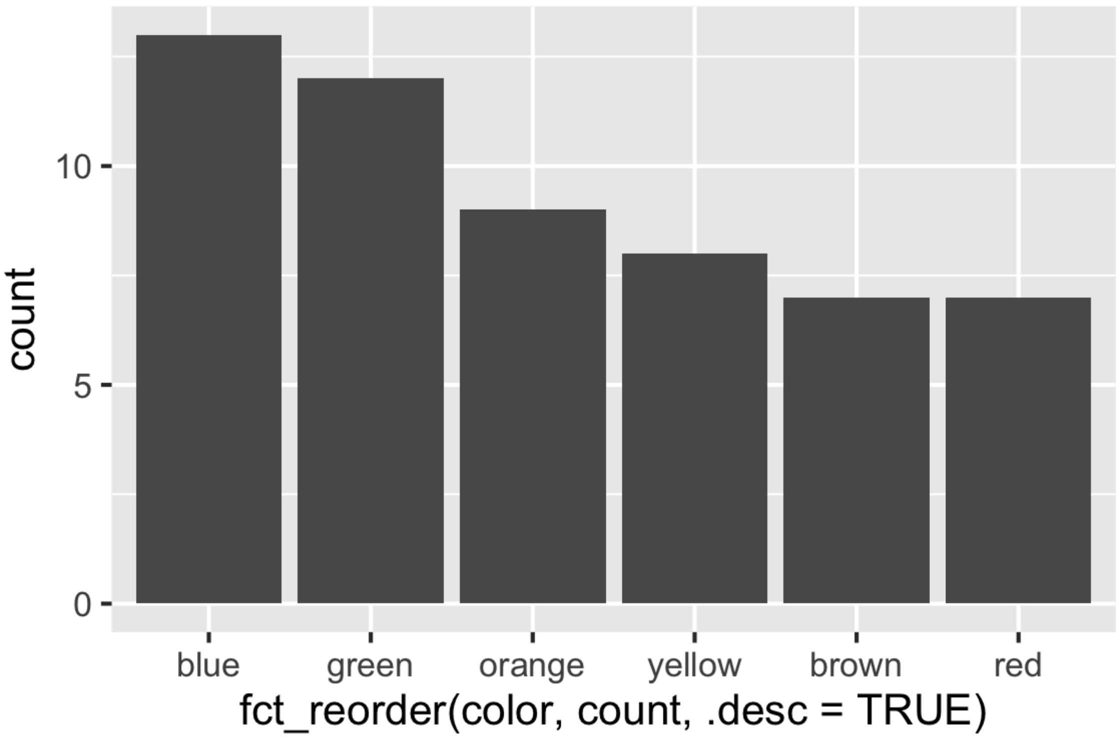
```r
x <- c("A", "B", "C", "move1", "D", "E", "move2", "F")

fct_relevel(x, "move1", "move2", after = Inf)
```

```
## [1] A     B     C     move1 D     E     move2 F
## Levels: A B C D E F move1 move2
```

Binned, nominal

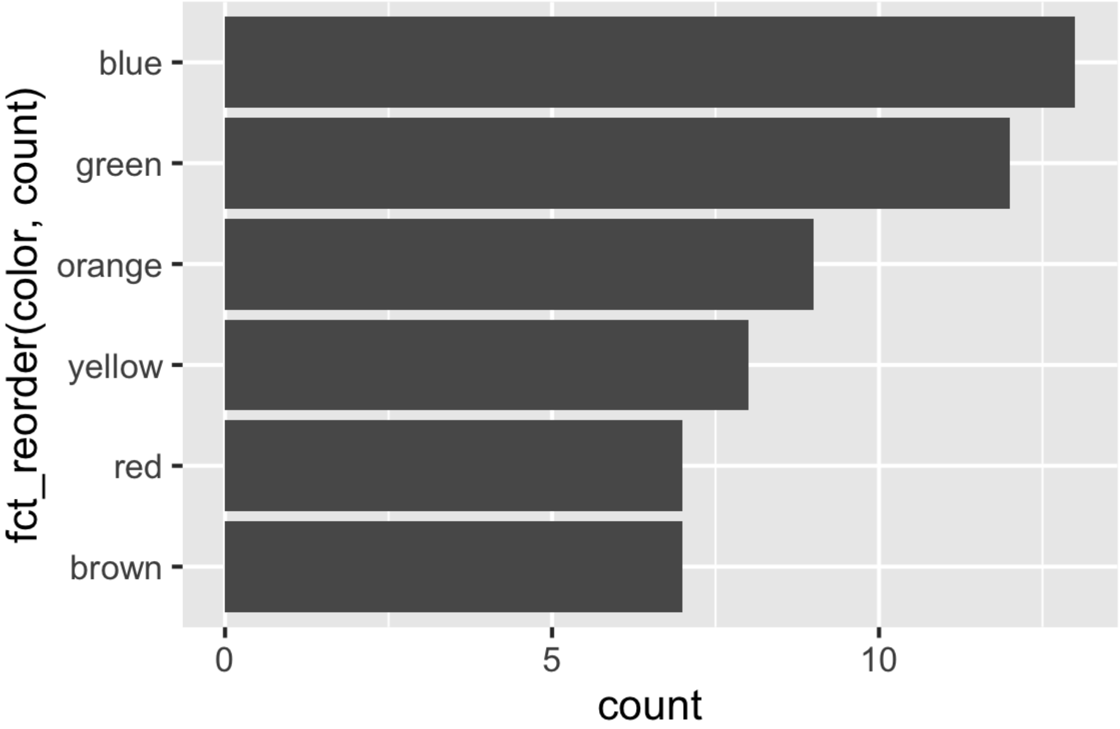
Order bars by frequency count using `fct_reorder()` (or `reorder()`)

```r
pack1 <- data.frame(
  color = c("blue", "brown", "green", "orange", "red", "yellow"),
  count = c(13, 7, 12, 9, 7, 8)
)

ggplot(pack1, aes(fct_reorder(color, count, .desc = TRUE), count)) +
  geom_col() +
  theme_grey(16)
```



Binned, nominal (horizontal bars)

```
ggplot(pack1, aes(fct_reorder(color, count), count)) +
  geom_col() +
  coord_flip() +
  theme_grey(16)
```



Unbinned, ordinal, correct level order

```
# data available here: https://github.com/jtr13/data
student <- read.csv("student_data.csv", stringsAsFactors = TRUE)
head(student)
```

```
##   School Level Affiliation
## 1     CC   U01      CCUNDC
## 2     CC   U01      CCUNDC
## 3     CC   U01      CCUNDC
## 4     CC   U01      CCUNDC
## 5     CC   U01      CCUNDC
## 6     GS   U03      GSUNDC
```

```
levels(student$Level)
```

```
## [1] "U00" "U01" "U02" "U03" "U04" "U05"
```

Unbinned, ordinal, correct level order

```r
# data available here: https://github.com/jtr13/data
student <- read.csv("student_data.csv", stringsAsFactors = TRUE)
head(student)
```

```
##   School Level Affiliation
## 1     CC   U01      CCUNDC
## 2     CC   U01      CCUNDC
## 3     CC   U01      CCUNDC
## 4     CC   U01      CCUNDC
## 5     CC   U01      CCUNDC
## 6     GS   U03      GSUNDC
```

```r
levels(student$Level)
```

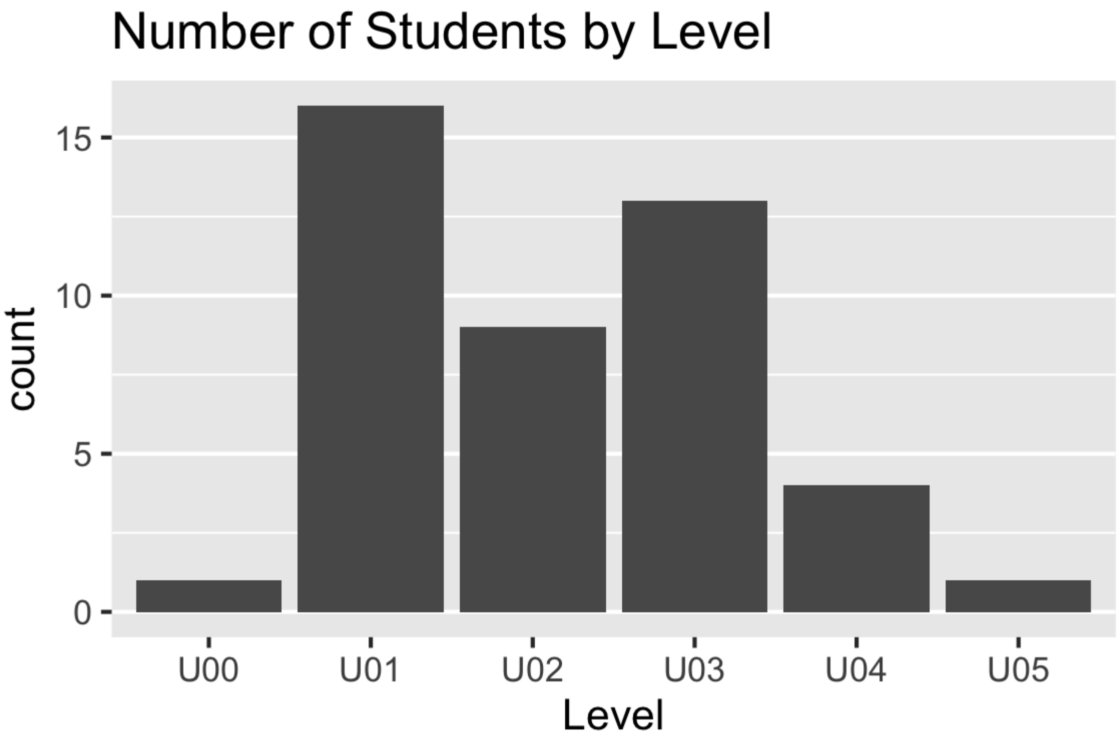
```
## [1] "U00" "U01" "U02" "U03" "U04" "U05"
```

```r
emo::ji("loudly crying face")
```

```
## 😭
```

Unbinned, ordinal, correct level order

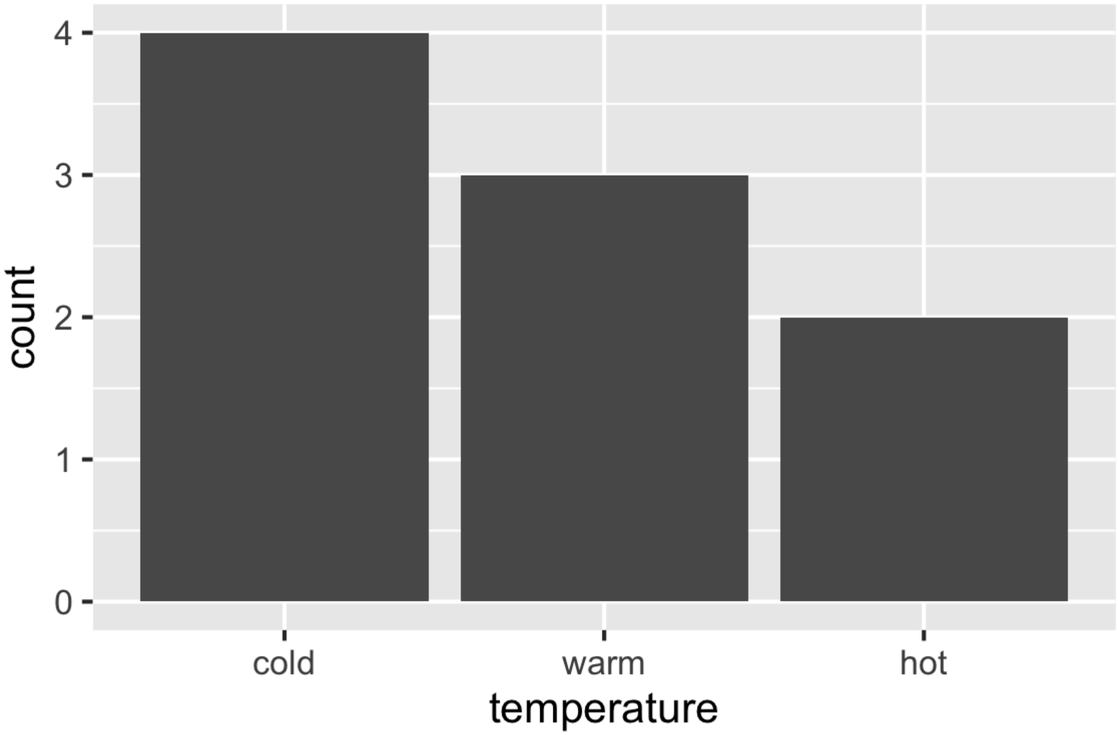
```
ggplot(student, aes(Level)) +
  geom_bar()  +
  ggtitle("Number of Students by Level") +
  theme_grey(16) +
  theme(panel.grid.major.x = element_blank())
```



Unbinned, ordinal, levels out of order

Use `fct_relevel()` (as with binned, ordinal data)

```r
df <- tibble(temperature = factor(c("cold", "warm", "hot", "hot", "warm",
                                    "warm", "cold", "cold", "cold")))
df %>%
  mutate(temperature = fct_relevel(temperature, "warm", after = 1)) %>%
  ggplot(aes(temperature)) +
  geom_bar() +
  theme_grey(16)
```



Unbinned, nominal data

```
dim(df)
```

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

```
head(df, 10)
```

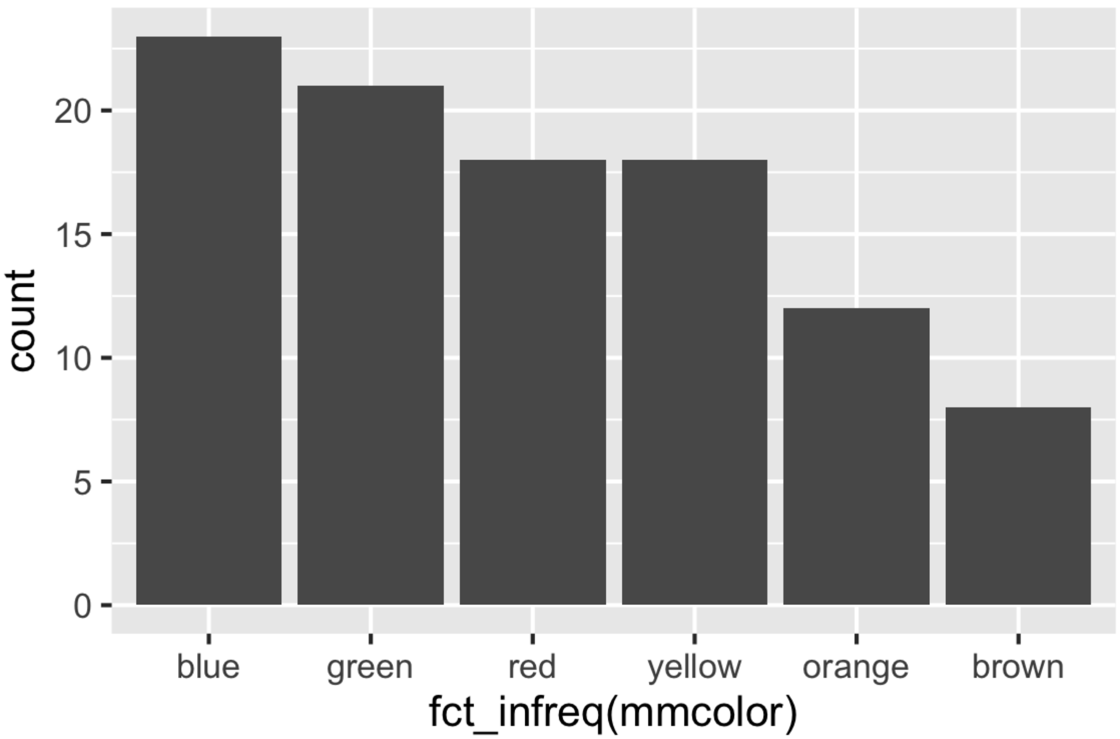
```
##    mmcolor
## 1      red
## 2    green
## 3   yellow
## 4      red
## 5    green
## 6     blue
## 7    green
## 8    green
## 9    brown
## 10     red
```

Unbinned, nominal data

`fct_infreq()` (default is decreasing order of frequency)

Vertical bars:

```
ggplot(df, aes(fct_infreq(mmcolor))) +
  geom_bar() +
  theme_grey(16)
```

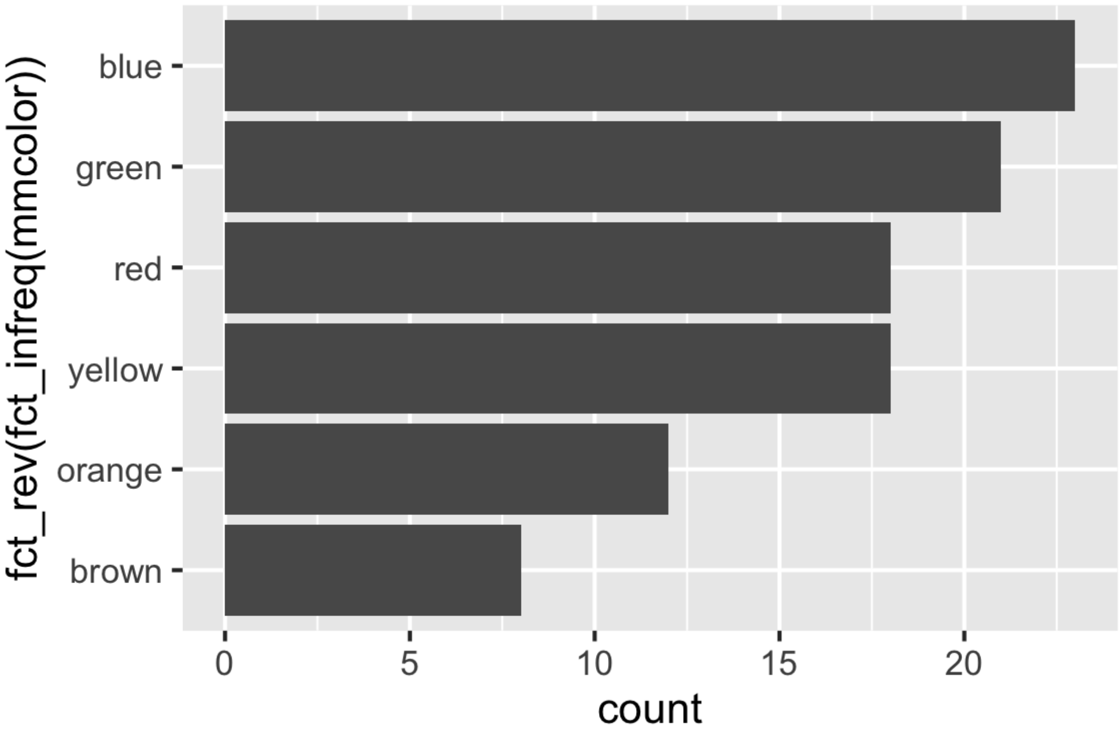


Unbinned, nominal data

`fct_rev(fct_infreq())`

Horizontal bars:

```
ggplot(df, aes(fct_rev(fct_infreq(mmcolor)))) +
  geom_bar() +
  coord_flip() +
  theme_grey(16)
```



Summary of useful **forcats** functions

`fct_recode(x, ...)` – change names of levels

`fct_inorder(x)` – set level order of `x` to row order

`fct_relevel(x, ...)` – manually set the order of levels of `x`

`fct_reorder(x, y)` – reorder `x` by `y`

`fct_infreq(x)` – order the levels of `x` by decreasing frequency

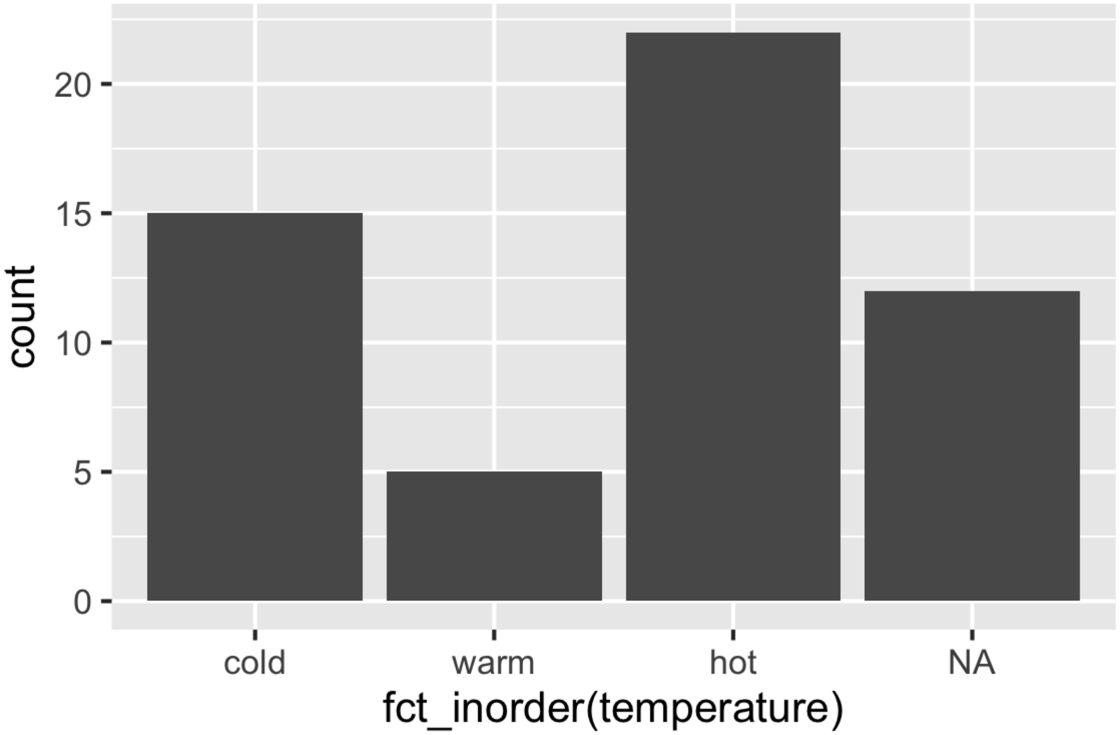
`fct_rev(x)` – reverse the order of factor levels of `x`

coming up:

`fct_explicit_na(x)` – turn NAs into a real factor level

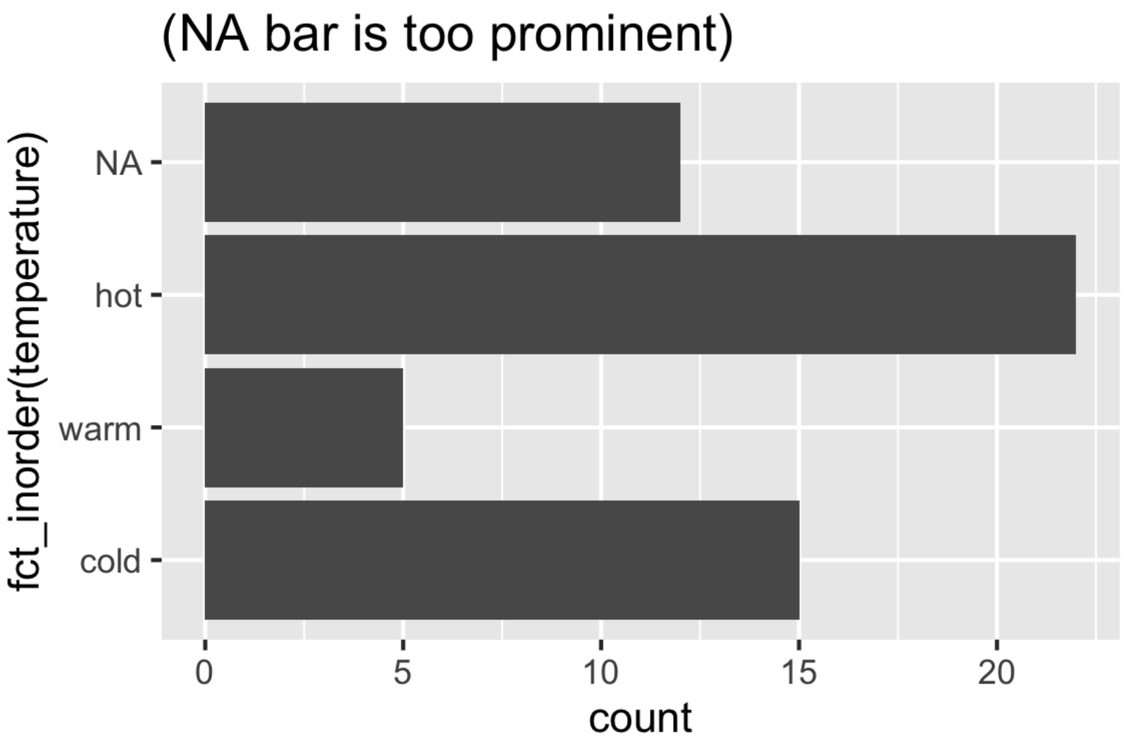
Dealing with NAs

```r
df <- data.frame(temperature = factor(c("cold", "warm", "hot", NA)),
                 count = c(15, 5, 22, 12))

ggplot(df, aes(x = fct_inorder(temperature), y = count)) +
  geom_col() +
  theme_grey(16)
```



Dealing with NAs

```r
df <- data.frame(temperature = factor(c("cold", "warm", "hot", NA)),
                 count = c(15, 5, 22, 12))

ggplot(df, aes(x = fct_inorder(temperature), y = count)) +
  geom_col() +
  coord_flip() +
  ggtitle("(NA bar is too prominent)") +
  theme_grey(16)
```



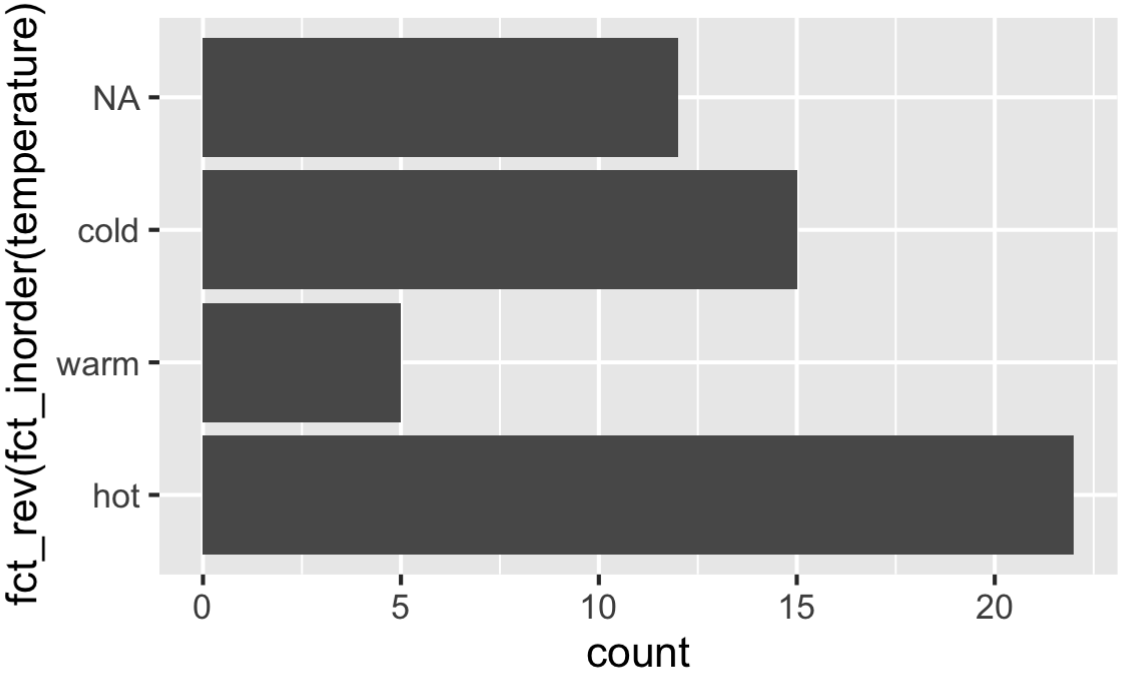
Dealing with NAs

```
df <- data.frame(temperature = factor(c("cold", "warm", "hot", NA)),
                 count = c(15, 5, 22, 12))
df
```

```
##   temperature count
## 1        cold    15
## 2        warm     5
## 3         hot    22
## 4        <NA>    12
```

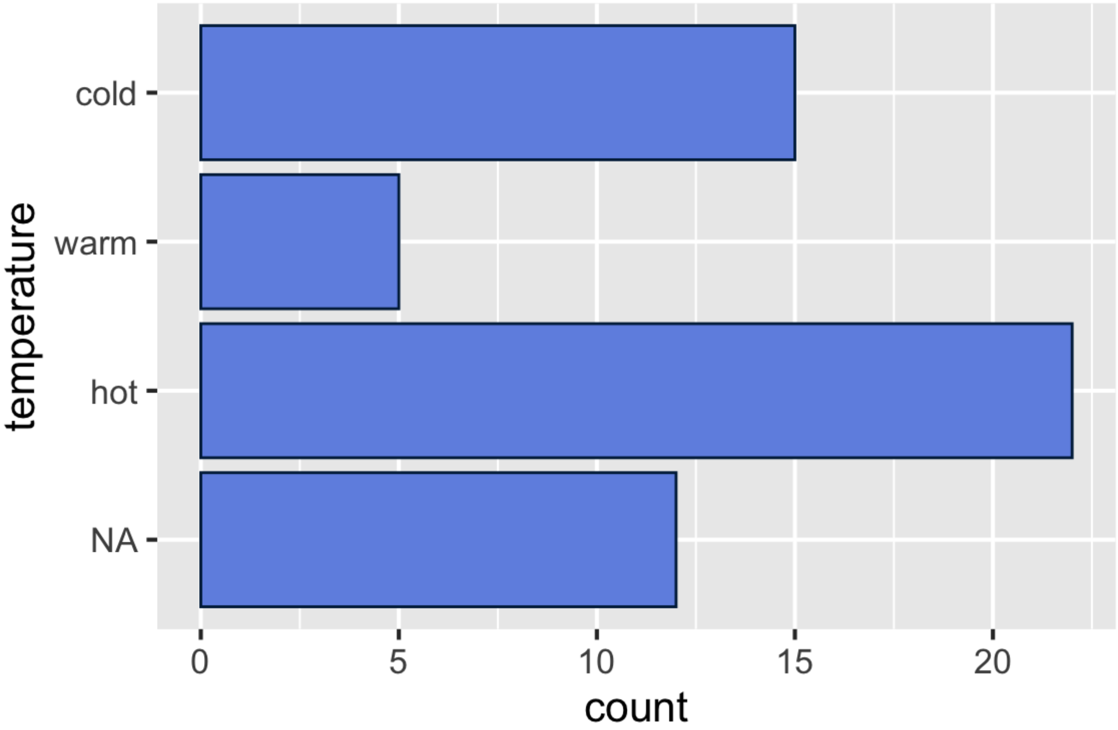
```
ggplot(df, aes(x = fct_rev(fct_inorder(temperature)), y = count)) +
  geom_col() +
  coord_flip() +
  ggtitle("(Reversing the factor levels doesn't help.)") +
  theme_grey(16)
```

(Reversing the factor levels doesn't help.)



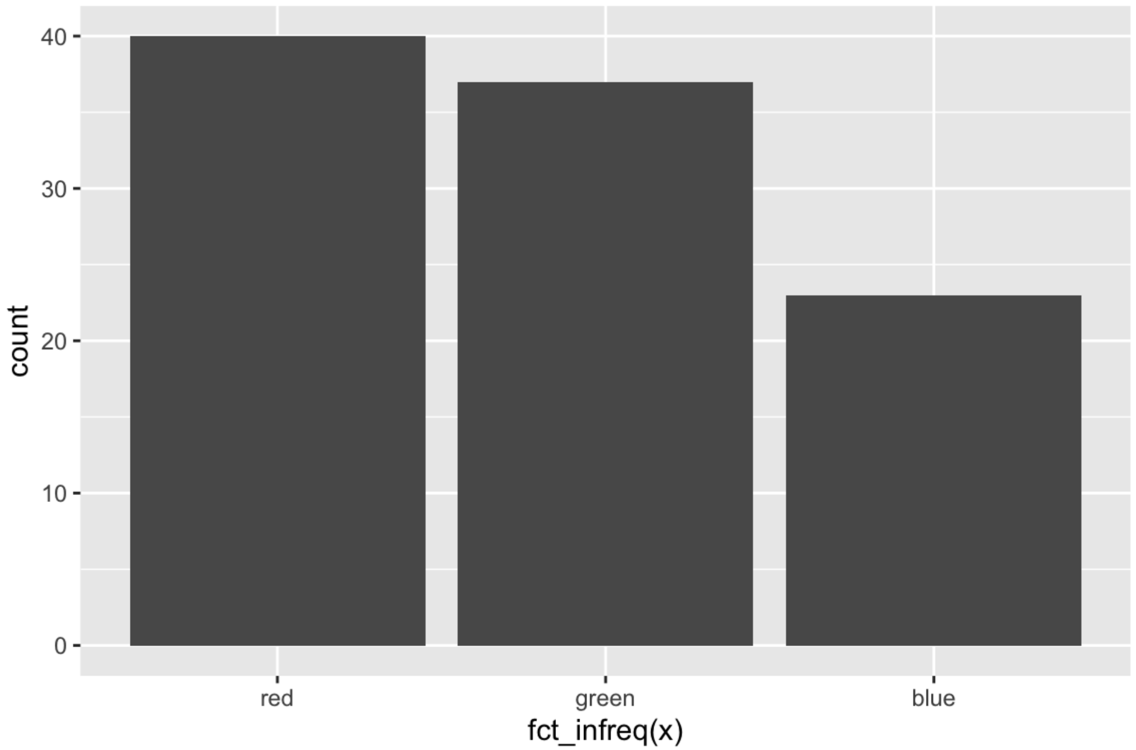
Dealing with NAs

```
df <- data.frame(temperature = factor(c("cold", "warm", "hot", NA)),
                 count = c(15, 5, 22, 12))

df %>%
  mutate(temperature = fct_explicit_na(temperature, "NA") %>%
           fct_relevel("NA", "hot", "warm", "cold")) %>%
  ggplot(aes(x = temperature, y = count)) +
  geom_col(color = mycolor, fill = myfill) +
  coord_flip() +
  theme_grey(16)
```



Binning

```
df <- data.frame(x = sample(c("red", "green", "blue"), 100, replace = TRUE))

ggplot(df, aes(fct_infreq(x))) + geom_bar()
```



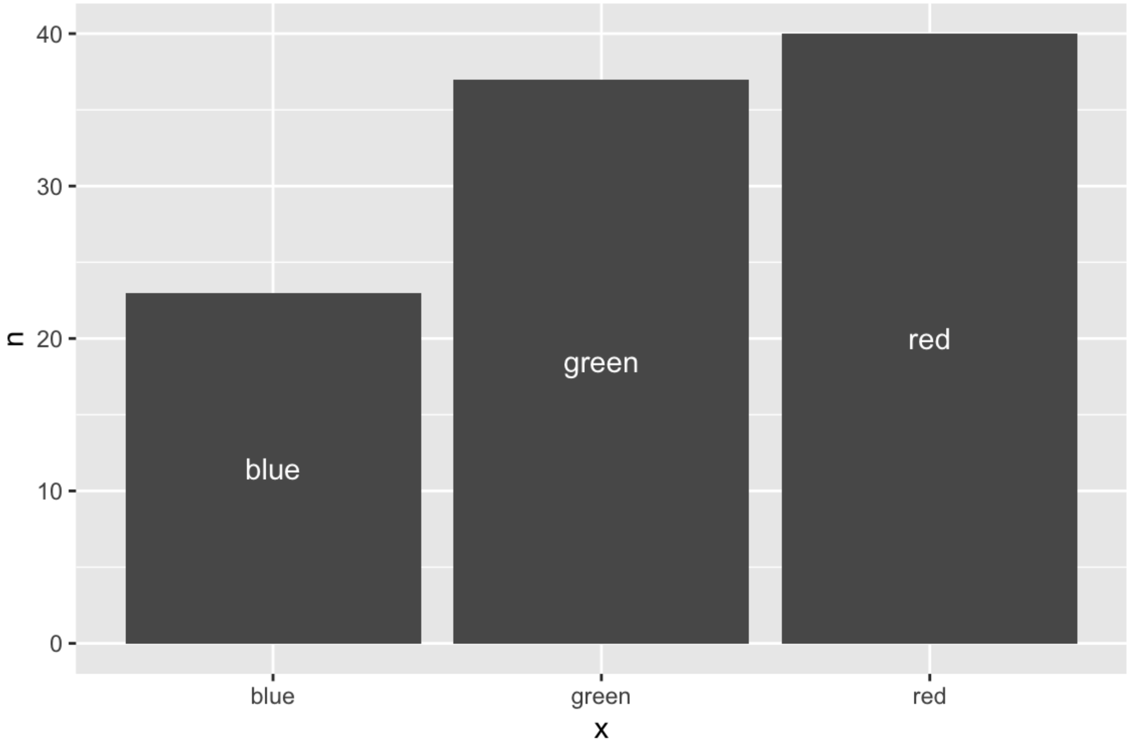
```
df %>% group_by(x) %>% summarize(n = n())
```

```
## # A tibble: 3 × 2
##   x         n
##   <chr> <int>
## 1 blue     23
## 2 green    37
## 3 red      40
```

```
binned_df <- df %>% count(x)

binned_df
```

```
##       x  n
## 1  blue 23
## 2 green 37
## 3   red 40
```

```
ggplot(binned_df, aes(x = x, y = n, label = x)) +
  geom_col() +
  geom_text(aes(y = n/2), col = "white")
```

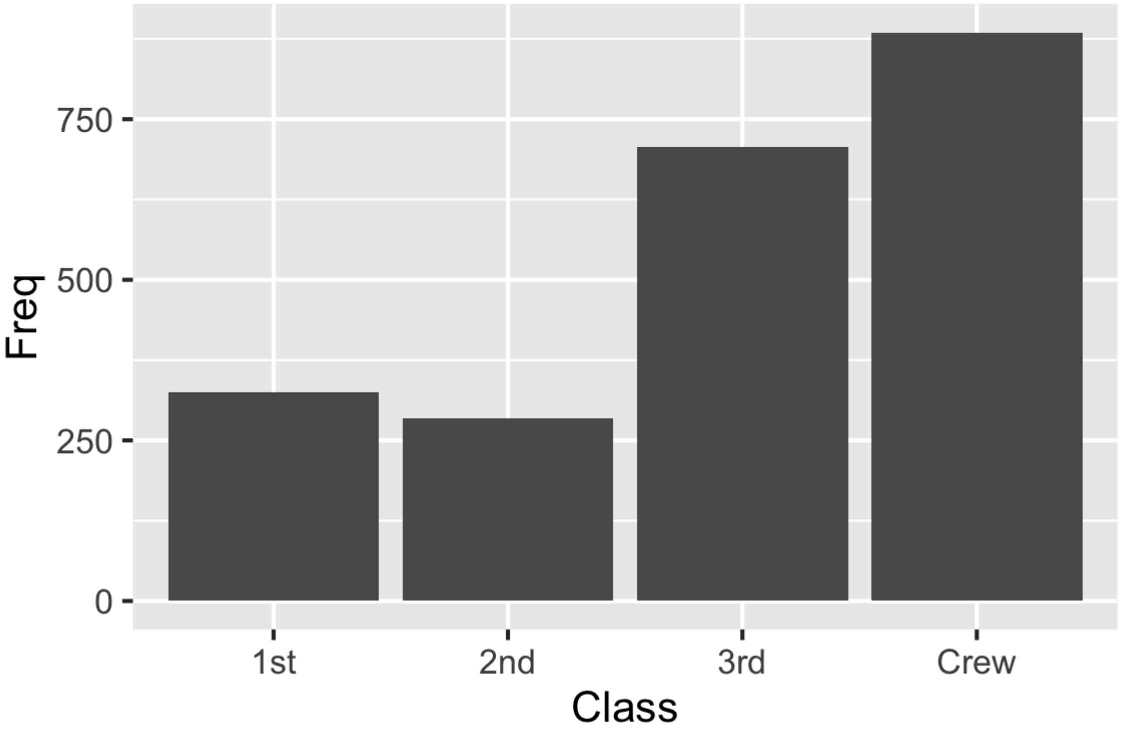


Rebinning

```
df <- as.data.frame(Titanic)
head(df)
```

```
##   Class    Sex   Age Survived Freq
## 1   1st   Male Child       No    0
## 2   2nd   Male Child       No    0
## 3   3rd   Male Child       No   35
## 4  Crew   Male Child       No    0
## 5   1st Female Child       No    0
## 6   2nd Female Child       No    0
```

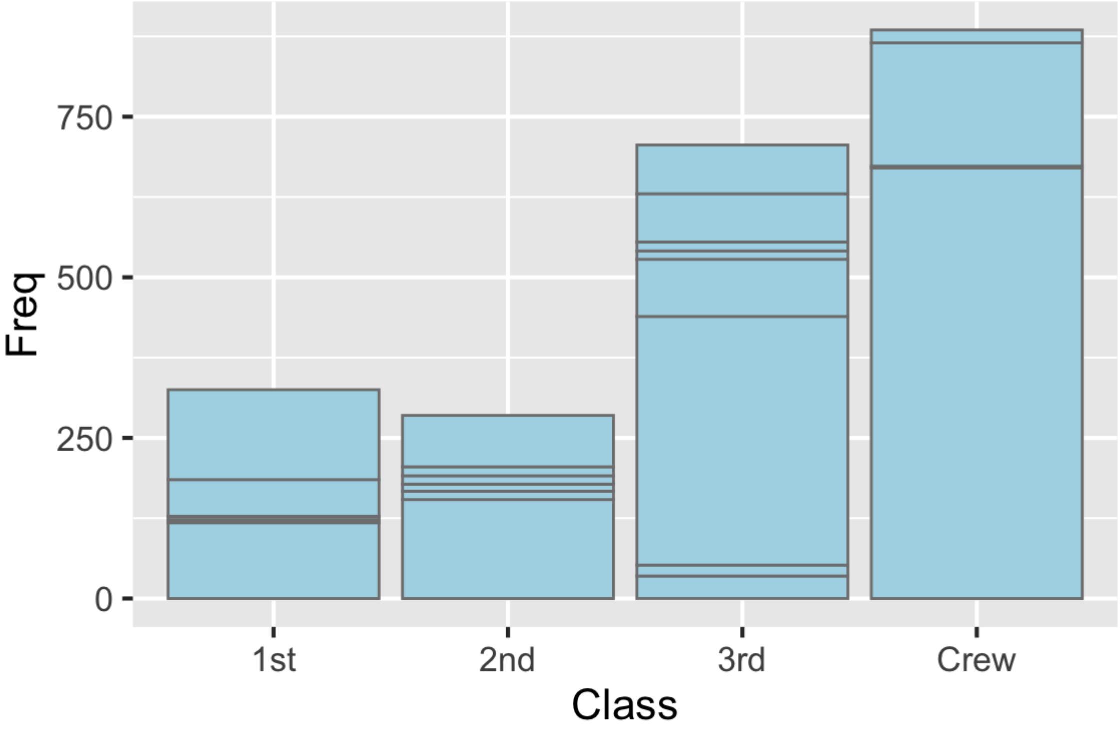
```
ggplot(df, aes(Class, Freq)) +
  geom_col() +
  theme_grey(16)
```


Freq
750
500
250
0
1st
2nd
3rd
Crew
Class

Rebinning

The problem:

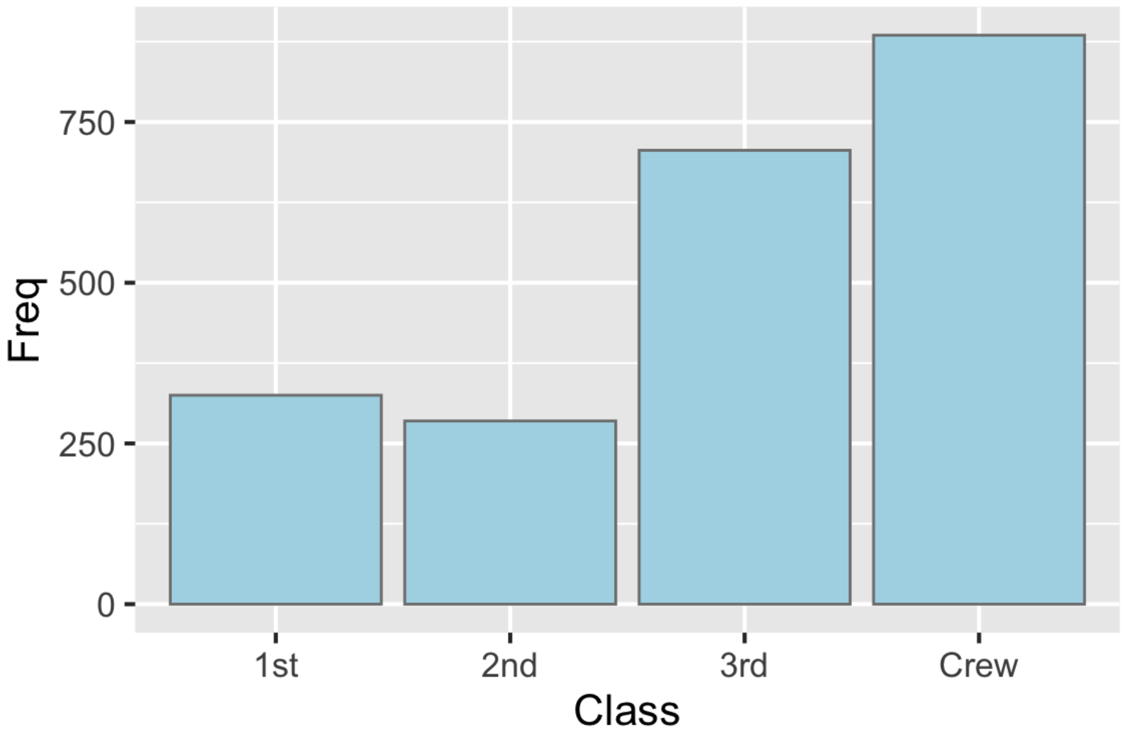
```
ggplot(df, aes(Class, Freq)) +
  geom_col(color = "grey50", fill = "lightblue") +
  theme_grey(16)
```



Rebinning

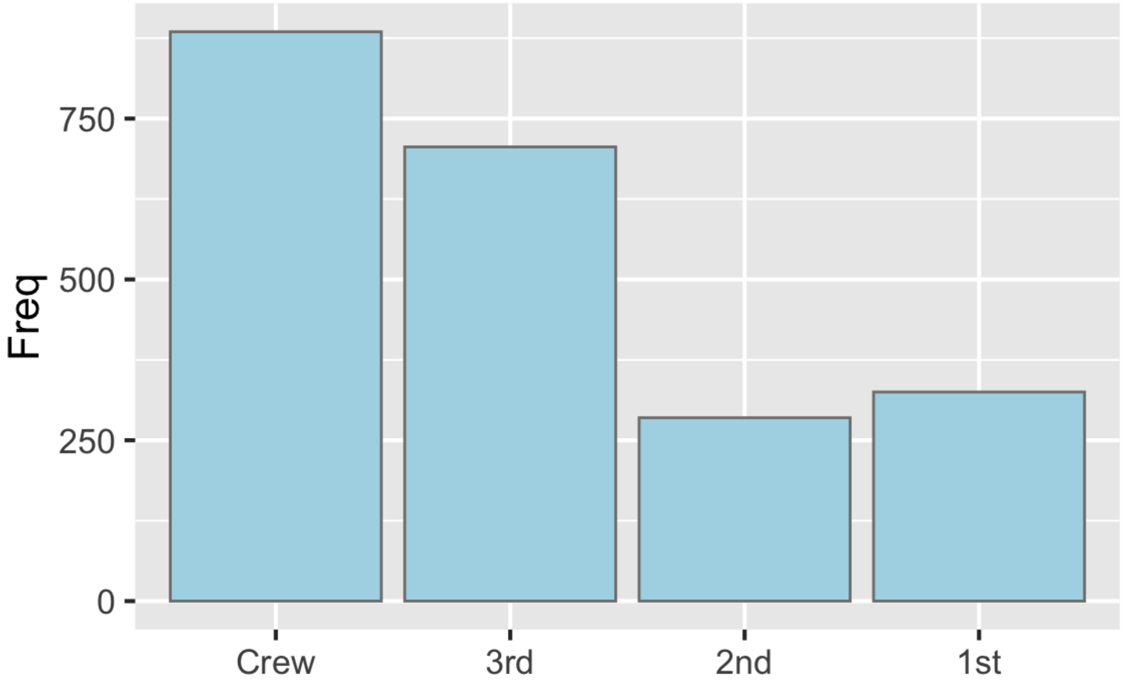
Rebin:

```
df %>%
  group_by(Class) %>%
  summarize(Freq = sum(Freq)) %>%
  ggplot(aes(Class, Freq)) +
  geom_col(color = "grey50", fill = "lightblue") +
  theme_grey(16)
```



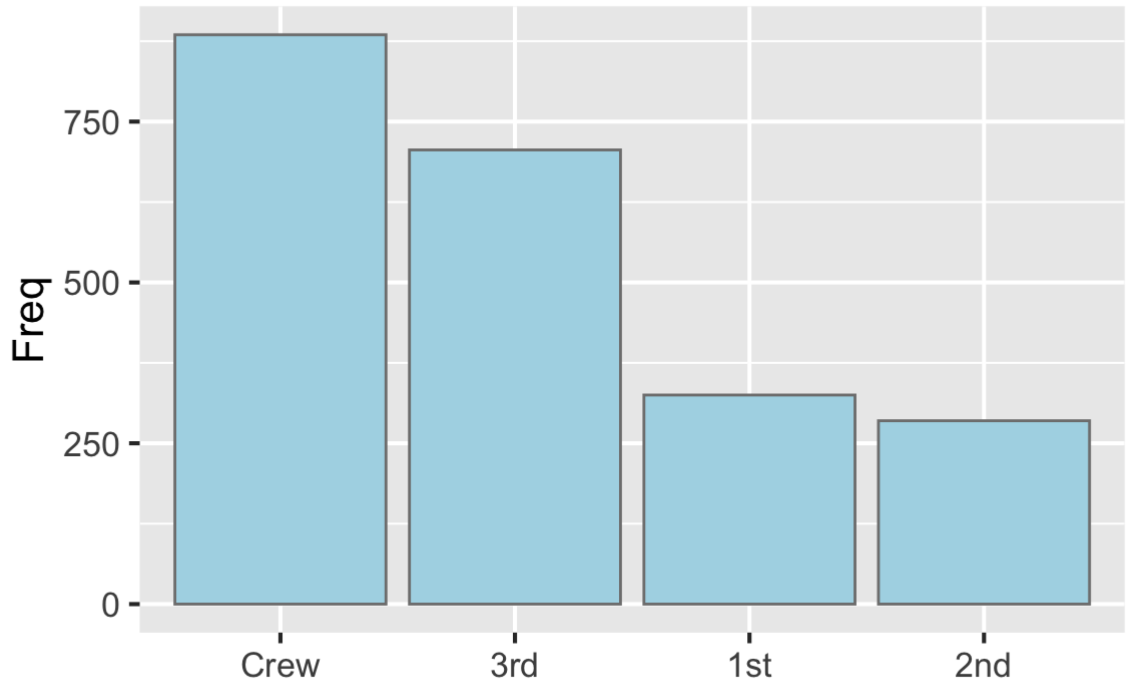
Natural order bias?

```
df %>%
  group_by(Class) %>%
  summarize(Freq = sum(Freq)) %>%
  ggplot(aes(fct_rev(Class), Freq)) +
  geom_col(color = "grey50", fill = "lightblue") +
  xlab("") +
  theme_grey(16)
```



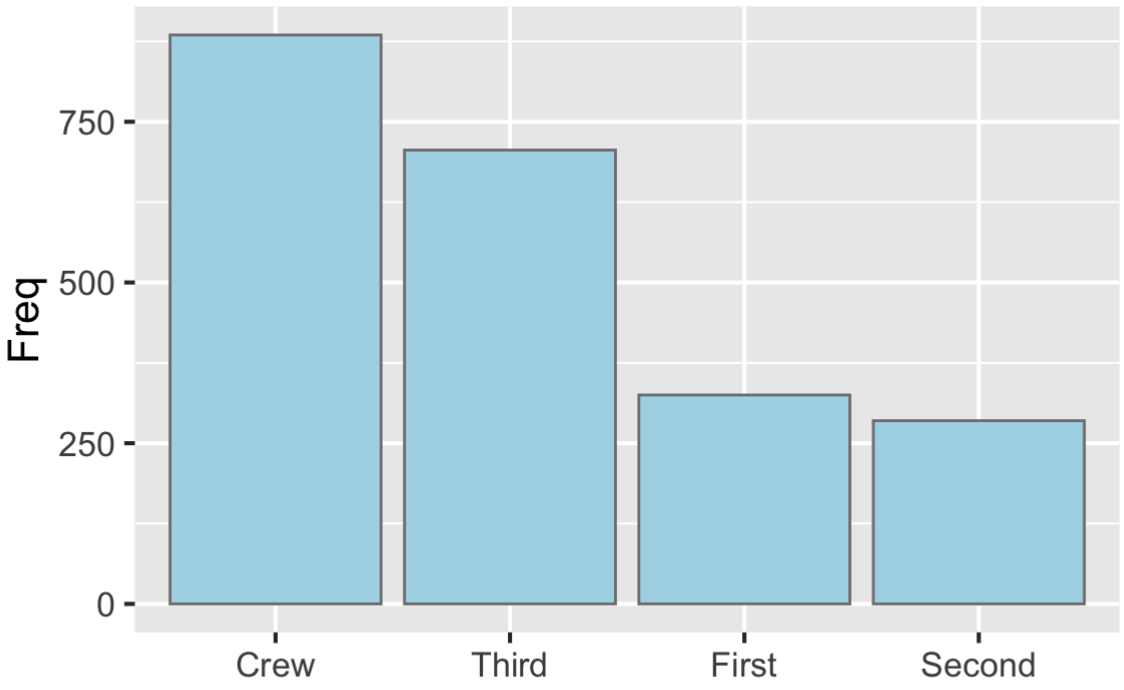
Is `Class` ordinal or nominal?

```r
df %>%
  group_by(Class) %>%
  summarize(Freq = sum(Freq)) %>%
  ggplot(aes(fct_reorder(Class, Freq, .desc = TRUE), Freq)) +
  geom_col(color = "grey50", fill = "lightblue") +
  xlab("") +
  theme_grey(16)
```



Is `Class` ordinal or nominal?

```r
df %>%
  mutate(Class = fct_recode(Class, Third = "3rd", First = "1st", Second = "2nd")) %>%
  group_by(Class) %>%
  summarize(Freq = sum(Freq)) %>%
  ggplot(aes(fct_reorder(Class, Freq, .desc = TRUE), Freq)) +
  geom_col(color = "grey50", fill = "lightblue") + xlab("") +
  theme_grey(16)
```



Percentages

```
df %>%
  group_by(Class) %>%
  summarize(Freq = sum(Freq)) %>%
  mutate(prop = Freq/sum(Freq))
```

```
## # A tibble: 4 × 3
##   Class  Freq  prop
##   <fct> <dbl> <dbl>
## 1 1st     325 0.148
## 2 2nd     285 0.129
## 3 3rd     706 0.321
## 4 Crew    885 0.402
```

Percentages, more than one group

Rebin first:

```
df2 <- df %>%
  group_by(Class, Survived) %>%
  summarize(Freq = sum(Freq)) %>%
  ungroup()  # very important
df2
```

```
## # A tibble: 8 × 3
##   Class Survived  Freq
##   <fct> <fct>    <dbl>
## 1 1st   No         122
## 2 1st   Yes        203
## 3 2nd   No         167
## 4 2nd   Yes        118
## 5 3rd   No         528
## 6 3rd   Yes        178
## 7 Crew  No         673
## 8 Crew  Yes        212
```

Percentages, more than one group

Overall percentages:

```
df2 %>%
  mutate(prop = Freq/sum(Freq))
```

```
## # A tibble: 8 × 4
##   Class Survived  Freq   prop
##   <fct> <fct>    <dbl>  <dbl>
## 1 1st   No         122 0.0554
## 2 1st   Yes        203 0.0922
## 3 2nd   No         167 0.0759
## 4 2nd   Yes        118 0.0536
## 5 3rd   No         528 0.240
## 6 3rd   Yes        178 0.0809
## 7 Crew  No         673 0.306
## 8 Crew  Yes        212 0.0963
```

Percentages, more than one group

Proportions for each `Class` sum to 1:

```
df2 %>%
  group_by(Class) %>%
  mutate(prop = Freq/sum(Freq)) %>%
  ungroup()
```

```
## # A tibble: 8 × 4
##   Class Survived  Freq  prop
##   <fct> <fct>    <dbl> <dbl>
## 1 1st   No         122 0.375
## 2 1st   Yes        203 0.625
## 3 2nd   No         167 0.586
## 4 2nd   Yes        118 0.414
## 5 3rd   No         528 0.748
## 6 3rd   Yes        178 0.252
## 7 Crew  No         673 0.760
## 8 Crew  Yes        212 0.240
```

Proportions for each level of `Survived` sum to 1:

```
df2 %>%
  # (arrange reorders the rows for viewing)
  arrange(Survived) %>%
  group_by(Survived) %>%
  mutate(prop = Freq/sum(Freq)) %>%
  ungroup()
```

```
## # A tibble: 8 × 4
##   Class Survived  Freq   prop
##   <fct> <fct>    <dbl>  <dbl>
## 1 1st   No         122 0.0819
## 2 2nd   No         167 0.112
## 3 3rd   No         528 0.354
## 4 Crew  No         673 0.452
## 5 1st   Yes        203 0.286
## 6 2nd   Yes        118 0.166
## 7 3rd   Yes        178 0.250
## 8 Crew  Yes        212 0.298
```

Percentages, more than one group

shortcut method (be careful!)

```
df %>%
  group_by(Class, Survived) %>%    # grouped by Class, Survived
  summarize(Freq = sum(Freq)) %>%    # grouped by Class only
  mutate(prop = Freq/sum(Freq)) %>%
  ungroup()
```

```
## # A tibble: 8 × 4
##   Class Survived  Freq  prop
##   <fct> <fct>    <dbl> <dbl>
## 1 1st   No         122 0.375
## 2 1st   Yes        203 0.625
## 3 2nd   No         167 0.586
## 4 2nd   Yes        118 0.414
## 5 3rd   No         528 0.748
## 6 3rd   Yes        178 0.252
## 7 Crew  No         673 0.760
## 8 Crew  Yes        212 0.240
```

`summarize()` removes the last group

```
groups(df)
```

```
## list()
```

```
df %>% group_by(Class, Survived) %>% groups()
```

```
## [[1]]
## Class
##
## [[2]]
## Survived
```

```
df %>% group_by(Class, Survived) %>% summarize(Freq = sum(Freq)) %>% groups()
```

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

Percentages, more than one group

shortcut method (be careful!)

```
df %>%
  group_by(Survived, Class) %>%    # grouped by Survived, Class ORDER MATTERS
  summarize(Freq = sum(Freq)) %>%    # grouped by Survived only
  mutate(prop = Freq/sum(Freq)) %>%
  ungroup()
```

```
## # A tibble: 8 × 4
##   Survived Class  Freq   prop
##   <fct>    <fct> <dbl>  <dbl>
## 1 No       1st     122 0.0819
## 2 No       2nd     167 0.112
## 3 No       3rd     528 0.354
## 4 No       Crew    673 0.452
## 5 Yes      1st     203 0.286
## 6 Yes      2nd     118 0.166
## 7 Yes      3rd     178 0.250
## 8 Yes      Crew    212 0.298
```