Working with factors in R

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Today's class is working with a very important component of R - factors.

Worksheet

Link to cm012 worksheet file.

Resources

References and tutorials

- Jenny Bryan's notes on factors

Package documentation

- forcats package

Load the required libraries. You might need to install library `forcats` first (install.packages("forcats"))

```
library(gapminder)
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.6     v dplyr   1.0.7
## v tidyr   1.1.4     v stringr 1.4.0
## v readr   2.1.1     v forcats 0.5.1
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(dplyr)
library(forcats)
library(ggplot2)
```

Recap of CM011

Outline of last lecture lecture

- here package
- read/write_csv (and friends)
- read_excel() function from readxl package
- data processing and importing

Motivating the need for factors in R

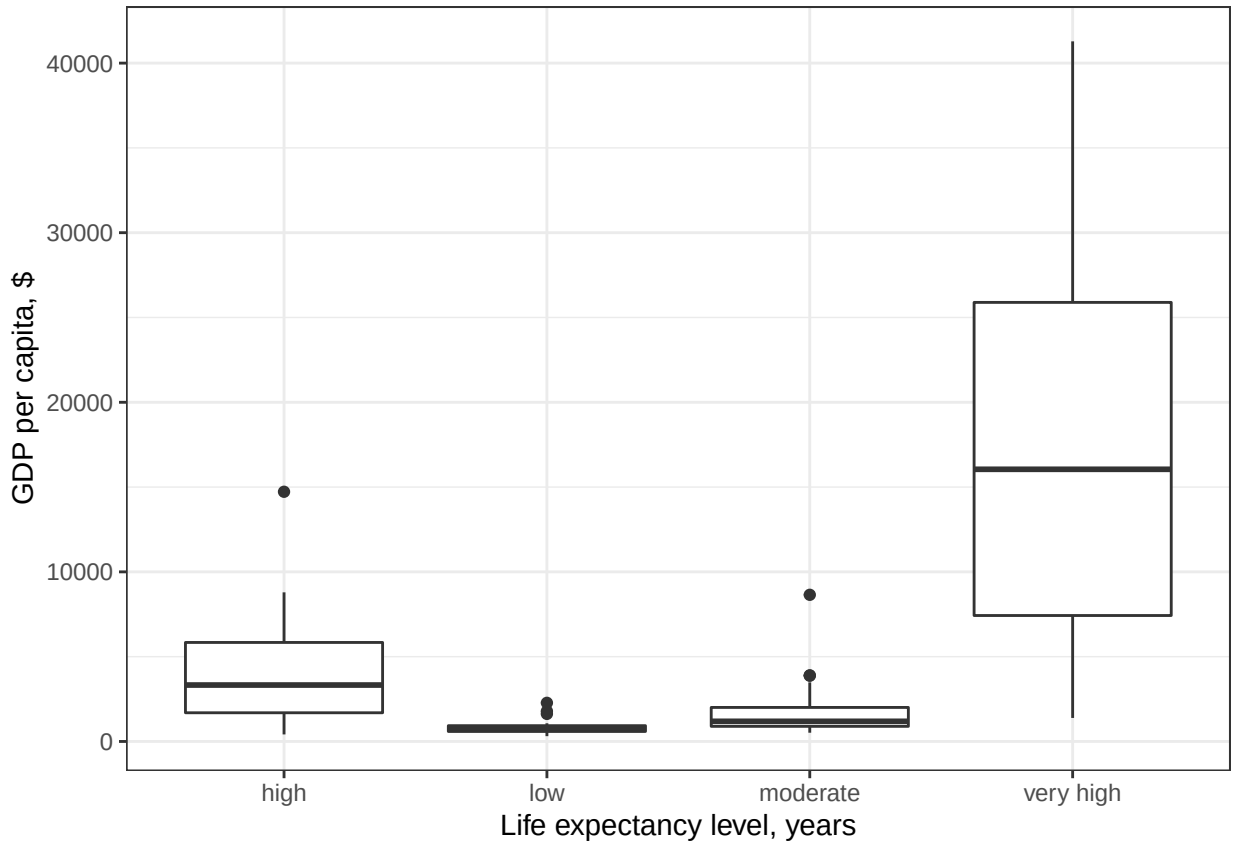
Activity 1: Using Factors for plotting

1.1 Let's look again into `gapminder` dataset and create a new cloumn, `life_level`, that contains five categories ("very high", "high","moderate", "low" and "very low") based on life expectancy in 1997. Assign categories accoring to the table below:

Criteria	life_level
less than 23	very low
between 23 and 48	low
between 48 and 59	moderate
between 59 and 70	high
more than 70	very high

Function `case_when()` is a tidier way to vectorise multiple `if_else()` statements. you can read more about this function here.

```
gapminder %>%
  filter(year == 1997) %>%
  mutate(life_level = case_when(lifeExp < 23 ~ 'very low',
                                lifeExp < 48~ 'low',
                                lifeExp < 59 ~ 'moderate',
                                lifeExp < 70 ~ 'high',
                                TRUE ~ 'very high')) %>%
  ggplot() + geom_boxplot(aes(x = life_level, y = gdpPercap)) +
  labs(y = "GDP per capita, $", x= "Life expectancy level, years") +
  theme_bw()
```



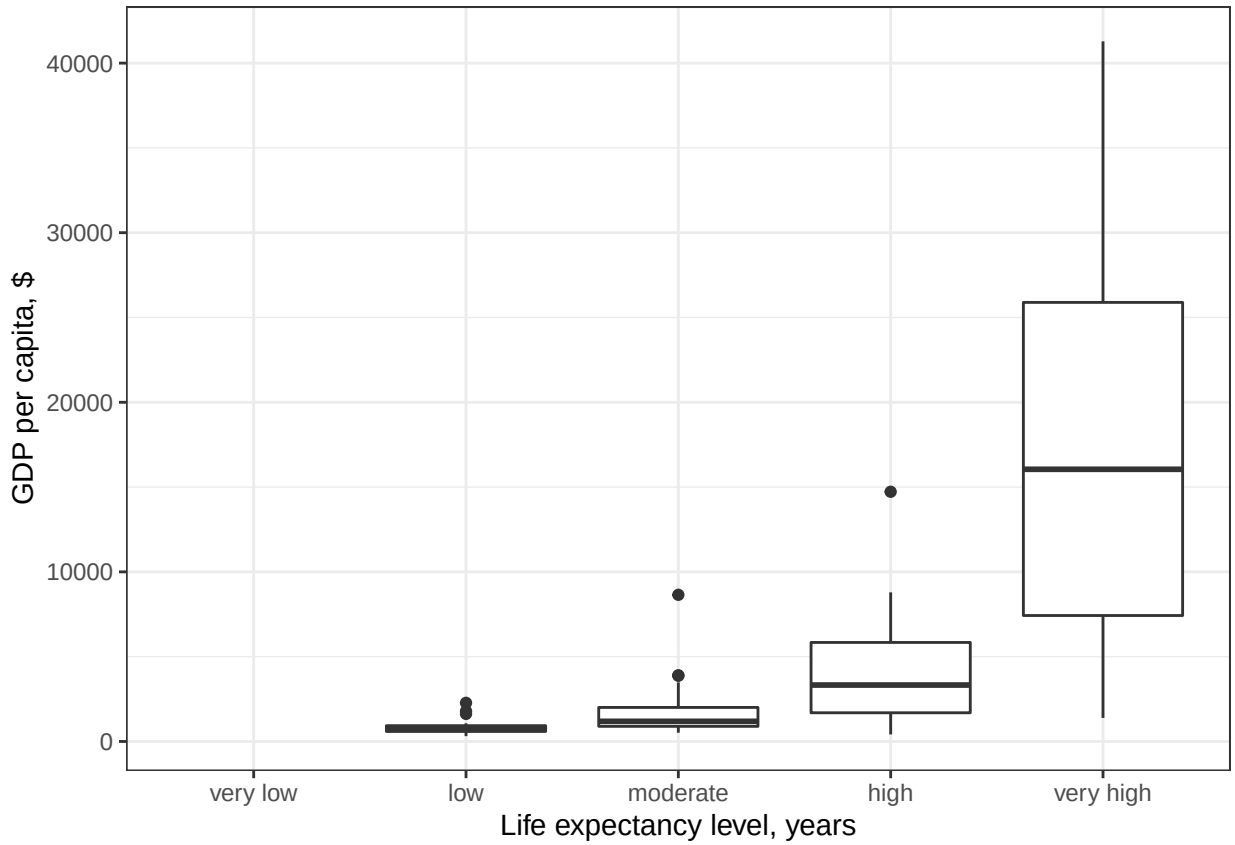
Do you notice anything odd/wrong about the graph?

We can make a few observations:

- It seems that none of the countries had a "very low" life-expectancy in 1997.
- However, since it was an option in our analysis it should be included in our plot. Right?
- Notice also how levels on x-axis are placed in the "wrong" order.

1.2 You can correct these issues by explicitly setting the levels parameter in the call to `factor()`. Use, `drop = FALSE` to tell the plot not to drop unused levels

```
gapminder %>%
  filter(year == 1997) %>%
  mutate(life_level = factor(case_when(lifeExp < 23 ~ 'very low',
                                lifeExp < 48~ 'low',
                                lifeExp < 59 ~ 'moderate',
                                lifeExp < 70 ~ 'high',
                                TRUE ~ 'very high'),
                levels = c("very low" , "low","moderate", "high","very high"))) %>%
  ggplot() + geom_boxplot(aes(x = life_level, y = gdpPercap)) +
  labs(y = "GDP per capita, $", x= "Life expectancy level, years") +
  theme_bw() +
  scale_x_discrete(drop = FALSE)
```



Inspecting factors (activity 2)

In Activity 1, we created our own factors, so now let's explore what categorical variables that we have in the `gapminder` dataset.

Exploring `gapminder$continent` (activity 2.1)

Use functions such as `str()`, `levels()`, `nlevels()` and `class()` to answer the following questions:

- what class is `continent`(a factor or charecter)?
- How many levels? What are they?
- What integer is used to represent factor "Asia"?

```
class(gapminder$continent)
```

```
## [1] "factor"
```

```
levels(gapminder$continent)
```

```
## [1] "Africa"   "Americas" "Asia"     "Europe"   "Oceania"
```

```
nlevels(gapminder$continent)
```

```
## [1] 5
```

```
str(gapminder$continent)
```

```
##  Factor w/ 5 levels "Africa","Americas",..: 3 3 3 3 3 3 3 3 3 3 ...
```

```
gapminder
```

```
## # A tibble: 1,704 x 6
##    country     continent  year lifeExp      pop gdpPercap
##    <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
##  1 Afghanistan Asia       1952    28.8  8425333      779.
##  2 Afghanistan Asia       1957    30.3  9240934      821.
##  3 Afghanistan Asia       1962    32.0 10267083      853.
##  4 Afghanistan Asia       1967    34.0 11537966      836.
##  5 Afghanistan Asia       1972    36.1 13079460      740.
##  6 Afghanistan Asia       1977    38.4 14880372      786.
##  7 Afghanistan Asia       1982    39.9 12881816      978.
##  8 Afghanistan Asia       1987    40.8 13867957      852.
##  9 Afghanistan Asia       1992    41.7 16317921      649.
## 10 Afghanistan Asia       1997    41.8 22227415      635.
## # ... with 1,694 more rows
```

Exploring `gapminder$country` (activity 2.2)

Let's explore what else we can do with factors:

Answer the following questions:

- How many levels are there in `country`?
- Filter `gapminder` dataset by 5 countries of your choice. How many levels are in your filtered dataset?

```
nlevels(gapminder$country)
```

```
## [1] 142
```

```
h_countries <- c("Egypt", "Haiti", "Romania", "Thailand", "Venezuela")

h_gap <- gapminder %>%
  filter(country %in% h_countries)

nlevels(h_gap$country)
```

```
## [1] 142
```

Dropping unused levels

What if we want to get rid of some levels that are "unused" - how do we do that?

The function `droplevels()` operates on all the factors in a data frame or on a single factor. The function `forcats::fct_drop()` operates on a factor.

```
h_gap_dropped <- h_gap %>%
  droplevels()

h_gap_dropped$country  %>%
  nlevels()
```

```
## [1] 5
```

Changing the order of levels

Let's say we wanted to re-order the levels of a factor using a new metric - say, count().

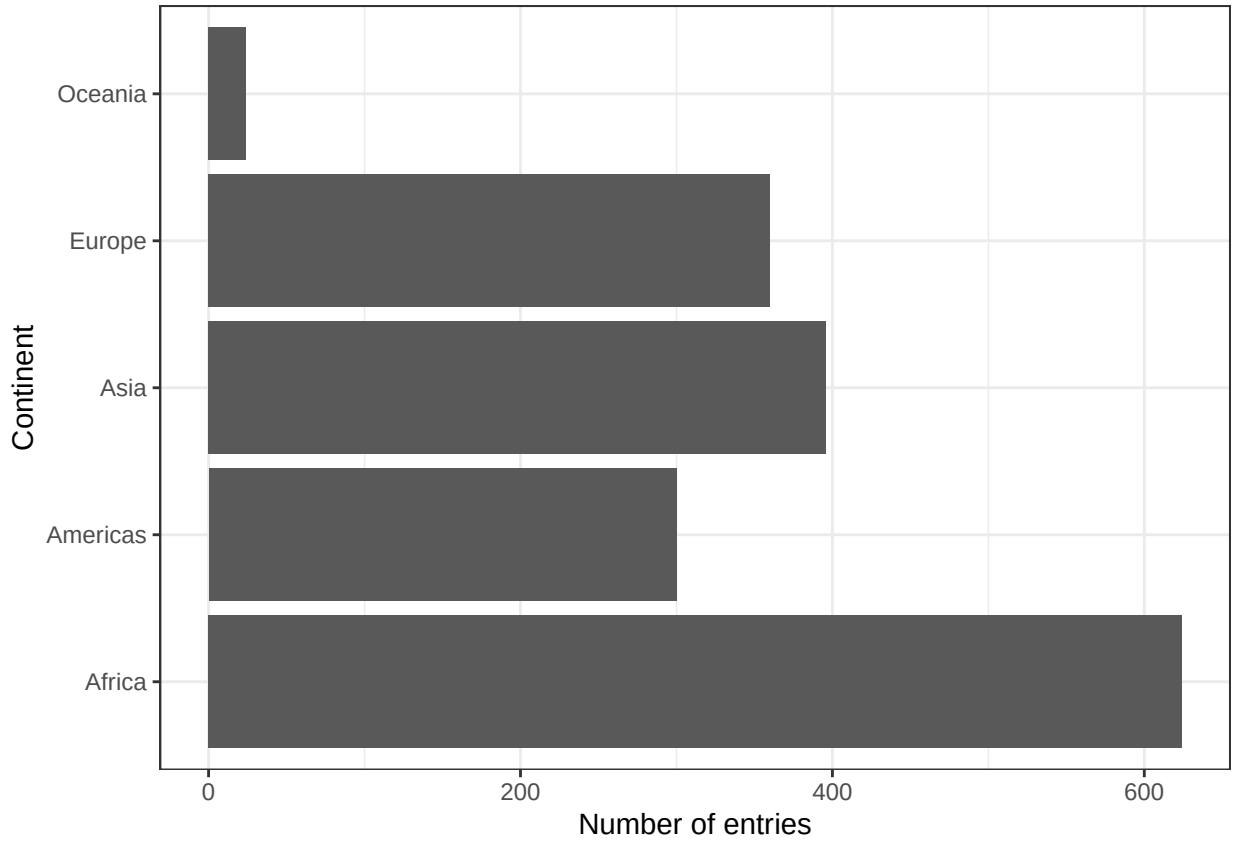
We should first produce a frequency table as a tibble using `dplyr::count()`:

```
gapminder %>%
  count(continent)
```

```
## # A tibble: 5 x 2
##   continent     n
##   <fct>     <int>
## 1 Africa      624
## 2 Americas    300
## 3 Asia        396
## 4 Europe      360
## 5 Oceania      24
```

The table is nice, but it would be better to visualize the data. Factors are most useful/helpful when plotting data. So let's first plot this:

```
gapminder %>%
  ggplot() +
  geom_bar(aes(continent)) +
  coord_flip()+
  theme_bw() +
  ylab("Number of entries") + xlab("Continent")
```



Think about how levels are normally ordered. It turns out that by default, R always sorts levels in alphabetical order. However, it is preferable to order the levels according to some principle:

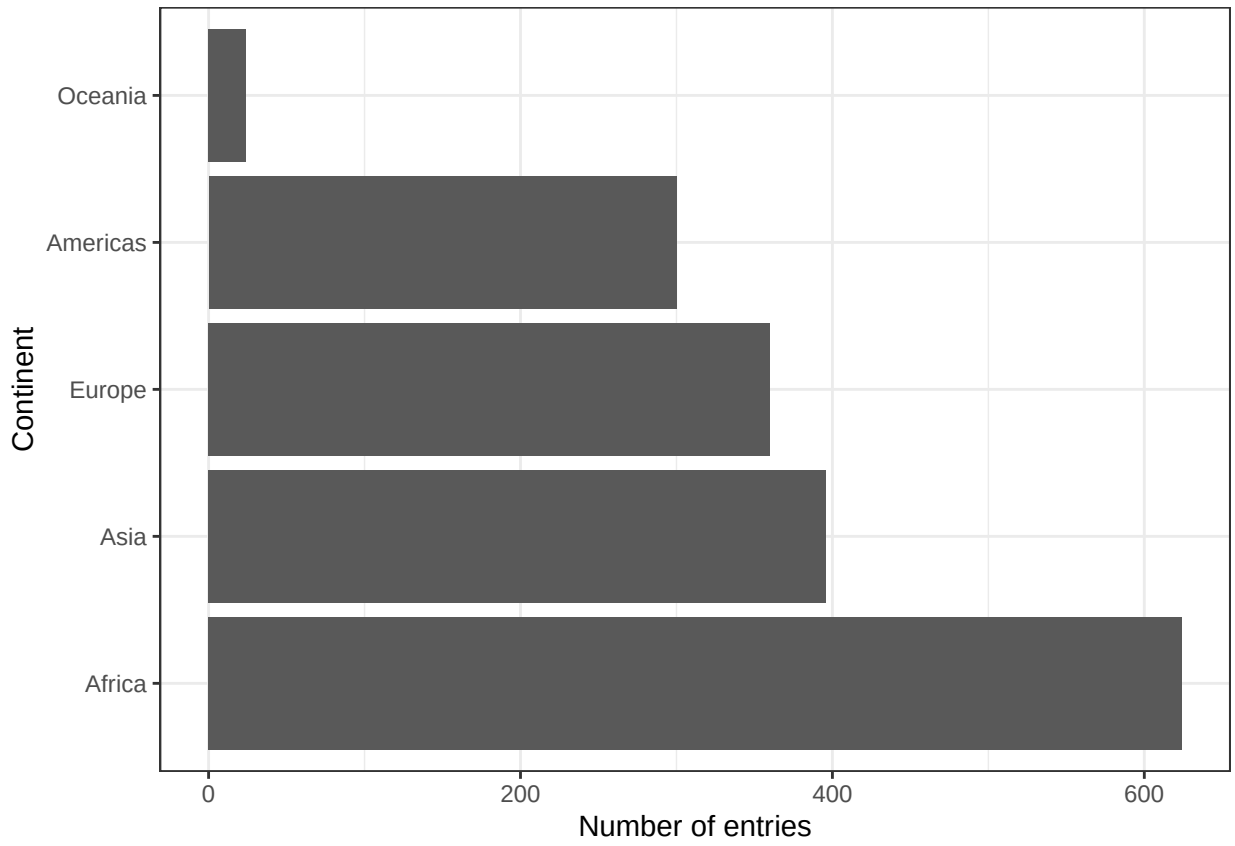
1. Frequency/count.

- Make the most common level the first and so on. Function `fct_infreq()` might be useful.

- The function `fct_rev()` will sort them in the opposite order.

For instance , ‘

```
gapminder %>%
  ggplot() +
  geom_bar(aes(fct_infreq(continent))) +
  coord_flip()+
  theme_bw() +
  ylab("Number of entries") + xlab("Continent")
```

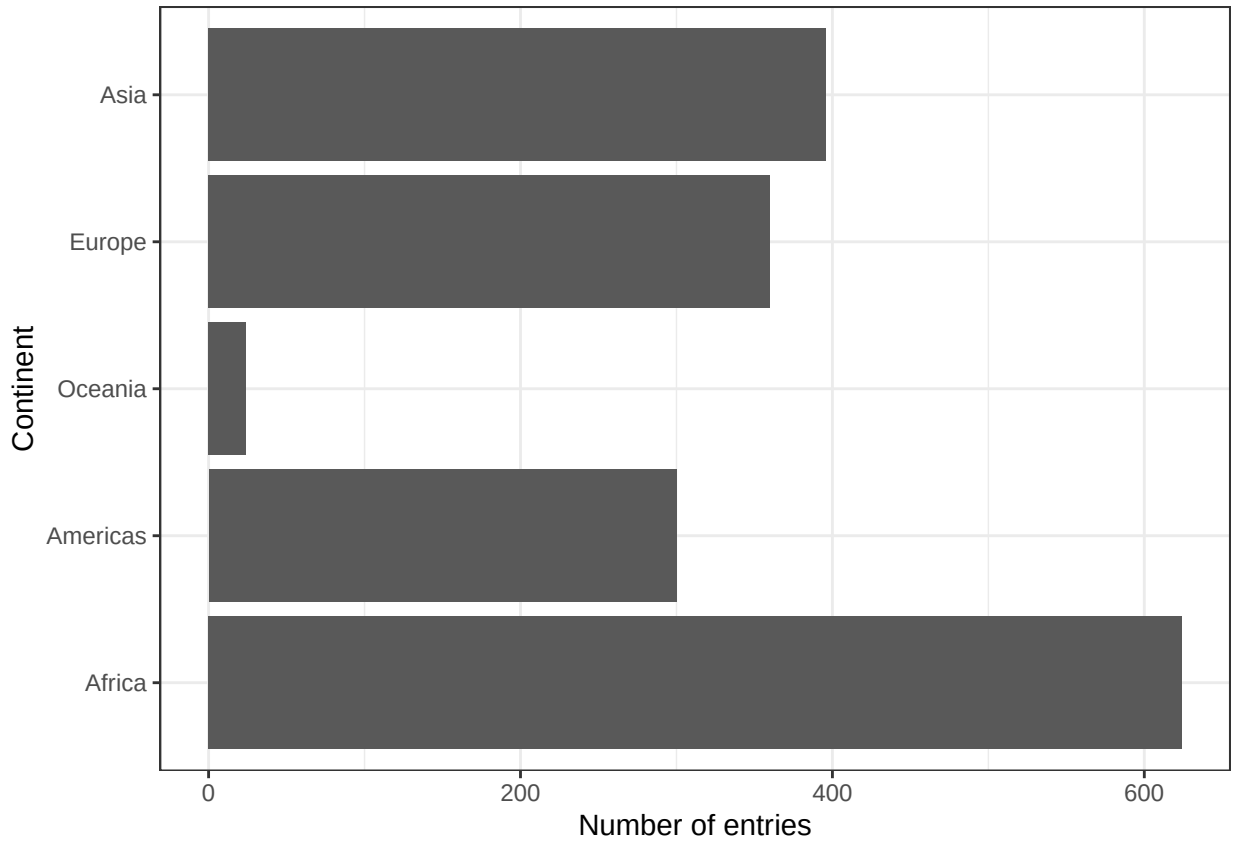


Section 9.6 of Jenny Bryan’s notes has some helpful examples.

2. Another variable.

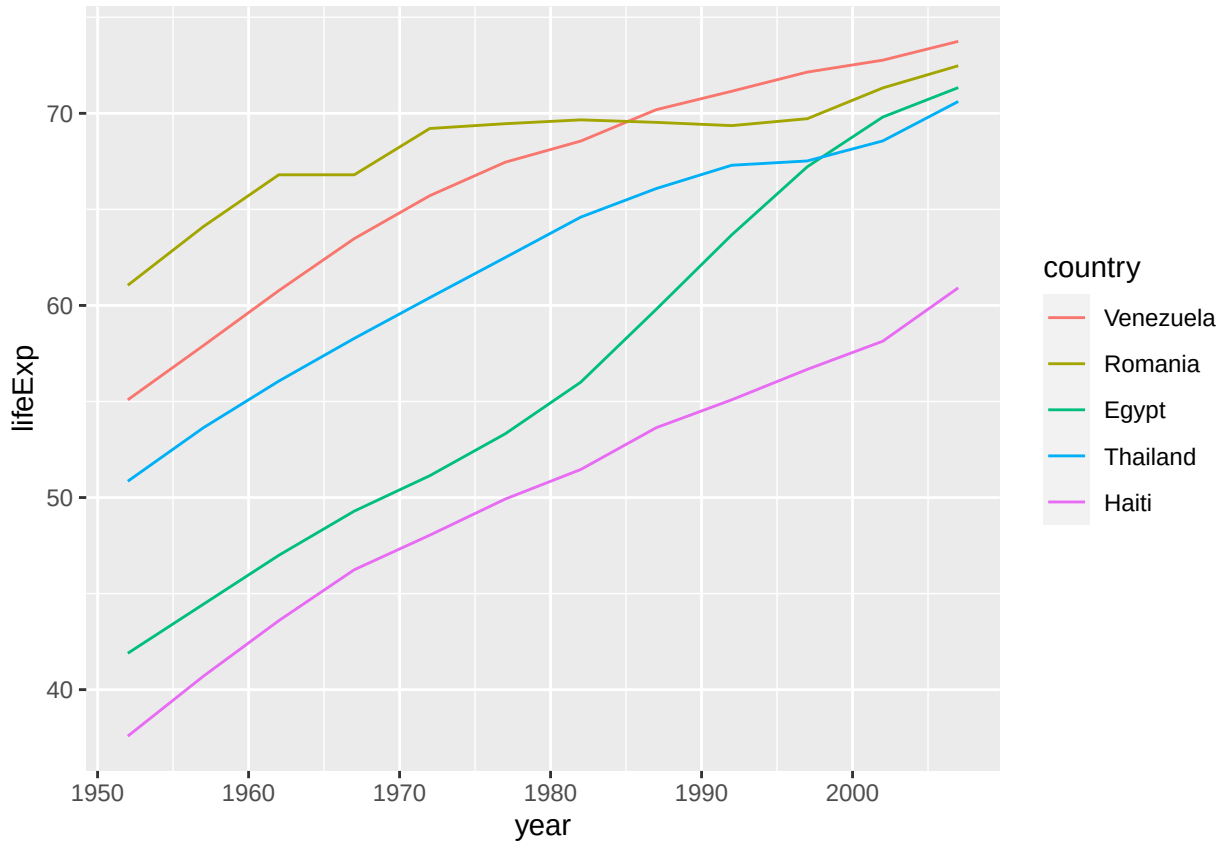
- For example, if we wanted to bring back our example of ordering `gapminder` countries by life expectancy, we can visualize the results using `fct_reorder()`.

```
##  default summarizing function is median()
gapminder %>%
  ggplot() +
  geom_bar(aes(fct_reorder(continent, lifeExp, max))) +
  coord_flip()+
  theme_bw() +
  xlab("Continent")+ylab("Number of entries")
```



Use `fct_reorder2()` when you have a line chart of a quantitative x against another quantitative y and your factor provides the color.

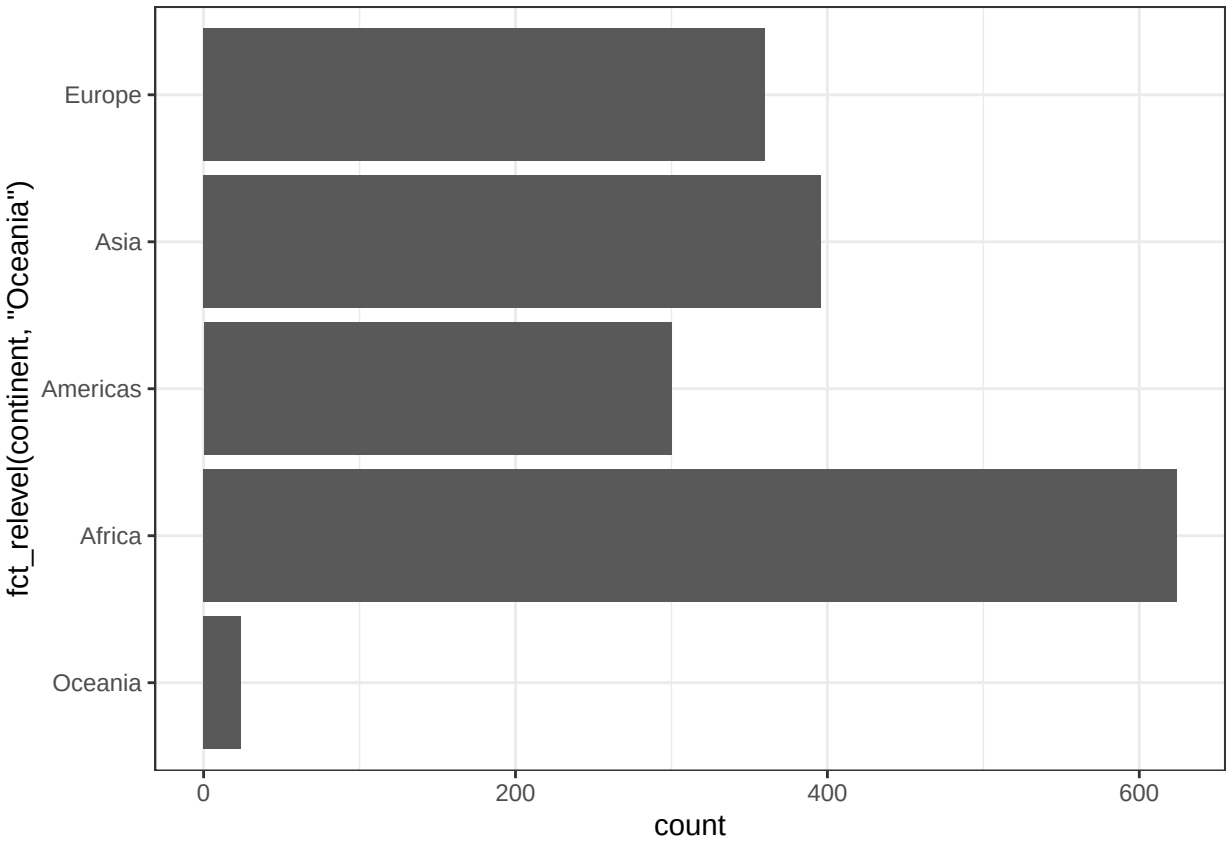
```
## order by life expectancy
ggplot(h_gap, aes(x = year, y = lifeExp,
                  color = fct_reorder2(country, year, lifeExp))) +
  geom_line() +
  labs(color = "country")
```



Change order of the levels manually

This might be useful if you are preparing a report for say, the state of affairs in Africa.

```
gapminder %>%
  ggplot() +
  geom_bar(aes(fct_relevel(continent,"Oceania"))) +
  coord_flip()+
  theme_bw()
```

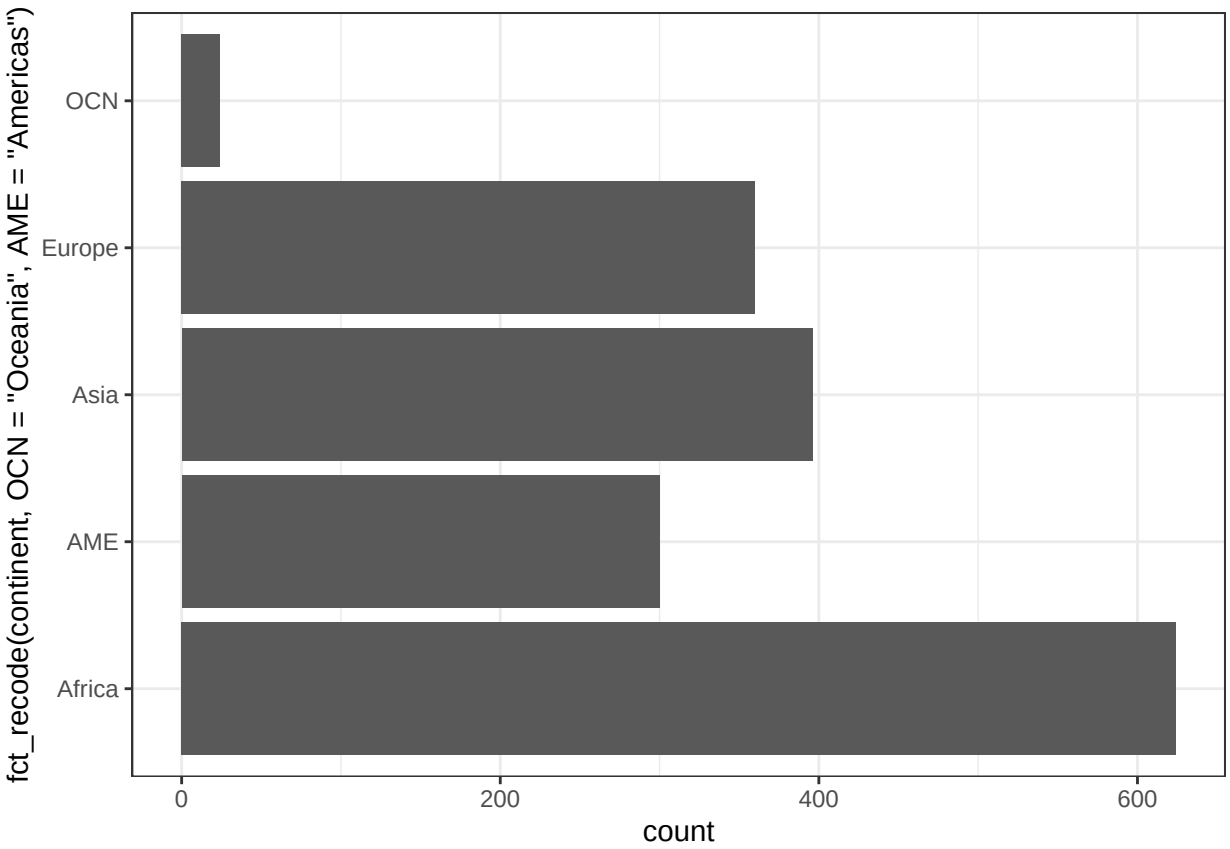


More details on reordering factor levels by hand can be found [here] https://forcats.tidyverse.org/reference/fct_relevel.html

Recoding factors

Sometimes you want to specify what the levels of a factor should be. For instance, if you had levels called "blk" and "brwn", you would rather they be called "Black" and "Brown" - this is called recoding. Lets recode `Oceania` and the `Americas` in the graph above as abbreviations `OCN` and `AME` respectively using the function `fct_recode()`.

```
gapminder %>%
  ggplot() +
  geom_bar(aes(fct_recode(continent,"OCN"="Oceania" , "AME" = "Americas"))) +
  coord_flip()+
  theme_bw()
```



Grow a factor (OPTIONAL)

Let's create two data frames,`df1` and `df2` each with data from two countries, dropping unused factor levels.

```
df1 <- gapminder %>%
  filter(country %in% c("United States", "Mexico"), year > 2000) %>%
  droplevels()
df2 <- gapminder %>%
  filter(country %in% c("France", "Germany"), year > 2000) %>%
  droplevels()
```

The country factors in df1 and df2 have different levels. Can we just combine them?

```
c(df1$country, df2$country)
```

```
## [1] Mexico        Mexico        United States United States France
## [6] France        Germany       Germany
## Levels: Mexico United States France Germany
```

The country factors in `df1` and `df2` have different levels. Can you just combine them using `c()`?

```
fct_c(df1$country, df2$country)
```

```
## [1] Mexico        Mexico        United States United States France
## [6] France        Germany       Germany
## Levels: Mexico United States France Germany
```

Explore how different forms of row binding work behave here, in terms of the country variable in the result.

```
bind_rows(df1, df2)
```

```
## # A tibble: 8 x 6
##   country       continent  year lifeExp       pop gdpPercap
##   <fct>         <fct>     <int>   <dbl>     <int>     <dbl>
## 1 Mexico        Americas   2002    74.9 102479927    10742.
## 2 Mexico        Americas   2007    76.2 108700891    11978.
## 3 United States Americas   2002    77.3 287675526    39097.
## 4 United States Americas   2007    78.2 301139947    42952.
## 5 France        Europe     2002    79.6  59925035    28926.
## 6 France        Europe     2007    80.7  61083916    30470.
## 7 Germany       Europe     2002    78.7  82350671    30036.
## 8 Germany       Europe     2007    79.4  82400996    32170.
```

```
rbind(df1, df2)
```

```
## # A tibble: 8 x 6
##   country       continent  year lifeExp       pop gdpPercap
##   <fct>         <fct>     <int>   <dbl>     <int>     <dbl>
## 1 Mexico        Americas   2002    74.9 102479927    10742.
## 2 Mexico        Americas   2007    76.2 108700891    11978.
## 3 United States Americas   2002    77.3 287675526    39097.
## 4 United States Americas   2007    78.2 301139947    42952.
## 5 France        Europe     2002    79.6  59925035    28926.
## 6 France        Europe     2007    80.7  61083916    30470.
## 7 Germany       Europe     2002    78.7  82350671    30036.
## 8 Germany       Europe     2007    79.4  82400996    32170.
```