Tables in R - Data frames and Tibbles

Day 1 - Introduction to Data Analysis with R

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March 14, 2025

Data frames

The built-in data structure for tables in R is a **data frame**.

Vectors in R can't represent data table where values are connected via rows

> Data frames are one of the **biggest and most important ideas** in R, and one of the things that make R different from other programming languages.
>
> (H. Wickham, Advanced R)

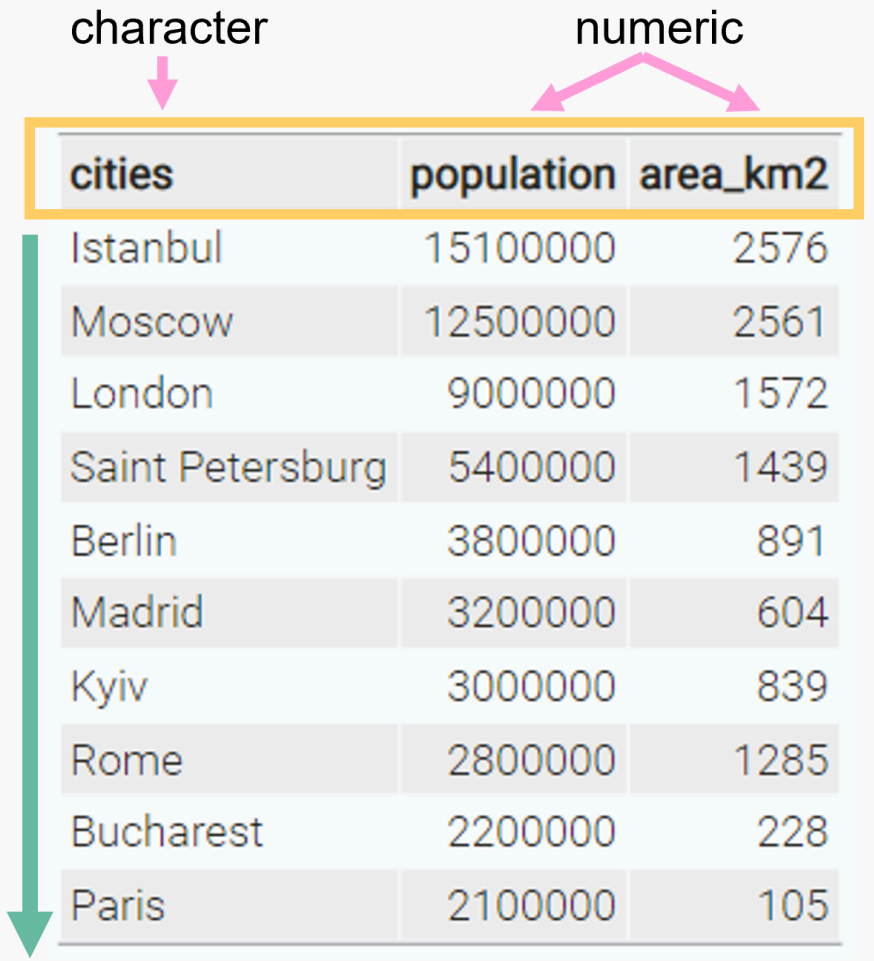
city_name	population_size	city_area
Istanbul	15100000	2576
Moscow	12500000	2561
London	9000000	1572
Saint Petersburg	5400000	1439
Berlin	3800000	891
Madrid	3200000	604
Kyiv	3000000	839
Rome	2800000	1285
Bucharest	2200000	228
Paris	2100000	105

Data frames

A data frame is a **named list of vectors** of the same length.

Basic properties of a data frame

- every **column is a vector**
- columns have a **header**
  - this is the name of the vector in the list
- within one column, all values are of the **same data type**
- every column has the same length



cities	population	area_km2
Istanbul	15100000	2576
Moscow	12500000	2561
London	9000000	1572
Saint Petersburg	5400000	1439
Berlin	3800000	891
Madrid	3200000	604
Kyiv	3000000	839
Rome	2800000	1285
Bucharest	2200000	228
Paris	2100000	105

Data frames

Data frames are created with the function `data.frame()`:

```
cities <- c(
  "Istanbul", "Moscow", "London",
  "Saint Petersburg", "Berlin","Madrid",
  "Kyiv", "Rome", "Bucharest","Paris")

population <- c(
  15.1e6, 12.5e6, 9e6, 5.4e6, 3.8e6,
  3.2e6, 3e6, 2.8e6, 2.2e6, 2.1e6)

area_km2 <- c(2576, 2561, 1572, 1439,
  891, 604, 839, 1285, 228, 105)

cities_dataframe <- data.frame(
  city_name = cities,
  population_size = population,
  city_area = area_km2
  )
```

```
#>           city_name population_size city_area
#> 1           Istanbul        15100000      2576
#> 2             Moscow        12500000      2561
#> 3             London         9000000      1572
#> 4  Saint Petersburg         5400000      1439
#> 5             Berlin         3800000       891
#> 6             Madrid         3200000       604
#> 7               Kyiv         3000000       839
#> 8               Rome         2800000      1285
#> 9           Bucharest         2200000       228
#> 10              Paris         2100000       105
```

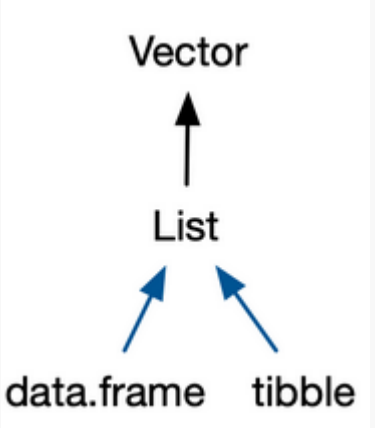
Tibbles

Tibbles are

> a **modern reimagining of the data frame**. Tibbles are designed to be (as much as possible) **drop-in replacements** for data frames.
>
> (Wickham, Advanced R)

Have a look at this book chapter for a full list of the differences between data frames and tibbles and the advantages of using tibbles.

- Tibbles have the same basic properties as data frames (named list of vectors)
- Everything that you can do with data frames, you can do with tibbles



Tibbles

Tibbles are a available from the `tibble` package.

Before we use tibbles, we need to install the package once using the function `install.packages`:

```
# This has do be done only once (in the console, not in the script)
install.packages("tibble")
```

Then, we need to load the package into our current R session using `library`:

```
# This has to be done every time R restarts
# Put it at the top of your script
library(tibble)
```

Tibbles

Create a tibble using the `tibble()` function:

```
library(tibble)

cities_tbl <- tibble(
  city_name = cities,
  population_size = population,
  city_area = area_km2
)
```

```
#> # A tibble: 10 × 3
#>    city_name        population_size city_area
#>    <chr>                      <dbl>     <dbl>
#>  1 Istanbul                15100000      2576
#>  2 Moscow                  12500000      2561
#>  3 London                   9000000      1572
#>  4 Saint Petersburg         5400000      1439
#>  5 Berlin                   3800000       891
#>  6 Madrid                   3200000       604
#>  7 Kyiv                     3000000       839
#>  8 Rome                     2800000      1285
#>  9 Bucharest                2200000       228
#> 10 Paris                    2100000       105
```

Exploring tibbles

How many rows?

```
nrow(cities_tbl)
#> [1] 10
```

How many columns?

```
ncol(cities_tbl)
#> [1] 3
```

What are the column headers?

```
names(cities_tbl)
#> [1] "city_name"       "population_size" "city_area"
```

Exploring tibbles

Look at the entire table in a separate window with `view()`:

```
view(cities_tbl)
```

Exploring tibbles

Get a quick summary of all columns:

```
summary(cities_tbl)
#>   city_name         population_size      city_area
#>  Length:10          Min.   : 2100000   Min.   : 105.0
#>  Class :character   1st Qu.: 2850000   1st Qu.: 662.8
#>  Mode  :character   Median : 3500000   Median :1088.0
#>                     Mean   : 5910000   Mean   :1210.0
#>                     3rd Qu.: 8100000   3rd Qu.:1538.8
#>                     Max.   :15100000   Max.   :2576.0
```

- Very useful for checking if everything is ok with your research data

Indexing tibbles

Indexing tibbles works similar to indexing vectors but with 2 dimensions instead of 1:

tibble [row_index, col_index or col_name]

- Missing row_index or col_index means *all rows* or *all columns* respectively.
- Indexing a tibble using `[]` always returns another tibble.

Indexing tibbles

```
# First row and first column
cities_tbl[1, 1]
#> # A tibble: 1 × 1
#>   city_name
#>   <chr>
#> 1 Istanbul
```

This is the same as

```
cities_tbl[1, "city_name"]
```

Indexing tibbles: rows

```
# rows 1 & 5, all columns:
cities_tbl[c(1, 5), ]
#> # A tibble: 2 × 3
#>   city_name population_size city_area
#>   <chr>               <dbl>     <dbl>
#> 1 Istanbul         15100000      2576
#> 2 Berlin            3800000       891
```

Indexing tibbles: columns

```
# All rows, first 2 columns
cities_tbl[ ,1:2] # same as cities_tbl[ , c(1, 2)]
# same as
cities_tbl[ ,c("city_name", "population_size")]
```

```
#> # A tibble: 10 × 2
#>   city_name population_size
#>   <chr>               <dbl>
#> 1 Istanbul         15100000
#> 2 Moscow           12500000
#> 3 London            9000000
#> # ℹ 7 more rows
```

Indexing tibbles: columns

Indexing columns by name is usually preferred to indexing by position

```
cities_tbl[ ,1:2] # okay
cities_tbl[ ,c("city_name", "population_size")] # better
```

Why?

- Code is much easier to read
- Code is more robust against
  - changes in column order
  - mistakes in the code (e.g. typos)

```
cities_tbl[ ,c(1,3)] # 3 instead of 2 -> wrong but no error
cities_tbl[ ,c("city_name", "popluation_size")] # typo -> wrong and error
```

> **General rule**
>
> Good code produces errors when something unintended or wrong happens

Tibbles: Select columns with $

Select an entire column from a tibble using `$` (this returns a vector instead of a tibble):

```
cities_tbl$city_name
#>  [1] "Istanbul"        "Moscow"          "London"          "Saint Petersburg"
#>  [5] "Berlin"          "Madrid"          "Kyiv"            "Rome"
#>  [9] "Bucharest"       "Paris"
```

Adding new columns

New columns can be added as vectors using the $ operator. The vectors need to have the same length as the tibble has rows.

```
# add a country column
cities_tbl$country <- c(
  "Turkey", "Russia", "UK", "Russia", "Germany", "Spain",
  "Ukraine", "Italy", "Romania", "France"
)
```

```
#> # A tibble: 10 × 4
#>    city_name        population_size city_area country
#>    <chr>                      <dbl>     <dbl> <chr>
#>  1 Istanbul                15100000      2576 Turkey
#>  2 Moscow                  12500000      2561 Russia
#>  3 London                   9000000      1572 UK
#>  4 Saint Petersburg         5400000      1439 Russia
#>  5 Berlin                   3800000       891 Germany
#>  6 Madrid                   3200000       604 Spain
#>  7 Kyiv                     3000000       839 Ukraine
#>  8 Rome                     2800000      1285 Italy
#>  9 Bucharest                2200000       228 Romania
#> 10 Paris                    2100000       105 France
```

Summary

> Tables in R: Data frames and tibbles

Summary I

data frames and tibbles

- can be used to represent tables in R
- are pretty similar, however tibbles are slightly conventient and modern
- are **named lists of vectors of the same length**
  - every column is a vector
  - columns have a header which is the name of the vector in the list
  - within one column, values are of same data type
  - every column has the same length

tibbles

- to use tibbles, install the package once with `install.packages("tibble")`
- put `library(tibble)` at the beginning of your script to load package

Summary II

Creating tibbles and data frames

```r
# data frame
data.frame(
  a = 1:3,
  b = c("a", "b", "c"),
  c = c(TRUE, FALSE, FALSE)
)
# tibble
tibble(
  a = 1:3,
  b = c("a", "b", "c"),
  c = c(TRUE, FALSE, FALSE)
)
# convert data frame to tibble
as_tibble(df)
```

Summary III

Looking at tibble structure

```
# structure of tibble and data types of columns
str(tbl)
# number of rows
nrow(tbl)
# number of columns
ncol(tbl)
# column headers
names(tbl)
# look at the data in a new window
tibble::view(tbl)
# summary of values from each column
summary(tbl)
```

Summary IV

Indexing tibbles and selecting columns

Return result as tibble:

```
# rows and columns by position
tbl[1:3, c(1, 3)]
tbl[1:3, ] # all columns
tbl[, 3] # column 3, all rows
tbl[3] # same as above

# columns by name
tbl[, c("colA", "colB")]
tbl[c("colA", "colB")]
```

Return result as vector:

```
tbl$colA # select colA
```

Now you

Task (15 min)

Tibbles

Find the task description here