Statistical Computing with R
Masters in Data Science 503 (S1&2)
Fourth Batch, SMS, TU, 2025

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Course Description:

- This is an outcome based course to introduce basic programming in R software followed by use of R software for Statistical Computing.
- It focuses on the use of R software for data manipulation, data summary/data visualization, models (supervised and unsupervised learnings) and communicate the findings

Learning outcomes:

- Understand, use and apply R software for basic programming (program)
- Understand, use and apply R software for data manipulation (wrangle)
- Understand, use and apply R software for data summary and visualization (explore)
- Understand, use and apply R software for supervised learning (model)
- Understand, use and apply R software for unsupervised learning (model)
- Understand, use and apply R software to communicate findings (communicate).

Course delivery and assessment in/for/of learning (F2F and Virtual Classroom):

- Didactic session
- Individual/Group work
- Project works
- Practical/Lab session
- Presentation
  - Individual
  - Group
- Assignments
- Report

Course books:

- Required (core):
  1. Wichham Hadley & Gloremund Garrette (2017). R for Data Science. O'Reilly Media Inc: Sebastopol, Canada. Available for free in HTML from this website: https://r4ds.had.co.nz/index.html [2nd Edition is available]
  2. Gareth, J., Daniela, W., Trevor, H., & Robert, T. (2013). *An introduction to statistical learning: with applications in R*. Spinger. Available for free from this website: https://www.statlearning.com/ [2021/23 updated version]
- Suggested (non-core):
  - Mailund Thomas (2017). Beginning Data Sciences in R: Data Analysis, Visualization, and Modelling for the Data Scientists. Apress: Aarhus, Denmark.
  - Goh Eric & Hui Ming (2019). Learn R for Applied Statistics. Apress: Singapore

Tools for this course:

- Software
  - **R**
  - Latest version recommended

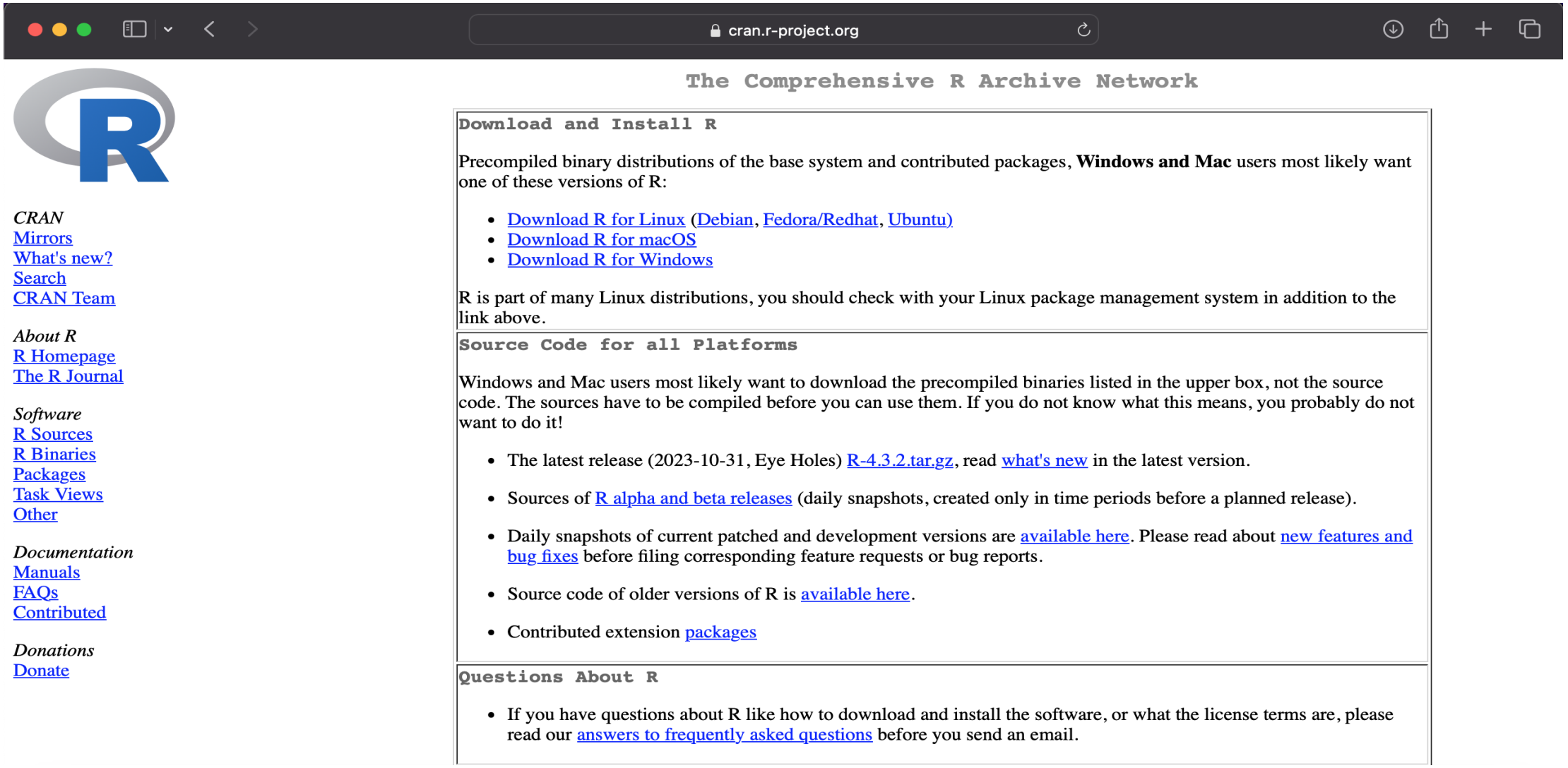
- IDE
  - **R Studio**
  - Latest version recommended

- Packages
  - **Base**
  - ***Recommended (tidyverse packages for data sciences)***
  - As per the requirement of the course

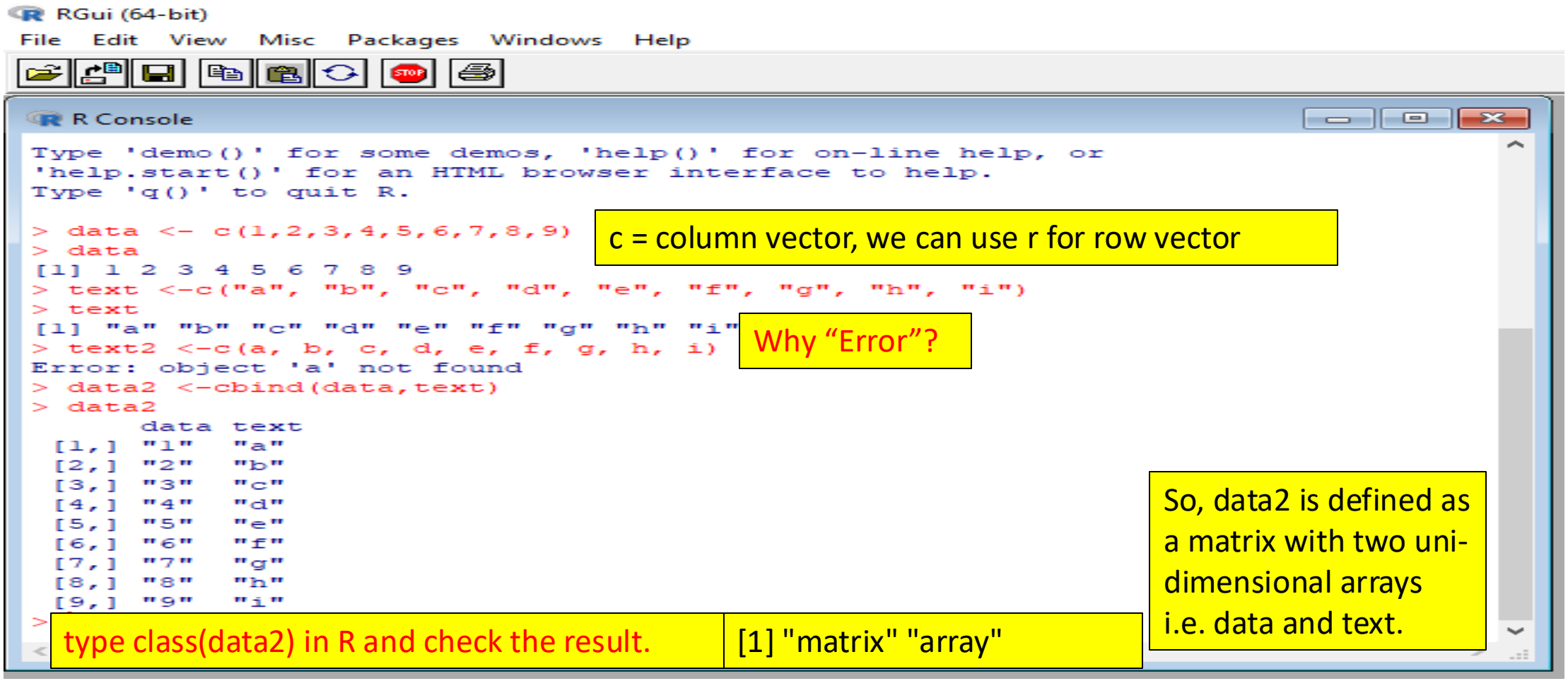
R: History (https://mran.microsoft.com/documents/what-is-r)

- First implemented in 1990's by Ross Ihaka and Robert Gentleman at University of Auckland, New Zealand
- Established as an open source project in 1995 by Ross Ihaka
- R project is managed by R core group since 1997
- R 1.0.0 was released in February 2000 (I saw it on September 2000)
- R is closely modeled on the S language for statistical computing conceived by John Chambers, Rick Baker, Trevor Hastie, Allan Wilks and others at Bell Labs in mid 1970s, and made publicly available in 1980s. (But, S and Splus software are commercial)
- Read "R: Past and Future History by Ross Ihaka" for more

R installation: CRAN Website

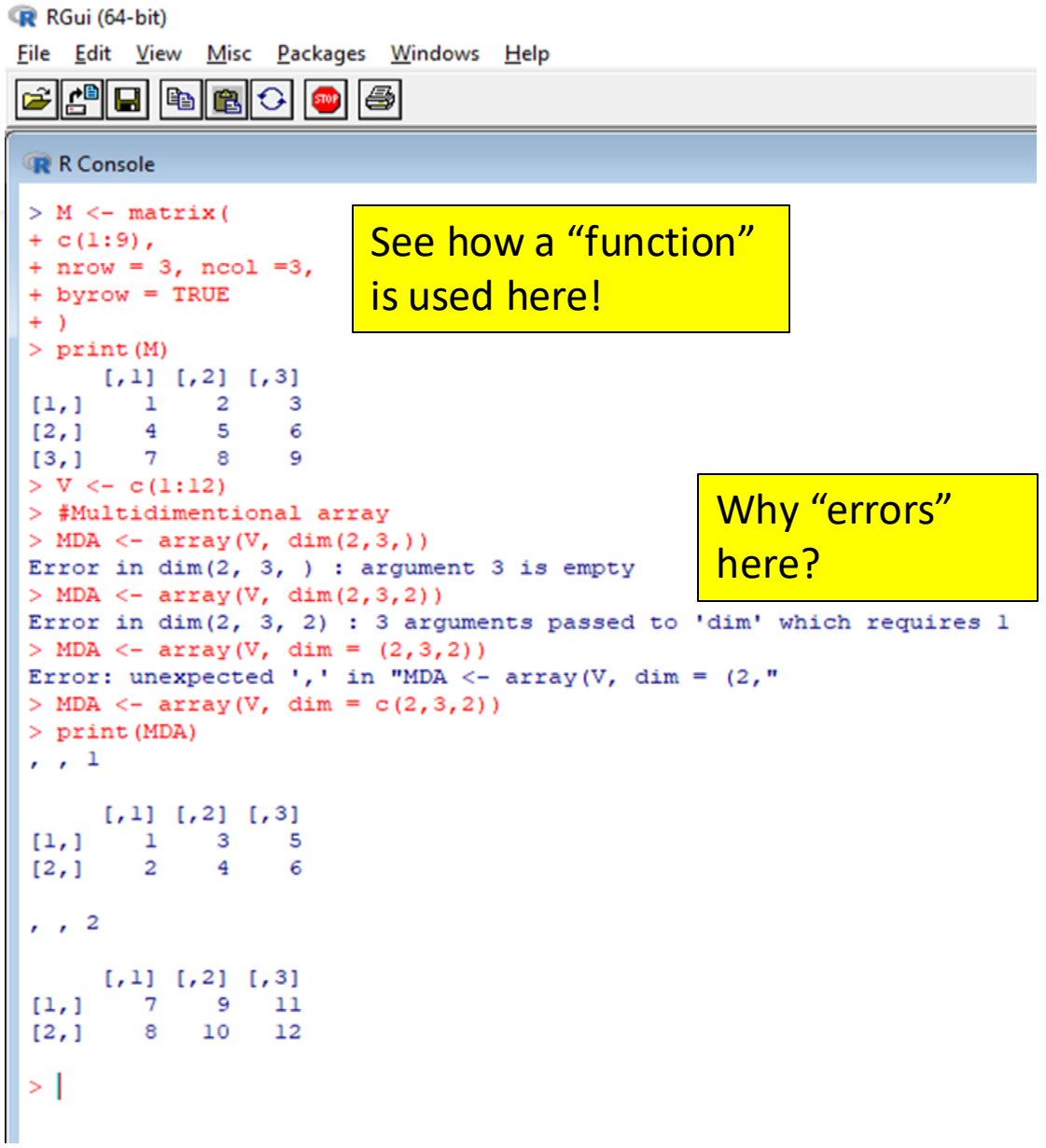


(Simple) Data entry in R:



Arrays and Matrices in R:

Arrays	Matrices
Arrays can contain greater than or equal to 1 dimensions.	Matrices contains 2 dimensions in a table like structure.
Array is a homogeneous data structure.	Matrix is also a homogeneous data structure.
It is a singular vector arranged into the specified dimensions.	It comprises of multiple equal length vectors stacked together in a table.
array() function can be used to create matrix by specifying the third dimension to be 1.	**matrix()** function however can be used to create at most 2-dimensional array.
Arrays are superset of matrices.	Matrices are a subset, special case of array where dimensions is two.
Limited set of collection-based operations.	Wide range of collection operations possible.
Mostly, intended for storage of data.	Mostly, matrices are intended for data transformation.



https://www.geeksforgeeks.org/array-vs-matrix-in-r-

Quick Think!

Individual assignment at Virtual classroom!

- What is “list” in R?
- How to create a list containing strings, numbers, vectors and a logical values in R?
- How to name the list elements in R?
- How to assess list elements in R?
- How to manipulate list elements in R?
- How to convert list to vectors in R?

We use “Data frame” a lot in R: (https://www.educba.com/data-frames-in-r/)

- Data frames in R language are the type of data structure that is used to store data in a tabular form which is of two dimensional.
- The data frames are special categories of list data structure in which the components are of equal length.
- R languages support the built-in function i.e. data.frame() to create the data frames and assign the data elements.

We use “Data frame” a lot in R because: (https://www.educba.com/data-frames-in-r/)

- R language supports the data frame name to modify and retrieve data elements from the data frames.
- Data frames in R structured as column name by the component name also, structured as rows by the component values.
- Data frames in R is a widely used data structure while developing the machine learning models in data science projects.

Creating a simple “data.frame” in R:

- df <- data.frame(x=c(1,2,3),y=c(2,3,4),z=c(3,4,5))
- df

```
  x y z
1 1 2 3
2 2 3 4
3 3 4 5
```

- class(df)

```
[1] "data.frame"
```

A small but realistic data frame and its use: (https://www.tutorialspoint.com/r/r_data_frames.htm)

#create data frame

- emp.data <- data.frame(

  emp_id = c(1:5),

  emp_name =c("Rick", "Dan", "Michelle", "Ryan", "Gary"),

  salary = c(623.3, 515.2, 611.0, 729.0, 845.25),

  start_date = as.Date(c("2012-01-01", "2013-09-23", "2014-11-15", "2014-05-11", "2015-03-27")),

  stringAsFactors = FALSE

)

#Print the data

- print(emp.data)

Sample Data frame in R:

RGui (64-bit)

File Edit View Misc Packages Windows Help

R Console

```
> emp.data <- data.frame(
+    emp_id = c (1:5),
+    emp_name = c("Rick","Dan","Michelle","Ryan","Gary"),
+    salary = c(623.3,515.2,611.0,729.0,843.25),
+
+    start_date = as.Date(c("2012-01-01", "2013-09-23", "2014-11-15", "2014-05-11",
+       "2015-03-27")),
+    stringsAsFactors = FALSE
+ )
> print(emp.data)
  emp_id emp_name salary start_date
1      1     Rick 623.30 2012-01-01
2      2      Dan 515.20 2013-09-23
3      3 Michelle 611.00 2014-11-15
4      4     Ryan 729.00 2014-05-11
5      5     Gary 843.25 2015-03-27
```

Structure and Summary of Sample Data Frame in R:

```
> # Get the structure of the data frame.
> str(emp.data)
'data.frame':   5 obs. of  4 variables:
 $ emp_id    : int  1 2 3 4 5
 $ emp_name  : chr  "Rick" "Dan" "Michelle" "Ryan" ...
 $ salary    : num  623 515 611 729 843
 $ start_date: Date, format: "2012-01-01" "2013-09-23" "2014-11-15" ...
> # Print the summary.
> print(summary(emp.data))
     emp_id    emp_name             salary        start_date
 Min.   :1   Length:5           Min.   :515.2   Min.   :2012-01-01
 1st Qu.:2   Class :character   1st Qu.:611.0   1st Qu.:2013-09-23
 Median :3   Mode  :character   Median :623.3   Median :2014-05-11
 Mean   :3                      Mean   :664.4   Mean   :2014-01-14
 3rd Qu.:4                      3rd Qu.:729.0   3rd Qu.:2014-11-15
 Max.   :5                      Max.   :843.2   Max.   :2015-03-27
> |
```

Extract part of data from Data Frame in R: (Very useful when working with large data)

```
> # Extract Specific columns.
> result <- data.frame(emp.data$emp_name,emp.data$salary)
> print(result)
  emp.data.emp_name emp.data.salary
1              Rick           623.30
2               Dan           515.20
3          Michelle           611.00
4              Ryan           729.00
5              Gary           843.25
> # Extract first two rows.
> result <- emp.data[1:2,]
> print(result)
  emp_id emp_name salary start_date
1      1      Rick  623.3 2012-01-01
2      2       Dan  515.2 2013-09-23
> # Extract 3rd and 5th row with 2nd and 4th column.
> result <- emp.data[c(3,5),c(2,4)]
> print(result)
  emp_name start_date
3 Michelle 2014-11-15
5     Gary 2015-03-27
> 
```

Add a new column in existing Data Frame:

```
> # Add the "dept" coulmn.
> emp.data$dept <- c("IT","Operations","IT","HR","Finance")
> v <- emp.data
> print(v)
  emp_id emp_name salary start_date        dept
1      1     Rick 623.30 2012-01-01          IT
2      2      Dan 515.20 2013-09-23  Operations
3      3 Michelle 611.00 2014-11-15          IT
4      4     Ryan 729.00 2014-05-11          HR
5      5     Gary 843.25 2015-03-27     Finance
```

Expand data frame in R (Adding cases):

```
> # Create the first data frame.
> emp.data <- data.frame(
+    emp_id = c (1:5),
+    emp_name = c("Rick","Dan","Michelle","Ryan","Gary"),
+    salary = c(623.3,515.2,611.0,729.0,843.25),
+
+    start_date = as.Date(c("2012-01-01", "2013-09-23", "2014-11-15", "2014-05-11",
+       "2015-03-27")),
+    dept = c("IT","Operations","IT","HR","Finance"),
+    stringsAsFactors = FALSE
+ )
> # Create the second data frame
> emp.newdata <- data.frame(
+    emp_id = c (6:8),
+    emp_name = c("Rasmi","Pranab","Tusar"),
+    salary = c(578.0,722.5,632.8),
+    start_date = as.Date(c("2013-05-21","2013-07-30","2014-06-17")),
+    dept = c("IT","Operations","Fianance"),
+    stringsAsFactors = FALSE
+ )
```

Already defined!
Cases: 1 to 5

Added data!
Cases: 6 to 8

Expand data frame in R (rbind is used):

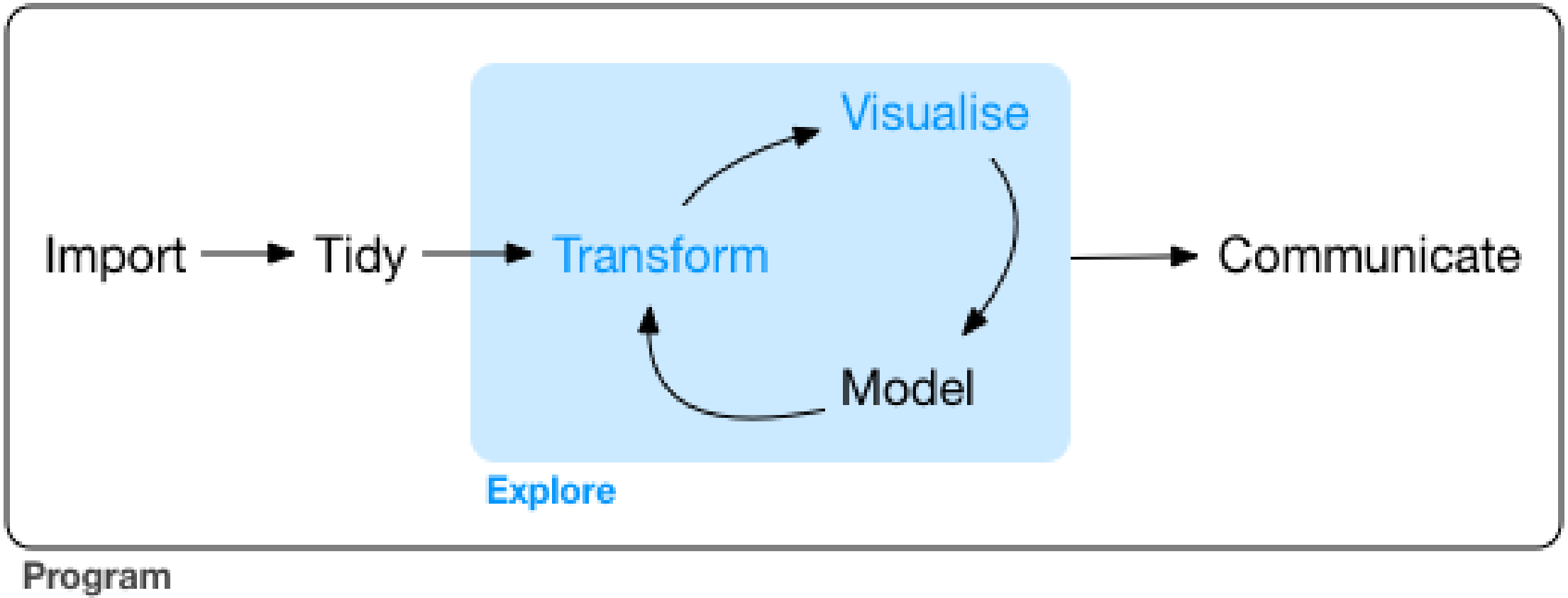
```
> # Bind the two data frames.
> emp.finaldata <- rbind(emp.data,emp.newdata)
> print(emp.finaldata)
  emp_id emp_name salary start_date          dept
1      1     Rick 623.30 2012-01-01            IT
2      2      Dan 515.20 2013-09-23 Operations
3      3 Michelle 611.00 2014-11-15            IT
4      4     Ryan 729.00 2014-05-11            HR
5      5     Gary 843.25 2015-03-27       Finance
6      6    Rasmi 578.00 2013-05-21            IT
7      7   Pranab 722.50 2013-07-30 Operations
8      8    Tusar 632.80 2014-06-17     Fianance
> |
```

Questions/queries?

- You can use this website to find more resources for R:

- https://stackoverflow.com/questions/tagged/r

Introduction to data science with R:



Import: First step of Data Science!

- What?
  - Data (What is?)
  - Big data (What is?)

- How?
  - Code (How to write?)
  - Packages (How to install, load and use?)
  - Any package or specific package for data science?

Import data in R: Text files

- Base
  - **read.table(), read.delim(), read.csv(), read.csv2()**
  - table = Reads text file e.g. data with 4 rows and 3 columns in R
  - delim = Tab separated values text file
  - csv = Comma separated values text file
  - csv2 = Semi-colon separate values text file

- Examples:
  - read.csv("C:/Documents/Users/Dell/Documents/covnep_252days.csv")
  - read.csv("covnep_252days.csv") works if this data is in the working directory **#getwd()**
  - read.csv(file.choose()) TO OPEN A NEW WINDOW TO READ FILE

Base read.csv function to read csv file:

RGui (64-bit)

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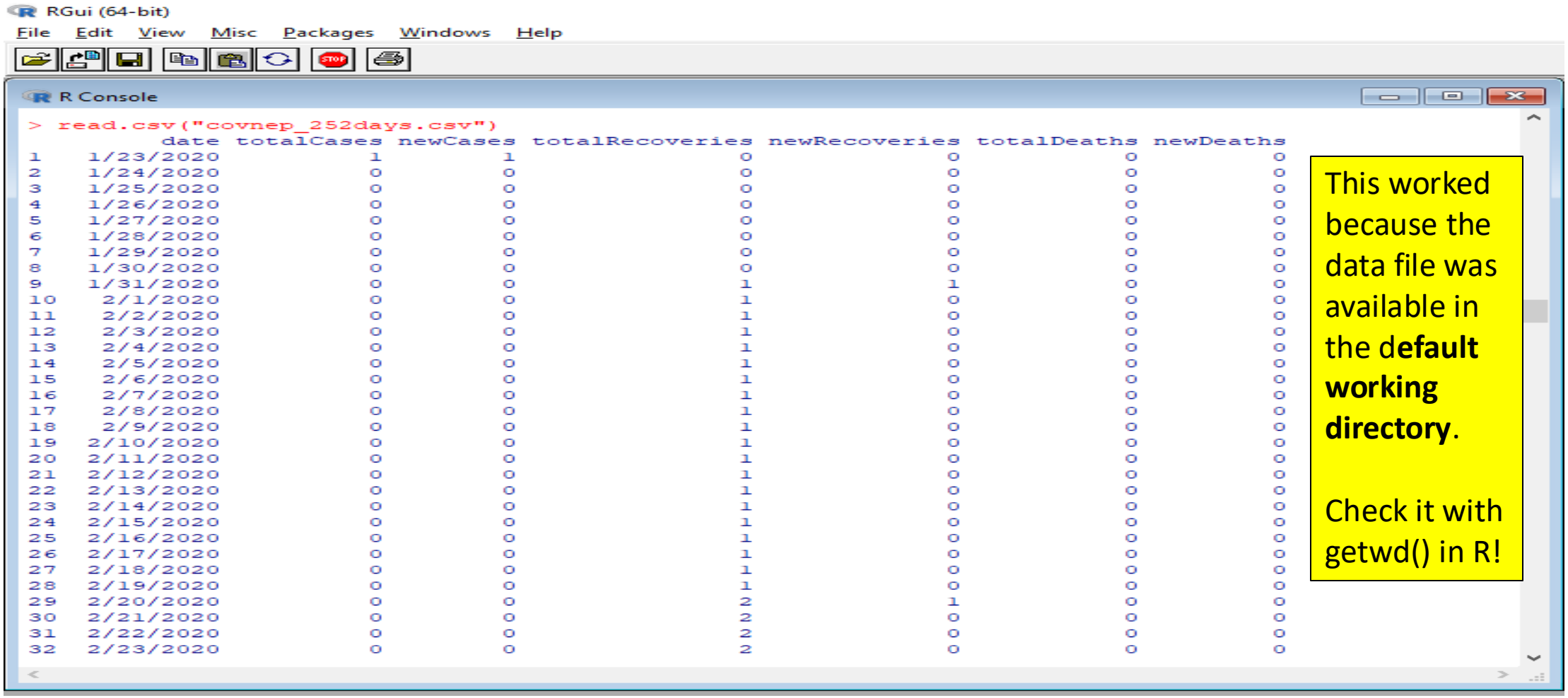
R Console

```
> read.csv("C:/Documents/covnep_252days.csv")
Error in file(file, "rt") : cannot open the connection
In addition: Warning message:
In file(file, "rt") :
  cannot open file 'C:/Documents/covnep_252days.csv': No such file or directory
> read.csv("C:/Users/Dell/Documents/covnep_252days.csv")
         date totalCases newCases totalRecoveries newRecoveries totalDeaths newDeaths
1    1/23/2020          1        1               0             0           0         0
2    1/24/2020          0        0               0             0           0         0
3    1/25/2020          0        0               0             0           0         0
4    1/26/2020          0        0               0             0           0         0
5    1/27/2020          0        0               0             0           0         0
6    1/28/2020          0        0               0             0           0         0
7    1/29/2020          0        0               0             0           0         0
8    1/30/2020          0        0               0             0           0         0
9    1/31/2020          0        0               1             1           0         0
10    2/1/2020          0        0               1             0           0         0
11    2/2/2020          0        0               1             0           0         0
12    2/3/2020          0        0               1             0           0         0
13    2/4/2020          0        0               1             0           0         0
14    2/5/2020          0        0               1             0           0         0
15    2/6/2020          0        0               1             0           0         0
16    2/7/2020          0        0               1             0           0         0
17    2/8/2020          0        0               1             0           0         0
18    2/9/2020          0        0               1             0           0         0
19   2/10/2020          0        0               1             0           0         0
20   2/11/2020          0        0               1             0           0         0
21   2/12/2020          0        0               1             0           0         0
22   2/13/2020          0        0               1             0           0         0
23   2/14/2020          0        0               1             0           0         0
24   2/15/2020          0        0               1             0           0         0
25   2/16/2020          0        0               1             0           0         0
26   2/17/2020          0        0               1             0           0         0
27   2/18/2020          0        0               1             0           0         0
```

Base read.csv function to read csv file: Get summary of this “data.frame” in R!



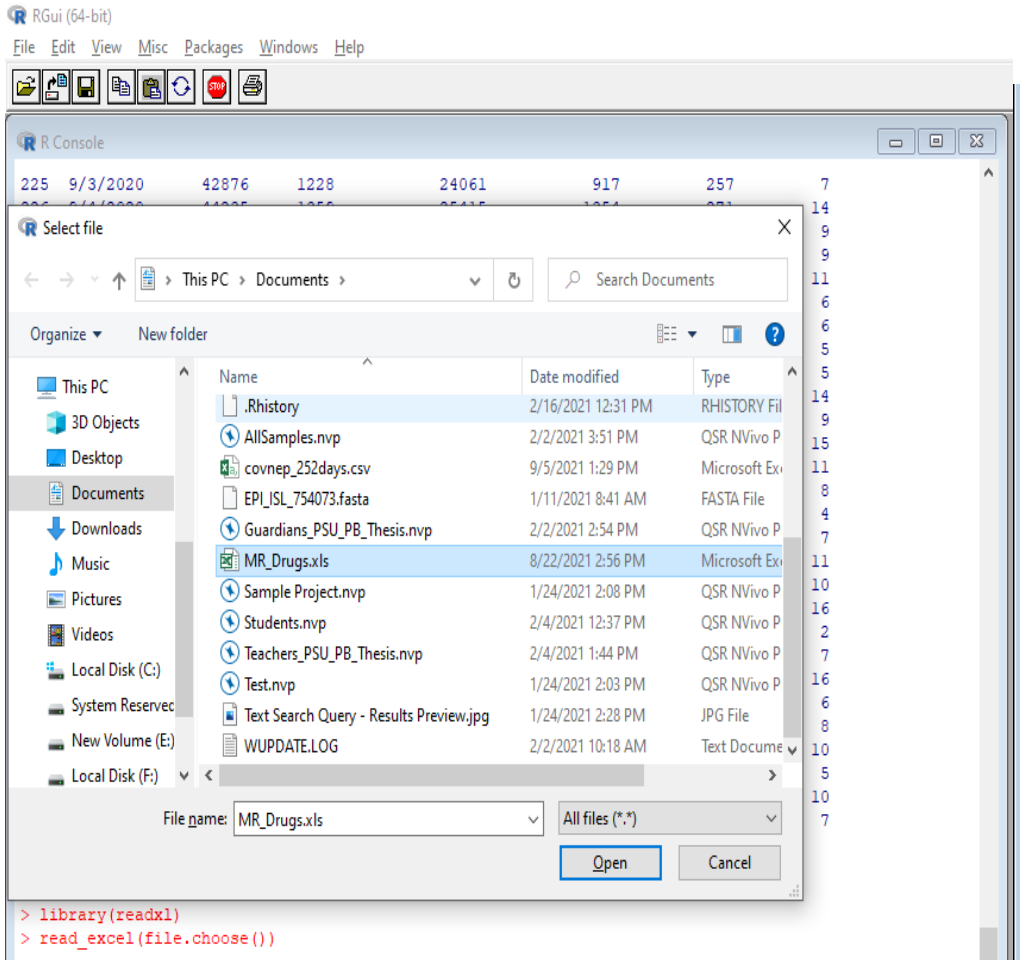
Import data in R: Excel files

- Packages:
  - “readxl”, “xlxs” packages

- How to use “readxl” package to read xls and xlxs excel files
  - Install.packages(“readxl”)
  - load(readxl)
  - my_data1 <- read_excel(“my_file.xls”)
  - my_data2 <- read_excel(“my_file.xlsx”)

- Use “xlxs” package if “readxl” package can’t read excel file with xlsx extensions!

Readxl package to read excel files:
Get summary of this “data.frame” in R!

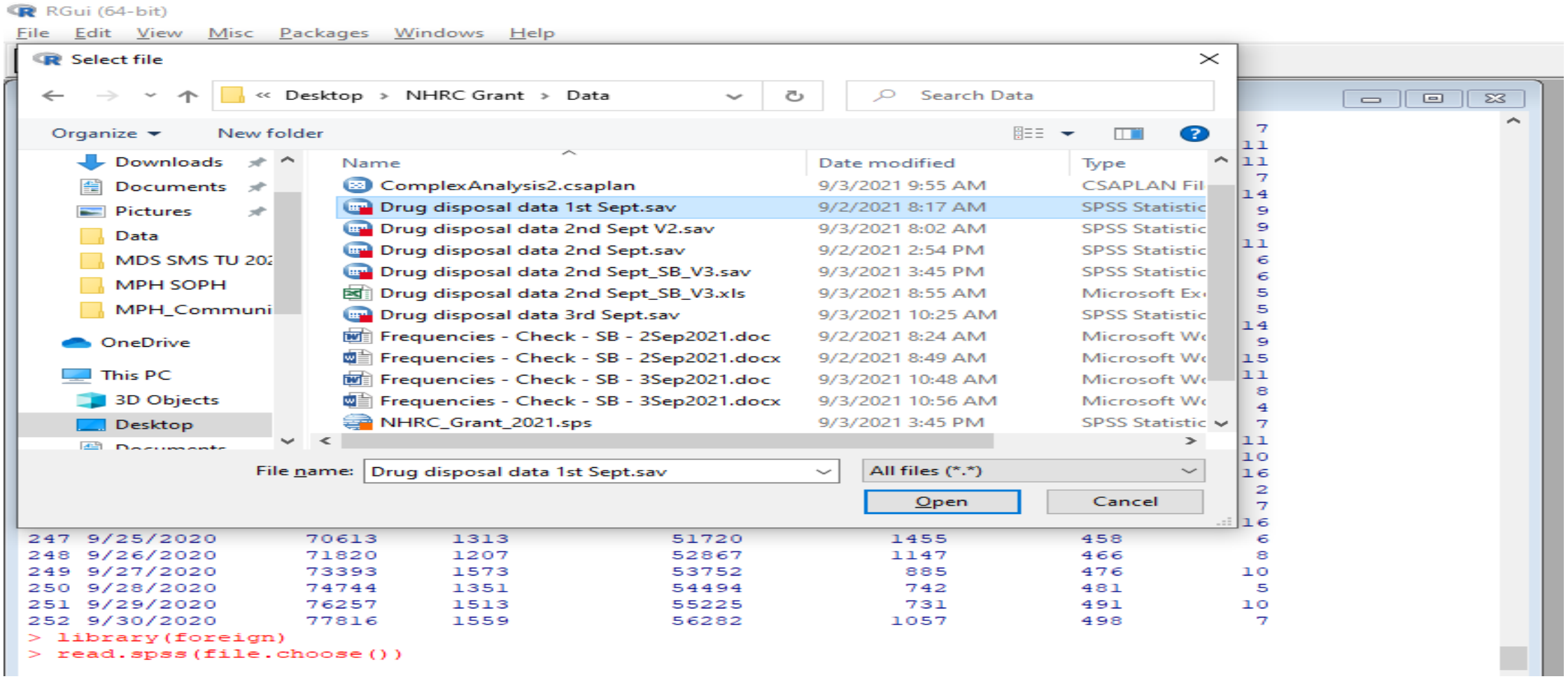



```
> library(readxl)
> read_excel(file.choose())
# A tibble: 972 x 27
      id   sex  city incol inco2 inco3 inco4 inco5 inco6 inco7 pinco1 pinco2 pinco3 pinco4 pinco5
   <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
 1  1001     2     1     0     0     0     0     0     1     0      6     -1     -1     -1     -1
 2  1002     2     1     0     1     0     0     0     0     0      2     -1     -1     -1     -1
 3  1003     2     1     0     0     0     0     0     1     0      6     -1     -1     -1     -1
 4  1004     2     1     0     1     0     0     0     0     0      2     -1     -1     -1     -1
 5  1005     2     1     0     0     0     0     0     0     1      7     -1     -1     -1     -1
 6  1006     2     1     1     1     0     0     0     0     0      2      1     -1     -1     -1
 7  1007     2     1     0     1     0     0     0     0     0      2     -1     -1     -1     -1
 8  1008     2     1     0     1     0     0     0     0     0      2     -1     -1     -1     -1
 9  1009     2     1     1     1     0     0     0     0     0      2      1     -1     -1     -1
10  1010     2     1     0     1     0     0     0     0     0      2     -1     -1     -1     -1
# ... with 962 more rows, and 12 more variables: pinco6 <dbl>, sinco1 <chr>, sinco2 <chr>,
#   sinco3 <chr>, sinco4 <chr>, sinco5 <chr>, sinco6 <chr>, crime1 <dbl>, crime2 <dbl>,
#   crime3 <dbl>, crime4 <dbl>, crime5 <dbl>
>
```

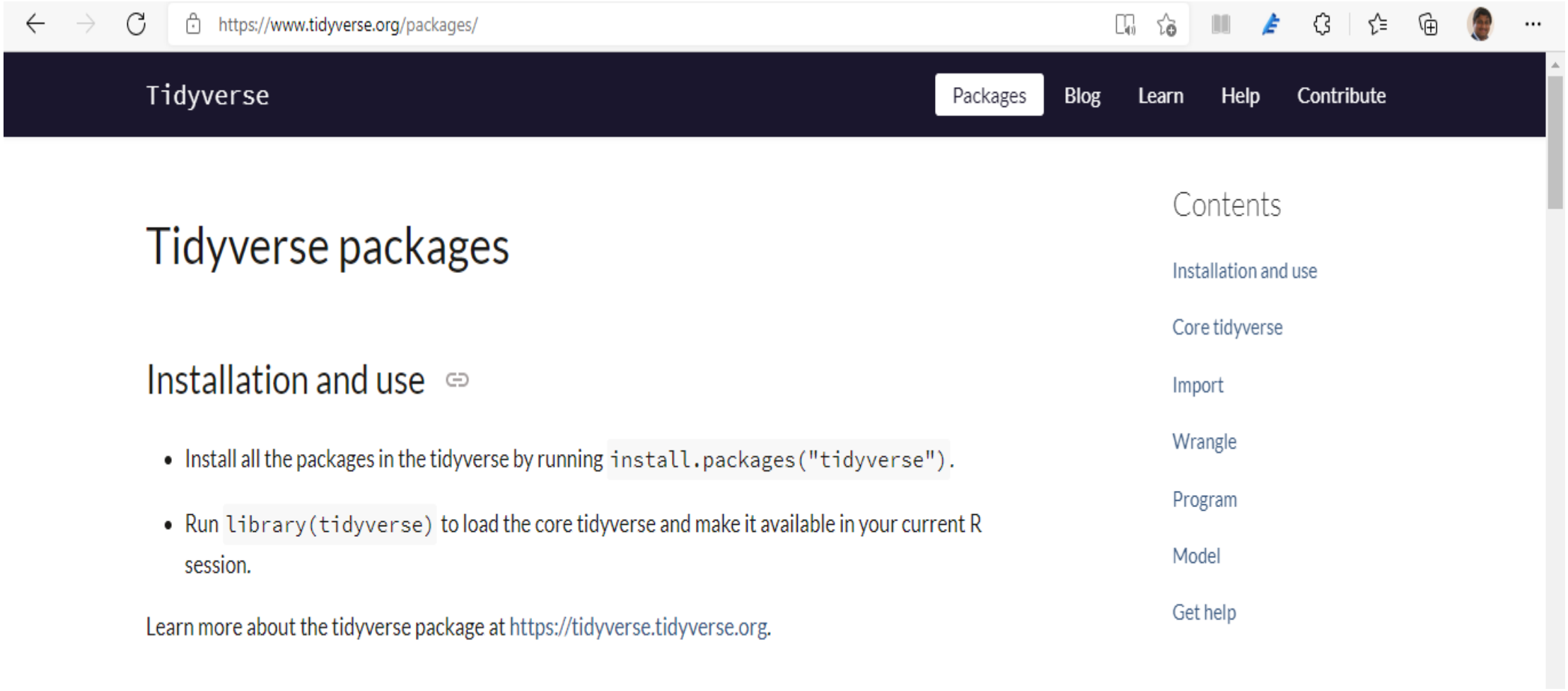
Import data in R: SPSS, Stata, Minitab files

- Packages:
  - “foreign”
- How to use “foreign” package?
  - Install the package in R using: install.packages(“foreign”) command
  - Load the package in R using: library(foreign) function
  - # Reads SPSS file with: read.spss(“datafile”, to.data.frame=TRUE)
  - # Reads Stata file with: read.stata(“datafile”, to.data.frame=T)
  - # Reads Minitab transport file with: read.mtp(“datafile”, to.data.frame=T)
- The “datafile” = “datafile.sav” or “datafile.dta” or “datafile.mtp” files must be in the working directory (Check with “getwd()” in R!)

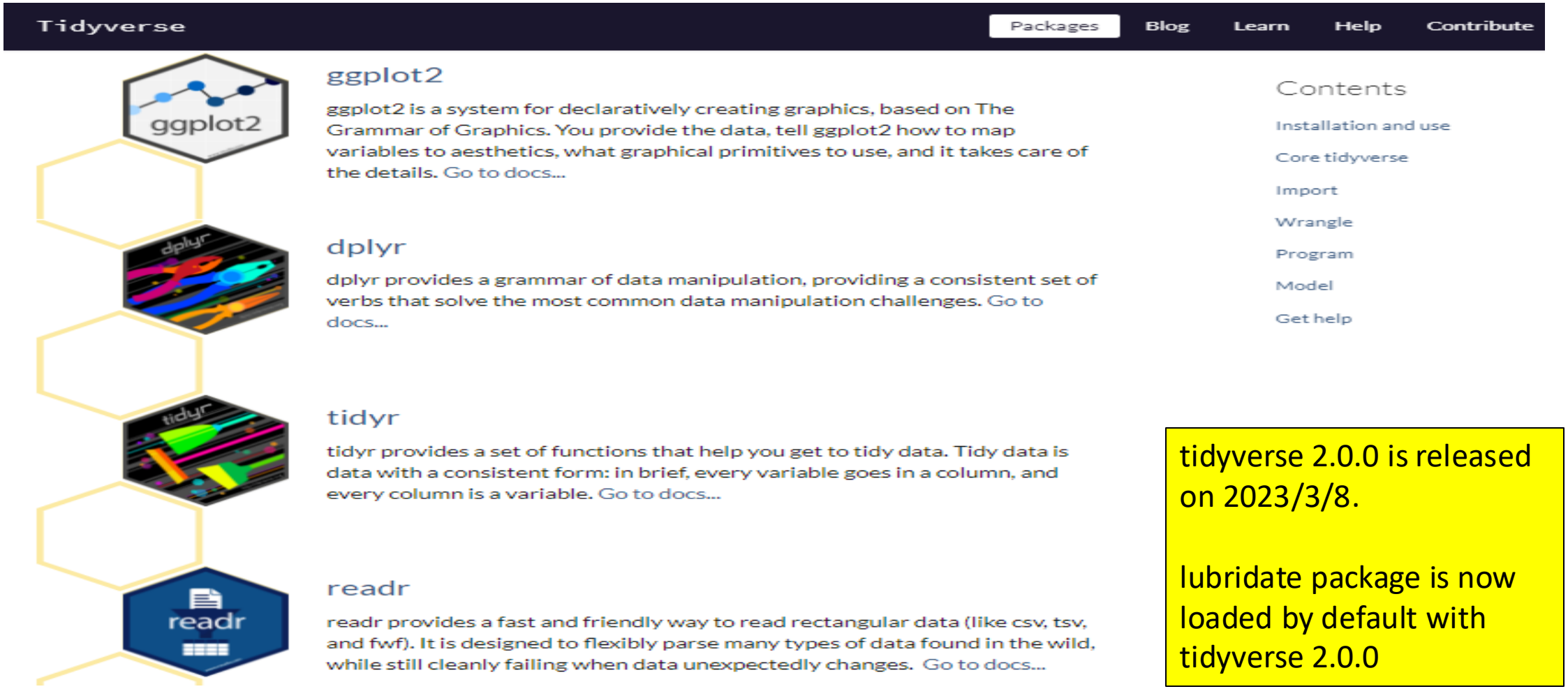
Reading SPSS with “Foreign” package:



The “tidyverse” package for data science:



Core “tidyverse” packages



tidyverse 2.0.0 is released on 2023/3/8.

lubridate package is now loaded by default with tidyverse 2.0.0

Import data in R: Self-Practice!

- Packages (of tidyverse):
  - “readr”

- How to use “readr” package as stand-alone package?
  - Install the package in R using: install.packages(“readr”) command
  - Load the package in R using: library(readr) function
  - # Read tab separated values read_tsv(file.choose())
  - # Read comma (",") separated values read_csv(file.choose())
  - # Read semicolon (";") separated values read_csv2(file.choose())

Import data in R: SPSS, Stata and SAS files (Self-Practice)

- Packages (of tidyverse):
  - “haven”
- How to use “haven” package?
  - It is part of the “tidyverse” package

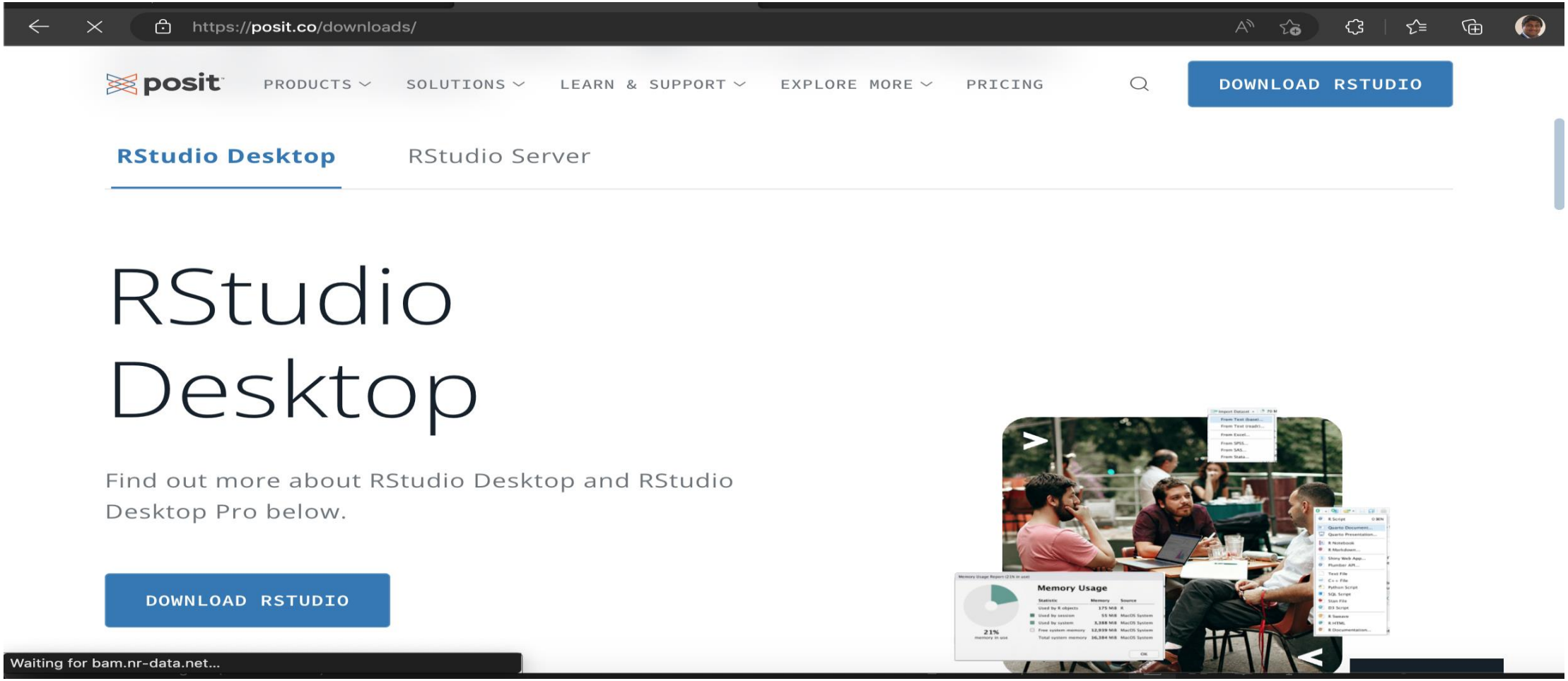
- It can be installed separately as follows:
  - Install.packages(“haven”)
  - load(haven)
  - read_sas(datafile.sas7bdat)
  - read_sav(datafile.sav)
  - read_dta(datafile.dta)

Installing r packages from other sources:

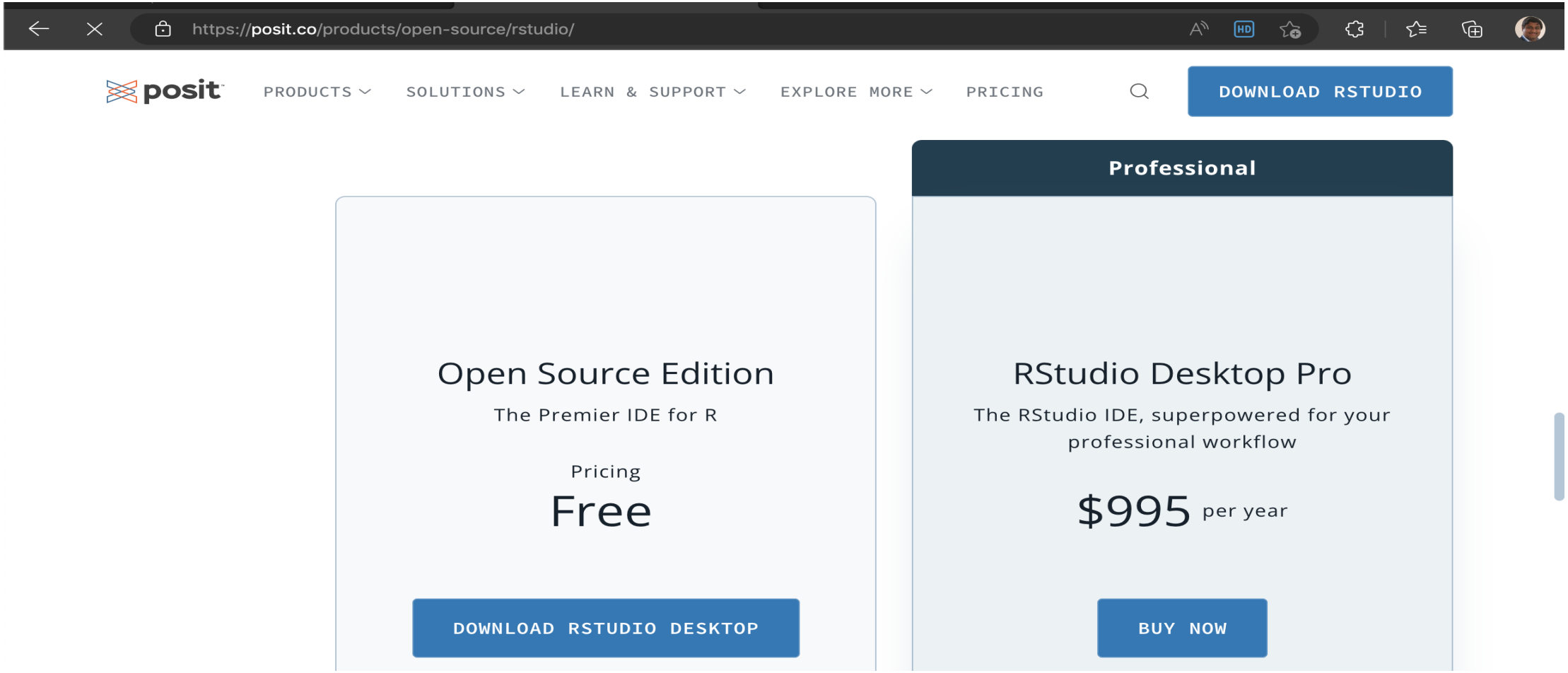
- We can use “GitHub”, which requires “devtools” or “githubinstall” package *a priori*
  - Install_github(“twitter/AnomalyDetection”)
  - githubinstall(“AnomanyDetection”)
  - We can install “latest” packages using this method but with a cost!

- We can use “Bioconductor” repository if we intend to work with Genomics/Bio-Informatics
  - Install Bioconductor Manager first
  - BioCManager::install(c(“GenomicFeature”, “AnnotationDbi”)

R Studio Desktop (for next class)
https://posit.co/downloads



R Studio Desktop IDE (for next class)
https://posit.co/products/open-source/rstudio



Question/Queries?

Thank you!

@shitalbhandary