Lecture 1.8 – Lists and Data Frames

Specific Learning Objectives:

OMG it's a study guide!!!!

1.1.10 – Create vectors, arrays, matrices, lists, and data frames.

1.1.11 – Understand vectors and vectorized calculations.

1.1.12 – Learn how to index vectors, arrays, matrices, lists, and data frames.

Data sets in base R

- Base R comes with several sample data sets.

  - To view: **`> data()`**

R data sets

```
Data sets in package 'datasets':

AirPassengers             Monthly Airline Passenger Numbers 1949-1960
BJsales                   Sales Data with Leading Indicator
BJsales.lead (BJsales)    Sales Data with Leading Indicator
BOD                       Biochemical Oxygen Demand
CO2                       Carbon Dioxide Uptake in Grass Plants
ChickWeight               Weight versus age of chicks on different diets
DNase                     Elisa assay of DNase
EuStockMarkets            Daily Closing Prices of Major European Stock Indices,
                          1991-1998
Formaldehyde              Determination of Formaldehyde
HairEyeColor              Hair and Eye Color of Statistics Students
Harman23.cor              Harman Example 2.3
Harman74.cor              Harman Example 7.4
Indometh                  Pharmacokinetics of Indomethacin
InsectSprays              Effectiveness of Insect Sprays
JohnsonJohnson            Quarterly Earnings per Johnson & Johnson Share
LakeHuron                 Level of Lake Huron 1875-1972
LifeCycleSavings          Intercountry Life-Cycle Savings Data
Loblolly                  Growth of Loblolly pine trees
Nile                      Flow of the River Nile
Orange                    Growth of Orange Trees
```

Data sets in base R

- To load into RStudio's environment:

```
> data(dataset.name)
> force(dataset.name)
```

```
> data(BOD)
> force(BOD)
  Time demand
1    1    8.3
2    2   10.3
3    3   19.0
4    4   16.0
5    5   15.6
6    7   19.8
>
```

```
> data("ToothGrowth")
> force(ToothGrowth)
    len supp dose
1   4.2   VC  0.5
2  11.5   VC  0.5
3   7.3   VC  0.5
4   5.8   VC  0.5
5   6.4   VC  0.5
6  10.0   VC  0.5
7  11.2   VC  0.5
```

Lists and Data Frames — What's the difference?

- Two very common classes that deal with *mixed* data types are **lists** and **data frames**.

  - Mixed data types would include different types of data in the same object (ex: characters, integers, and numerics).

  - Both lists and data frames can handle mixed data types, but they come with some differences.

- To compare and contrast, load the following data sets into your R Studio environment:

  - List example:

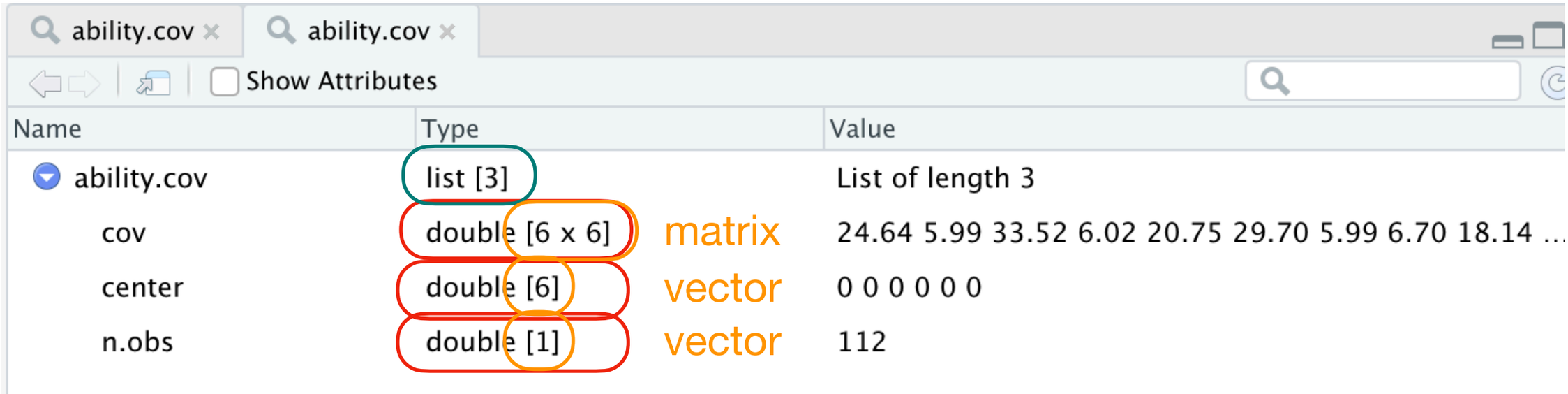
    `ability.cov`

  - Data frame example:

    `ToothGrowth`

Characteristics of Lists

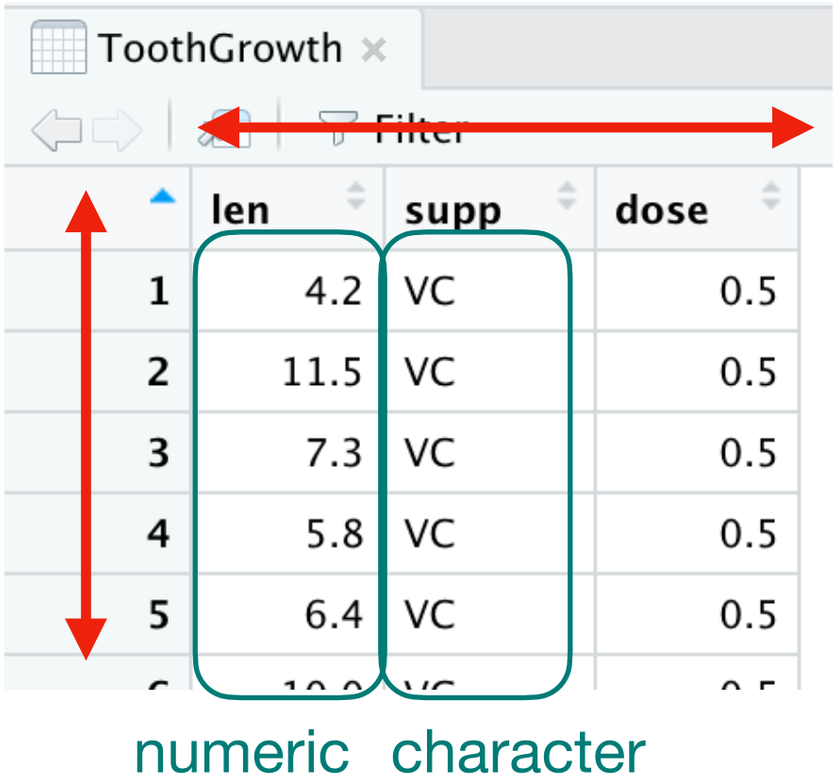
- List example shows a few characteristics of lists.



- Lists can have as many members as you want (this example has 3)
- Each member in a list can be a different size
- Each member can be a different class (but within an element, they must be the same type/class).
- Each member can be different data type!
- (not shown) A member can even be another list!

Characteristics of Data Frames

- Data frame example shows a few characteristics of data frames.



- Data frames are limited to 2D structures (like matrices).
- Data frames can have different data types in different columns (but must have the same type within a column)
- Data frames can have as many columns and rows as you'd like, but all columns must have the same number of rows and all rows have to have the same number of columns.

Check Your Understanding

Which class of object would you use if you needed:

a) **Members of different sizes**

b) **Members of different classes**

c) **Both a and b**

	List	Data frame
a)	✓	✗
b)	✓	✓
c)	✓	✗

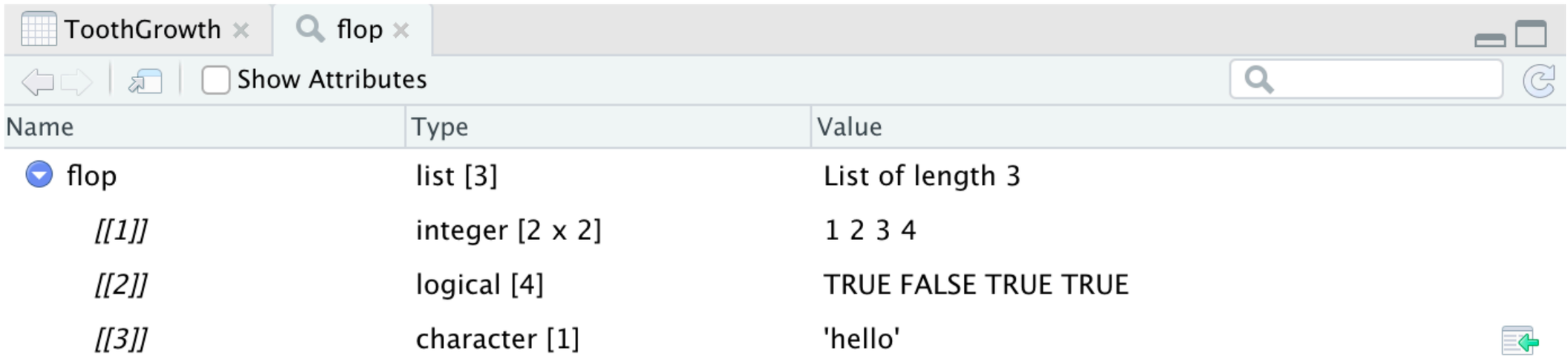
Creating and Viewing Lists

- Creating lists is easy with **`list()`**

```
> flop <- list(matrix(data=1:4, nrow=2, ncol=2), c(T,F,T,T), "hello")
```

- Inspect your list using **`View()`**

```
> View(flop)
```



- Inspect individual members of your list using the button

- The button will give you the code for reference of member.

Member Reference of Lists

- There are several ways of calling individual elements of lists.

ToothGrowth × flop ×

Show Attributes

Name	Type	Value
flop	list [3]	List of length 3
[[1]]	integer [2 x 2]	1 2 3 4
[[2]]	logical [4]	TRUE FALSE TRUE TRUE
[[3]]	character [1]	'hello'

- Double brackets give access to members of the list:

```
> flop[[3]]
[1] "hello"
```

```
> flop[[1]]
     [,1] [,2]
[1,]    1    3
[2,]    2    4
```

- Adding single brackets will reference individual elements of the member:

```
> flop[[2]][2]
[1] FALSE
```

```
> flop[[1]][4]
[1] 4
```

Member Reference of Lists

- If you want multiple members from a list, you can perform list slicing by using single brackets with a vector:

```
> flop[c(2,3)]
[[1]]
[1]  TRUE FALSE  TRUE  TRUE

[[2]]
[1] "hello"
```

Pulls both members 2 and 3

- For easy reference, you can also name members of your list:

```
> names(flop) <- c("mymatrix", "mylogicals", "mystring")
```

Name	Type	Value
flop	list [3]	List of length 3
mymatrix	integer [2 x 2]	1 2 3 4
mylogicals	logical [4]	TRUE FALSE TRUE TRUE
mystring	character [1]	'hello'

- Reference using a dollar sign:

```
> flop$mylogicals
[1]  TRUE FALSE  TRUE  TRUE
```

```
> flop$mymatrix[1,1]
[1] 1
```

List Info

- Information for lists is a bit different than for other classes

  - If you use length, you will get the number of members:

```
> length(flop)
[1] 3
```

  - Most other functions will return NULL if you use them on lists:

```
> dim(flop)
NULL
```

- But you can use the same functions on individual members for info:

```
> dim(flop$mymatrix)
[1] 2 2
```

```
> length(flop$mystring)
[1] 1
```

Modifying Lists

- Modifying lists is easy!

  - Add members by simply assigning a new number or named member to the list:

```
> flop[[4]]<- c(3,4,7,1,10)
> flop$blep <- "Haha"
```

flop × flop ×

Show Attributes

Name	Type	Value
flop	list [5]	List of length 5
[[1]]	integer [2 x 2]	1 2 3 4
[[2]]	logical [4]	TRUE FALSE TRUE TRUE
[[3]]	character [1]	'hello'
[[4]]	double [5]	3 4 7 1 10
blep	character [1]	'Haha'

  - Adding elements to each member depends on the data type of the member!

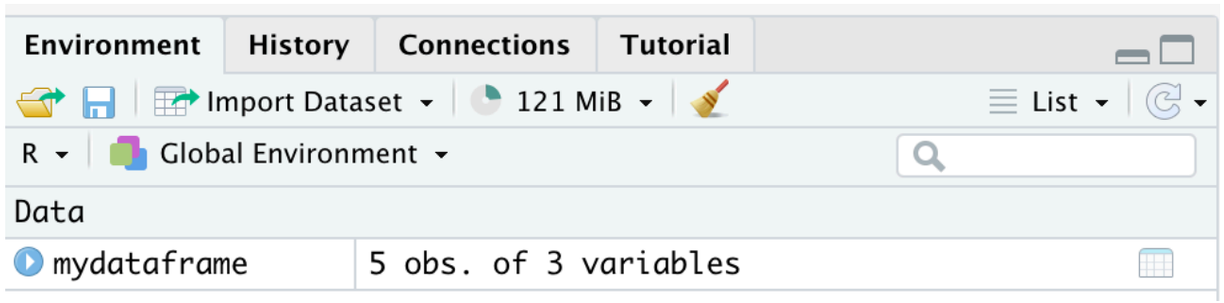
Check Your Understanding

Create a list in which each member contains one of each data types you've learned so far in the course!

Creating Data Frames

- Create a data frame using **`data.frame()`**

```
> mydataframe <- data.frame(x=c(3.2, 5.4, 2.5, 4.4, 7.8), y=c(2.1, 1.0, 3.3, 2.9, 4.1),
+                           condition=c(T,F,T,T,F))
```



mydataframe

Filter

	x	y	condition
1	3.2	2.1	TRUE
2	5.4	1.0	FALSE
3	2.5	3.3	TRUE
4	4.4	2.9	TRUE
5	7.8	4.1	FALSE

Data frames report observations (or rows) and variables (or columns)

- You can set column names during data-frame construction!

- Rename column names using **`colnames()`**

```
> colnames(mydataframe) <- c("up","down","cow")
```

Indexing Data Frames

- There are a LOT of ways of indexing data within data frames.

  - Similar to matrices, you can specify row and column positions with square brackets:

mydataframe

Filter

	x	y	condition
1	3.2	2.1	TRUE
2	5.4	1.0	FALSE
3	2.5	3.3	TRUE
4	4.4	2.9	TRUE
5	7.8	4.1	FALSE

```
> mydataframe[2,3]
[1] FALSE
```

```
> mydataframe[2,2]
[1] 1
```

- You can also use double square brackets to call columns.

```
> mydataframe[["y"]]
[1] 2.1 1.0 3.3 2.9 4.1
```

```
> mydataframe[["y"]][4]
[1] 2.9
```

- You can *also* use a dollar sign to call columns.

```
> mydataframe$y
[1] 2.1 1.0 3.3 2.9 4.1
```

```
> mydataframe$y[4]
[1] 2.9
```

Data-frame Indexing Alignment Chart

```
df <- data.frame(x = 1:3, y = 4:6)
```

LAWFUL GOOD

```
df[["y"]]
```

NEUTRAL GOOD

```
pull(df, y)
```

CHAOTIC GOOD

```
select(df, y)[[1]]
```

LAWFUL NEUTRAL

```
df[,"y"]
```

TRUE NEUTRAL

```
df$y
```

CHAOTIC NEUTRAL

```
df[, names(df)=="y"]
```

LAWFUL EVIL

```
select_at(df,
vars(matches("^y$")))[[1]]
```

NEUTRAL EVIL

```
df[,2]
```

CHAOTIC EVIL

```
pmap_int(df, function(x,y){y})
```

Modifying Data Frames

- Modifying data frames is similar to list, but also has some additional helpful functions.

  - Add a column by assigning it with a new name:

```
> mydataframe$metric <- seq(1,5)
```

(Remember, the new column has to be the same length as the number of rows in the data frame!)

mydataframe

Filter

	x	y	condition	metric
1	3.2	2.1	TRUE	1
2	5.4	1.0	FALSE	2
3	2.5	3.3	TRUE	3
4	4.4	2.9	TRUE	4
5	7.8	4.1	FALSE	5

  - Add multiple rows by using “row bind” **`rbind()`**:

```
> mydataframe <- rbind(mydataframe, mydataframe)
```

Binds two copies of `mydataframe` together!

  - Add multiple columns by using “column bind” **`cbind()`**:

```
> mydataframe <- cbind(mydataframe, mydataframe)
```

Info on Data Frames

- There are some helpful functions for data frames that will make life a bit easier!

- Print out the first few lines of a data frame: **`head()`**

```
> head(ToothGrowth)
   len supp dose
1  4.2   VC  0.5
2 11.5   VC  0.5
3  7.3   VC  0.5
4  5.8   VC  0.5
5  6.4   VC  0.5
6 10.0   VC  0.5
```

(Note: these also work with other data classes)

- Print out the last few lines of a data frame: **`tail()`**

```
> tail(ToothGrowth)
    len supp dose
55 24.8   OJ    2
56 30.9   OJ    2
57 26.4   OJ    2
58 27.3   OJ    2
59 29.4   OJ    2
60 23.0   OJ    2
```

- Print out a summary of elements in the data frame: **`summary()`**

```
> summary(ToothGrowth)
      len        supp         dose      
 Min.   : 4.20   OJ:30   Min.   :0.500  
 1st Qu.:13.07   VC:30   1st Qu.:0.500  
 Median :19.25           Median :1.000  
 Mean   :18.81           Mean   :1.167  
 3rd Qu.:25.27           3rd Qu.:2.000  
 Max.   :33.90           Max.   :2.000  
```

Automatically summarizes each column!

Summary statistics appropriate for data type!

Check Your Understanding

In the `ToothGrowth` data set, how can you print out all the measured tooth lengths from their study?

How can you find the mean and standard deviation of these lengths?

Logical Record Subsets

- Information can also be pulled based on a logical test for most data structures (lists and data frames included!)

    - This is really useful if you don't care what the element position is, you care more about the value of the elements.

You run the following line to create a matrix:

```
my.matrix2 <- matrix(seq(1,21), nrow=7, byrow=TRUE)
```

Which line of code will subset only two-digit numbers (those greater than 9)?

- one option: **`my.matrix2[4:7, ]`**
- another option: **`my.matrix2[my.matrix2>9]`**

```
> my.matrix2>9
      [,1]  [,2]  [,3]
[1,] FALSE FALSE FALSE
[2,] FALSE FALSE FALSE
[3,] FALSE FALSE FALSE
[4,]  TRUE  TRUE  TRUE
[5,]  TRUE  TRUE  TRUE
[6,]  TRUE  TRUE  TRUE
[7,]  TRUE  TRUE  TRUE
```

```
> my.matrix2[my.matrix2>9]
 [1] 10 13 16 19 11 14 17 20 12 15 18 21
```

Logical Record Subsets

- In data frames, be a little careful to specify whether you are looking for the record in a column or a row.

    - The easiest way to do this is to come up with the test first and then where it is searching second.

Example: In the **`ToothGrowth`** data set, find all the data associated with animals given orange juice as their supplement.

- We want to first create the test. How can we restrict data to only orange juice (OJ)?

```
ToothGrowth$supp == "OJ"
```

- Now use this logical vector to retrieve the records:

```
ToothGrowth[ToothGrowth$supp == "OJ", ]
```

Get all the rows where this statement is true

And get ALL columns for those rows!

Check Your Understanding

In the `ToothGrowth` data set, how can you print out all the measured tooth lengths from their study that were only given a dose of 1.0?

How can you find the mean and standard deviation of these lengths?

Can you find the mean of the tooth lengths for animals given an OJ dose of 1.0?

Action Items

1. **Complete Assignments 1.10 and 1.11.**

2. **Read Davies Ch. 6 for next time.**