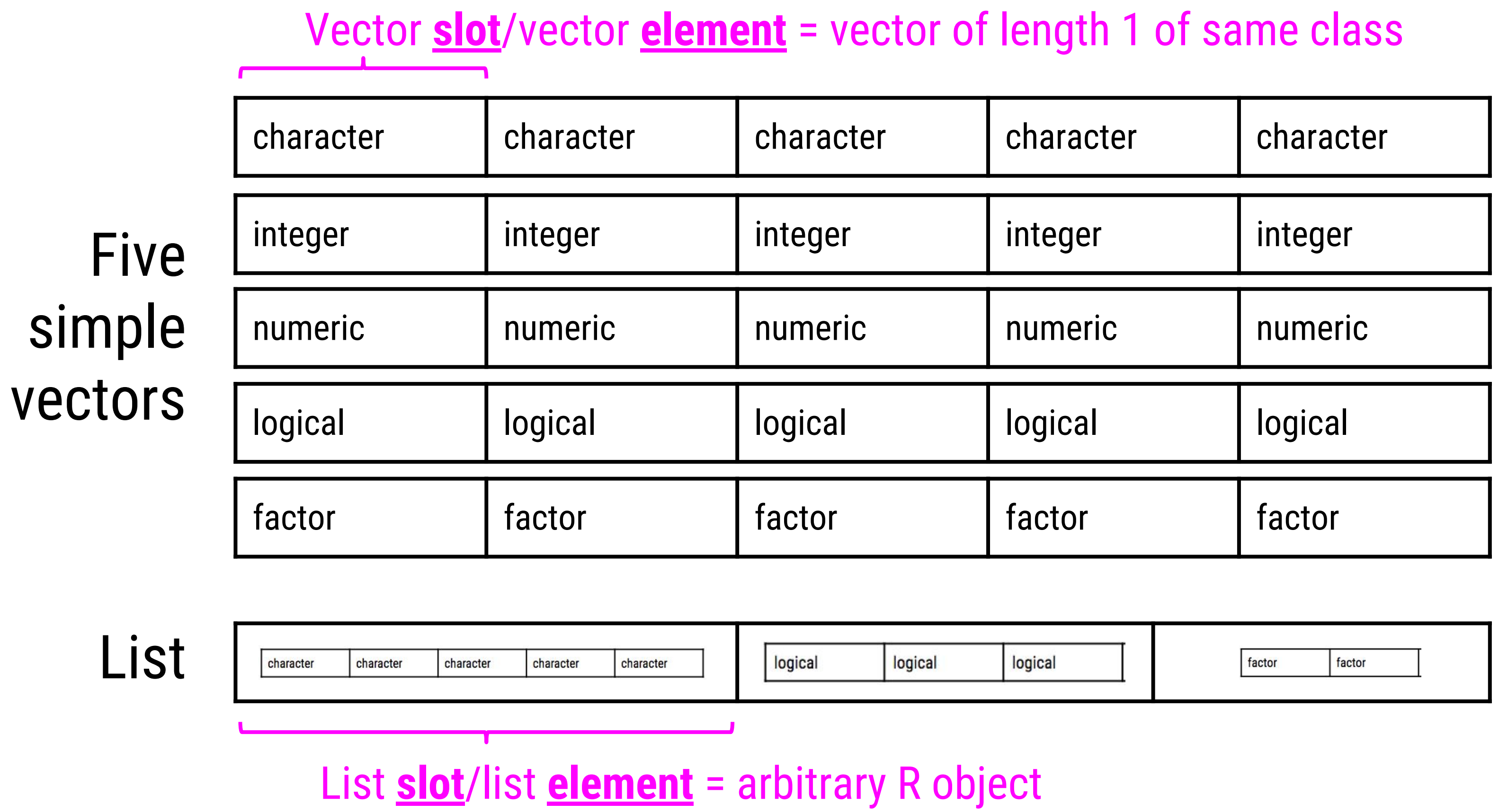
Lists & Data Frames

Introduction to R


Vector slot/vector element = vector of length 1 of same class
Five simple vectors
character
integer
numeric
logical
factor
List
character
logical
factor
List slot/list element = arbitrary R object

Comparing lists to simple vectors

Creating lists

The `list` function: `list(obj_1, obj_2, ..., obj_n)`

```
> responses_student1 <- list(c(4,20,3), c("bear",
"giraffe"), c("red", "orange", "yellow", "green", "blue",
"purple"))
> responses_student1
[[1]] 1st list slot/element (unnamed)
[1]  4 20  3

[[2]] 2nd list slot/element (unnamed)
[1] "bear"    "giraffe"

[[3]] 3rd list slot/element (unnamed)
[1] "red"    "orange" "yellow" "green"  "blue"   "purple"
```

Adding names to a list (method 1)

Use the `names` function:

```
> names(responses_student1) <- c("numbers", "animals",
"colors")
> responses_student1
$numbers 1st list slot/element (named “numbers”)
[1]  4 20  3

$animals 2nd list slot/element (named “animals”)
[1] "bear"    "giraffe"

$colors  3rd list slot/element (named “colors”)
[1] "red"    "orange" "yellow" "green"  "blue"   "purple"
```

Adding names to a list (method 2)

Using named arguments in the `list` function:

Named arguments

```
> responses_student2 <- list(numbers = 1:5, animals =
c("T-rex", "tiger", "lion"), colors = c("red", "green"))
> responses_student2
$numbers
[1] 1 2 3 4 5

$animals
[1] "T-rex" "tiger" "lion"

$colors
[1] "red"   "green"
```

1st list slot/element (named "`numbers`")

2nd list slot/element (named "`animals`")

3rd list slot/element (named "`colors`")

List of lists

```
> responses_all_students <- list(responses_student1, responses_student2)
> responses_all_students
[[1]]
```

1st list slot/element (unnamed)

```
[[1]]$numbers
[1]  4 20  3

[[1]]$animals
[1] "bear"    "giraffe"

[[1]]$colors
[1] "red"    "orange" "yellow" "green"  "blue"   "purple"


[[2]]
```

2nd list slot/element (unnamed)

```
[[2]]$numbers
[1] 1 2 3 4 5

[[2]]$animals
[1] "T-rex" "tiger" "lion"

[[2]]$colors
[1] "red"   "green"
```

List of lists (with names)

```
> list(st1 = responses_student1, st2 = responses_student2)
$st1
```

1st list slot/element (named “`st1`”)

```
$st1$numbers
[1]  4 20  3

$st1$animals
[1] "bear"    "giraffe"

$st1$colors
[1] "red"    "orange" "yellow" "green"  "blue"   "purple"


$st2
```

2nd list slot/element (named “`st2`”)

```
$st2$numbers
[1] 1 2 3 4 5

$st2$animals
[1] "T-rex" "tiger" "lion"

$st2$colors
[1] "red"   "green"
```

Relationship between lists and data frames

All data frames are lists. Data frames are lists where each list element is a simple vector of the same length.

```
> head(mtcars)
                   mpg cyl disp  hp drat    wt  qsec vs am gear carb
Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1
```

These columns form the individual list elements (all length-6 simple vectors).

Relationship between lists and data frames (as.list)

```
> as.list(head(mtcars))
$mpg
[1] 21.0 21.0 22.8 21.4 18.7 18.1
$cyl
[1] 6 6 4 6 8 6
$disp
[1] 160 160 108 258 360 225
$hp
[1] 110 110  93 110 175 105
$drat
[1] 3.90 3.90 3.85 3.08 3.15 2.76
$wt
[1] 2.620 2.875 2.320 3.215 3.440 3.460
$qsec
[1] 16.46 17.02 18.61 19.44 17.02 20.22
$vs
[1] 0 0 1 1 0 1
$am
[1] 1 1 1 0 0 0
$gear
[1] 4 4 4 3 3 3
$carb
[1] 4 4 1 1 2 1
```

Each list element is named with the corresponding column name of the data frame.

List subsetting

How can we extract certain parts of a list?

- Double square brackets: `[[`
- Dollar sign notation: `$`
- Single square brackets: `[`

Subsetting: double square brackets

Within the brackets, specify an integer index or a character string.

For lists:

Named list

```
> l <- list(a = 1:7, b = c("foo", "bar", "biz"))
> res1 <- l[[2]]
> res2 <- l[["b"]]
> res1
[1] "foo" "bar" "biz"
> res2
[1] "foo" "bar" "biz"
> class(l)
[1] "list"
> class(res1)
[1] "character"
> class(res2)
[1] "character"
```

Integer index

Character string (requires list elements to be named)

The extracted objects are **character vectors**, not lists.

Subsetting: double square brackets

Within the brackets, specify an integer index or a character string.

For data frames:

```
> iris_subset <- head(iris, 3)
> iris_subset
  Sepal.Length Sepal.Width Petal.Length Petal.Width Species
1          5.1         3.5          1.4         0.2  setosa
2          4.9         3.0          1.4         0.2  setosa
3          4.7         3.2          1.3         0.2  setosa
> iris_subset[[2]]
[1] 3.5 3.0 3.2
> iris_subset[["Sepal.Width"]]
[1] 3.5 3.0 3.2
```

Data frame with 3 rows, 5 columns

Integer index

Character string

The extracted objects are **numeric vectors**, not lists.

Subsetting: dollar sign notation

After the `$`, specify a name in the list (no quotes).

For lists:

```
> l <- list(a = 1:7, b = c("foo", "bar", "biz"))
> l$b
[1] "foo" "bar" "biz"
```

← No quotes around b

The extracted object is a **character vector**, not a list.

Subsetting: dollar sign notation

After the `$`, specify a name in the list (no quotes).

For data frames:

```
> iris_subset
  Sepal.Length Sepal.Width Petal.Length Petal.Width Species
1          5.1         3.5          1.4         0.2  setosa
2          4.9         3.0          1.4         0.2  setosa
3          4.7         3.2          1.3         0.2  setosa
> iris_subset$Sepal.Width
[1] 3.5 3.0 3.2
```

No quotes around Sepal.Width

The extracted object is a **numeric vector**, not a list.

Subsetting: single square brackets

The previous forms of subsetting ([[and $) **simplify** the output.

- Original object is a more complex object (list) than the extracted objects (basic vectors).

$$\begin{tikzcd}\text{List} \arrow[r, "\text{subset}"] & \text{Basic vector}\end{tikzcd}$$

(character, integer, numeric, logical, factor)

Single square bracket subsetting **preserves** the class of the output.

$$\begin{tikzcd}\text{List} \arrow[r, "\text{subset}"] & \text{List}\end{tikzcd}$$

Subsetting: single square brackets

Just like `[[`, specify an integer index or a character string.

For lists:

```
> l <- list(a = 1:7, b = c("foo", "bar", "biz"))
> l[2]
$b
[1] "foo" "bar" "biz"

> l["b"]
$b
[1] "foo" "bar" "biz"

> class(l[2])
[1] "list"
> class(l["b"])
[1] "list"
```

Seeing this indicates that the extracted output is a list

Verifying that the output is a list

Subsetting: single square brackets

Just like `[[`, specify an integer index or a character string.

For data frames:

```
> iris_subset[2]
  Sepal.Width
1         3.5
2         3.0
3         3.2
> iris_subset["Sepal.Width"]
  Sepal.Width
1         3.5
2         3.0
3         3.2
> class(iris_subset[2])
[1] "data.frame"
> class(iris_subset["Sepal.Width"])
[1] "data.frame"
```

Extracted output is displayed as a column which indicates that it is a data frame

Verifying that the output is a data frame

Summary

- Lists are a flexible way to store complex data.
    - Can be created from scratch with the `list` function
- Subsetting lists
    - Double brackets
        - Specify integer index or character string (in quotes)
        - Class-simplifying operation
    - Dollar sign
        - Specify name (no quotes)
        - Class-simplifying operation
    - Single bracket
        - Specify integer index or character string (in quotes)
        - Class-preserving operation