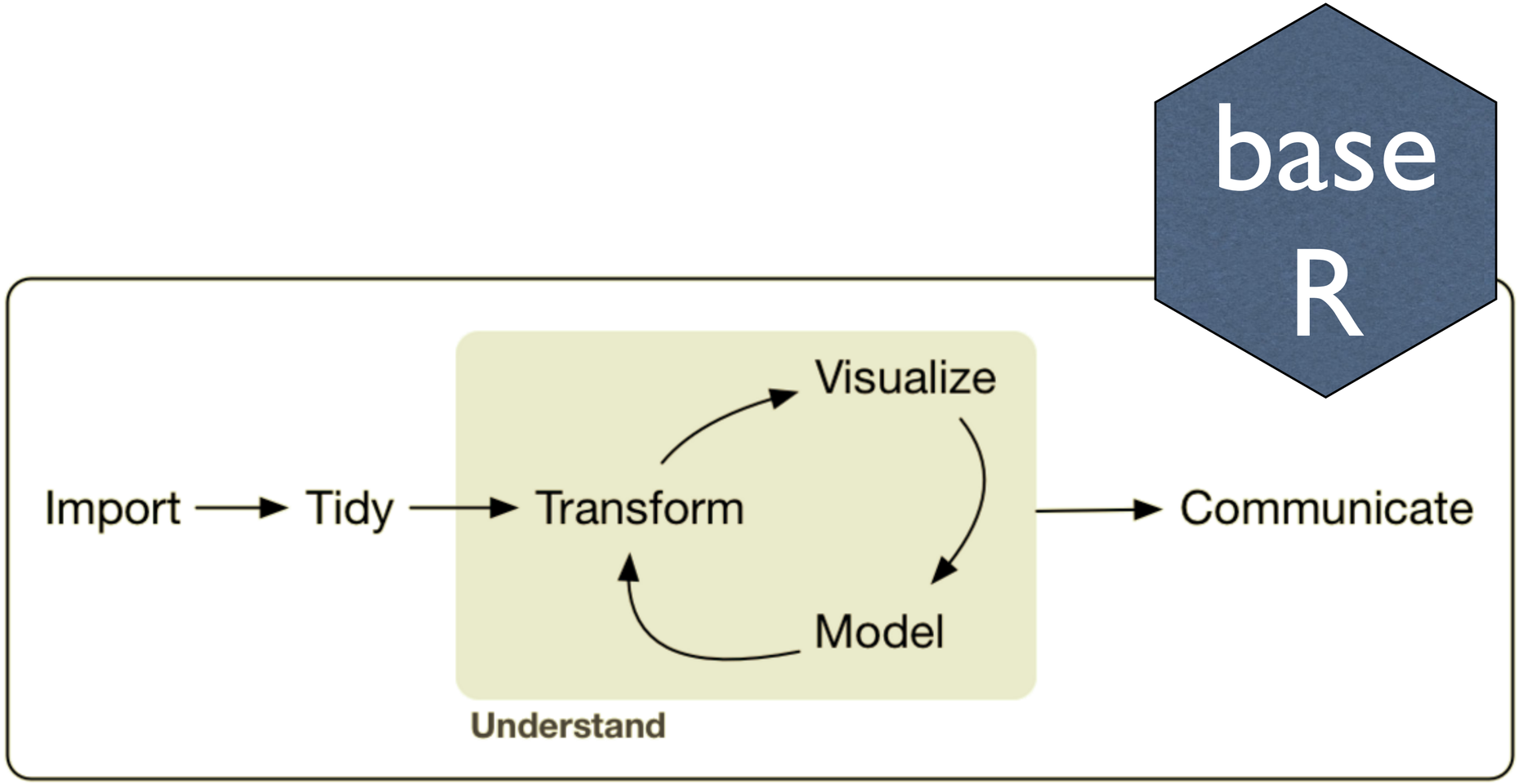
These materials adapted by Amelia McNamara from the RStudio CC BY-SA materials Introduction to R (2014) and Master the Tidyverse (2017).

Introduction to R & RStudio: deck 03: Data types

Amelia McNamara
Visiting Assistant Professor of Statistical and Data Sciences
Smith College

January 2018

1. Vectors
2. Matrices
3. Data types
4. Coercion



From *R for Data Science* by Hadley Wickham and Garrett Grolemund.

Your Turn 1

Look at the R object WorldPhones (by typing its name in your notebook or the Console and hitting enter).

What is inside of WorldPhones?

WorldPhones

	N.Amer	Europe	Asia	S.Amer	Oceania	Africa	Mid.Amer
1951	45939	21574	2876	1815	1646	89	555
1956	60423	29990	4708	2568	2366	1411	733
1957	64721	32510	5230	2695	2526	1546	773
1958	68484	35218	6662	2845	2691	1663	836
1959	71799	37598	6856	3000	2868	1769	911
1960	76036	40341	8220	3145	3054	1905	1008
1961	79831	43173	9053	3338	3224	2005	1076

You can save more than a single number in an object by creating a *vector*, *matrix*, or *array*.

Vectors

Your turn

How many dimensions does a vector have?

1 2 3 4 5 6

How many dimensions does a vector have?

vectors

Combine multiple elements into a one dimensional array.

Create with the c function (for "concatenate").

```
vec <- c(1, 2, 3, 10, 100)
vec
```

Your turn

What happens in your Environment when you run this code?

In your Notebook?

```
vec <- c(1, 2, 3, 10, 100)
vec
```

vectors

Combine multiple elements into a one dimensional array.

Create with the c function (for "concatenate").

```
vec <- c(1, 2, 3, 10, 100)
vec
# 1   2   3  10 100
```

Matrices

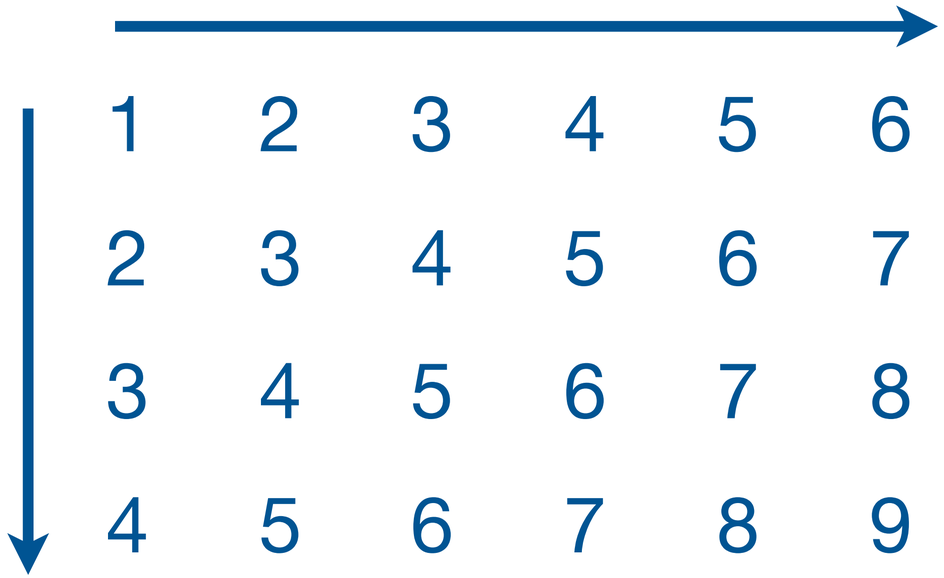
Uncommon, but good to know

Your turn

How many dimensions does a matrix have?

1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9

How many dimensions does a matrix have?

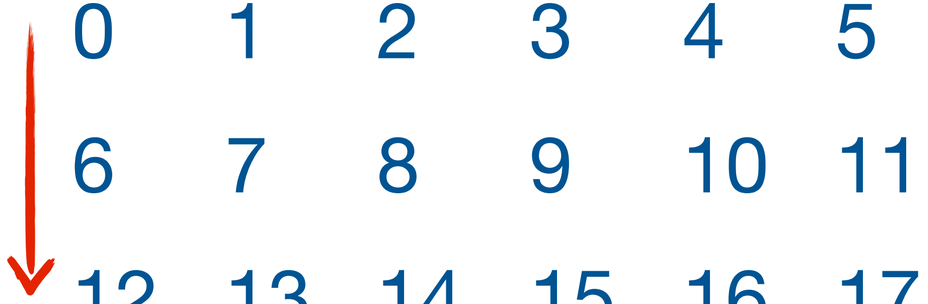


Your turn

The matrix below is named **M**.
What is the value of $\mathbf{M}_{34}$?

0	1	2	3	4	5
6	7	8	9	10	11
12	13	14	15	16	17
18	19	20	21	22	23

The matrix below is named **M**.
What is the value of $\mathbf{M}_{34}$?



The matrix below is named **M**.
What is the value of $\mathbf{M}_{34}$?

The matrix below is named **M**.
What is the value of $\mathbf{M}_{34}$?

matrices

multiple elements stored in a two dimensional array.

Create with the matrix function.

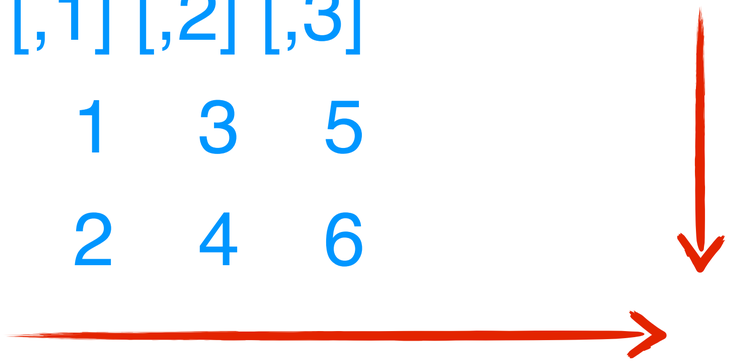
```
mat <- matrix(c(1, 2, 3, 4, 5, 6), nrow = 2)
mat
#      [,1] [,2] [,3]
# [1,]    1    3    5
# [2,]    2    4    6
```

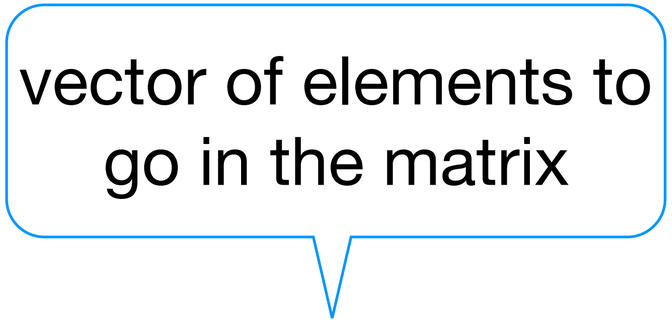
matrices

Combine multiple elements into a two dimensional array.

Create with the matrix function.

```
mat <- matrix(c(1, 2, 3, 4, 5, 6), nrow = 2)
mat
#      [,1] [,2] [,3]
# [1,]    1    3    5
# [2,]    2    4    6
```






```
matrix(c(1, 2, 3, 4, 5, 6), nrow = 2)
#      [,1] [,2] [,3]
# [1,]    1    3    5
# [2,]    2    4    6
```

number of rows for matrix

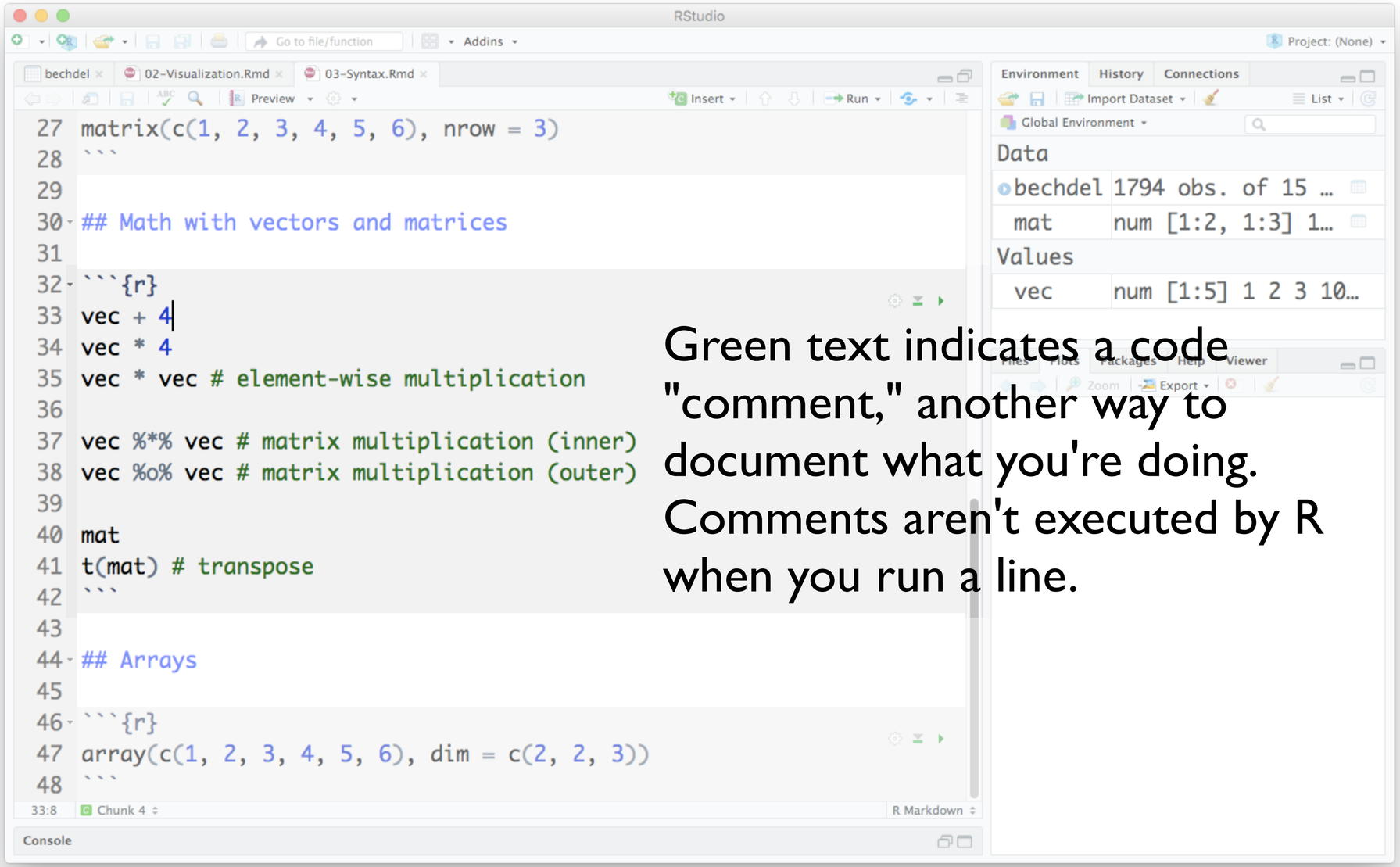
```
matrix(c(1, 2, 3, 4, 5, 6), nrow = 2)
#      [,1] [,2] [,3]
# [1,]    1    3    5
# [2,]    2    4    6
```

```
matrix(c(1, 2, 3, 4, 5, 6), nrow = 3)
#      [,1] [,2]
# [1,]    1    4
# [2,]    2    5
# [3,]    3    6
```

R as a calculator (again)

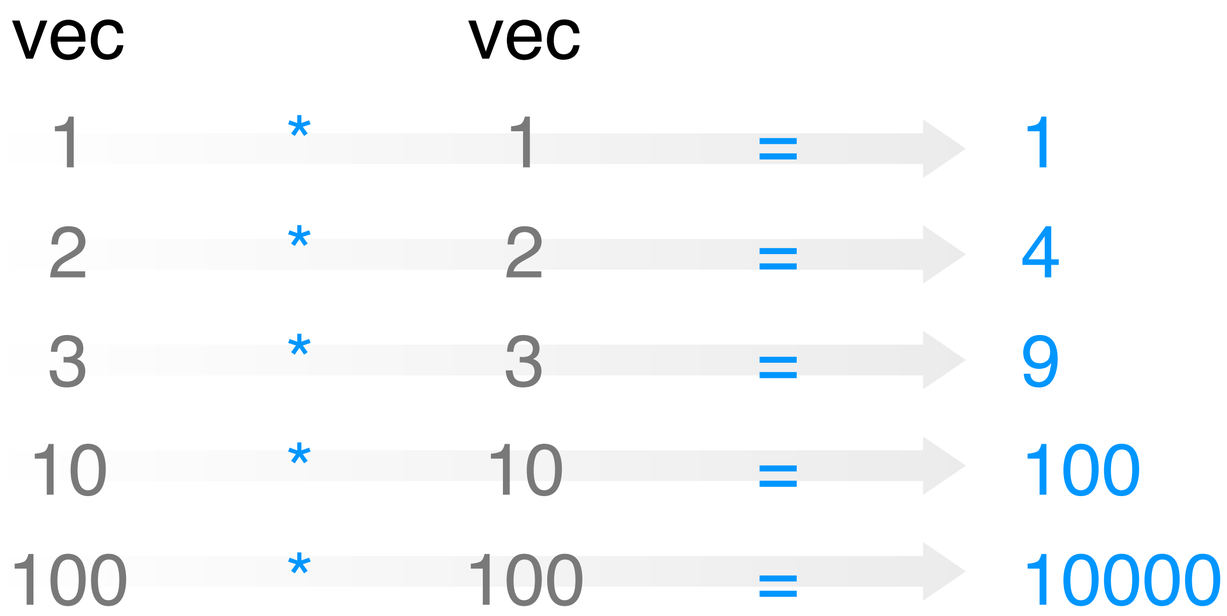
Math: element-wise

```
vec + 4
# 5   6   7  14 104

vec * 4
# 4   8  12  40 400

vec * vec
# 1     4     9   100 10000
```



Green text indicates a code "comment," another way to document what you're doing. Comments aren't executed by R when you run a line.

```
vec * vec
# 1    4    9   100 10000
```



Matrix multiplication

```
vec %*% vec # inner
#      [,1]
# [1,] 10114
```

```
vec %o% vec # outer
#      [,1] [,2] [,3] [,4]  [,5]
# [1,]    1    2    3   10   100
# [2,]    2    4    6   20   200
# [3,]    3    6    9   30   300
# [4,]   10   20   30  100  1000
# [5,]  100  200  300 1000 10000
```

```
mat
#      [,1] [,2] [,3]
# [1,]    1    3    5
# [2,]    2    4    6

t(mat)
#      [,1] [,2]
# [1,]    1    2
# [2,]    3    4
# [3,]    5    6
```

arrays

Combine multiple elements into an array that has three or more dimensions.

Create with the array function.

```
array(c(1, 2, 3, 4, 5, 6), dim = c(2, 2, 3))
```

arrays

Combine multiple elements into an array that has three or more dimensions.

Create with the array function.

```
array(c(1, 2, 3, 4, 5, 6), dim = c(2, 2, 3))
```

Another uncommon structure

Data types

Warm up

	A	B	C	D
1	date	president	democrat	unemploy
2	Mar 31, 1968	Lyndon Johnson	TRUE	2709
3	Apr 30, 1968	Lyndon Johnson	TRUE	2740
4	May 31, 1968	Lyndon Johnson	TRUE	2938
5	Jun 30, 1968	Lyndon Johnson	TRUE	2883
6	Jul 31, 1968	Lyndon Johnson	TRUE	2768
7	Aug 31, 1968	Lyndon Johnson	TRUE	2686
8	Sep 30, 1968	Lyndon Johnson	TRUE	2689
9	Oct 31, 1968	Lyndon Johnson	TRUE	2715
10	Nov 30, 1968	Lyndon Johnson	TRUE	2685
11	Dec 31, 1968	Lyndon Johnson	TRUE	2718
12	Jan 31, 1969	Richard Nixon	FALSE	2692
13	Feb 28, 1969	Richard Nixon	FALSE	2712
14	Mar 31, 1969	Richard Nixon	FALSE	2758
15	Apr 30, 1969	Richard Nixon	FALSE	2713
16	May 31, 1969	Richard Nixon	FALSE	2816
17	Jun 30, 1969	Richard Nixon	FALSE	286
18	Jul 31, 1969	Richard Nixon	FALSE	
19	Aug 31, 1969	Richard Nixon	FALSE	
20	Sep 30, 1969	Richard Nixon	FALSE	
21	Oct 31, 1969	Richard Nixon	FALSE	
22	Nov 30, 1969	Richard Nixon	FALSE	

What **types** of data appear in this spreadsheet?

data types

Like Excel, Numbers, etc., R can recognize different types of data.

We'll look at four basic types:

- numbers
- character strings (text)
- logical
- factor

numeric

Any number, no quotes.

Appropriate for math.

```
1 + 1
```

```
3000000
```

```
class(0.00001)
# "numeric"
```

character

Any symbols surrounded by quotes.

Appropriate for words, variable names, messages, any text.

```
"hello"

class("hello")
# "character"
```

```
"hello" + "world"
# Error

nchar("hello")
# 5

paste("hello", "world")
# "hello world"
```

Your turn

Which of these are numbers? **What are the others?** How can you tell?

1 "1" "one"

logical

TRUE or FALSE

R's form of binary data. Useful for logical tests.

```
3 < 4
# TRUE

class(TRUE)
# "logical"

class(T)
# "logical"
```

factor

R's form of categorical data. Saved as an integer with a set of labels (e.g. levels).

```
fac <- factor(c("a", "b", "c"))
fac
# a b c
# Levels: a b c

class(fac)
# factor
```

Use great caution with factors

Quiz

```
x <- c(1, 2, 3)
```

What is the difference between these?

```
x
```

```
"x"
```

Type	Examples
numeric	0, 1, -2, 3.1415, 0.0005
character	"Amelia", "Agree", "31"
logical	TRUE, FALSE
factor	a c c b Levels: a b c

Your turn 2

Make a vector that contains the number 1, the letter R, and the logical TRUE.

What class of data is the vector?

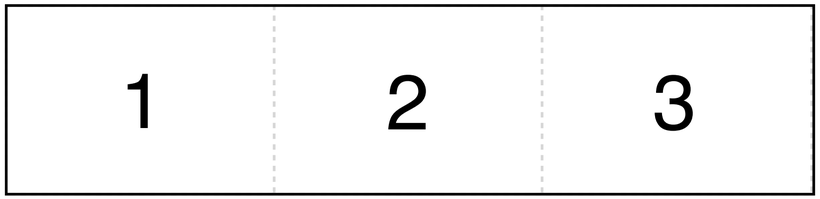
```
vec <- c(1, "R", TRUE)
class(vec)
# "character"

vec
# "1"    "R"    "TRUE"

# What is R doing?
```

Your turn

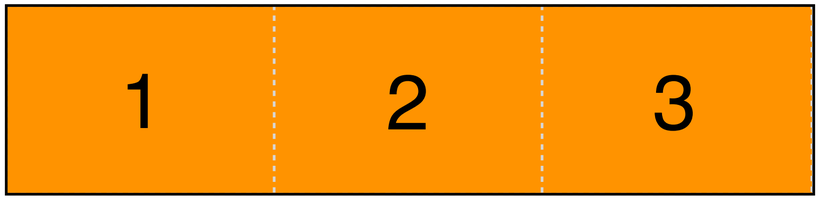
Another way to see the class of an object is in the Environment pane. Does the Environment agree with what you found using class()?

Vector

Vector

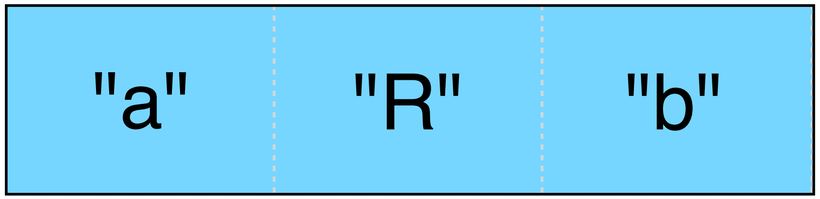


Vector



numeric

Vector

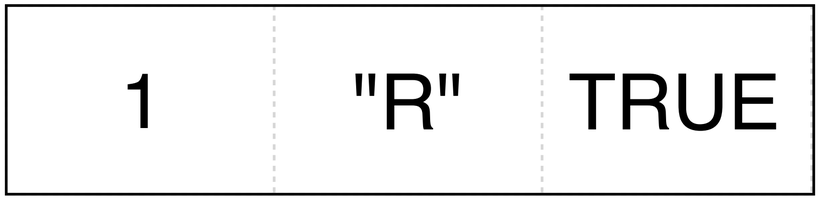


character

Vector

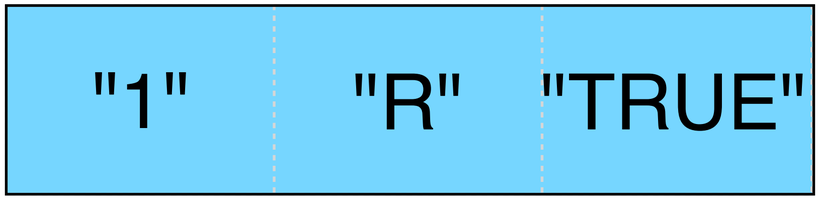
logical

Vector



?

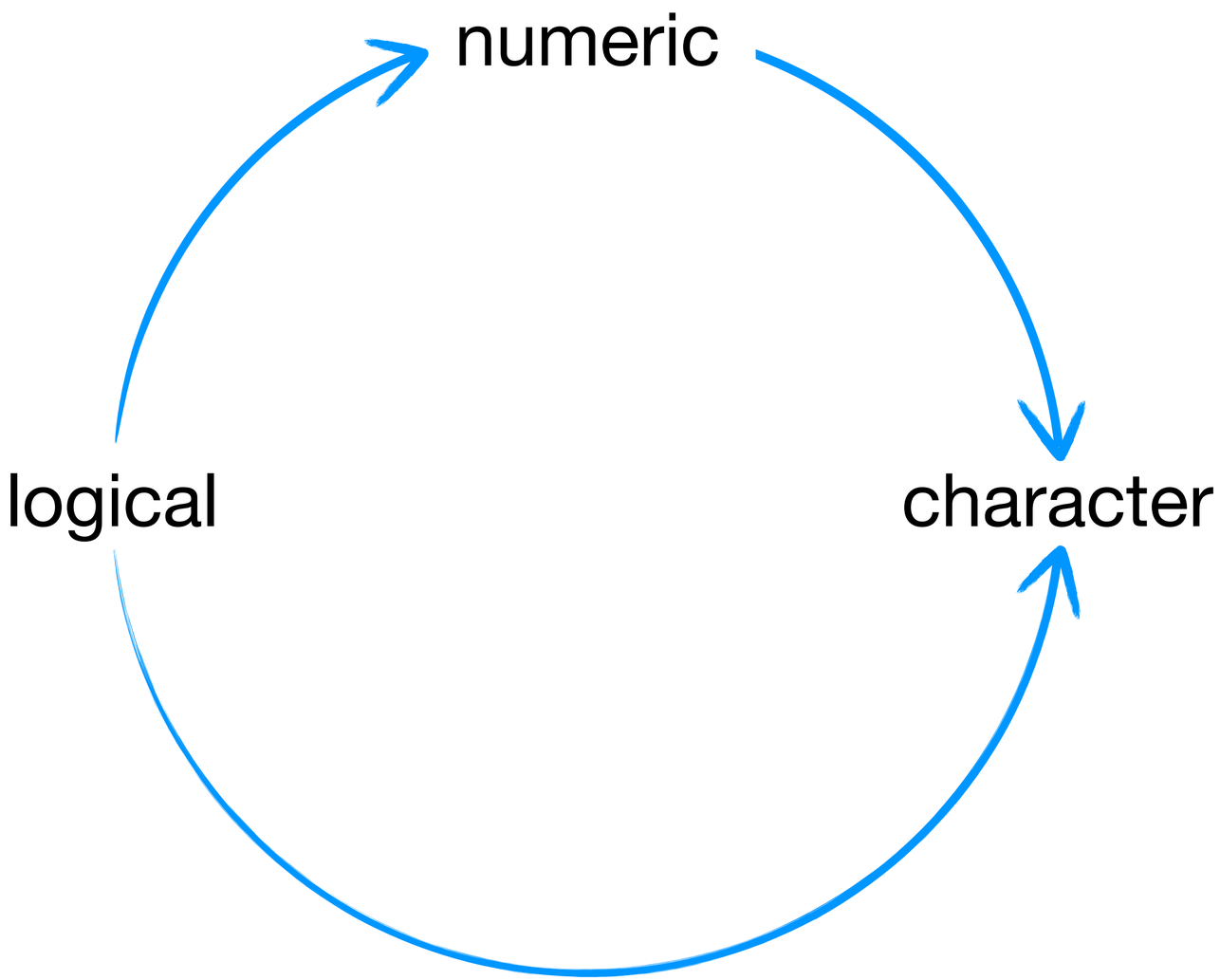
Vector



character

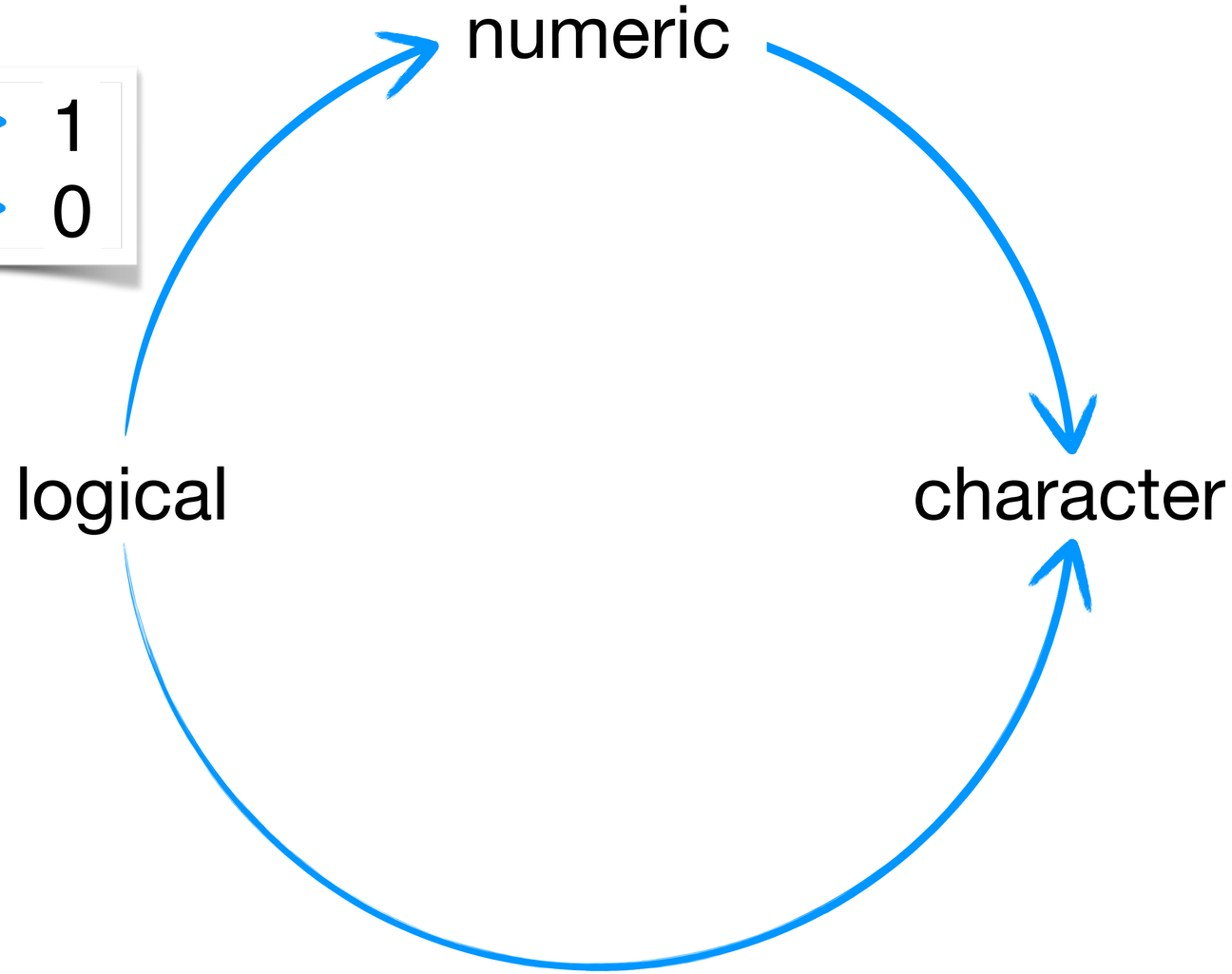
Coercion

coercion

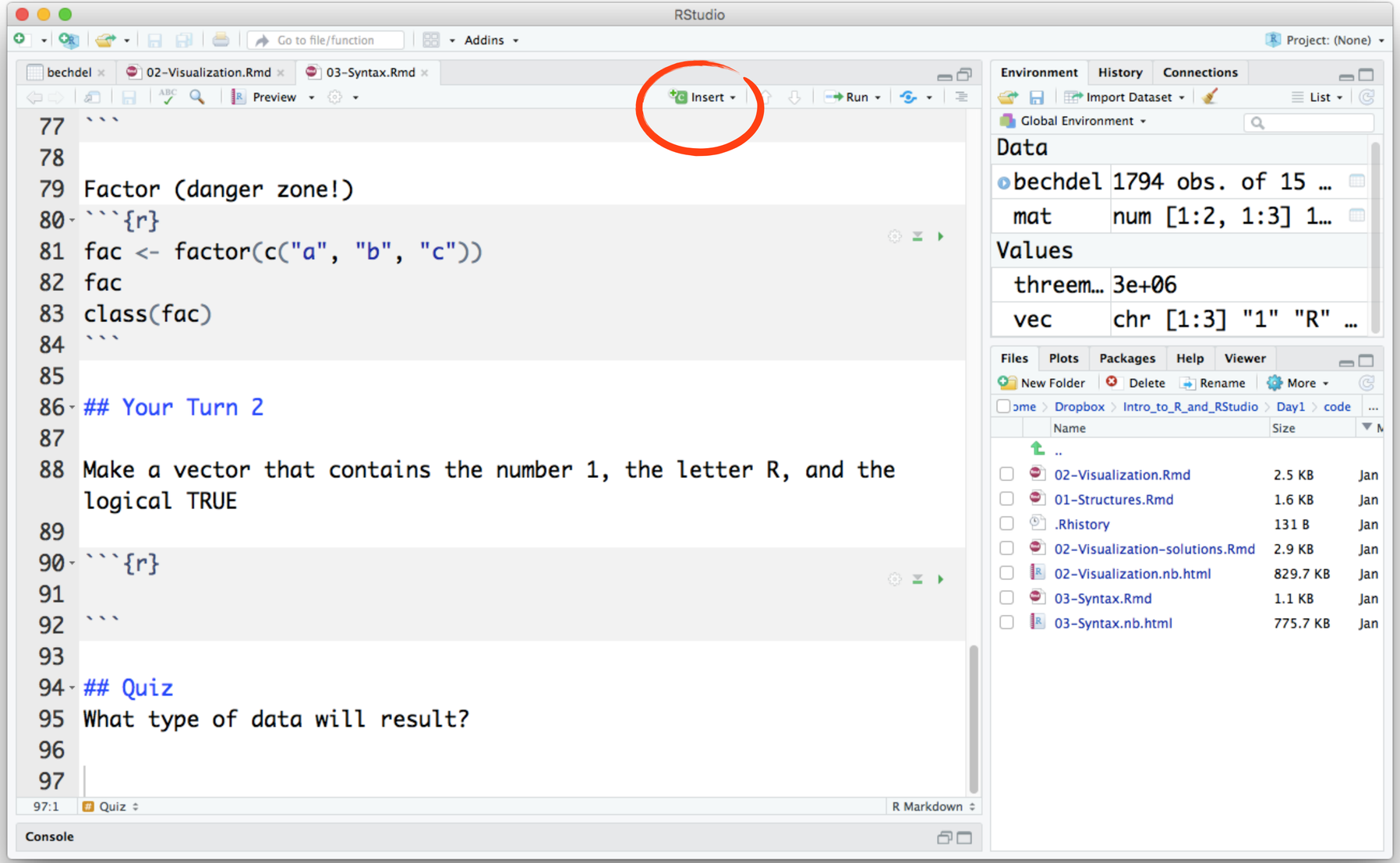


coercion

TRUE → 1
FALSE → 0

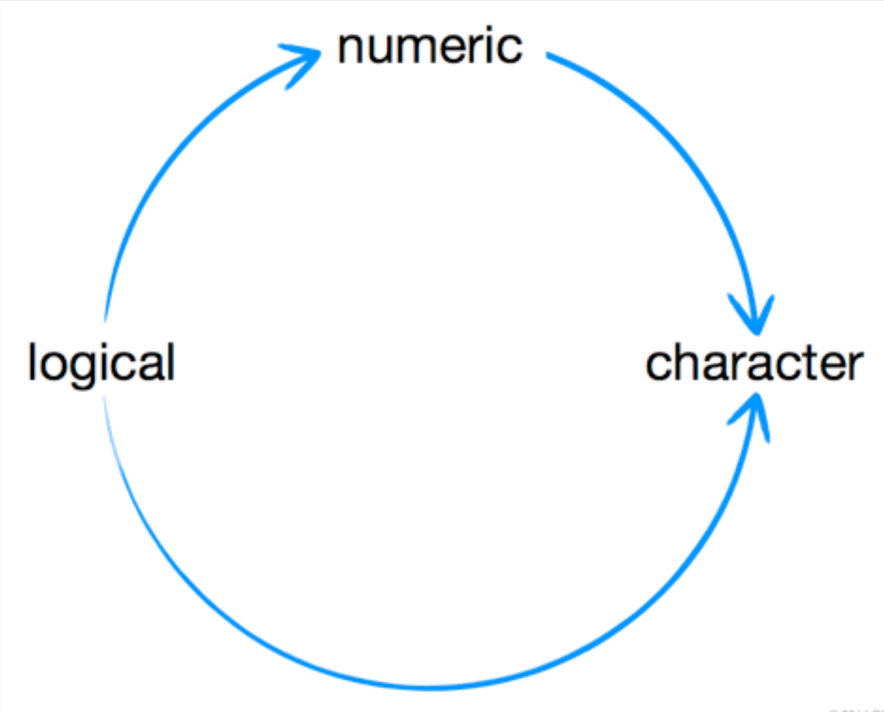


I'm going to give you a "quiz", and you might want to create your own chunk to try out some code. Use the Insert button to insert one



Quiz

What type of data will result?



c(5, "two")

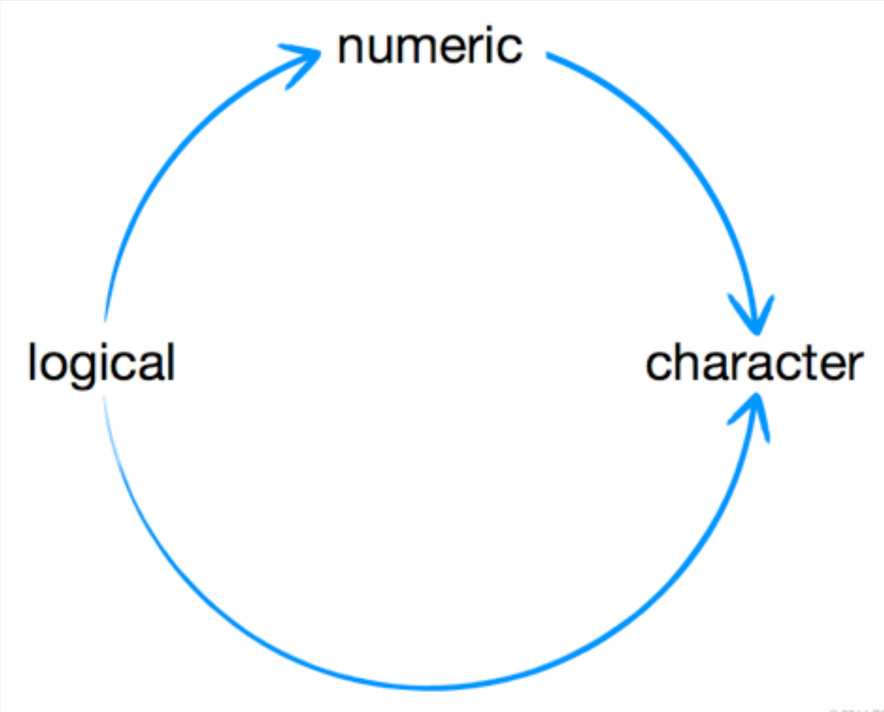
c(TRUE, "a")

c(1, "TRUE")

TRUE + 5

Quiz

What type of data will result?



c(5, "two")
character

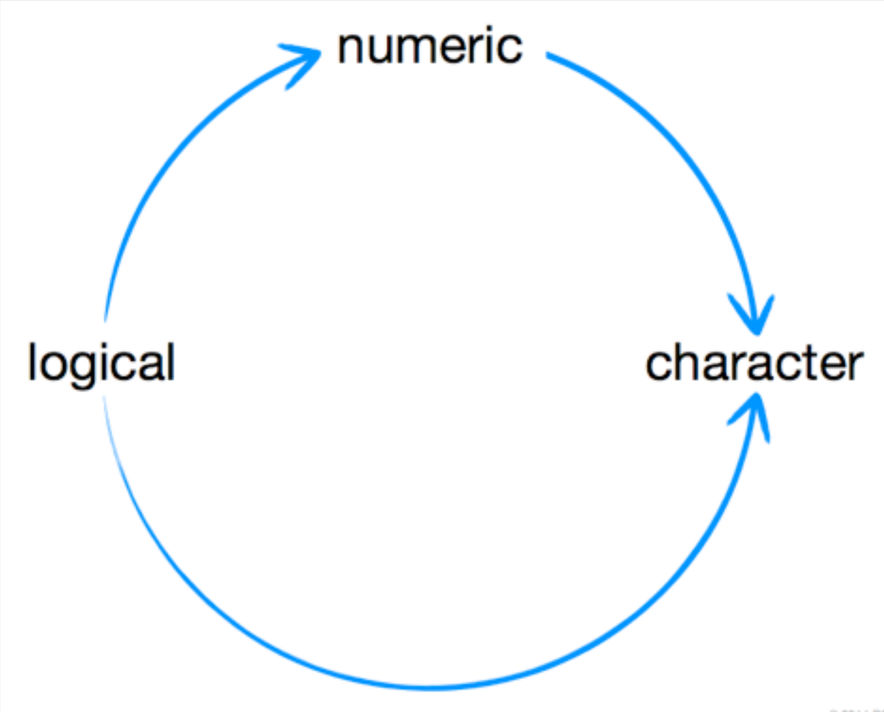
c(TRUE, "a")

c(1, "TRUE")

TRUE + 5

Quiz

What type of data will result?



c(5, "two")
character

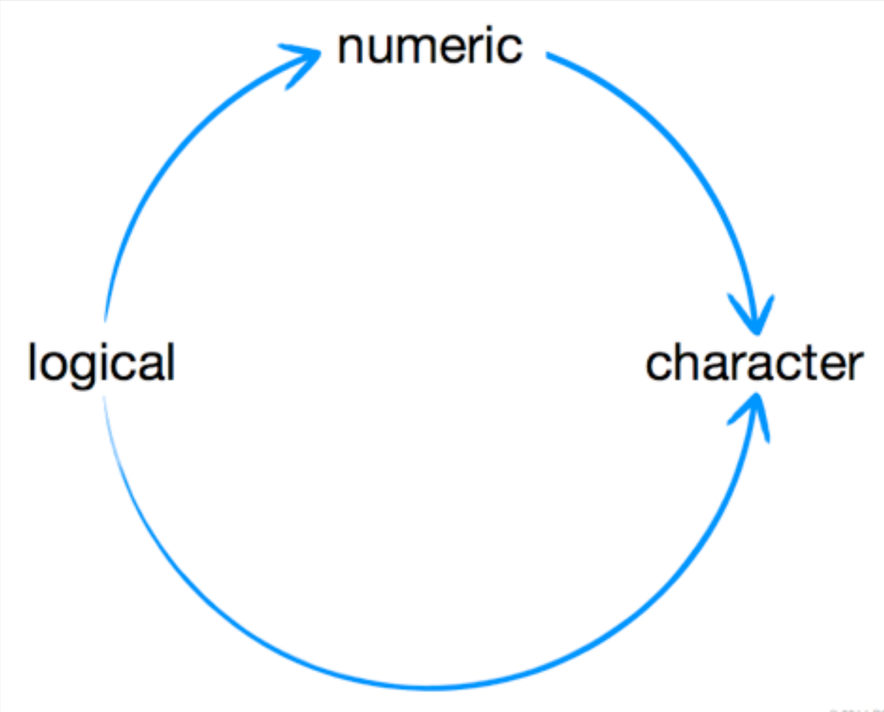
c(TRUE, "a")
character

c(1, "TRUE")

TRUE + 5

Quiz

What type of data will result?



c(5, "two")
character

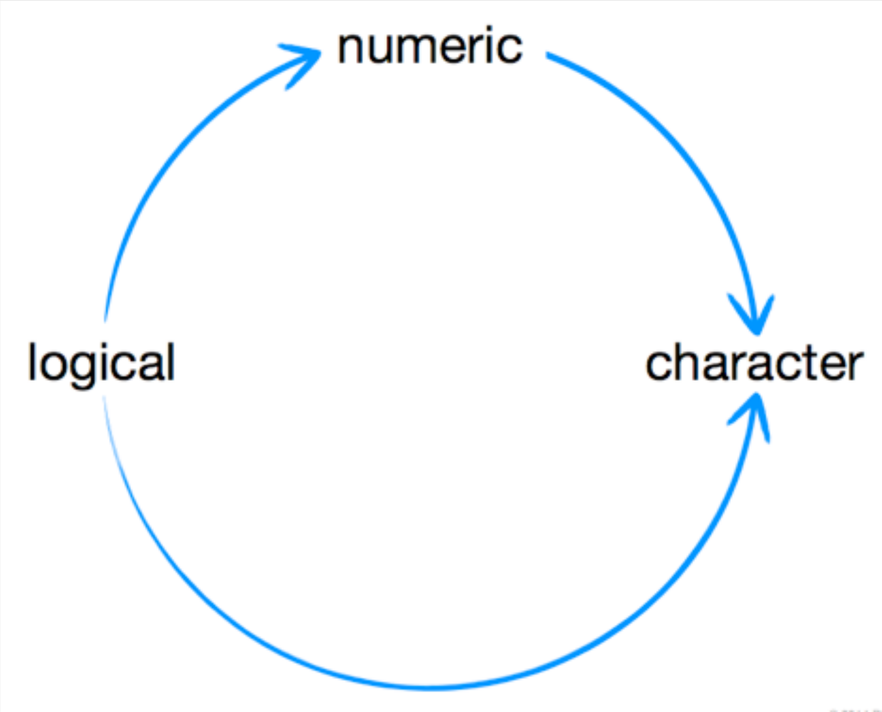
c(TRUE, "a")
character

c(1, "TRUE")
character

TRUE + 5

Quiz

What type of data will result?



c(5, "two")
character

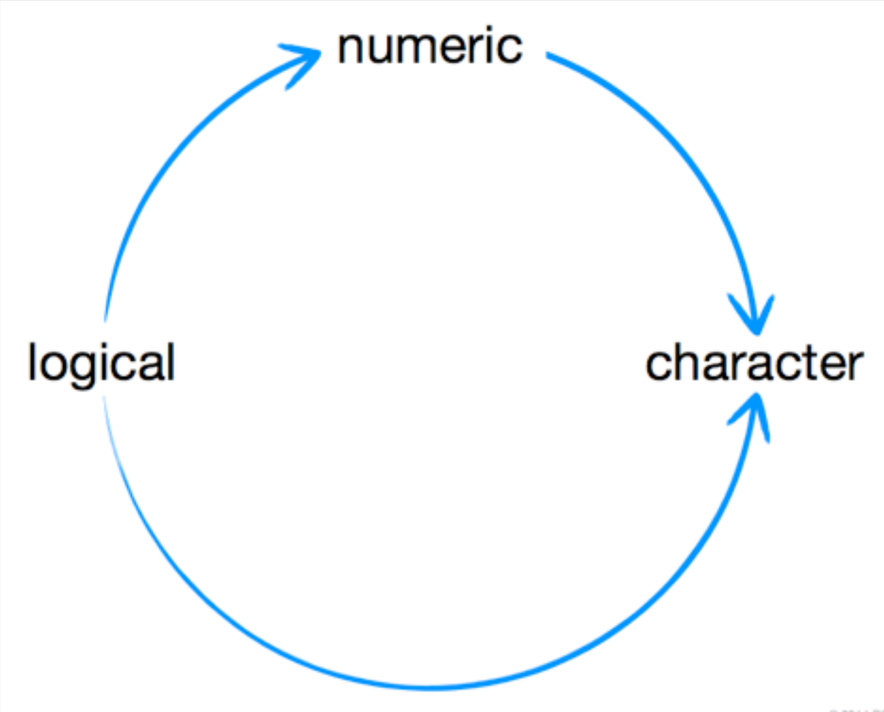
c(TRUE, "a")
character

c(1, "TRUE")
character

TRUE + 5

Quiz

What type of data will result?



c(5, "two")
character

c(TRUE, "a")
character

c(1, "TRUE")
character

TRUE + 5
numeric

manual coercion

function	coerces data to
as.numeric	numeric
as.character	character
as.logical	logical
as.factor	factor

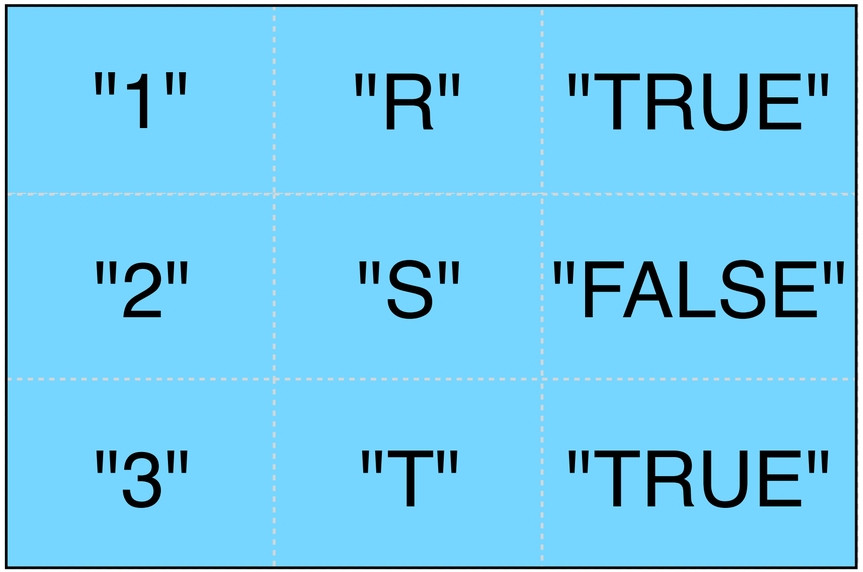
```
as.numeric("1")
as.character(TRUE)
```

Matrix

1	"R"	TRUE
2	"S"	FALSE
3	"T"	TRUE

?

Matrix



character

Matrix

"1"	"R"	"TRUE"
"2"	"S"	"FALSE"
"3"	"T"	"TRUE"

What if you want different data types in the same object?

Lists and data frames

lists and data frames

lists and *data frames* generalize vectors and matrices to allow multiple types of data

Lists

lists

A list is a one dimensional group of R objects.

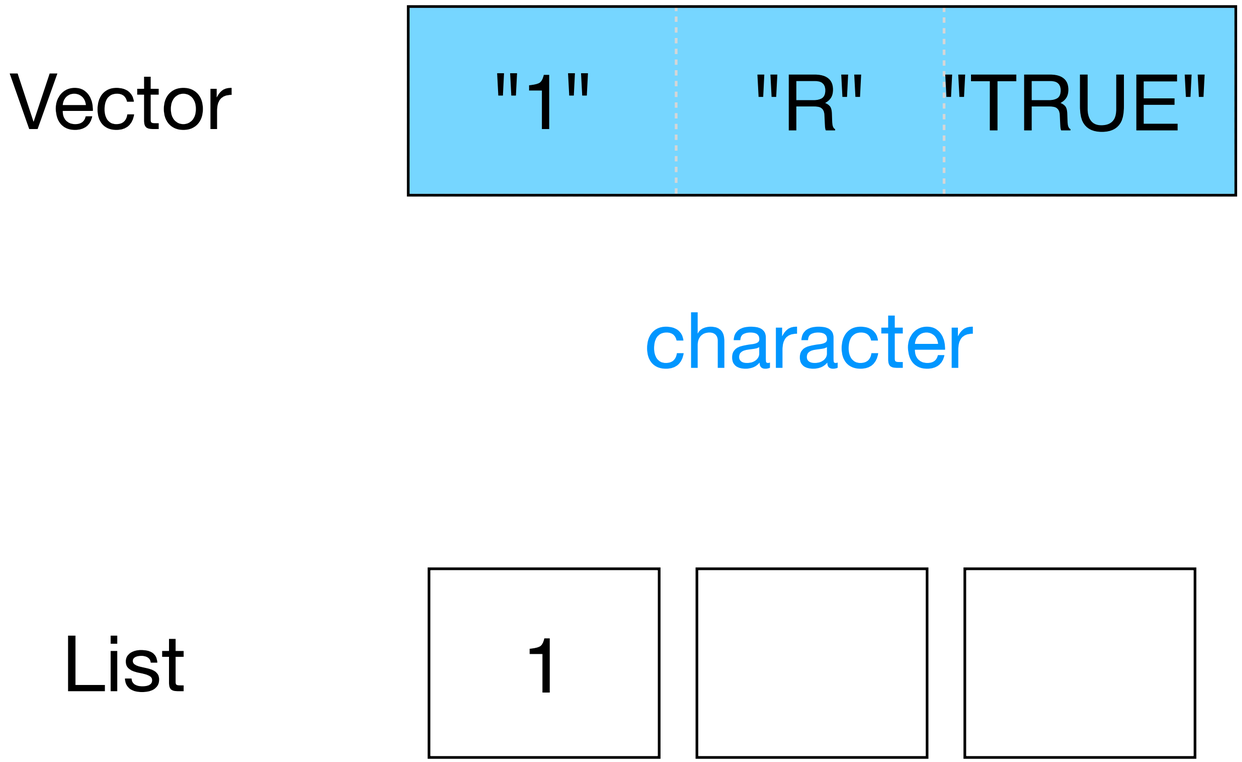
Create lists with list

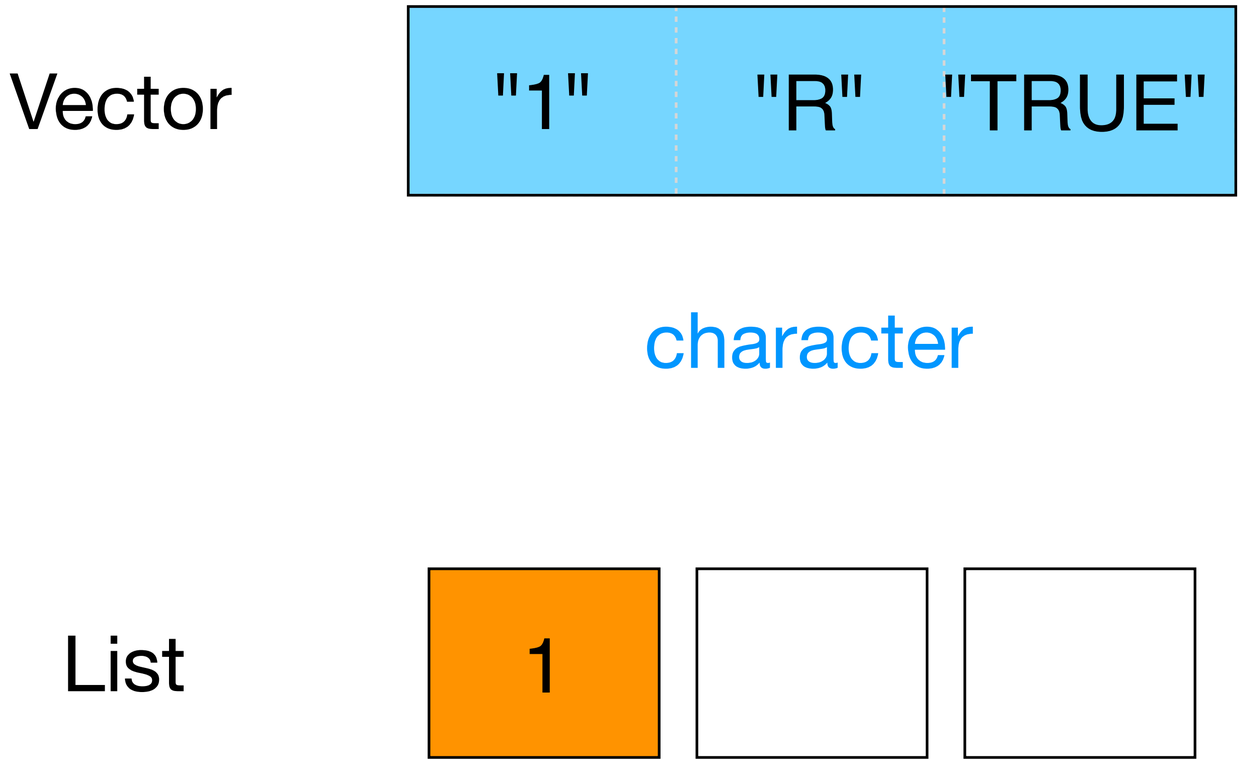
```
lst <- list(1, "R", TRUE)

class(lst)

# "list"
```

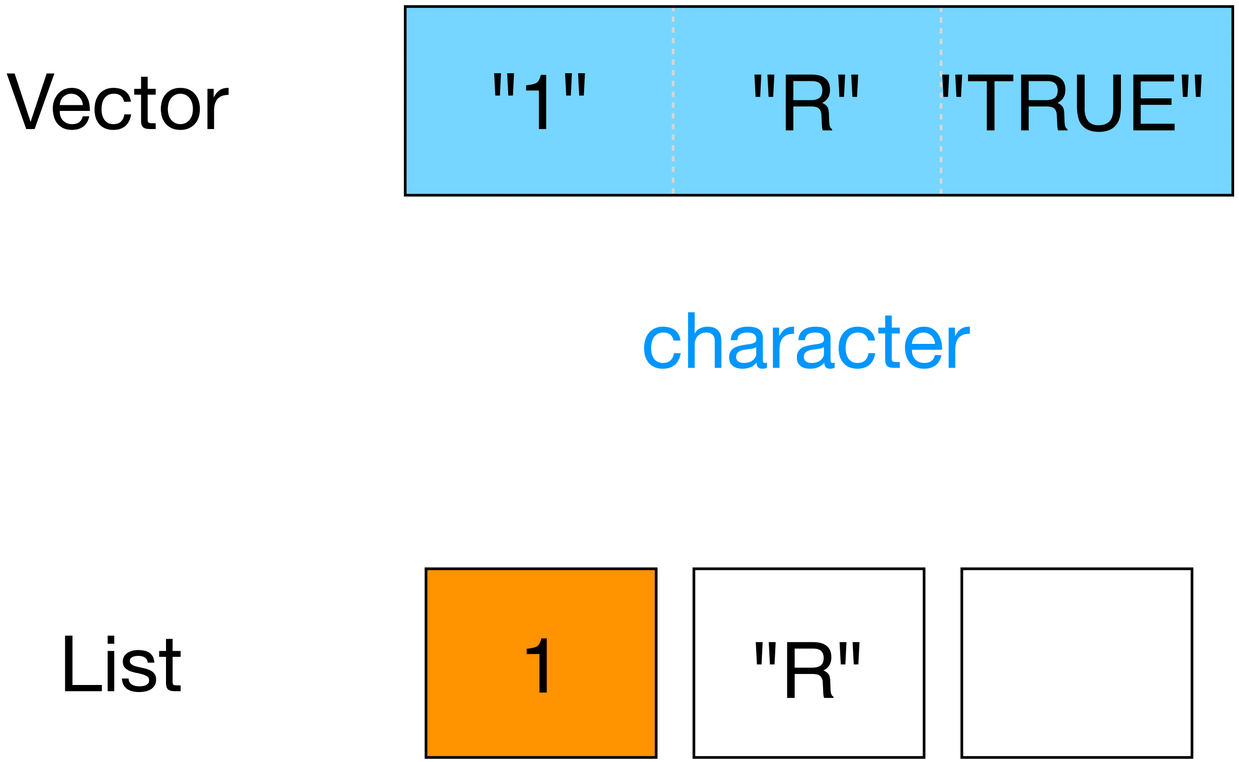
Vector

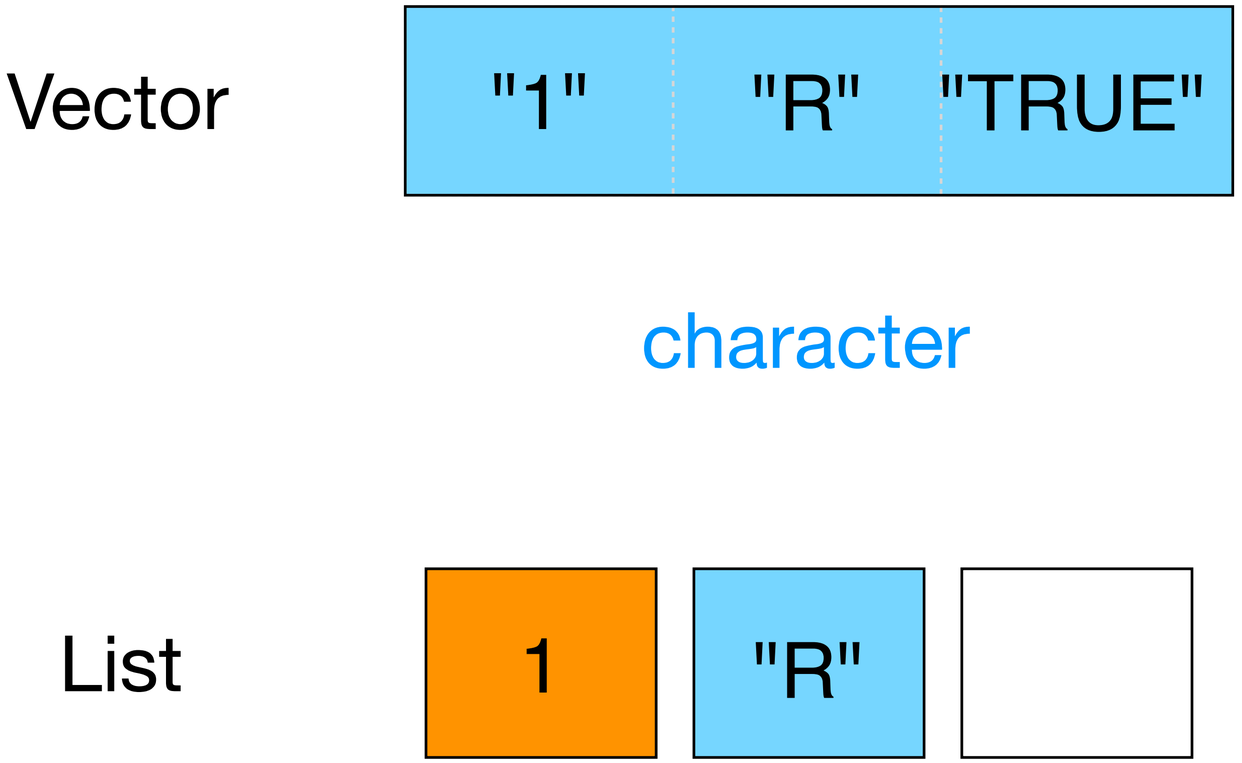
character

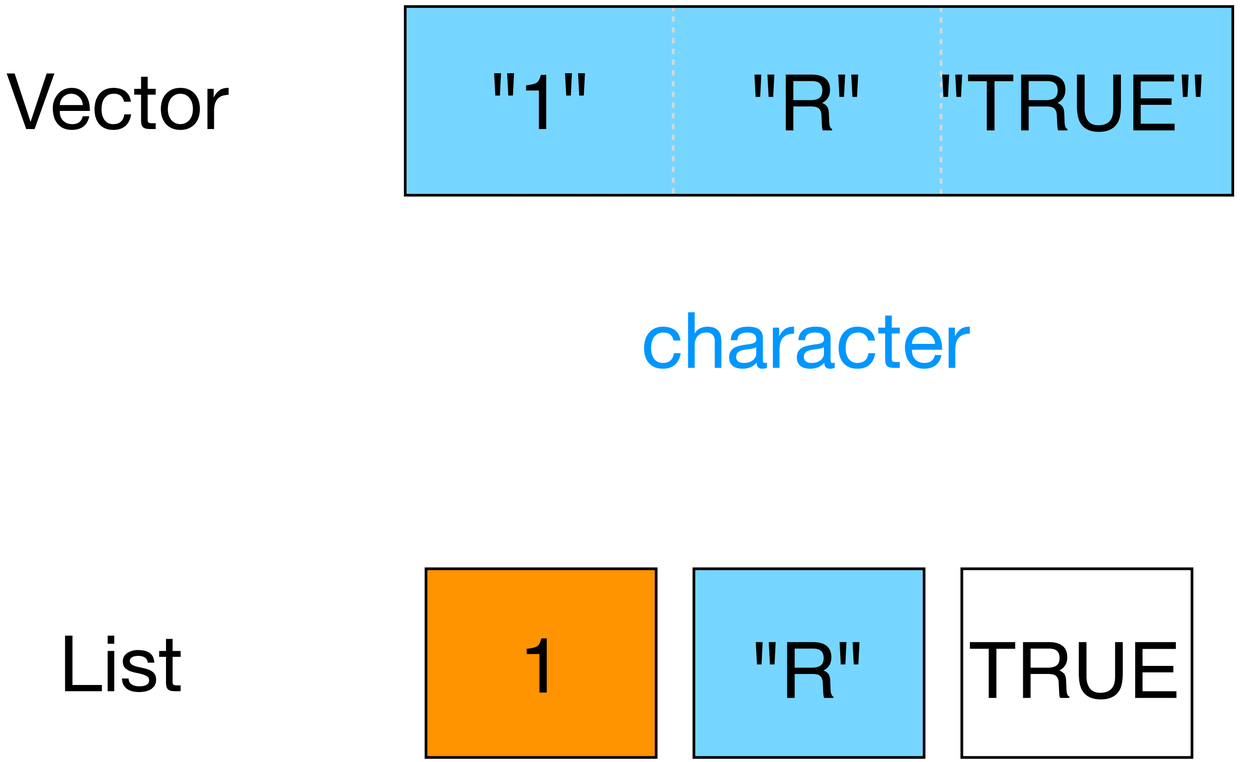
List

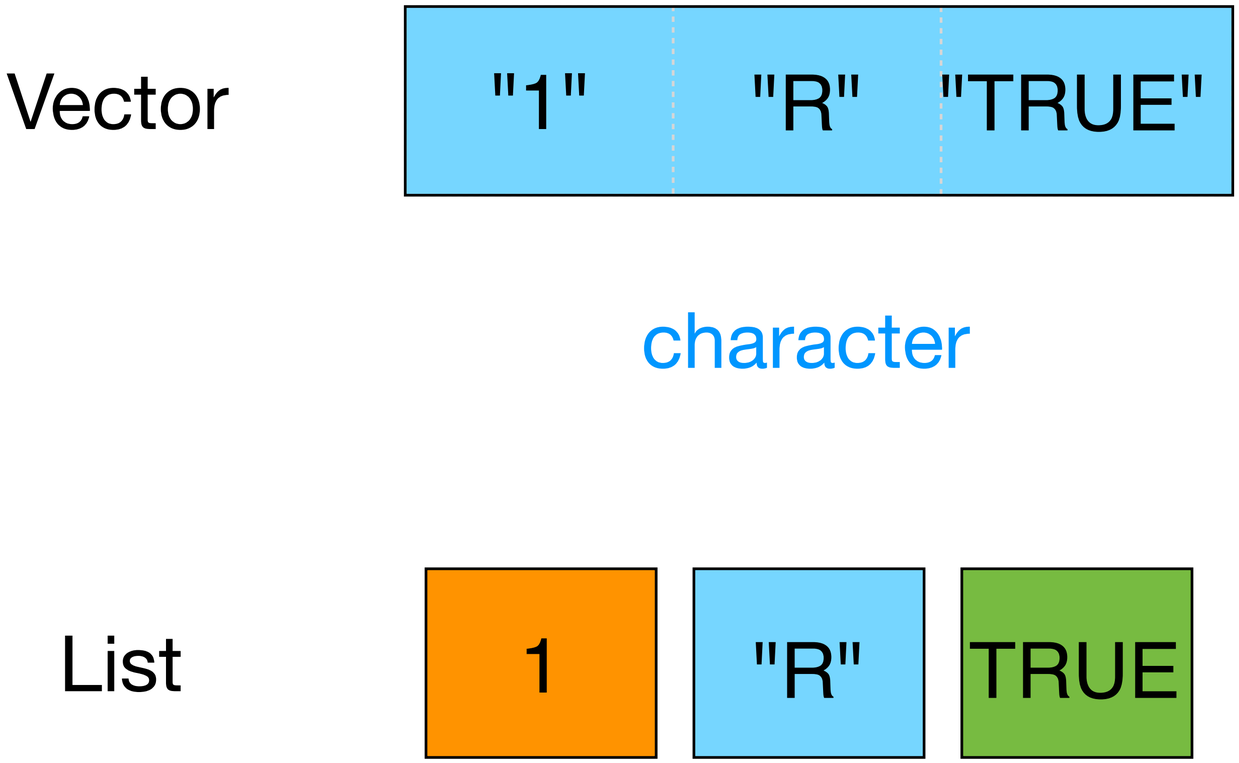

Vector
"1"
"R"
"TRUE"
character
List
1


Vector
"1"
"R"
"TRUE"
character
List
1
numeric


Vector
"1"
"R"
"TRUE"
character
List
1
"R"
numeric

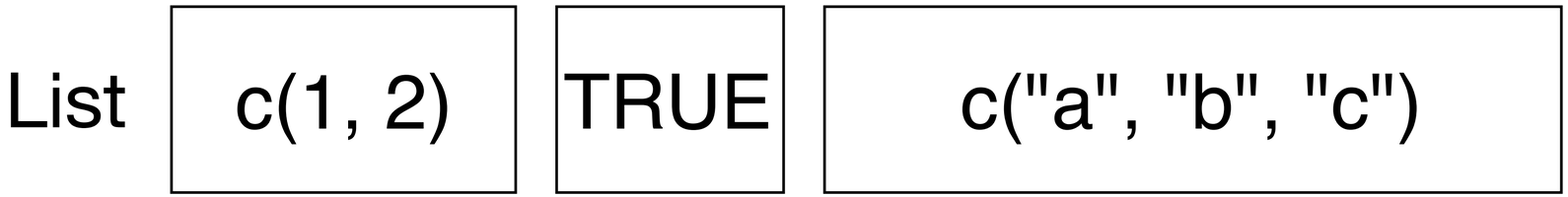

Vector
"1"
"R"
"TRUE"
character
List
1
"R"
numeric
character


Vector
"1"
"R"
"TRUE"
character
List
1
"R"
TRUE
numeric
character

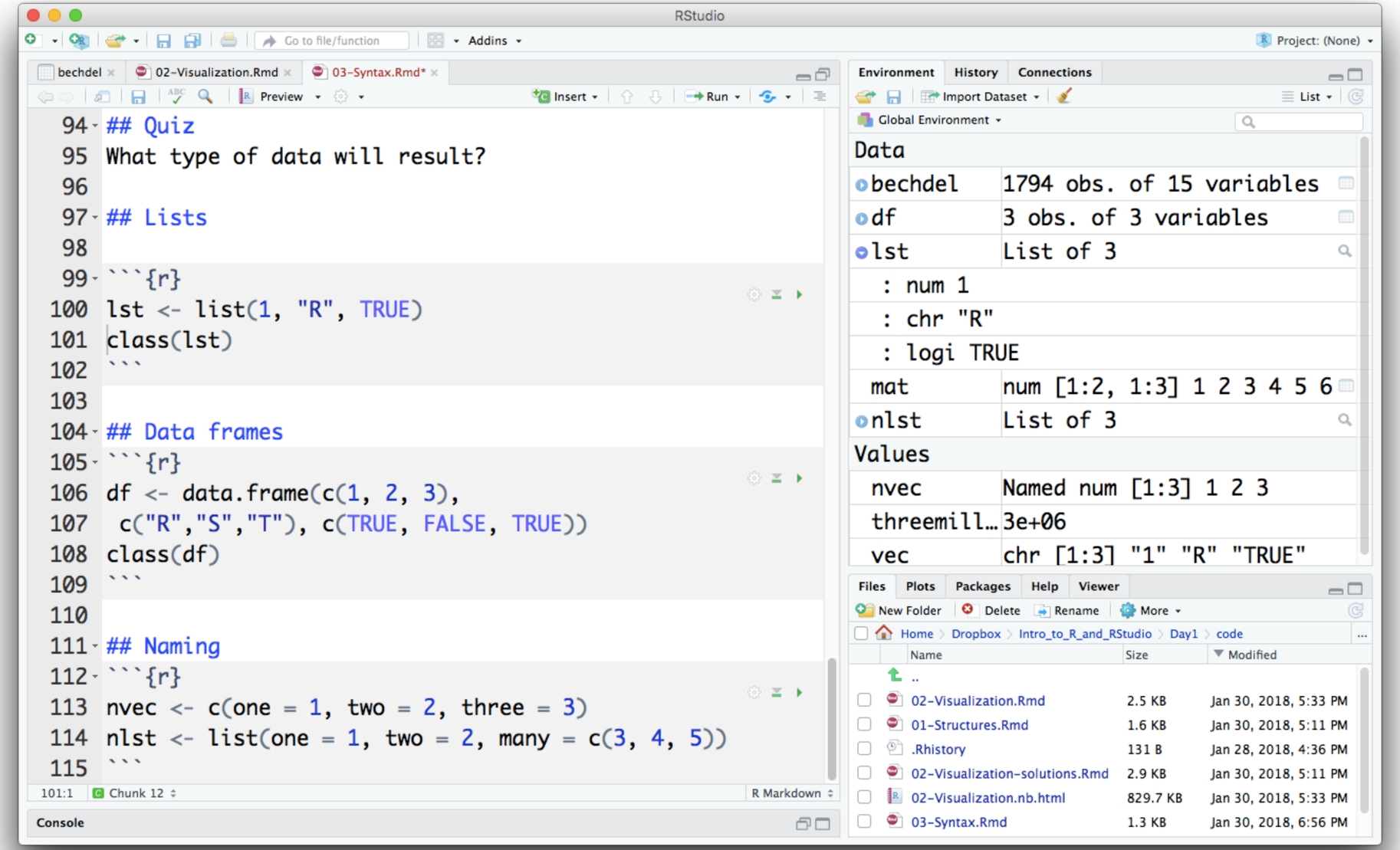

Vector
"1"
"R"
"TRUE"
character
List
1
"R"
TRUE
numeric
character
logical

The elements of a list can be anything. Even vectors or other lists.

```
list(c(1, 2), TRUE, c("a", "b", "c"))
```



List viewer in RStudio



Data frames

data frame

A data frame is a two dimensional group of R objects.

Each column in a data frame can be a different type

```
df <- data.frame(c(1, 2, 3),
 c("R","S","T"), c(TRUE, FALSE, TRUE))
class(df)
# "data.frame"
```

Your turn

We've already seen a data frame today. What was it called? What kinds of data were in it?

Matrix

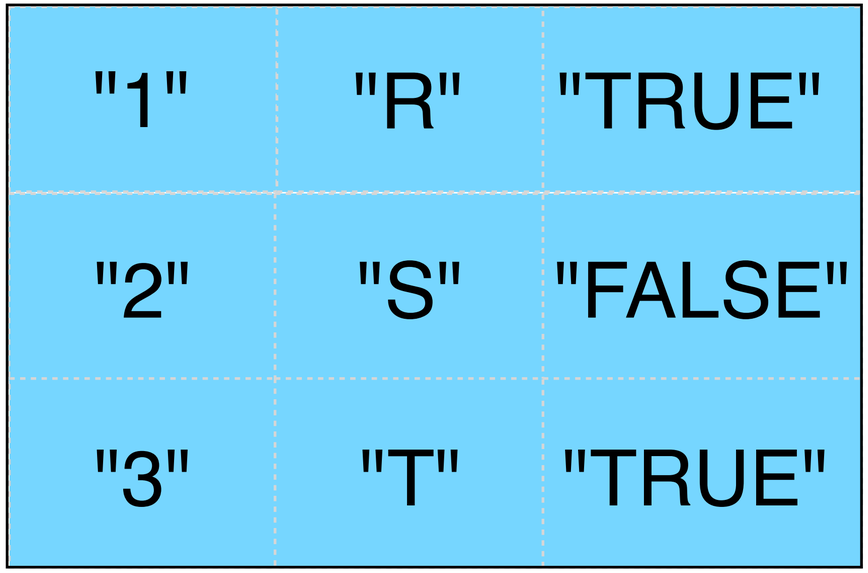
"1"	"R"	"TRUE"
"2"	"S"	"FALSE"
"3"	"T"	"TRUE"

character

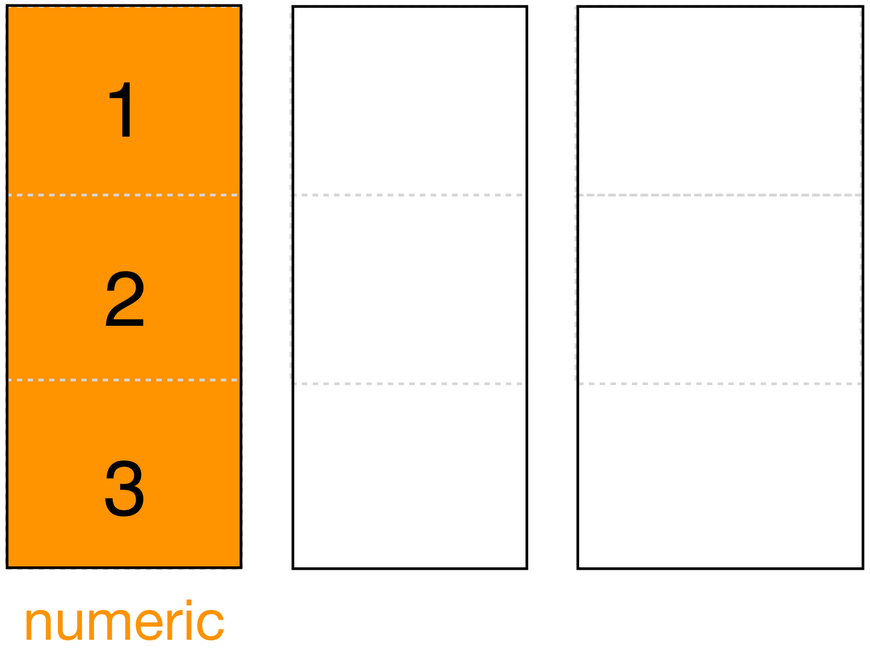
data frame

1		
2		
3		

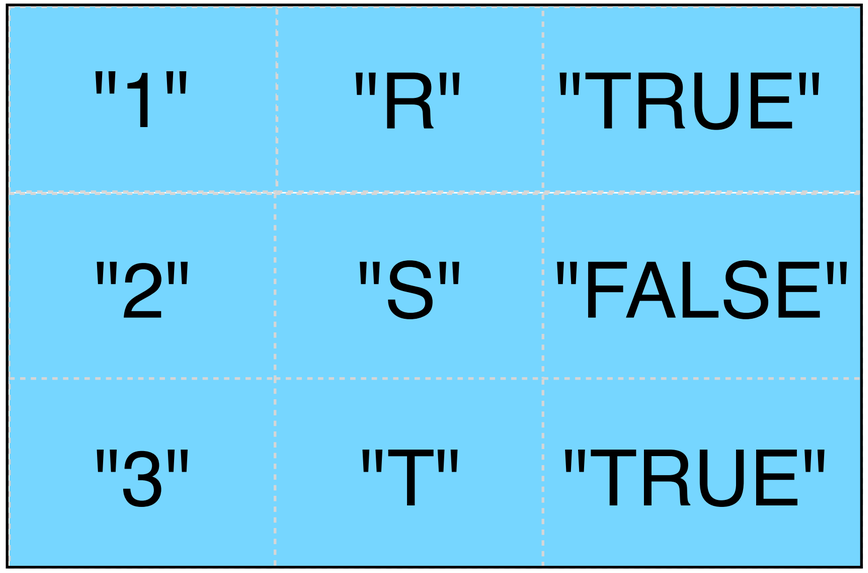
Matrix



data frame

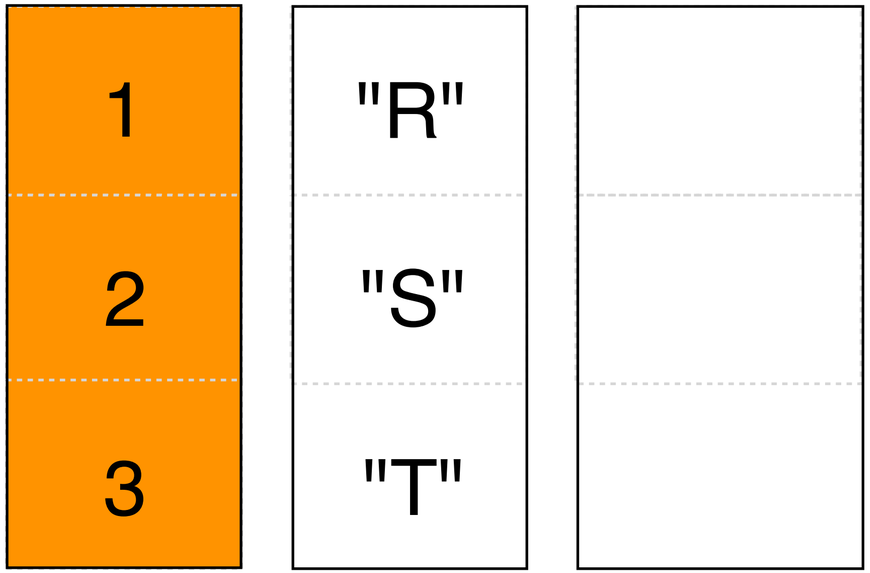


Matrix



character

data frame



numeric

Matrix

"1"	"R"	"TRUE"
"2"	"S"	"FALSE"
"3"	"T"	"TRUE"

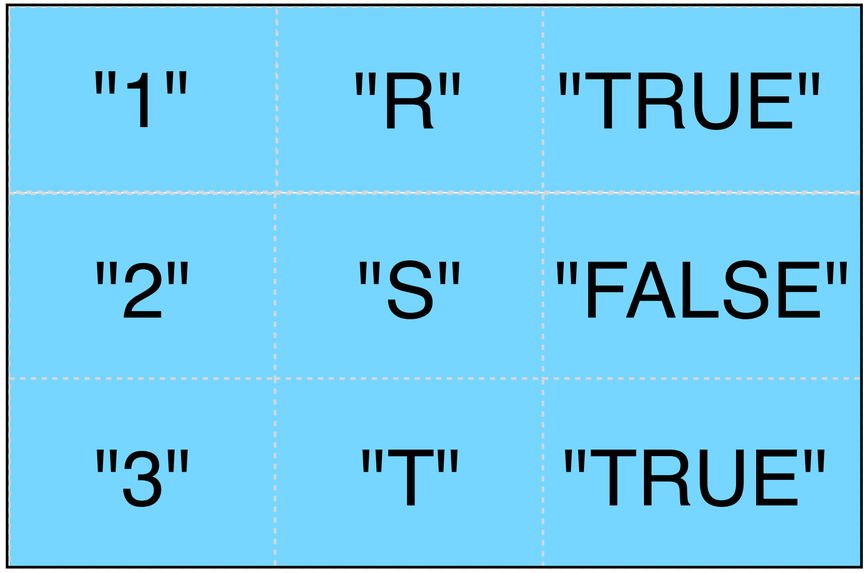
character

data frame

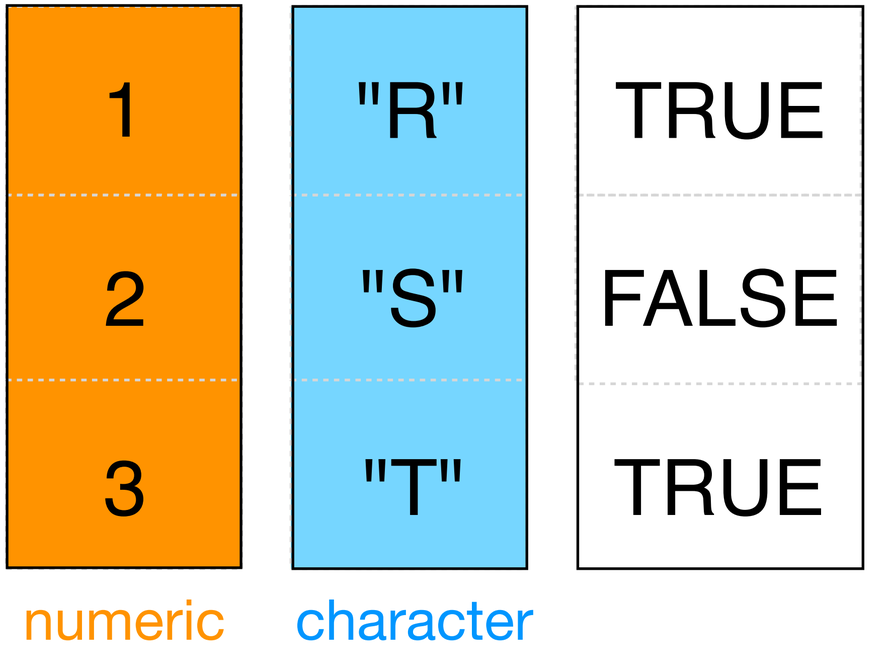
1	"R"	
2	"S"	
3	"T"	

numeric character

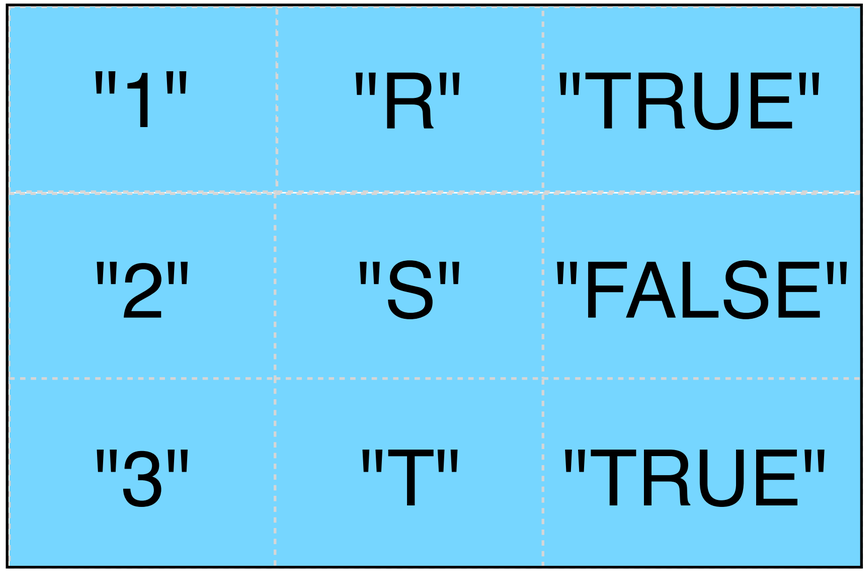
Matrix



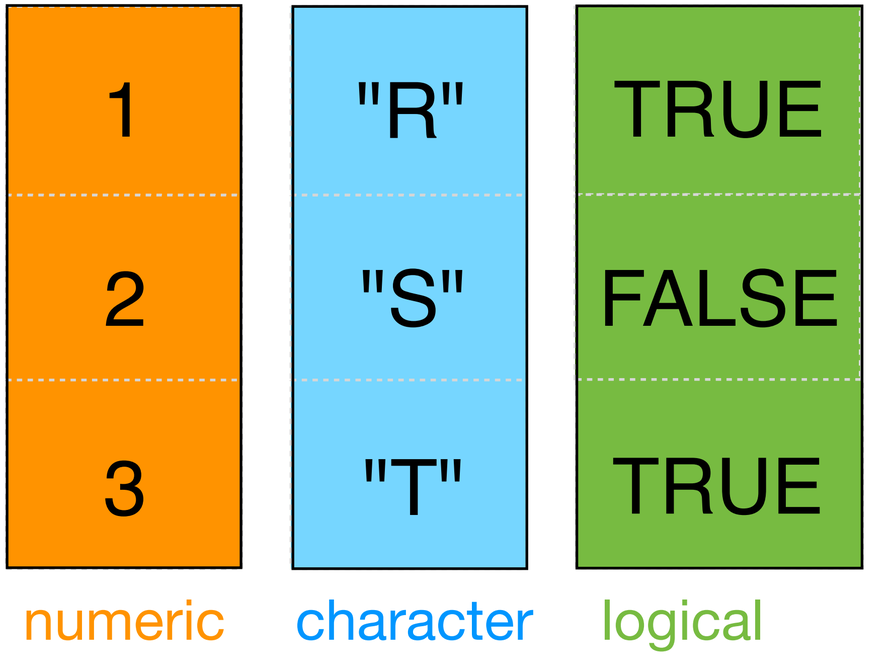
data frame



Matrix



data frame



names

You can name the elements of a vector, list, or data frame when you create them.

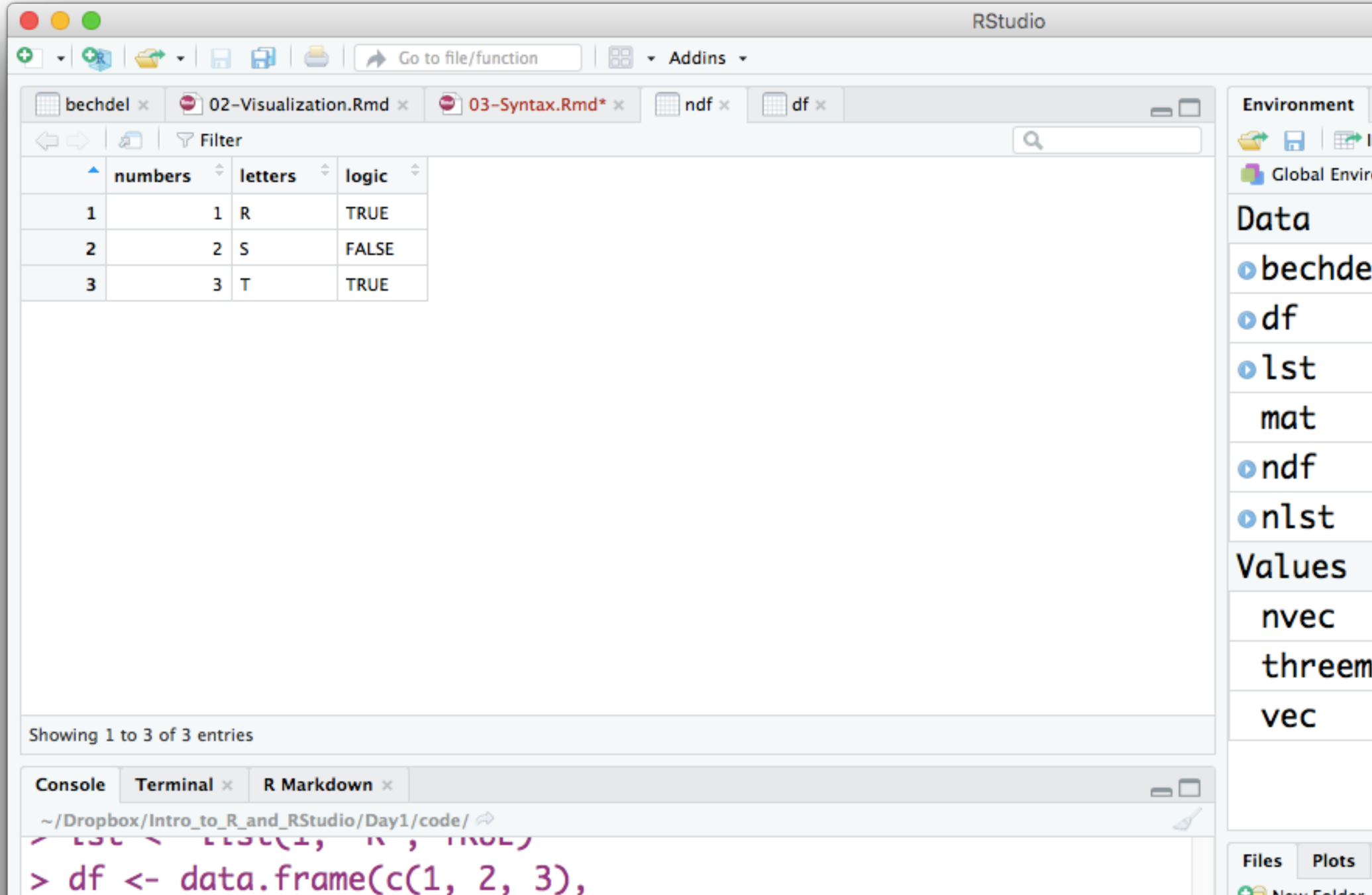
```
nvec <- c(one = 1, two = 2, three = 3)

nvec
# one  two three
#   1    2     3
```

```
nlst <- list(one = 1, two = 2,
             many = c(3, 4, 5))

nlst
# $one
# [1] 1
#
# $two
# [1] 2
#
# $many
# [1] 3 4 5
```

```
ndf <- data.frame(numbers = c(1, 2, 3),
                  letters = c("R","S","T"),
                  logic = c(TRUE, FALSE, TRUE))

ndf
#   numbers letters logic
# 1       1       R  TRUE
# 2       2       S FALSE
# 3       3       T  TRUE
```

Your turn

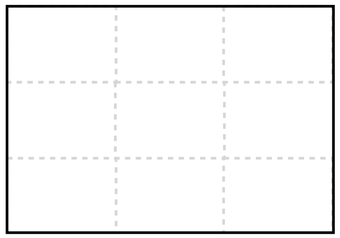
Use the RStudio data preview to compare `df` and `ndf`

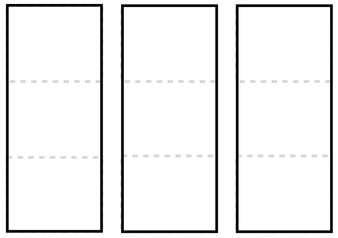

RStudio
Go to file/function
Addins
bechdel
02-Visualization.Rmd
03-Syntax.Rmd*
ndf
df
Filter
numbers
letters
logic
1 1 R TRUE
2 2 S FALSE
3 3 T TRUE
Showing 1 to 3 of 3 entries
Environment
Global Envir
Data
bechde
df
lst
mat
ndf
nlst
Values
nvec
threem
vec
Console
Terminal
R Markdown
~/Dropbox/Intro_to_R_and_RStudio/Day1/code/
> df <- data.frame(c(1, 2, 3),
Files
Plots

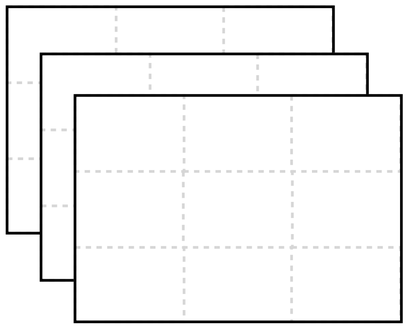
You can also see the names with names

```
names(ndf)
# [1] "numbers" "letters" "logic"

names(nvec)
# [1] "one"   "two"   "three"
```

	single type	multiple types
1D	Vector	List
2D	Matrix	Data frame
nD	Array	





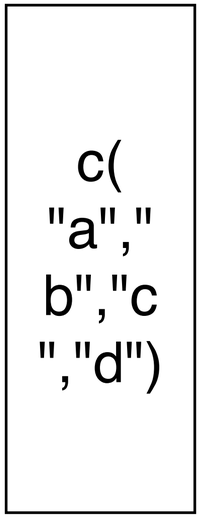


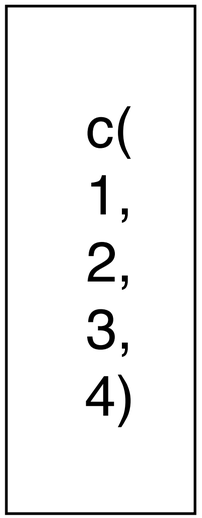
How R makes a data frame

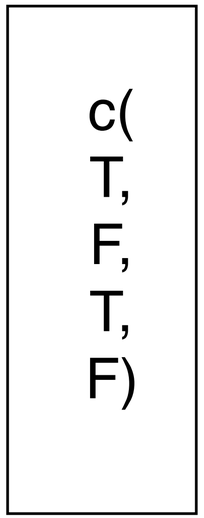
List

c("a","b","c","d")	c(1, 2, 3, 4)	c(T, F, T, F)

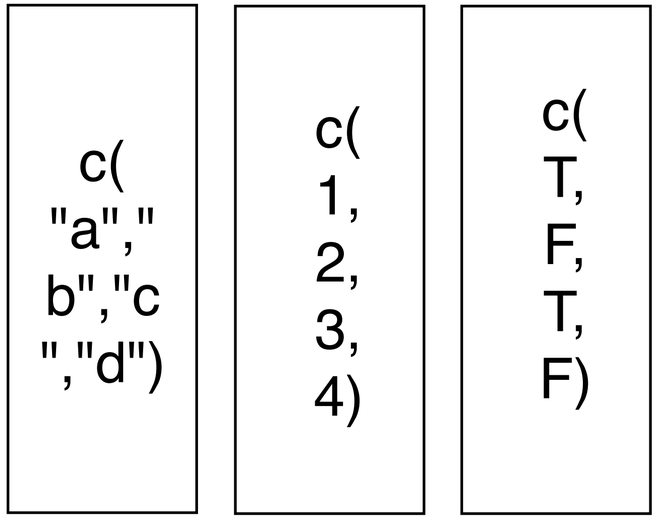
List





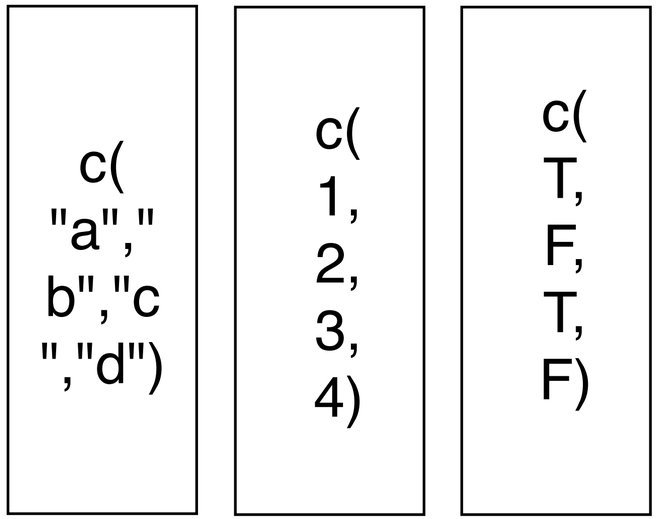


List



~~List~~

data frame



helper functions for data structures

	create	change to	check	get names	get dimensions
vector	c, vector	as.vector	is.vector	names	length
matrix	matrix	as.matrix	is.matrix	rownames, colnames	dim, nrow, ncol
array	array	as.array	is.array	dimnames	dim
list	list	as.list	is.list	names	length
data frame	data.frame	as.data.frame	is.data.frame	names	dim, nrow, ncol