Reading Data Tables

STAT 133

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So far ...

So far

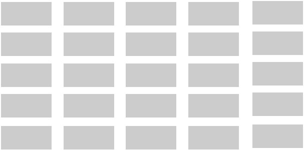
- Data Structures in R
    - Vectors and Factors
    - Matrices and Arrays
    - Data Frames and Lists
- Emphasis on **vectors**
- Atomic -vs- Non-atomic objects
- Vectorization
- Recycling
- Bracket Notation

Datasets

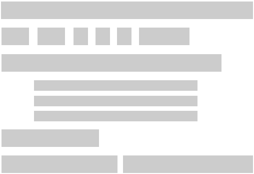
Datasets

You'll have some sort of (raw) data to work with

tabular



non-tabular



Some Data

Leia Skywalker
Female
1.50m tall

Luke Skywalker
Male
1.72m tall

Han Solo
Male
1.80m tall

Toy Data (tabular layout)

name	gender	height
Leia Skywalker	female	1.50
Luke Skywalker	male	1.72
Han Solo	male	1.80

Data Table (conceptually)

- Conceptually (and visually), tabular data consists of a rectangular array of cells
- Tables have rows and columns
- Intersection of row and column gives a cell
- A data value lies in each table cell

Data can also be
in non-tabular format

Toy Data (XML format)

```xml
<subject>
  <name>Leia Skywalker</name>
  <gender>female</gender>
  <height>1.50</height>
</subject>
<subject>
  <name>Luke Skywalker</name>
  <gender>male</gender>
  <height>1.72</height>
</subject>
<subject>
  <name>Han Solo</name>
  <gender>male</gender>
  <height>1.80</height>
</subject>
```

Toy Data (JSON format)

```
{
  "subject" : {
    "name" : "Leia Skywalker",
    "gender" : "female",
    "height" : 1.50
  },
  "subject" : {
    "name" : "Luke Skywalker",
    "gender" : "male",
    "height" : 1.72
  },
  "subject" : {
    "name" : "Han Solo",
    "gender" : "male",
    "height" : 1.80
  }
}
```

Toy Data (other format)

```
"Leia Skywalker"
gender: female
height: 1.50

"Luke Skywalker"
gender: male
height: 1.72

"Han Solo"
gender: male
height: 1.80
```

Toy Data (other format)

```
Leia Skywalker
F 1.50
***
Luke Skywalker
M 1.72
***
Han Solo
M 1.80
```

Data Tables

Many datasets come in tabular form: rectangular array of rows and columns (e.g. spreadsheet)

In this lecture we'll focus on how to read this type of data in R (we'll talk about how to read other types of datasets in a different lecture)

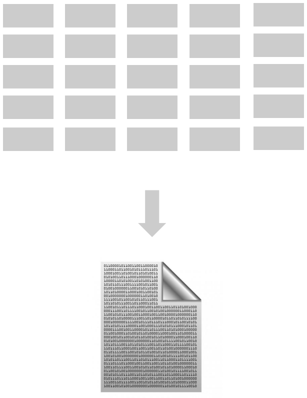
Data Tables

How to store tables in a file?

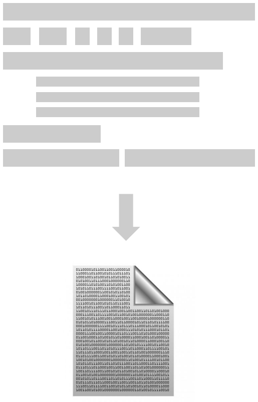
name	gender	height
Leia Skywalker	female	1.50
Luke Skywalker	male	1.72
Han Solo	male	1.80

Files and Memory

tabular



non-tabular



Files and Formats

- We store Data Sets in files
- A **file** is simply a block of computer memory
- A file can be as small as just a few bytes or it can be several gigabytes in size (thousands of millions of bytes)

BIT

- The most fundamental unit of computer memory is the **bit**
  - can be a tiny magnetic region on a hard disk
  - can be a tiny transistor on a memory disk
  - can be a tiny dent in the reflective material on a CD or DVD
- A bit is like a switch, it can only take two values:
  - **on** (1)
  - **off** (0)
- A bit is a single **binary digit** (0 or 1)

Binary Digit

- All computers are binary (0, 1)
- Binary code is used to store everything
  - numbers: 0, 1, -30, 3.1416, ...
  - characters: a, $,), ...
  - instructions: `sum`, `sqrt`, ...
  - colors: *red, green, blue*, ...

Representing Numbers

Recall that when we write a 3-digit number, e.g.

105

Representing Numbers

Recall that when we write a 3-digit number, e.g.

105

we are using the decimal system:

- **1** hundreds
- **0** tens
- **5** ones

that is: $(1 \times 10^2) + (0 \times 10^1) + (5 \times 10^0)$

where the digits range 0, 1, 2, ..., 9

Representing Numbers in Binary

The binary number

1101001

Representing Numbers in Binary

The binary number

1101001

now we have powers of 2 and digits 0 and 1

$$(1\times 2^6)+(1\times 2^5)+(0\times 2^4)+(1\times 2^3)+(0\times 2^2)+(0\times 2^1)+(1\times 2^0)$$

Representing Numbers in Binary

The binary number

$$\mathbf{1101001}$$

now we have powers of 2 and digits 0 and 1

$(1\times 2^6)+(1\times 2^5)+(0\times 2^4)+(1\times 2^3)+(0\times 2^2)+(0\times 2^1)+(1\times 2^0)$

In decimal digits this is: $64 + 32 + 8 + 1 = 105$

Representing Numbers in Binary

Clicker: What is the decimal value of the following 4-digit binary number

$$\mathbf{1110}$$

- A: 5
- B: 8
- C: 14
- D: 12

Representing Numbers in Binary

Clicker: What is the decimal value of the following 4-digit binary number

1110

- A: 5
- B: 8
- C: 14
- D: 12

$$(1 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0)$$

Representing Numbers in Binary

Clicker: What is the decimal value of the following 4-digit binary number

1110

- A: 5
- B: 8
- C: 14
- D: 12

$(1 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0)$

8 + 4 + 2 + 0 = **14**

BITS

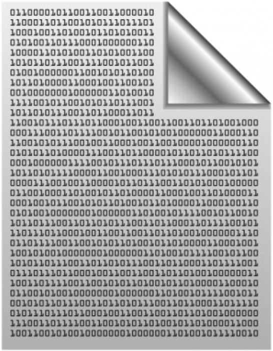
1 bit	2 bits	3 bits	4 bits	
0 = 0	00 = 0	000 = 1	0000 = 1	1000 = 9
1 = 1	01 = 1	001 = 2	0001 = 2	1001 = 10
	10 = 2	010 = 3	0010 = 3	1010 = 11
	11 = 3	011 = 4	0011 = 4	1011 = 12
		100 = 5	0100 = 5	1100 = 13
		101 = 6	0101 = 6	1101 = 14
		110 = 7	0110 = 7	1110 = 15
		111 = 8	0111 = 8	1111 = 16

Each additional bit doubles the number of possible permutations. N bits represent values 0 to 2^{N-1}

Bits and Bytes

- A collection of 8 bits is a **byte**
- Each byte can store:
  - numbers: 00000000 (0), to 11111111 (255)
  - has a memory address: 0, 1, 2, ...
- To store bigger numbers, we use several bytes
  - 2 bytes: 0 to 65,535
  - 4 bytes: 0 to 4,294,967,295
  - 4 bytes (1 byte for ±): ± 2,147,483,648
- Every memory device has a storage capacity indicating the number of bytes it can hold

Files and Formats



Every file is binary in the sense that it consists of 0s and 1s

Files and Formats

A file format:

- is a way of interpreting the bytes in a file
- specifies how bits are used to encode information in a digital storage medium
- For example, in the simplest case, a **plain text** format means that each byte is used to represent a single character

Some Confusing Terms

- Text files
- Plain text files
- Formatted text files
- Enriched text files

Some Confusing Terms

Let's take the term **text files** to mean a file that consists mainly of ASCII characters ... and that uses newline characters to give humans the perception of lines

Norman Matloff (2011)

The Art of R Programming

Plain Text Files

- By text files we mean plain text files
- Plain text as an umbrella term for any file that is in a human-readable form (`.txt, .csv, .xml, .html`)
- Text files stored as a sequence of characters
- Each character stored as a single byte of data
- Data is arranged in rows, with several values stored on each row
- Text files that can be read and manipulated with a text editor

Mandatory Reading

Introduction to Data Technologies (ItDT)
by Paul Murrell

- Preface
- Chap 1: Introduction
- Chap 5: Data Storage

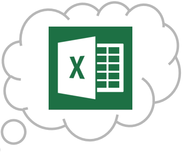
Tabular Datasets

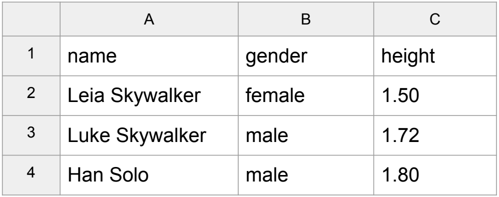
Data Tables

How to store tables in a file?

name	gender	height
Leia Skywalker	female	1.50
Luke Skywalker	male	1.72
Han Solo	male	1.80

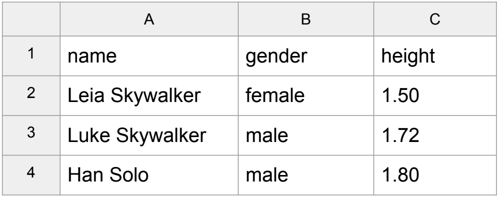
Storing a Data Table





	A	B	C
1	name	gender	height
2	Leia Skywalker	female	1.50
3	Luke Skywalker	male	1.72
4	Han Solo	male	1.80

How NOT to store a Data Table



	A	B	C
1	name	gender	height
2	Leia Skywalker	female	1.50
3	Luke Skywalker	male	1.72
4	Han Solo	male	1.80

Every time you save a
data file in **xls** format ...

God kills a kitten

Dataset "starwarstoy"

name	gender	height	weight	jedi	species	weapon
Luke Skywalker	male	1.72	77	jedi	human	lightsaber
Leia Skywalker	female	1.50	49	no_jedi	human	blaster
Obi-Wan Kenobi	male	1.82	77	jedi	human	lightsaber
Han Solo	male	1.80	80	no_jedi	human	blaster
R2-D2	male	0.96	32	no_jedi	droid	unarmed
C-3PO	male	1.67	75	no_jedi	droid	unarmed
Yoda	male	0.66	17	jedi	yoda	lightsaber
Chewbacca	male	2.28	112	no_jedi	wookiee	bowcaster

Source: Wookiepedia http://starwars.wikia.com/wiki

Data Table (computationally)

How to store data cells?

What type of format?

Character Delimited Text

- A common way to store data in tabular form is via text files
- To store the data we need a way to separate data values
- Each line represents a “row”
- The idea of “columns” is conveyed with delimiters
- In summary, fields within each line are separated by the **delimiter**
- Quotation marks are used when the delimiter character occurs within one of the fields

Plain Text Formats

- There are two main subtypes of plain text format, depending on how the separated values are identified in a row
- Delimited formats
- Fixed-width formats

Delimited Formats

In a delimited format, values within a row are separated by a special character, or **delimiter**

Delimiter	Description
`" "`	white space
`","`	comma
`"\t"`	tab
`";"`	semicolon

Space Delimited (txt)

```
name gender height weight jedi species weapon
"Luke Skywalker" male 1.72 77 jedi human lightsaber
"Leia Skywalker" female 1.50 49 no_jedi human blaster
"Obi-Wan Kenobi" male 1.82 77 jedi human lightsaber
"Han Solo" male 1.80 80 no_jedi human blaster
"R2-D2" male 0.96 32 no_jedi droid unarmed
"C-3PO" male 1.67 75 no_jedi droid unarmed
"Yoda" male 0.66 17 jedi yoda lightsaber
"Chewbacca" male 2.28 112 no_jedi wookiee bowcaster
```

Comma Delimited (csv)

```
name,gender,height,weight,jedi,species,weapon
Luke Skywalker,male,1.72,77,jedi,human,lightsaber
Leia Skywalker,female,1.50,49,no_jedi,human,blaster
Obi-Wan Kenobi,male,1.82,77,jedi,human,lightsaber
Han Solo,male,1.80,80,no_jedi,human,blaster
R2-D2,male,0.96,32,no_jedi,droid,unarmed
C-3PO,male,1.67,75,no_jedi,droid,unarmed
Yoda,male,0.66,17,jedi,yoda,lightsaber
Chewbacca,male,2.28,112,no_jedi,wookiee,bowcaster
```

Tab Delimited (txt, tsv)

```
name  gender  height  weight  jedi  species weapon
"Luke Skywalker"  male  1.72  77  jedi  human lightsaber
"Leia Skywalker"  female  1.50  49  no_jedi human blaster
"Obi-Wan Kenobi"  male  1.82  77  jedi  human lightsaber
"Han Solo"  male  1.80  80  no_jedi human blaster
"R2-D2" male  0.96  32  no_jedi droid unarmed
"C-3PO" male  1.67  75  no_jedi droid unarmed
"Yoda"  male  0.66  17  jedi  yoda  lightsaber
"Chewbacca" male  2.28  112 no_jedi wookiee bowcaster
```

Fixed-width Formats

- In a fixed-width format, each value is allocated a **fixed number of characters** within every row

Fixed-Width (txt)

```
name              gender  height weight jedi
"Luke Skywalker"  male    1.72   77     jedi
"Leia Skywalker"  female  1.50   49     no_jedi
"Obi-Wan Kenobi"  male    1.82   77     jedi
"Han Solo"        male    1.80   80     no_jedi
"R2-D2"           male    0.96   32     no_jedi
"C-3PO"           male    1.67   75     no_jedi
"Yoda"            male    0.66   17     jedi
"Chewbacca"       male    2.28   112    no_jedi
```

In Summary

Plain Text Formats

- The simplest way to store information in computer memory is a file with a **plain text format**
- The basic conceptual structure of a plain text format is that the **data are arranged in rows**, with several values stored on each row
- The main characteristic of a plain text format is that all of the information in a file, even numeric information, is stored as text

Importing Data Tables in R

R Data Import Manual

There's a wide range of ways and options to import data tables in R.

The authoritative document to know almost all about importing (and exporting) data is the manual **R Data Import/Export**
`http://cran.r-project.org/doc/manuals/r-release/R-data.html`

Importing Data Tables

The most common way to read and import tables in R is by using `read.table()` and friends

The read data output is always a **data.frame**

read.table()

```
read.table(file, header = FALSE, sep = "", quote = "\"'",
           dec = ".", row.names, col.names,
           as.is = !stringsAsFactors,
           na.strings = "NA", colClasses = NA, nrows = -1,
           skip = 0, check.names = TRUE,
           fill = !blank.lines.skip,
           strip.white = FALSE, blank.lines.skip = TRUE,
           comment.char = "#",
           allowEscapes = FALSE, flush = FALSE,
           stringsAsFactors = default.stringsAsFactors(),
           fileEncoding = "", encoding = "unknown", text,
           skipNul = FALSE)
```

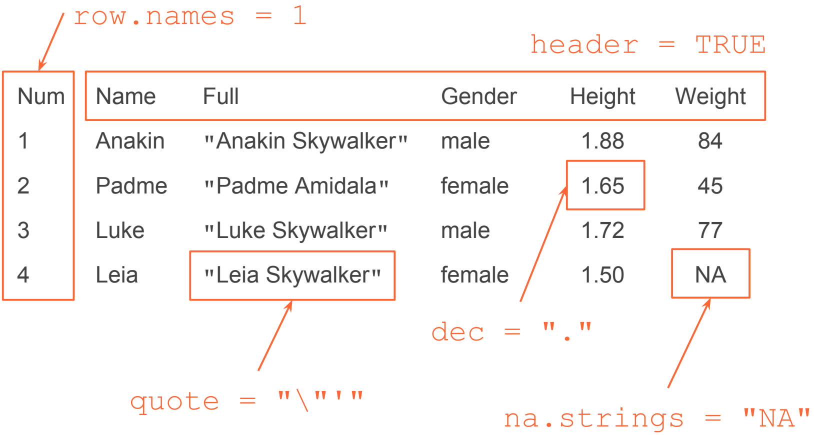
Some read.table() arguments

Argument	Description
`file`	name of file
`header`	whether column names are in 1st line
`sep`	field separator
`quote`	quoting characters
`dec`	character for decimal point
`row.names`	optional vector of row names
`col.names`	optional vector of column names
`na.strings`	character treated as missing values
`colClasses`	optional vector of classes for columns
`nrows`	maximum number of rows to read in
`skip`	number of lines to skip before reading data
`check.names`	check valid column names
`stringsAsFactors`	should characters be converted to factors

Consider some dataset

Num	Name	Full	Gender	Height	Weight
1	Anakin	"Anakin Skywalker"	male	1.88	84
2	Padme	"Padme Amidala"	female	1.65	45
3	Luke	"Luke Skywalker"	male	1.72	77
4	Leia	"Leia Skywalker"	female	1.50	NA

Arguments for `read.table()`



`row.names = 1`

`header = TRUE`

Num	Name	Full	Gender	Height	Weight
1	Anakin	"Anakin Skywalker"	male	1.88	84
2	Padme	"Padme Amidala"	female	1.65	45
3	Luke	"Luke Skywalker"	male	1.72	77
4	Leia	"Leia Skywalker"	female	1.50	NA

`dec = "."`

`quote = "\"'"`

`na.strings = "NA"`

Assumption

For simplicity's sake, we'll assume that all data files are located in your working directory:

e.g. `"/Users/Gaston/Documents"`

starwarstoy.txt

```
name gender height weight jedi species weapon
"Luke Skywalker" male 1.72 77 jedi human lightsaber
"Leia Skywalker" female 1.5 49 no_jedi human blaster
"Obi-Wan Kenobi" male 1.82 77 jedi human lightsaber
"Han Solo" male 1.8 80 no_jedi human blaster
"R2-D2" male 0.96 32 no_jedi droid unarmed
"C-3PO" male 1.67 75 no_jedi droid unarmed
"Yoda" male 0.66 17 jedi yoda lightsaber
"Chewbacca" male 2.28 112 no_jedi wookiee bowcaster
```

Lecture data files at:

https://github.com/gastonstat/stat133/tree/master/datasets

Reading `starwarstoy.txt`

Blank space delimiter `" "`

```r
# using read.table()
sw_txt <- read.table(
  file = "starwarstoy.txt",
  header = TRUE)
```

Note: by default `read.table()` (and friends) convert character strings into factors

Reading `starwarstoy.txt`

Compare to this other option:

```r
# first column as row names
sw_txt1 <- read.table(
  file = "starwarstoy.txt",
  header = TRUE,
  row.names = 1)
```

Reading starwarstoy.txt

Limit the number of rows to read in (first 4 individuals):

```r
# first column as row names
sw_txt2 <- read.table(
  file = "starwarstoy.txt",
  header = TRUE,
  row.names = 1,
  nrows = 4)
```

Reading `starwarstoy.txt`

Let's skip the first row (no header):

```r
# first column as row names
sw_txt3 <- read.table(
  file = "starwarstoy.txt",
  header = FALSE,
  skip = 1,
  row.names = 1,
  nrows = 4)
```

starwarstoy.csv

```
name,gender,height,weight,jedi,species,weapon
Luke Skywalker,male,1.72,77,jedi,human,lightsaber
Leia Skywalker,female,1.5,49,no_jedi,human,blaster
Obi-Wan Kenobi,male,1.82,77,jedi,human,lightsaber
Han Solo,male,1.8,80,no_jedi,human,blaster
R2-D2,male,0.96,32,no_jedi,droid,unarmed
C-3PO,male,1.67,75,no_jedi,droid,unarmed
Yoda,male,0.66,17,jedi,yoda,lightsaber
Chewbacca,male,2.28,112,no_jedi,wookiee,bowcaster
```

Reading starwarstoy.csv

Comma delimiter ","

```
# using read.table()
sw_csv <- read.table(file = "starwarstoy.csv",
                     header = TRUE,
                     sep = ",")

# using read.csv()
sw_csv <- read.csv(file = "starwarstoy.csv")
```

starwarstoy.csv2

```
name;gender;height;weight;jedi;species;weapon
Luke Skywalker;male;1,72;77;jedi;human;lightsaber
Leia Skywalker;female;1,5;49;no_jedi;human;blaster
Obi-Wan Kenobi;male;1,82;77;jedi;human;lightsaber
Han Solo;male;1,8;80;no_jedi;human;blaster
R2-D2;male;0,96;32;no_jedi;droid;unarmed
C-3PO;male;1,67;75;no_jedi;droid;unarmed
Yoda;male;0,66;17;jedi;yoda;lightsaber
Chewbacca;male;2,28;112;no_jedi;wookiee;bowcaster
```

Reading `starwarstoy.csv2`

Semicolon delimiter "," and decimal symbol ","

```r
# using read.table()
sw_csv2 <- read.table(file = "starwarstoy.csv",
                      header = TRUE,
                      sep = ";", dec = ",")

# using read.csv2()
sw_csv2 <- read.csv2(file = "starwarstoy.csv2")
```

starwarstoy.tsv

```
name  gender height weight jedi species weapon
Luke Skywalker male 1.72 77 jedi human lightsaber
Leia Skywalker female 1.5 49 no_jedi human blaster
Obi-Wan Kenobi male 1.82 77 jedi human lightsaber
Han Solo male 1.8 80 no_jedi human blaster
R2-D2 male 0.96 32 no_jedi droid unarmed
C-3PO male 1.67 75 no_jedi droid unarmed
Yoda male 0.66 17 jedi yoda lightsaber
Chewbacca male 2.28 112 no_jedi wookiee bowcaster
```

Reading starwarstoy.tsv

Tab delimiter "\t"

```r
# using read.table()
sw_tsv <- read.table(file = "starwarstoy.tsv",
                     header = TRUE,
                     sep = "\t")

# using read.delim()
sw_tsv <- read.delim(file = "starwarstoy.tsv")
```

starwarstoy.dat

```
name%gender%height%weight%jedi%species%weapon
Luke Skywalker%male%1.72%77%jedi%human%lightsaber
Leia Skywalker%female%1.5%49%no_jedi%human%blaster
Obi-Wan Kenobi%male%1.82%77%jedi%human%lightsaber
Han Solo%male%1.8%80%no_jedi%human%blaster
R2-D2%male%0.96%32%no_jedi%droid%unarmed
C-3PO%male%1.67%75%no_jedi%droid%unarmed
Yoda%male%0.66%17%jedi%yoda%lightsaber
Chewbacca%male%2.28%112%no_jedi%wookiee%bowcaster
```

Reading starwarstoy.dat

Note that this file has "%" as delimiter

```r
# using read.table()
sw_dat <- read.table(file = "starwarstoy.dat",
                     header = TRUE,
                     sep = "%")
```

read.table() and friends

Function	Description
`read.csv()`	comma separated values
`read.csv2()`	semicolon separated values (Europe)
`read.delim()`	tab separated values
`read.delim2()`	tab separated values (Europe)

There is also the `read.fwf()` function for reading a table of **fixed width format**

Considerations

What is the field separator?

- space `" "`
- tab `"\t"`
- comman `","`
- semicolon `";"`
- other?

Considerations

Does the data file contains:

- row names?
- column names?
- missing values?
- special characters?

Summary

So far ...

- There are multiple ways to import data tables
- The workhorse function is `read.table()`
- But you can use the other wrappers, e.g. `read.csv()`
- The output is a `"data.frame"` object

Location of data file

Sometimes the issue is not the type of file but its location

- zip file
- url (`http` standard)
- url (`https` HTTP secure)

Reading compressed files

R provides various `connections` functions for opening and reading compressed files:

- `unz()` reads only a single zip file
- `gzfile()` for gzip, bzip2, xz, lzma
- `bzfile()` for bzip2
- `xzfile()` for xz

You pass a connection to the argument `file` in any of the reading files functions.

Reading zip files

```
unz(description, filename)
```

- `description` is the full path to the zip file with `.zip` extension if required
- `filename` is the name of the file

Reading a single zip file

`starwarstoy.zip` contains a copy of the file `starwarstoy.txt`; to import it in R type:

```r
sw_zip <- read.table(
  file = unz(description = "starwarstoy.zip",
             "starwarstoy.txt")
)
```

Connection for the web

Using `url()`

```
url(description, open = "", blocking = TRUE,
    encoding = getOption("encoding"))
```

The main input for `url()` is the `description` which has to be a complete URL, including scheme such as `http://`, `ftp://`, or `file://`

Example of url connection

For instance, let's create an url connection to

```
# creating a url connection to some file
edu <- url("http://gastonsanchez.com/education.csv")

# what's in 'edu'
edu


##                               description
## "http://gastonsanchez.com/education.csv"
##                                     class
##                                     "url"
##                                      mode
##                                       "r"
##                                      text
##                                    "text"
##                                    opened
##                                  "closed"
##                                  can read
##                                     "yes"
##                                 can write
##                                      "no"


# is open?
isOpen(edu)


## [1] FALSE
```

About Connections

Should we care?

- Most of the times we don't need to explicitly use `url()`.
- Connections can be used anywhere a file name could be passed to functions like `read.table()`
- Usually, the reading functions —eg `read.table()`, `read.csv()`— will take care of the URL connection for us.
- However, there may be occassions in which we will need to specify a `url()` connection.

Good to Know

Terms of Service

Some times, reading data directly from a website may be against the terms of use of the site.

Web Politeness

When you're reading (and "playing" with) content from a web page, make a local copy as a courtesy to the owner of the web site so you don't overload their server by constantly rereading the page. To make a copy from inside of R, look at the `download.file()` function.

Downloading Files

Downloading files from the web

It is good advice to download a copy of the file to your computer, and then play with it.

Let's use `download.file()` to save a copy in our working directory. In this case we create the file `education.csv`

```
# download a copy in your working directory
download.file("http://gastonsanchez.com/education.csv",
              "education.csv")
```

Reading files via https

To read data tables via https (to connect via a secured HTTP) we need to use the R package "RCurl"

```
# load package RCurl
library(RCurl)

# URL of data file
url <- getURL("https://???")

# import data in R (through a text connection)
df <- read.csv(textConnection(url),
               row.names = 1, header = TRUE)
```

Clicker poll

Which of the following sentences is TRUE

A) spreadsheet formats have no limits on the numbers of columns and rows

B) spreadsheet format is always better than a plain text or binary data format

C) a lot of unnecessary additional information is stored in a spreadsheet file

D) All of the above

R package "readr"

Package "readr"

The package "readr" (by Wickham *et al*) is a new package that makes it easy to read many types of tabular data

http://blog.rstudio.org/2015/04/09/readr-0-1-0/

http://cran.r-project.org/web/packages/readr/vignettes/design.html

Package "readr"

```r
# remember to install 'readr'
install.packages("readr")

# load it
library(readr)
```

"readr" Functions

- Fixed width files with `read_table()` and `read_fwf()`
- Delimited files with `read_delim()`, `read_csv()`, `read_tsv()`, and `read_csv2()`

About "readr"

"readr" functions ...

- are around 10x faster than base functions
- are more consistent (better designed)
- produce data frames that are easier to use
- they have more flexible column specification

Input Arguments

- file
- col_names
- col_types
- progress

Input Arguments

`file` gives the file to read; a url or local path. A local path can point to a a zipped, bzipped, xzipped, or gzipped file it'll be automatically uncompressed in memory before reading.

Input Arguments

`col_names`: describes the column names (equivalent to `header` in base R). It has three possible values:

- `TRUE` will use the the first row of data as column names.
- `FALSE` will number the columns sequentially.
- A character vector to use as column names.

Input Arguments

`col_types` (equivalent to `colClasses` automatically detects column types:

- `col_logical()` contains only logical values
- `col_integer()` integers
- `col_double())` doubles (reals)
- `col_euro_double()` "Euro" doubles that use commas `","` as decimal separator
- `col_date()` Y-m-d dates
- `col_datetime()`: ISO8601 date times
- `col_character()`: everything else

Column Types Correspondence

Type	Abbreviation
col_logical()	l
col_integer()	i
col_numeric()	n
col_double()	d
col_euro_double()	e
col_date()	D
col_datetime()	T
col_character()	c
col_skip()	_

Column Types

Overriding default choice of `col_types`

Use a compact string: `"dc__d"`. Each letter corresponds to a column so this specification means: read first column as double, second as character, skip the next two and read the last column as a double. (There's no way to use this form with column types that need parameters.)

Column Types

Overriding default choice of `col_types`

Another way to override the default choices of column types is by passing a list of `col_...` objects:

```
read_csv("iris.csv", col_types = list(
  Sepal.Length = col_double(),
  Sepal.Width = col_double(),
  Petal.Length = col_double(),
  Petal.Width = col_double(),
  Species = col_factor(c("setosa", "versicolor", "virginica"))
))
```

Output

- Characters are never automatically converted to factors
- Column names are left as is
  (i.e. there is no `check.names = TRUE`)
- Use backticks to refer to variables with unusual names:

```
df$`Income ($000)`
```

- Row names are never set
- The output has class

```
c("tbl_df", "tbl", "data.frame")
```

"starwarstoy.csv"

```
name,gender,height,weight,jedi,species,weapon
Luke Skywalker,male,1.72,77,jedi,human,lightsaber
Leia Skywalker,female,1.50,49,no_jedi,human,blaster
Obi-Wan Kenobi,male,1.82,77,jedi,human,lightsaber
Han Solo,male,1.80,80,no_jedi,human,blaster
R2-D2,male,0.96,32,no_jedi,droid,unarmed
C-3PO,male,1.67,75,no_jedi,droid,unarmed
Yoda,male,0.66,17,jedi,yoda,lightsaber
Chewbacca,male,2.28,112,no_jedi,wookiee,bowcaster
```

String Columns as factors

By default, functions in "readr" do not convert character strings into factors. But you can specify what columns to be imported as factors (you must specify the levels):

```
sw1 <- read_csv(
  file = "starwarstoy.csv",
  col_types = list(
    gender = col_factor(c("male", "female")))
)
```

Importing selected columns

"readr" allows you to import specific columns of a dataset

```r
# importing just first 4 columns
sw4 <- read_csv(
  file = "starwarstoy.csv",
  col_types = "ccnn___"
)
```

Main functions in `"readr"`

- `read_table()`
- `read_delim()`
- `read_csv()`
- `read_csv2()`
- `read_tsv()`
- `read_fwf()`

Foreign Files

Data Table (foreign files)

It is not uncommon to have tabular datasets in foreign files (e.g. from other programs)

Files from other programs

Type	Package	Function
Excel	"gdata"	read.xls()
Excel	"xlsx"	read.xlsx()
Excel	"readxl"	read_excel()
SPSS	"foreign"	read.spss()
SAS	"foreign"	read.ssd()
SAS	"foreign"	read.xport()
Matlab	"R.matlab"	readMat()
Stata	"foreign"	read.dta()
Octave	"foreign"	read.octave()
Minitab	"foreign"	read.mtp()
Systat	"foreign"	read.systat()