Reading Data Tables

STAT 133

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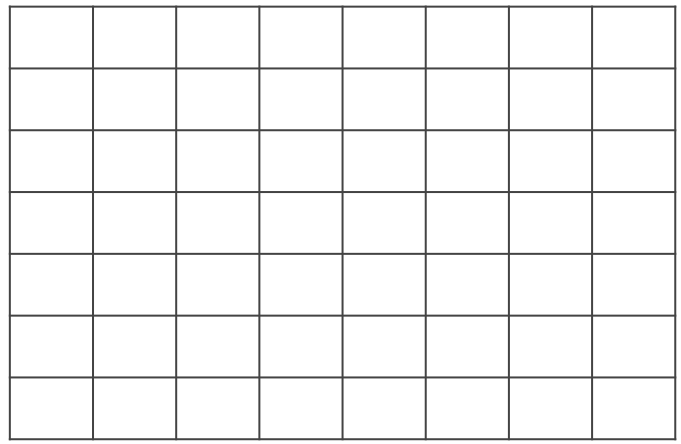
Tabular Datasets

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 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

Dataset “starwarstoy”

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

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
- Separation of values is done with **field 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

Common Delimiters

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

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)
```

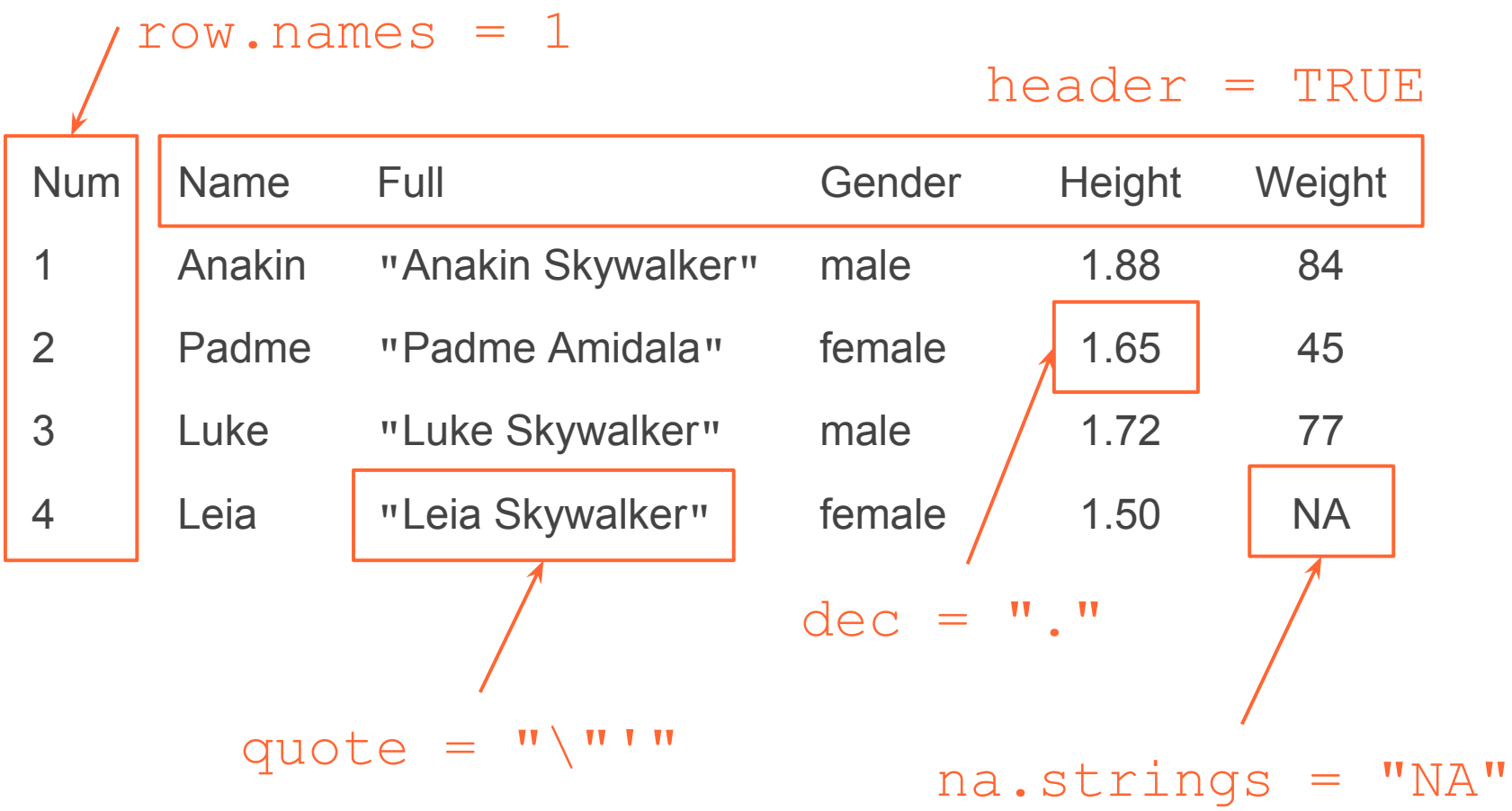
read.table() arguments

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()`



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 `" "`

```
# 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:

```
# 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):

```
# 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):

```
# 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 ","

```
# 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"

```
# 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

```
# 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:

```
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.

Goot 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 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)
```

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()`

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_double()`	`d`
`col_euro_double()`	`e`
`col_date()`	`D`
`col_datetime()`	`T`
`col_character()`	`c`

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"))
))
```

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

```
# 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()`