Week 01a-p Intro to R, OIS Lab 0a

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3 OIStats-v3: Introduction to R and RStudio

You may want to turn on "Soft-wrap R Source Files" in Tools/Global Options/Code

The goal of this lab is to introduce you to R and RStudio,

- which you'll be using throughout the course
- both to learn the statistical concepts discussed in the textbook
- and also to analyze real data and come to informed conclusions.

To straighten out which is which:

- R is the name of the programming language itself and

- RStudio is a convenient interface.

4 Explore R as we go

As the labs progress, you are encouraged to explore beyond what the labs dictate;

- a willingness to experiment will make you a much better programmer.

Before we get to that stage, however,

- you need to build some basic fluency in R.

Today we begin with the fundamental building blocks of R and RStudio:

- the interface,
- reading in data, and
- basic commands.

The panel in the upper right contains

- your workspace as well as
- a history of the commands that you've previously entered.

Any plots that you generate will

- show up in the panel in the lower right corner.

The panel on the left is where the action happens.

- It's called the console. Every time you launch RStudio,
- it will have the same text at the top of the console
  - telling you the version of R that you're running.

Below that information is the prompt.

- As its name suggests, this prompt is really a request,
  - a request for a command.

Initially, interacting with R is all about

- typing commands and
- interpreting the output.

These commands and their syntax have evolved over decades

- and now provide what many users feel is a fairly natural way
- to access data and organize, describe, and
- invoke statistical computations.

To get you started, enter the following command at the R prompt

- (i.e. right after > on the console).
- You can either type it in manually or copy and paste it from this document.

```
source("http://www.openintro.org/stat/data/arbuthnot.R")
```

This command instructs R to access the OpenIntro website

- and fetch some data: the Arbuthnot baptism counts for boys and girls.

You should see that the workspace area

- in the upper righthand corner of the RStudio window
- now lists a data set called arbuthnot

- that has 82 observations on 3 variables.

As you interact with R, you will create a series of objects.

- Sometimes you load them as we have done here,
- and sometimes you create them yourself
    - as the byproduct of a computation
    - or some analysis you have performed.

Note that because you are accessing data from the web,

- this command (and the entire assignment)
- will work in a computer lab, in the library, or in your dorm room;
- anywhere you have access to the Internet.

5 The Data: Dr. Arbuthnot's Baptism Records

The Arbuthnot data set refers to Dr. John Arbuthnot,

-an 18th century physician, writer, and mathematician.

He was interested in the ratio of newborn boys to newborn girls,

- so he gathered the baptism records for children born in London
- for every year from 1629 to 1710.

6 Arbuthnot was an 18th Century Physician

We can take a look at the data by typing its name into the console.

```
head(arbuthnot)
```

```
##   year boys girls
## 1 1629 5218  4683
## 2 1630 4858  4457
## 3 1631 4422  4102
## 4 1632 4994  4590
## 5 1633 5158  4839
## 6 1634 5035  4820
```

```
tail(arbuthnot)
```

```
##    year boys girls
## 77 1705 8366  7779
## 78 1706 7952  7417
## 79 1707 8379  7687
## 80 1708 8239  7623
## 81 1709 7840  7380
## 82 1710 7640  7288
```

```
summary(arbuthnot)
```

```
##       year           boys          girls     
##  Min.   :1629   Min.   :2890   Min.   :2722  
##  1st Qu.:1649   1st Qu.:4759   1st Qu.:4457  
##  Median :1670   Median :6073   Median :5718  
##  Mean   :1670   Mean   :5907   Mean   :5535  
##  3rd Qu.:1690   3rd Qu.:7576   3rd Qu.:7150
##  Max.   :1710   Max.   :8426   Max.   :7779
```

What you should see are four columns of numbers,

- each row representing a different year:
    - the first entry in each row is simply the row number
        - (an index we can use to access the data from individual years if we want),
    - the second is the year, and
    - the third and fourth are the numbers of boys and girls baptized that year, respectively.

Use the scrollbar on the right side of the console window

- to examine the complete data set.

Note that the row numbers in the first column are not part of Arbuthnot's data.

- R adds them as part of its printout
- to help you make visual comparisons.

You can think of them as the index that you see on the left side of a spreadsheet.

- In fact, the comparison to a spreadsheet will generally be helpful.

R has stored Arbuthnot's data

- in a kind of spreadsheet or table
- called a data frame.

Dataframes in R are very powerful

- Python has introduced their own dataframes, named "Pandas"

You can see the dimensions of this data frame by typing:

```r
dim(arbuthnot)
```

```
## [1] 82  3
```

This command should output [1] 82 3,

- indicating that there are 82 rows and 3 columns
    - (we'll get to what the [1] means in a bit),
- just as it says next to the object in your workspace.

You can see the names of these columns (or variables) by typing:

```r
names(arbuthnot)
```

```
## [1] "year"  "boys"  "girls"
```

You should see that the data frame contains

- the columns year, boys, and girls.

At this point, you might notice that many of the commands in R

- look a lot like functions from math class;
- that is, invoking R commands
    - means supplying a function with some number of arguments.

The dim and names commands, for example,

- each took a single argument,
- the name of a data frame.

One advantage of RStudio is that it comes with a built-in data viewer.

- Click on the name arbuthnot in the upper right window
    - that lists the objects in your workspace.

This will bring up an alternative display of the Arbuthnot counts

- in the upper left window.
- You can close the data viewer
    - by clicking on the “x” in the upper lefthand corner.

7 Some Exploratory Data Analysis

type: section

8 Lets access the data in our dataframe

Let’s start to examine the data a little more closely.

We can access the data in a single column of a data frame

- separately using a command like

```
arbuthnot$boys
```

```
##  [1] 5218 4858 4422 4994 5158 5035 5106 4917 4703 5359 5366 5518 5470 5460
## [15] 4793 4107 4047 3768 3796 3363 3079 2890 3231 3220 3196 3441 3655 3668
## [29] 3396 3157 3209 3724 4748 5216 5411 6041 5114 4678 5616 6073 6506 6278
## [43] 6449 6443 6073 6113 6058 6552 6423 6568 6247 6548 6822 6909 7577 7575
## [57] 7484 7575 7737 7487 7604 7909 7662 7602 7676 6985 7263 7632 8062 8426
## [71] 7911 7578 8102 8031 7765 6113 8366 7952 8379 8239 7840 7640
```

This command will only show the number of boys baptized each year.

9 Exercise 1 What command would you use to extract just the counts of girls baptized? Try it!

10 Girls Baptized

Notice that the way R has printed these data is different.

- When we looked at the complete data frame,
    - we saw 82 rows, one on each line of the display.

These data are no longer structured in a table with other variables,

- so they are displayed one right after another.

Objects that print out in this way are called vectors;

- they represent a set of numbers.

R has added numbers in [brackets] along the left side of the printout

- to indicate locations within the vector.
- For example, 5218 follows [1],
    - indicating that 5218 is the first entry in the vector.

    - And if [43] starts a line,
    - then that would mean the first number on that line
    - would represent the 43rd entry in the vector.

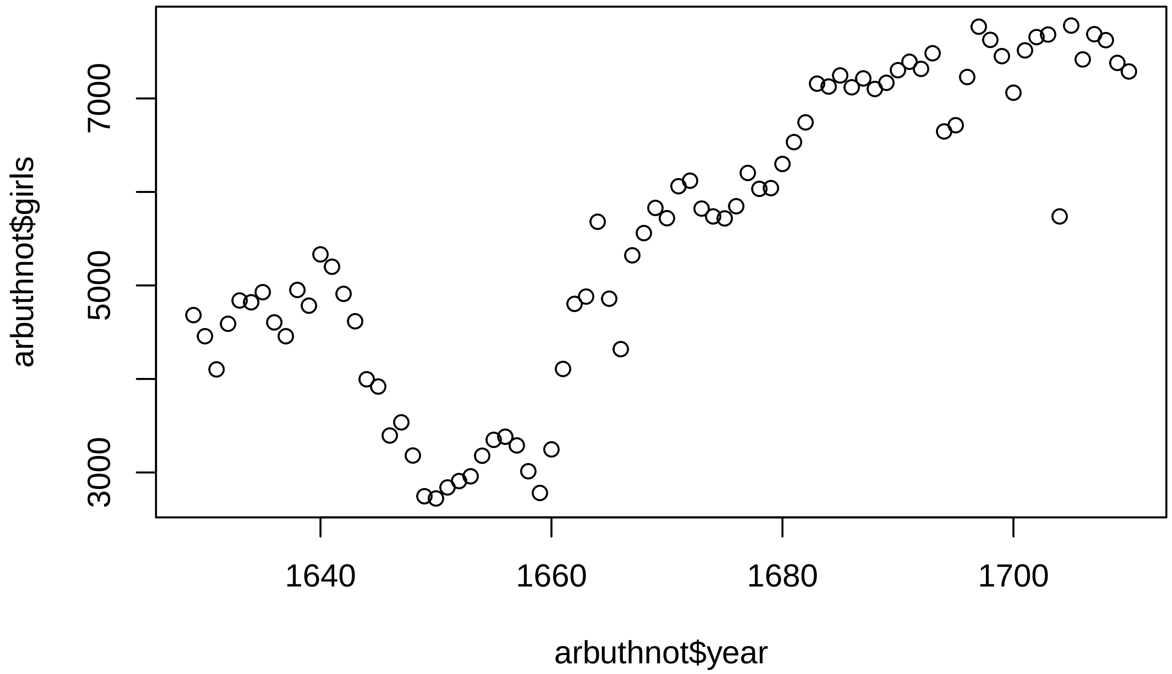
11 Lets do some Data Visualization using R's Base Graphics

R has some powerful functions for making graphics.

We can create a simple plot of the number of girls

- baptized per year with the command

```
plot(x = arbuthnot$year, y = arbuthnot$girls)
```



By default, R creates a scatterplot

- with each x,y pair
- indicated by an open circle.

The plot itself should appear under

- the "Plots" tab of the lower right panel of RStudio.

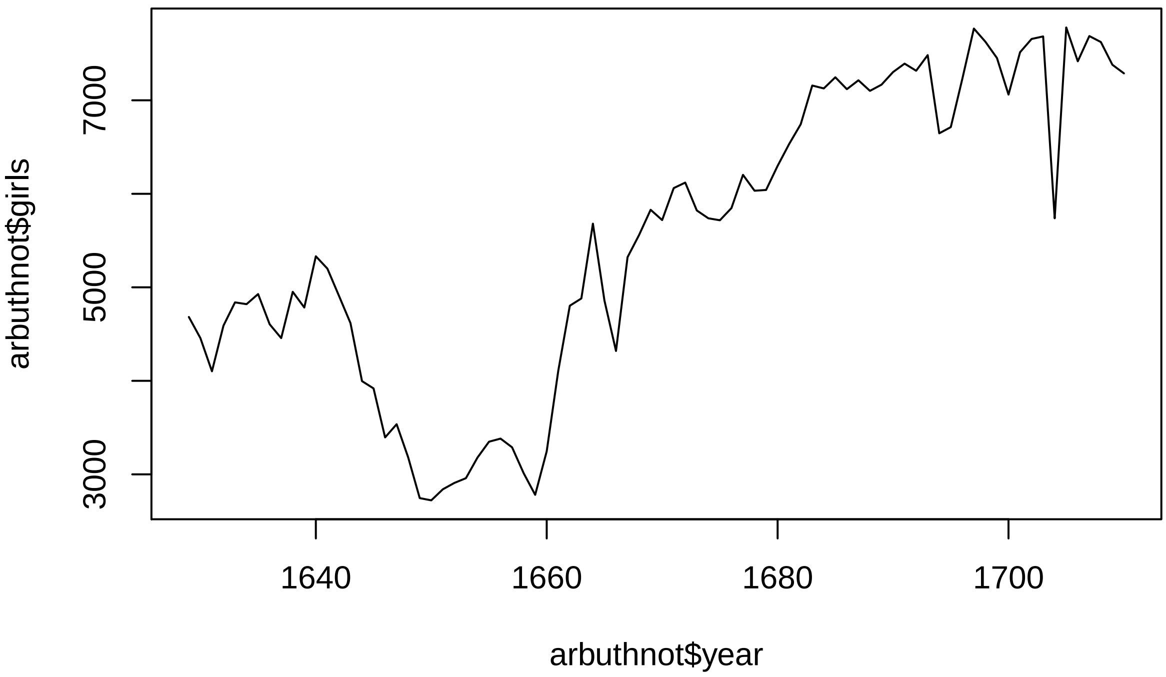
Notice that the command above again looks like a function,

- this time with two arguments separated by a comma.
    - The first argument in the plot function
        * specifies the variable for the x-axis and
    - The second for the y-axis.

If we wanted to connect the data points with lines,

- we could add a third argument,
- the letter "l" for line.

```
plot(x = arbuthnot$year, y = arbuthnot$girls, type = "l")
```



You might wonder how you are supposed to know

- that it was possible to add that third argument.

Thankfully, R documents all of its functions extensively.

To read what a function does and

- learn the arguments that are available to you,
- just type in a question mark
  - followed by the name of the function that you're interested in.

Try the following.

```
?plot
```

```
## starting httpd help server ... done
```

Notice that the help file replaces the plot

- in the lower right panel.

You can toggle between plots and help files

- using the tabs at the top of that panel.

12 Exercise 2 Is there an apparent trend in the number of girls baptized over the years?

13 Trend in the number of girls baptized over the years

Now, suppose we want to plot the total number of baptisms.

To compute this, we could use the fact that R is really just a big calculator.

We can type in mathematical expressions like

```
5218 + 4683
```

```
## [1] 9901
```

to see the total number of baptisms in 1629.

We could repeat this once for each year,

- but there is a faster way.
- If we add the vector for baptisms for boys and girls,
    - R will compute all sums simultaneously.

```
arbuthnot$boys + arbuthnot$girls
```

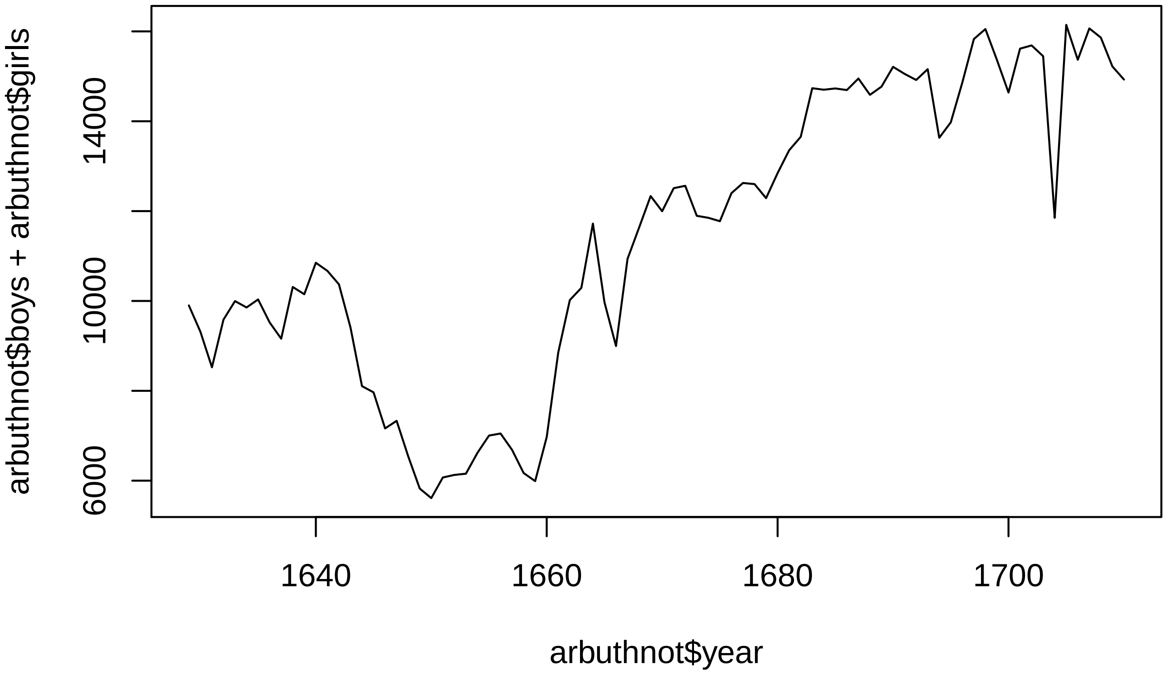
```
##  [1]  9901  9315  8524  9584  9997  9855 10034  9522  9160 10311 10150
## [12] 10850 10670 10370  9410  8104  7966  7163  7332  6544  5825  5612
## [23]  6071  6128  6155  6620  7004  7050  6685  6170  5990  6971  8855
## [34] 10019 10292 11722  9972  8997 10938 11633 12335 11997 12510 12563
## [45] 11895 11851 11775 12399 12626 12601 12288 12847 13355 13653 14735
## [56] 14702 14730 14694 14951 14588 14771 15211 15054 14918 15159 13632
## [67] 13976 14861 15829 16052 15363 14639 15616 15687 15448 11851 16145
## [78] 15369 16066 15862 15220 14928
```

What you will see are 82 numbers

- (in that packed display, because we aren't looking at a data frame here),
- each one representing the sum we're after.
- Take a look at a few of them and verify that they are right.

Therefore, we can make a plot of the total number of baptisms per year with the command

```
plot(arbuthnot$year, arbuthnot$boys + arbuthnot$girls, type = "l")
```



This time, note that we left out the names of the first two arguments.

We can do this because the help file shows

- that the default for plot is for
  - the first argument to be the x-variable and
- the second argument to be the y-variable.

Similarly to how we computed the proportion of boys,

- we can compute the ratio of the number of boys
- to the number of girls baptized in 1629 with

```
5218/4683
```

```
## [1] 1.114243
```

or we can act on the complete vectors with the expression

```
arbuthnot$boys/arbuthnot$girls
```

```
##  [1] 1.114243 1.089971 1.078011 1.088017 1.065923 1.044606 1.036120
##  [8] 1.067752 1.055194 1.082189 1.121656 1.034884 1.051923 1.112016
## [15] 1.038120 1.027521 1.032661 1.109867 1.073529 1.057215 1.121267
## [22] 1.061719 1.137676 1.107290 1.080095 1.082416 1.091371 1.084565
## [29] 1.032533 1.047793 1.153901 1.146905 1.156075 1.085988 1.108584
## [36] 1.063369 1.052697 1.083121 1.055242 1.092266 1.116143 1.097744
## [43] 1.064016 1.052778 1.043112 1.065354 1.059647 1.120575 1.035467
## [50] 1.088679 1.034100 1.039530 1.044237 1.024466 1.058536 1.062860
## [57] 1.032846 1.064054 1.072498 1.054359 1.060974 1.083128 1.036526
## [64] 1.039092 1.025792 1.050850 1.081931 1.055748 1.037981 1.104904
## [71] 1.061594 1.073219 1.078254 1.048981 1.010673 1.065354 1.075460
## [78] 1.072132 1.090022 1.080808 1.062331 1.048299
```

The proportion of newborns that are boys

```
5218/(5218 + 4683)
```

```
## [1] 0.5270175
```

or this may also be computed for all years simultaneously:

```
arbuthnot$boys/(arbuthnot$boys + arbuthnot$girls)
```

```
##  [1] 0.5270175 0.5215244 0.5187705 0.5210768 0.5159548 0.5109082 0.5088698
##  [8] 0.5163831 0.5134279 0.5197362 0.5286700 0.5085714 0.5126523 0.5265188
## [15] 0.5093518 0.5067868 0.5080341 0.5260366 0.5177305 0.5139059 0.5285837
## [22] 0.5149679 0.5322023 0.5254569 0.5192526 0.5197885 0.5218447 0.5202837
## [29] 0.5080030 0.5116694 0.5357262 0.5342132 0.5361942 0.5206108 0.5257482
## [36] 0.5153557 0.5128359 0.5199511 0.5134394 0.5220493 0.5274422 0.5232975
## [43] 0.5155076 0.5128552 0.5105507 0.5158214 0.5144798 0.5284297 0.5087122
## [50] 0.5212285 0.5083822 0.5096910 0.5108199 0.5060426 0.5142178 0.5152360
## [57] 0.5080788 0.5155165 0.5174905 0.5132301 0.5147925 0.5199527 0.5089677
## [64] 0.5095857 0.5063659 0.5123973 0.5196766 0.5135590 0.5093183 0.5249190
## [71] 0.5149385 0.5176583 0.5188268 0.5119526 0.5026541 0.5158214 0.5181790
## [78] 0.5174052 0.5215362 0.5194175 0.5151117 0.5117899
```

Note that with R as with your calculator,

- you need to be conscious of the order of operations.

Here, we want to divide the number of boys

- by the total number of newborns,
  - so we have to use parentheses.
- Without them, R will
  - first do the division,
  - then the addition,
    - giving you something that is not a proportion.

14 Exercise 3 Now, make a plot of the proportion of boys over time.

15 The proportion of boys over time

What do you see?

Tip: If you use the up and down arrow keys,

- you can scroll through your previous commands,
- your so-called command history.

You can also access it by

- clicking on the history tab in the upper right panel.

This will save you a lot of typing in the future.

Finally, in addition to simple mathematical operators

- like subtraction and division,
- you can ask R to make comparisons
  - like greater than, >, less than, <, and equality, ==.

For example, we can ask if boys outnumber girls in each year

- with the expression

```
arbuthnot$boys > arbuthnot$girls
```

```
##  [1] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [15] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [29] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [43] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [57] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [71] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
```

This command returns 82 values

- of either TRUE if that year had more boys than girls,
- or FALSE if that year did not (the answer may surprise you).

This output shows a different kind of data than we have considered so far.

In the arbuthnot data frame our values are numerical

- (the year, the number of boys and girls).

Here, we've asked R to create logical data,

- data where the values are either TRUE or FALSE.

In general, data analysis will involve many different kinds of data types,

- and one reason for using R is that
- it is able to represent and compute with many of them.

This seems like a fair bit for your first lab, so let's stop here.

To exit RStudio you can

- click the "x" in the upper right corner of the whole window.
- you will be prompted to save your workspace.
  - If you click "save", RStudio will save
    * the history of your commands and
    * all the objects in your workspace
    * so that the next time you launch RStudio,
    * you will see arbuthnot and you
    * will have access to the commands you typed in your previous session.

For now, click "save", then start up RStudio again.

16 Excercises To Do On Your Own

17 Study Present Day Baptism Records, Are the results the same?

In the previous few pages,

- you recreated some of the displays and

- preliminary analysis of Arbuthnot's baptism data.

Your assignment involves repeating these steps,

- but for present day birth records in the United States.

Load up the present day data with the following command.

```
source("http://www.openintro.org/stat/data/present.R")
```

The data are stored in a data frame called present.

What years are included in this data set?

What are the dimensions of the data frame and what are the variable or column names?

How do these counts compare to Arbuthnot's? Are they on a similar scale?

Does Arbuthnot's observation about boys

- being born in greater proportion than girls hold up in the U.S.?

Make a plot that displays the boy-to-girl ratio for every year in the data set.

- What do you see?

In what year did we see the most total number of births in the U.S.?

- You can refer to the help files or
- the R reference card
- to find helpful commands.

These data come from a report by the Centers for Disease Control.

Check it out if you would like to read more about

- an analysis of sex ratios at birth in the United States.

18 Conclusion

That was a short introduction to R and RStudio,

- but we will provide you with more functions
- and a more complete sense of the language as the course progresses.

Feel free to browse around the websites

- for R and
- RStudio
- if you're interested in learning more,
  - or find more labs for practice.

19 Links

This is a product of OpenIntro - that is released under a Creative Commons Attribution-ShareAlike 3.0 Unported.

This lab was adapted for OpenIntro - by Andrew Bray and Mine Çetinkaya-Rundel - from a lab written by Mark Hansen of UCLA Statistics.