Introduction to R and RStudio

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 texbook 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.

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.

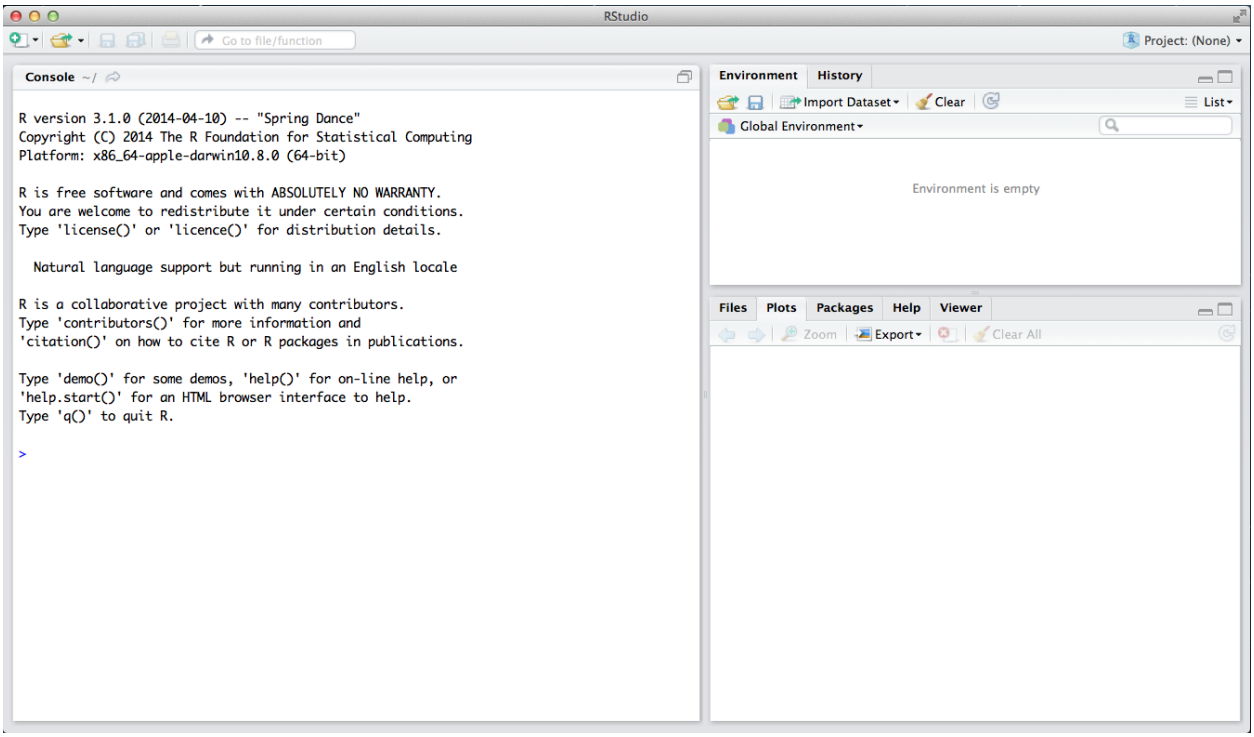


Figure 1: rinterface

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*. Everytime 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 (literally) 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("more/arbuthnot.R")
library(tinytex)
library(rmarkdown)
library(knitr)
library(tinytex)
```

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.

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

```
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
## 7  1635 5106  4928
## 8  1636 4917  4605
## 9  1637 4703  4457
## 10 1638 5359  4952
## 11 1639 5366  4784
## 12 1640 5518  5332
## 13 1641 5470  5200
## 14 1642 5460  4910
## 15 1643 4793  4617
## 16 1644 4107  3997
## 17 1645 4047  3919
## 18 1646 3768  3395
## 19 1647 3796  3536
## 20 1648 3363  3181
## 21 1649 3079  2746
## 22 1650 2890  2722
## 23 1651 3231  2840
## 24 1652 3220  2908
## 25 1653 3196  2959
## 26 1654 3441  3179
## 27 1655 3655  3349
## 28 1656 3668  3382
```

```
## 29 1657 3396  3289
## 30 1658 3157  3013
## 31 1659 3209  2781
## 32 1660 3724  3247
## 33 1661 4748  4107
## 34 1662 5216  4803
## 35 1663 5411  4881
## 36 1664 6041  5681
## 37 1665 5114  4858
## 38 1666 4678  4319
## 39 1667 5616  5322
## 40 1668 6073  5560
## 41 1669 6506  5829
## 42 1670 6278  5719
## 43 1671 6449  6061
## 44 1672 6443  6120
## 45 1673 6073  5822
## 46 1674 6113  5738
## 47 1675 6058  5717
## 48 1676 6552  5847
## 49 1677 6423  6203
## 50 1678 6568  6033
## 51 1679 6247  6041
## 52 1680 6548  6299
## 53 1681 6822  6533
## 54 1682 6909  6744
## 55 1683 7577  7158
## 56 1684 7575  7127
## 57 1685 7484  7246
## 58 1686 7575  7119
## 59 1687 7737  7214
## 60 1688 7487  7101
## 61 1689 7604  7167
## 62 1690 7909  7302
## 63 1691 7662  7392
## 64 1692 7602  7316
## 65 1693 7676  7483
## 66 1694 6985  6647
## 67 1695 7263  6713
## 68 1696 7632  7229
## 69 1697 8062  7767
## 70 1698 8426  7626
## 71 1699 7911  7452
## 72 1700 7578  7061
## 73 1701 8102  7514
## 74 1702 8031  7656
## 75 1703 7765  7683
## 76 1704 6113  5738
## 77 1705 8366  7779
## 78 1706 7952  7417
## 79 1707 8379  7687
## 80 1708 8239  7623
## 81 1709 7840  7380
## 82 1710 7640  7288
```

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*.

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

```
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:

```
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 *Environment* pane (upper right window) that lists the objects in your workspace. This will bring up an alternative display of the data set in the *Data Viewer* (upper left window). You can close the data viewer by clicking on the x in the upper lefthand corner.

Some Exploration

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 4793
## [16] 4107 4047 3768 3796 3363 3079 2890 3231 3220 3196 3441 3655 3668 3396 3157
## [31] 3209 3724 4748 5216 5411 6041 5114 4678 5616 6073 6506 6278 6449 6443 6073
## [46] 6113 6058 6552 6423 6568 6247 6548 6822 6909 7577 7575 7484 7575 7737 7487
## [61] 7604 7909 7662 7602 7676 6985 7263 7632 8062 8426 7911 7578 8102 8031 7765
## [76] 6113 8366 7952 8379 8239 7840 7640
```

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

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

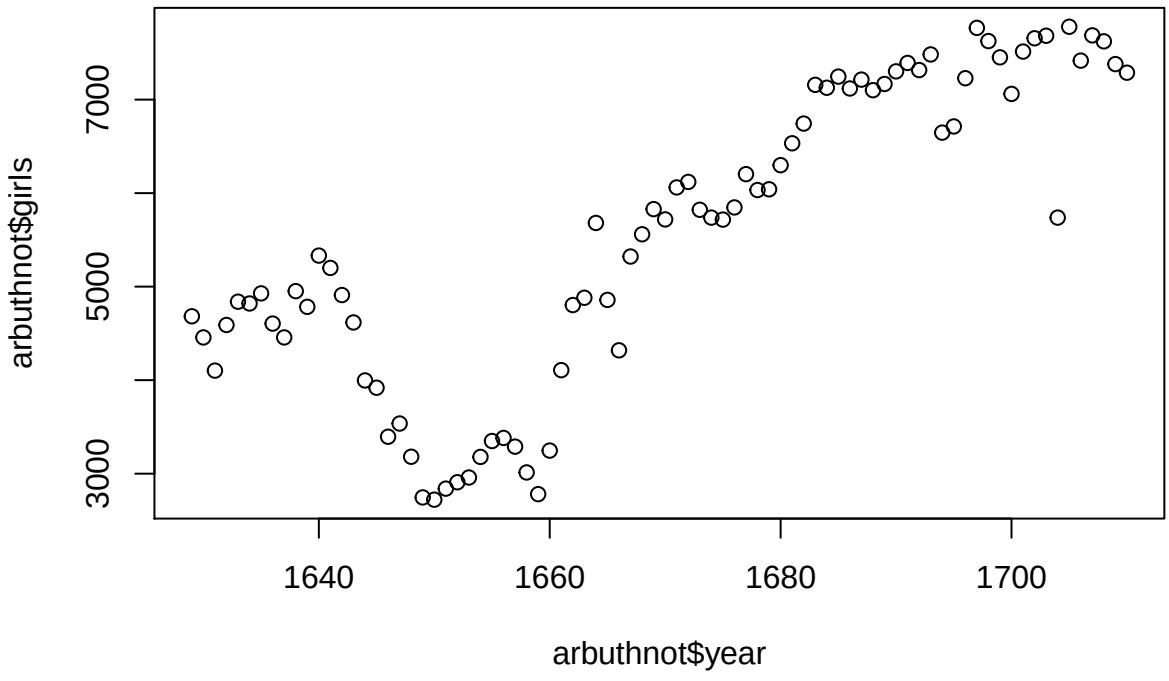
```
arbuthnot$girls
```

```
##  [1] 4683 4457 4102 4590 4839 4820 4928 4605 4457 4952 4784 5332 5200 4910 4617
## [16] 3997 3919 3395 3536 3181 2746 2722 2840 2908 2959 3179 3349 3382 3289 3013
## [31] 2781 3247 4107 4803 4881 5681 4858 4319 5322 5560 5829 5719 6061 6120 5822
## [46] 5738 5717 5847 6203 6033 6041 6299 6533 6744 7158 7127 7246 7119 7214 7101
## [61] 7167 7302 7392 7316 7483 6647 6713 7229 7767 7626 7452 7061 7514 7656 7683
## [76] 5738 7779 7417 7687 7623 7380 7288
```

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.

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

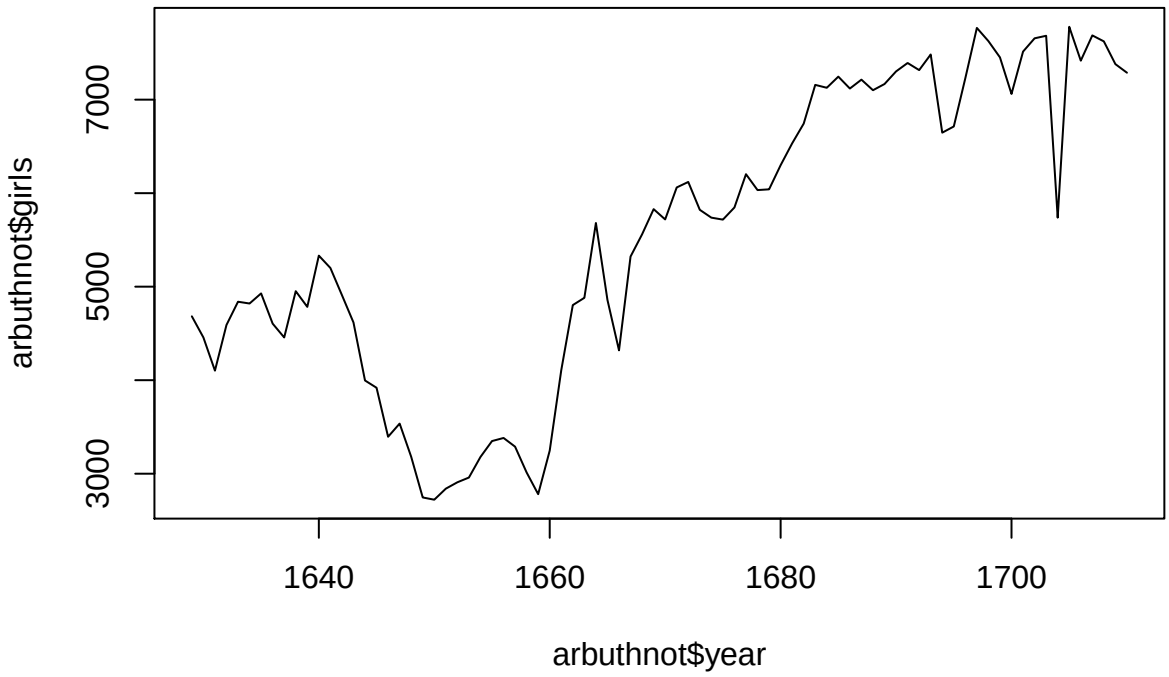
```
plot(x = arbuthnot$year, y = arbuthnot$girls)
```



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.

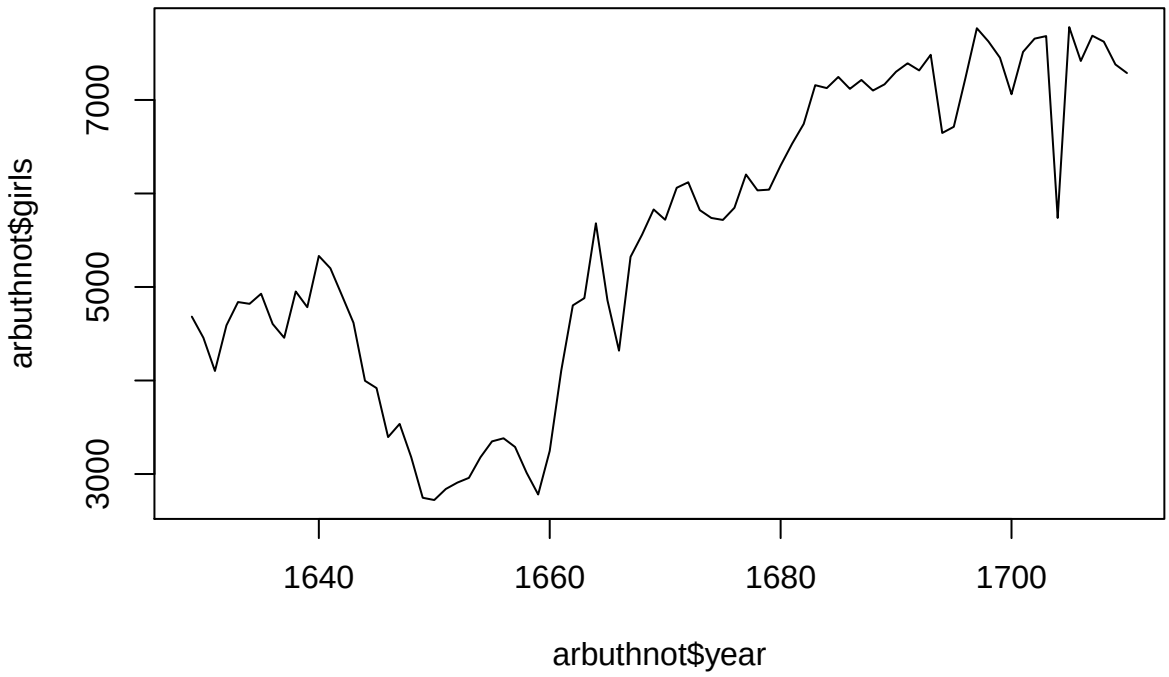
```
?plot
```

```
## Help on topic 'plot' was found in the following packages:
##
##   Package               Library
##   graphics              /Library/Frameworks/R.framework/Versions/4.0/Resources/library
##   base                  /Library/Frameworks/R.framework/Resources/library
##
##
## Using the first match ...
```

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.

2. Is there an apparent trend in the number of girls baptized over the years?
   How would you describe it?

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



With ploting girls a long with year, we can observe that girs decrease from 1640 to 1660, but shows dramatically increasing trend from 1660 to 1710.

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
```

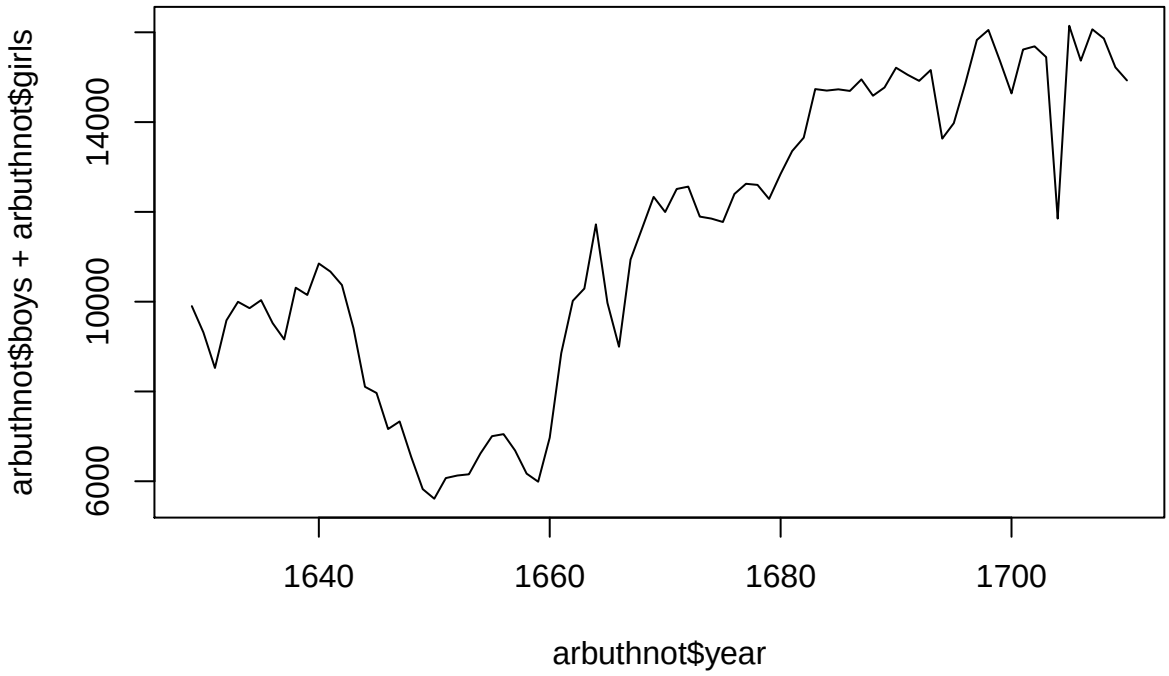
to see the total number of baptisms in 1629. We could repeat this once for each year, but there is a faster way. If we add the vector for baptisms for boys and girls, R will compute all sums simultaneously.

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

```
##  [1]  9901  9315  8524  9584  9997  9855 10034  9522  9160 10311 10150 10850
## [13] 10670 10370  9410  8104  7966  7163  7332  6544  5825  5612  6071  6128
## [25]  6155  6620  7004  7050  6685  6170  5990  6971  8855 10019 10292 11722
## [37]  9972  8997 10938 11633 12335 11997 12510 12563 11895 11851 11775 12399
## [49] 12626 12601 12288 12847 13355 13653 14735 14702 14730 14694 14951 14588
## [61] 14771 15211 15054 14918 15159 13632 13976 14861 15829 16052 15363 14639
## [73] 15616 15687 15448 11851 16145 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 1.067752
##  [9] 1.055194 1.082189 1.121656 1.034884 1.051923 1.112016 1.038120 1.027521
## [17] 1.032661 1.109867 1.073529 1.057215 1.121267 1.061719 1.137676 1.107290
## [25] 1.080095 1.082416 1.091371 1.084565 1.032533 1.047793 1.153901 1.146905
```

```
## [33] 1.156075 1.085988 1.108584 1.063369 1.052697 1.083121 1.055242 1.092266
## [41] 1.116143 1.097744 1.064016 1.052778 1.043112 1.065354 1.059647 1.120575
## [49] 1.035467 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 1.039092
## [65] 1.025792 1.050850 1.081931 1.055748 1.037981 1.104904 1.061594 1.073219
## [73] 1.078254 1.048981 1.010673 1.065354 1.075460 1.072132 1.090022 1.080808
## [81] 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:

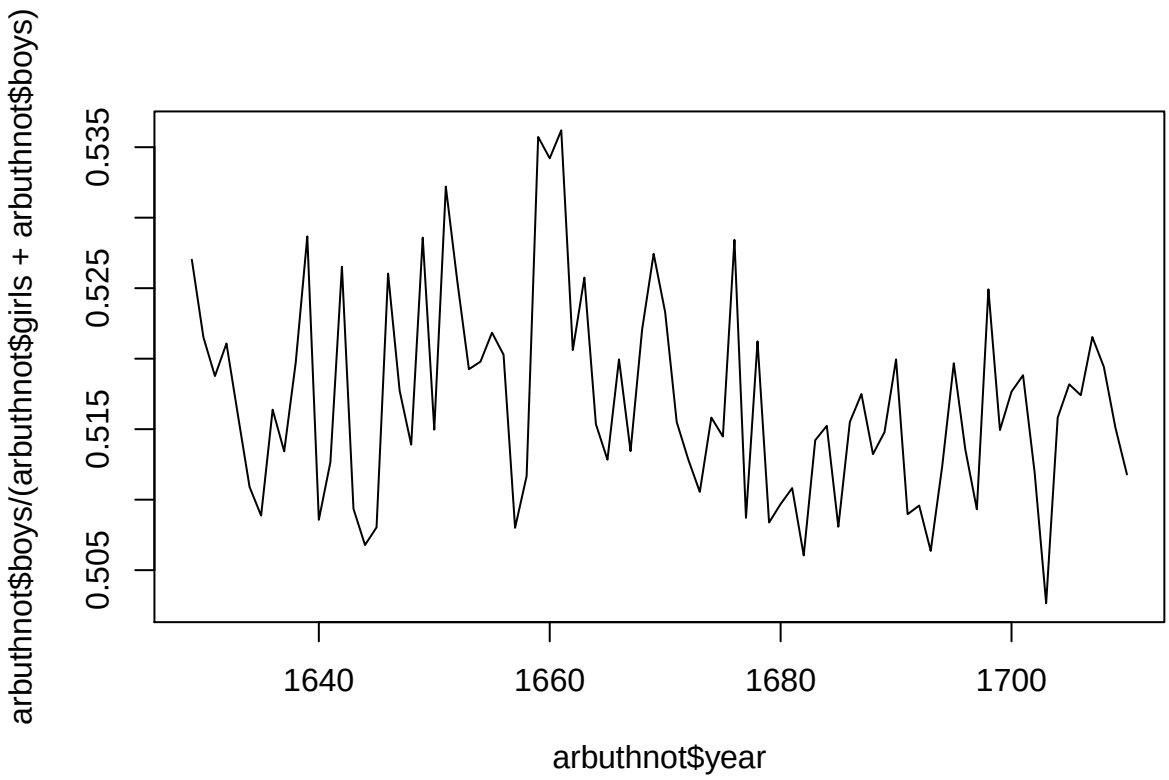
```
arbuthnot$boys / (arbuthnot$boys + arbuthnot$girls)
```

```
##  [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.

3. Now, make a plot of 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.

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



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 TRUE
## [16] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [31] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [46] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [61] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [76] 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.

On Your Own

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("more/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?

```
present$year
```

```
##  [1] 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954
## [16] 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969
## [31] 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
## [46] 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
## [61] 2000 2001 2002
```

The years in the "present" data are included from 1940 to 2002.

```
dim(present)
```

```
## [1] 63  3
```

The "present"data expresses 3 columns and 63 rows.

```
names(present)
```

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

The 3 variables in the columns are "years","boys",and "girls".

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

```
Pb<-present$boys
Pb
```

```
##  [1] 1211684 1289734 1444365 1508959 1435301 1404587 1691220 1899876 1813852
## [10] 1826352 1823555 1923020 1971262 2001798 2059068 2073719 2133588 2179960
## [19] 2152546 2173638 2179708 2186274 2132466 2101632 2060162 1927054 1845862
## [28] 1803388 1796326 1846572 1915378 1822910 1669927 1608326 1622114 1613135
## [37] 1624436 1705916 1709394 1791267 1852616 1860272 1885676 1865553 1879490
## [46] 1927983 1924868 1951153 2002424 2069490 2129495 2101518 2082097 2048861
## [55] 2022589 1996355 1990480 1985596 2016205 2026854 2076969 2057922 2057979
```

```
Ab<-arbuthnot$boys
Ab
```

```
##  [1] 5218 4858 4422 4994 5158 5035 5106 4917 4703 5359 5366 5518 5470 5460 4793
## [16] 4107 4047 3768 3796 3363 3079 2890 3231 3220 3196 3441 3655 3668 3396 3157
## [31] 3209 3724 4748 5216 5411 6041 5114 4678 5616 6073 6506 6278 6449 6443 6073
## [46] 6113 6058 6552 6423 6568 6247 6548 6822 6909 7577 7575 7484 7575 7737 7487
## [61] 7604 7909 7662 7602 7676 6985 7263 7632 8062 8426 7911 7578 8102 8031 7765
## [76] 6113 8366 7952 8379 8239 7840 7640
```

```
Pb-Ab
```

```
## Warning in Pb - Ab: longer object length is not a multiple of shorter object
## length
```

```
##  [1] 1206466 1284876 1439943 1503965 1430143 1399552 1686114 1894959 1809149
## [10] 1820993 1818189 1917502 1965792 1996338 2054275 2069612 2129541 2176192
## [19] 2148750 2170275 2176629 2183384 2129235 2098412 2056966 1923613 1842207
## [28] 1799720 1792930 1843415 1912169 1819186 1665179 1603110 1616703 1607094
## [37] 1619322 1701238 1703778 1785194 1846110 1853994 1879227 1859110 1873417
## [46] 1921870 1918810 1944601 1996001 2062922 2123248 2094970 2075275 2041952
## [55] 2015012 1988780 1982996 1978021 2008468 2019367 2069365 2050013 2050317
## [64] 1204082 1282058 1437380 1501696 1427669 1396525 1682794 1891965 1806274
## [73] 1818250 1815524 1915255 1965149 1993432 2051116 2065340 2125349 2172120
## [82] 2144906
```

```
mean(Pb-Ab)
```

```
## Warning in Pb - Ab: longer object length is not a multiple of shorter object
## length
```

```
## [1] 1855522
```

```
Pg<-present$girls
Pg
```

```
##  [1] 1148715 1223693 1364631 1427901 1359499 1330869 1597452 1800064 1721216
## [10] 1733177 1730594 1827830 1875724 1900322 1958294 1973576 2029502 2074824
## [19] 2051266 2071158 2078142 2082052 2034896 1996388 1967328 1833304 1760412
## [28] 1717571 1705238 1753634 1816008 1733060 1588484 1528639 1537844 1531063
## [37] 1543352 1620716 1623885 1703131 1759642 1768966 1794861 1773380 1789651
## [46] 1832578 1831679 1858241 1907086 1971468 2028717 2009389 1982917 1951379
## [55] 1930178 1903234 1901014 1895298 1925348 1932563 1981845 1968011 1963747
```

```
Ag<-arbuthnot$girls
Ag
```

```
##  [1] 4683 4457 4102 4590 4839 4820 4928 4605 4457 4952 4784 5332 5200 4910 4617
## [16] 3997 3919 3395 3536 3181 2746 2722 2840 2908 2959 3179 3349 3382 3289 3013
## [31] 2781 3247 4107 4803 4881 5681 4858 4319 5322 5560 5829 5719 6061 6120 5822
## [46] 5738 5717 5847 6203 6033 6041 6299 6533 6744 7158 7127 7246 7119 7214 7101
## [61] 7167 7302 7392 7316 7483 6647 6713 7229 7767 7626 7452 7061 7514 7656 7683
## [76] 5738 7779 7417 7687 7623 7380 7288
```

```
Pg-Ag
```

```
## Warning in Pg - Ag: longer object length is not a multiple of shorter object
## length
```

```
##  [1] 1144032 1219236 1360529 1423311 1354660 1326049 1592524 1795459 1716759
## [10] 1728225 1725810 1822498 1870524 1895412 1953677 1969579 2025583 2071429
## [19] 2047730 2067977 2075396 2079330 2032056 1993480 1964369 1830125 1757063
## [28] 1714189 1701949 1750621 1813227 1729813 1584377 1523836 1532963 1525382
## [37] 1538494 1616397 1618563 1697571 1753813 1763247 1788800 1767260 1783829
## [46] 1826840 1825962 1852394 1900883 1965435 2022676 2003090 1976384 1944635
## [55] 1923020 1896107 1893768 1888179 1918134 1925462 1974678 1960709 1956355
## [64] 1141399 1216210 1357984 1421188 1352270 1323102 1589826 1792612 1714155
## [73] 1725663 1722938 1820147 1869986 1892543 1950877 1965889 2021879 2067444
## [82] 2043978
```

```
mean(Pg-Ag)
```

```
## Warning in Pg - Ag: longer object length is not a multiple of shorter object
## length
```

```
## [1] 1764536
```

```
(Pg+Pb)-(Ag+Ab)
```

```
## Warning in (Pg + Pb) - (Ag + Ab): longer object length is not a multiple of
## shorter object length
```

```
##  [1] 2350498 2504112 2800472 2927276 2784803 2725601 3278638 3690418 3525908
## [10] 3549218 3543999 3740000 3836316 3891750 4007952 4039191 4155124 4247621
## [19] 4196480 4238252 4252025 4262714 4161291 4091892 4021335 3753738 3599270
## [28] 3513909 3494879 3594036 3725396 3548999 3249556 3126946 3149666 3132476
## [37] 3157816 3317635 3322341 3482765 3599923 3617241 3668027 3626370 3657246
## [46] 3748710 3744772 3796995 3896884 4028357 4145924 4098060 4051659 3986587
## [55] 3938032 3884887 3876764 3866200 3926602 3944829 4044043 4010722 4006672
## [64] 2345481 2498268 2795364 2922884 2779939 2719627 3272620 3684577 3520429
## [73] 3543913 3538462 3735402 3835135 3885975 4001993 4031229 4147228 4239564
## [82] 4188884
```

```
mean((Pg+Pb)-(Ag+Ab))
```

```
## Warning in (Pg + Pb) - (Ag + Ab): longer object length is not a multiple of
## shorter object length
```

```
## [1] 3620058
```

```
Pb/Pg
```

```
##  [1] 1.054817 1.053969 1.058429 1.056767 1.055757 1.055391 1.058698 1.055449
##  [9] 1.053820 1.053760 1.053716 1.052078 1.050934 1.053399 1.051460 1.050742
## [17] 1.051286 1.050672 1.049374 1.049480 1.048873 1.050057 1.047948 1.052717
## [25] 1.047188 1.051137 1.048540 1.049964 1.053417 1.052997 1.054719 1.051845
## [33] 1.051271 1.052129 1.054797 1.053605 1.052538 1.052569 1.052657 1.051749
## [41] 1.052837 1.051615 1.050597 1.051976 1.050199 1.052061 1.050876 1.050000
## [49] 1.049991 1.049720 1.049676 1.045849 1.050017 1.049955 1.047877 1.048928
## [57] 1.047062 1.047643 1.047190 1.048791 1.047998 1.045686 1.047986
```

```
mean(Pb/Pg)
```

```
## [1] 1.051353
```

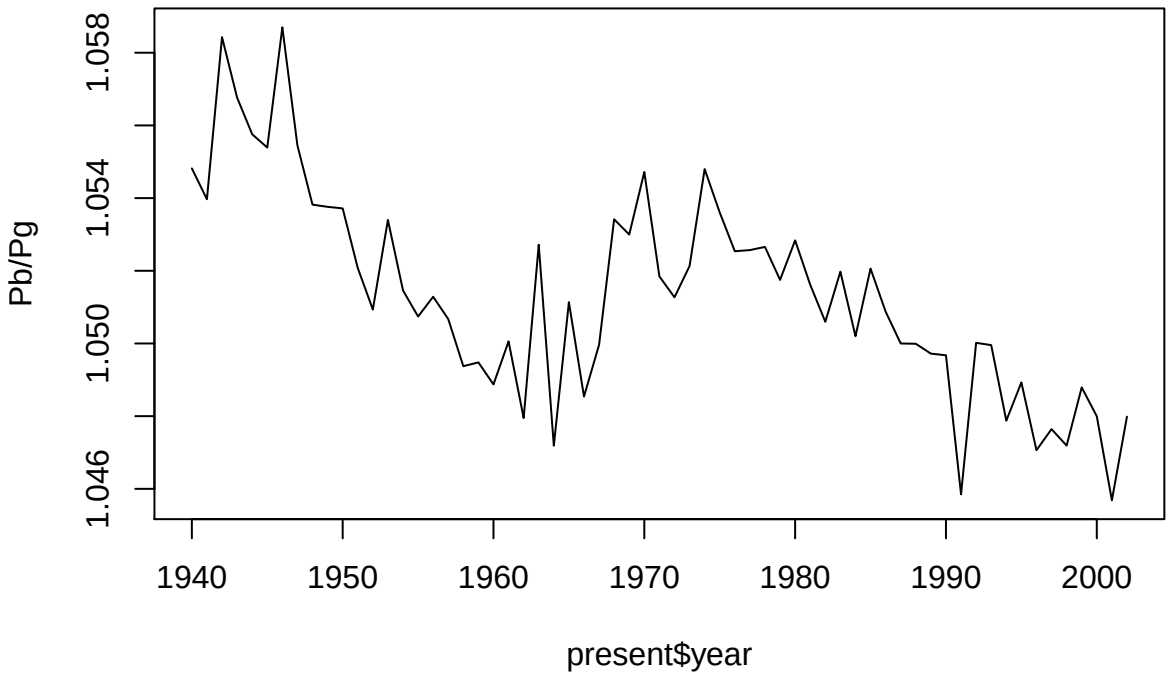
```
mean(Ab/Ag)
```

```
## [1] 1.070748
```

The counts of variables in "present" is much larger than the "arbuthnt", but the boy to girl ratio is very similar through the years, 1.05 in "present" compare to 1.07 in "arbuthnot" in average.

- Make a plot that displays the boy-to-girl ratio for every year in the data set. What do you see? Does Arbuthnot's observation about boys being born in greater proportion than girls hold up in the U.S.? Include the plot in your response.

```
plot(present$year,Pb/Pg, type = "l")
```



According to the plot of boy to ratio with the "present" data, we can observe that the Arbuthnot's observation about boys being born in greater proportion than girls hold up, but the plot shows boys to girls ratio is in downward trending, which means girls may exceed boys in one day or boys may not continued with born in greater proportion than girls.

- 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 http://cran.r-project.org/doc/contrib/Short-refcard.pdf to find helpful commands.

```
max(Pb+Pg)
```

```
## [1] 4268326
```

```
which.max(Pb+Pg)
```

```
## [1] 22
```

```
present[22,]
```

```
##    year    boys   girls
## 22 1961 2186274 2082052
```

The most total number of birth in data is in 1961 in the U.S, it shows 2186274 in boys and 2082052 in girls, with total birth 4268326.

These data come from a report by the Centers for Disease Control http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_20.pdf. Check it out if you would like to read more about an analysis of sex ratios at birth in the United States.

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 at http://openintro.org.