StatR 101: Fall 2012
Homework 2 - Solutions
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1. (a) *Formulate a prediction regarding the appeal of table tennis between male and female students.*

   Typically, boys enjoy sports more than girls, so there might be some preference among the boys. In general, however, ping pong seems like a sport with universal appeal, so the differences might not be so stark.

   (b) *Present a table summarizing the total number of responses for male, female and total number of students in each of the five categories.*

   There are several ways to do this. Here's some compact code that generates a summary table:

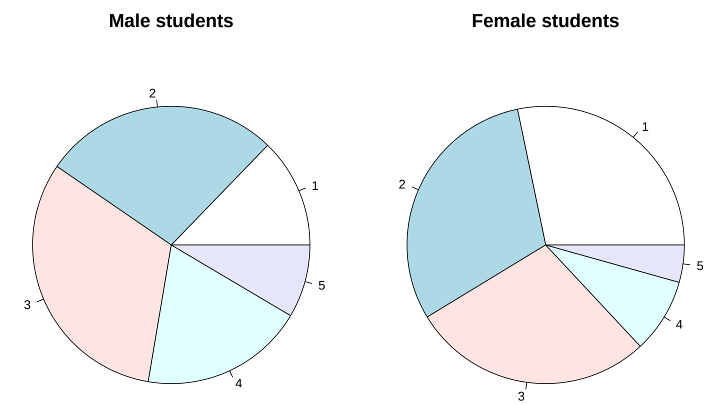
```
p <- Students$Pingpong
s <- Students$Sex
SummaryTable <- data.frame(cbind(table(p,s),Total = table(p)))
# here is an optional last row with the sex totals
SummaryTable <- rbind(SummaryTable, Total = colSums(SummaryTable))
```

   Produces the following data frame:

```
      Female Male Total
1         13    6    19
2         14   13    27
3         13   15    28
4          4    9    13
5          2    4     6
Total     46   47    93
```

   (c) *Make side by side pie charts of pingpong enjoyment, one for males and one for females. Label each pie. Export this graphic to a file (e.g. `pdf`, `png`, `bmp`, etc) with high resolution.*

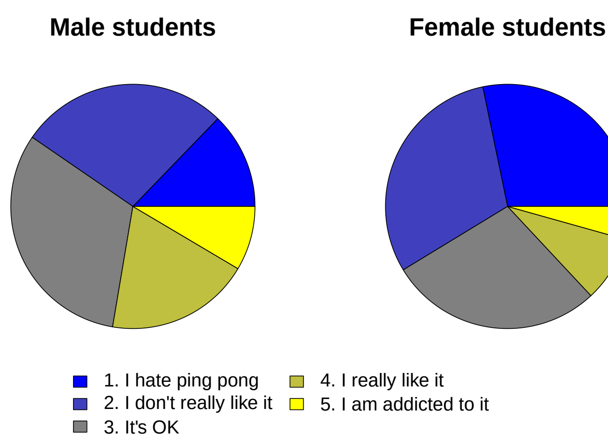
   Here is a very basic pie plot:



And the code to produce it:

```
par(mfrow=c(1,2), mar=c(0,0,2,0), cex.main=1.5)
pie(table(p[s=="Male"]), main="Male students")
pie(table(p[s=="Female"]), main="Female students")
```

Here is a somewhat more customized plot that looks better on the page.




```
cols <- rgb(0:4/4, 0:4/4, 4:0/4)
labels <- c("1. I hate ping pong", "2. I don't really like it",
            "3. It's OK", "4. I really like it", "5. I am addicted to it")
par(mfrow=c(1,2), mar=c(6,0,2,0), cex.main=2)
pie(table(p[s=="Male"]), main="Male students", lab="", col=cols)
legend(-.5,-1,legend=labels, fill=cols, ncol=2, adj=0, xpd=NA, cex=1.5, bty="n")
pie(table(p[s=="Female"]), main="Female students", lab="", col=cols)
```

There's quite a bit going on here, e.g. the customized color palette using `rgb()`, the creation of a legend, which can only straddle both pies because of the subtle `xpd = NA` argument, and the liberal use of the `cex` (**c**haracter **ex**pansion) for the titles and the legends.

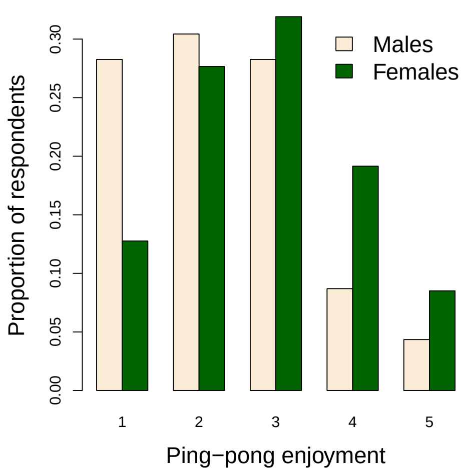
(d) *Produce a 2×5 matrix (call it `M1`) summarizing the proportional distribution of male and female students in each category such that* $\sum_{i=1}^{5} P_{male,i} = 1$ *and* $\sum_{i=1}^{5} P_{female,i} = 1$

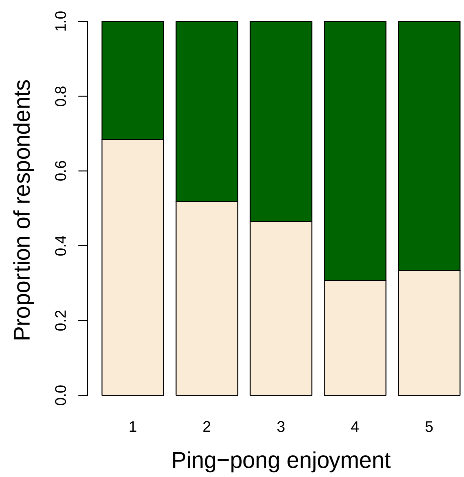
```
> M1 <- as.matrix(table(s,p))/rowSums(as.matrix(table(s,p)))
> M1
        p
s                 1          2          3          4          5
  Female 0.28260870 0.30434783 0.28260870 0.08695652 0.04347826
  Male   0.12765957 0.27659574 0.31914894 0.19148936 0.08510638
```

(e) *Produce a 5×2 matrix (call it `M2`) summarizing the proportion for each response of male and female respondents.* $P_{male,i} + P_{female,i} = 1$ *for each category* i.

```
> M2 <- as.matrix(table(p,s))/rowSums(as.matrix(table(p,s)))
> M2
   s
p      Female      Male
  1 0.6842105 0.3157895
  2 0.5185185 0.4814815
  3 0.4642857 0.5357143
  4 0.3076923 0.6923077
  5 0.3333333 0.6666667
```

(f) *Produce two barplots using the following commands: `barplot(M1, beside = TRUE)` and `barplot(t(M2))`. Add a label the x-axis and customize the colors of the columns so they are not the (boring) grey default. Use the `legend()` command to add a legend identifying your unique colors with different sexes.*





```
par(mfrow=c(1,2), cex.lab=1.5)
cols <- c("antiquewhite", "darkgreen")
barplot(M1, beside=TRUE, col=cols,
        xlab="Ping-pong enjoyment", ylab="Proportion of respondents")
legend("topright", fill=cols, legend=c("Males", "Females"), bty="n", cex=1.5)
barplot(t(M2), col=cols, xlab="Ping-pong enjoyment", ylab="Proportion of respondents")
```

There are, of course, other ways to customize these plots.

(g) *What conclusions do you draw from these tables and plots with respect to your initial prediction? Which of the four output plots do you feel is most informative? Why?*

Both male and female students showed a wide range of interest in table tennis, though there were far fewer females in the top categories, with only 10% in the 4 and 5 categories, compared to 27.5% of male students in the top two categories. It is not so easy to compare these two samples directly in the pie charts - though you can see clearly that the bluest wedges are larger for the females than the males. The first barplot contains the most information, showing the relative distribution of male and female table tennis enjoyment across all categories. The second barplot is a good illustration of the trend of fewer and fewer females at high levels of enjoyment; however, it makes a somewhat artificial visual equivalence between the responses in category 5 (of which there were only 6) to responses in other categories (e.g. category 3 has 28 responses).

2. **Analysis of global patterns:**

   (a) No need to present anything for this problem.

   (b) *create a data frame of the 10 countries with the lowest and highest GDP per capita, the highest and lowest birth rates, and the lowest literacy. Present this as a table in your document. Comment on any patterns that you identify in these columns.*

```
Poorest <- Country[order(GDP)][1:10]
Richest <- Country[order(GDP, decreasing = TRUE)][1:10]
LeastBabies <- Country[order(Birthrate)][1:10]
MostBabies <- Country[order(Birthrate, decreasing = TRUE)][1:10]
LowestLiteracy <- Country[order(Literacy)][1:10]
Development <- data.frame(Poorest, Richest, LeastBabies, MostBabies, LowestLiteracy)
```

	Poorest	Richest	LeastBabies	MostBabies	LowestLiteracy
1	Congo, D.R.	Qatar	Hong Kong	Niger	Mali
2	Liberia	Luxembourg	Japan	Mali	South Sudan
3	Burundi	Singapore	Germany	Uganda	Niger
4	Zimbabwe	Norway	Andorra	Afghanistan	Burkina Faso
5	Eritrea	Brunei	Italy	Sierra Leone	Guinea
6	Central African Republic	United Arab Emirates	Macau	Burkina Faso	Chad
7	Niger	United States	Guernsey	Somalia	Ethiopia
8	Sierra Leone	Hong Kong	Austria	Angola	Sierra Leone
9	Malawi	Switzerland	Bosnia and Herzegovina	Liberia	Benin
10	Togo	Netherlands	Lithuania	Congo, D.R.	Senegal

Note that there is considerable overlap between the countries with lowest GDP, highest birthrate, and lowest literacy, suggesting connections between these indices of development. In particular, there are 4 countries in comment in the list of poorest and highest birthrate, 4 countries in common between the most babies and lowest literacy, and 2 in common for the highest birthrate and lowest literacy (Niger and Burkina Faso make all three lists). The countries on all three lists are predominantly sub-Saharan African, with only one non-African country (Afghanistan) making the list. Note that you can ask R to report these results using a combination of `match()` or `%in%` and subsampling, for example:

```
> sum(Poorest %in% MostBabies)
[1] 4
> MostBabies[MostBabies %in% LowestLiteracy]
[1] Niger        Mali         Sierra Leone Burkina Faso
> Continent[match(MostBabies, Country)]
[1] Africa Africa Africa Asia   Africa Africa Africa Africa Africa Africa
```

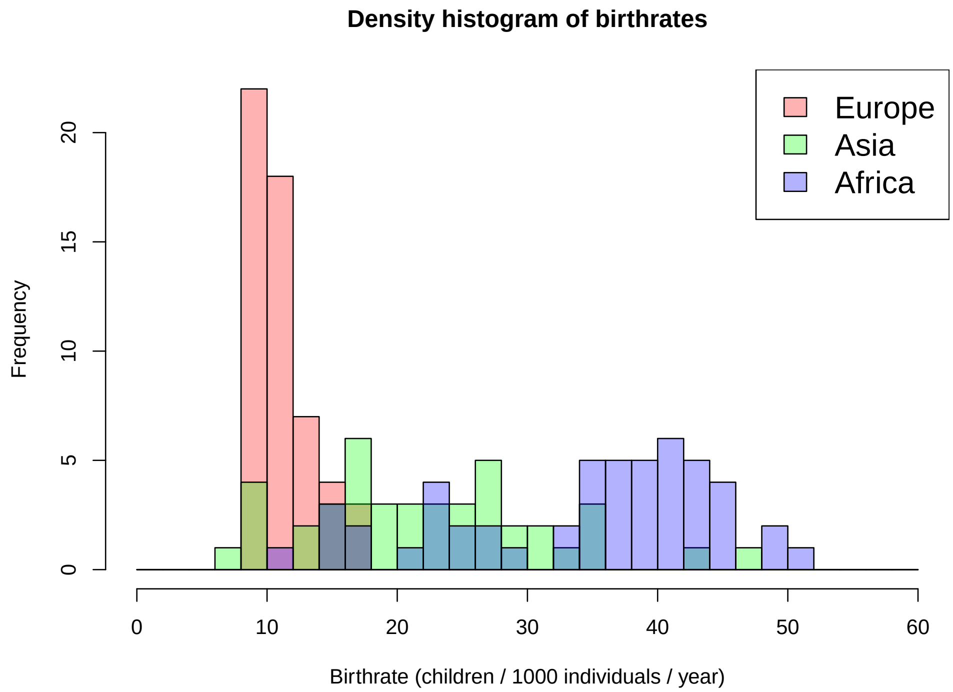
Somewhat interestingly, the overlap between wealthiest countries and the those with lowest birth rate is somewhat weaker, with only Hong Kong making both lists. The wealthiest countries are distributed throughout the globe (Asia, Europe, North America, Oceania), while the fewest babies are primarily European countries at various levels of development and well-developed Asian economies.

(c) *Identify the 10 countries with the highest and lowest densities, respectively, and present two tables that include their population, area and percentage of water coverage.*
Code and output below:

```
> Density <- Population/Area
> LeastDense <- Country[order(Density)][1:10]
> MostDense <- Country[order(Density, decreasing = TRUE)][1:10]
> data.frame(Country, Population, Area, Density, Water)[match(LeastDense, Country),]
             Country Population    Area    Density Water
144        Greenland      56452 2166086 0.02606175    NA
5   Falkland Islands       3000   12173 0.24644705  0.00
12  Pitcairn Islands         50      47 1.06382979  0.00
109         Mongolia    2822900 1564100 1.80480788  0.68
3     Western Sahara     531000  266000 1.99624060  0.00
89           Namibia    2088669  824268 2.53396832  0.12
175        Australia   22722835 7692024 2.95407750  0.76
162          Iceland     318452  103000 3.09176699  2.67
90          Botswana    1800098  582000 3.09295189  2.58
132         Suriname     525000  163820 3.20473691  4.77
> data.frame(Country, Population, Area, Density, Water)[match(MostDense, Country),]
         Country Population Area   Density Water
16  Vatican City        500    0       Inf  0.00
220        Macau     556800   30 18560.000  0.00
212       Monaco      35000    2 17500.000  0.00
93      Dominica    9378818  751 12488.439  0.72
211    Singapore    5076700  710  7150.282  1.43
225    Hong Kong    7097600 1104  6428.986  4.53
187    Gibraltar      29441    6  4906.833  0.00
129      Bahrain    1234596  758  1628.755  0.00
195        Malta     417608  316  1321.544  0.00
181      Bermuda      64566   54  1195.667  0.00
```

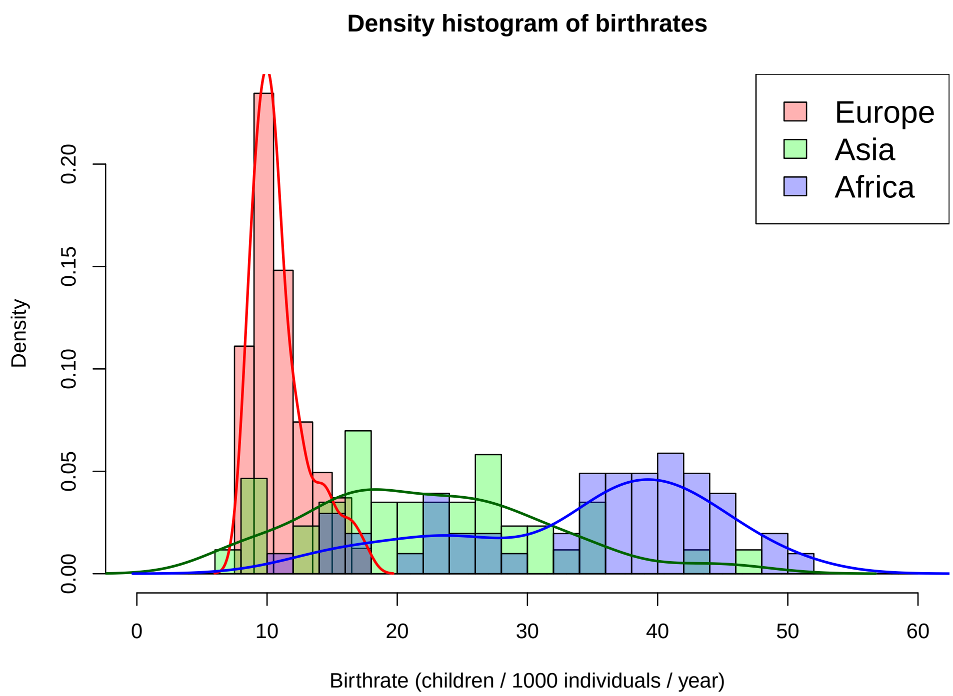
Note that these results are somewhat difficult to interpret, because of the extremely large range (orders of magnitude) between the largest and smallest countries, both by area and population. Anomalous countries (like Vatican City) yield nonsensical results (infinite density). Still, generally we note that countries with the lowest densities tend to be quite arid, or inhospitably tropical, and the highest densities are in city-states and/or islands.

(d) Using the in-class lab as a model, create an overlapping *frequency* histogram of birth rates in Europe, Asia, and Africa in three different, transparent colors. Add a legend to the plot identifying the continents. Make sure that the axes are appropriately labeled and the plot has a meaningful title. Experiment with the bin widths to find one that you feel best illustrates the patterns.




```
hist(Birthrate[Continent=="Europe"], breaks=seq(0,60,2), col=rgb(1,0,0,.3),
    xlab="Birthrate (children / 1000 individuals / year)",
    main="Density histogram of birthrates")
hist(Birthrate[Continent=="Asia"], breaks=seq(0,60,2), add=TRUE,
     col=rgb(0,1,0,.3))
hist(Birthrate[Continent=="Africa"], breaks=seq(0,60,2), add=TRUE,
     col=rgb(0,0,1,.3))
legend("topright", fill=rgb(c(1,0,0),c(0,1,0),c(0,0,1),.3),
       legend=c("Europe", "Asia", "Africa"), cex=1.5)
```

(e) Create a *density* histogram of the same data, and add fitted density lines. Note that unlike a frequency histogram, in a density histogram, the bin widths can be tuned for each individual data set.




```
hist(Birthrate[Continent=="Europe"], breaks=seq(0,60,1.5),
     col=rgb(1,0,0,.3), freq=FALSE,
     xlab="Birthrate (children / 1000 individuals / year)",
     main="Density histogram of birthrates")
hist(Birthrate[Continent=="Asia"], breaks=seq(0,60,2), add=TRUE,
     col=rgb(0,1,0,.3), freq=FALSE)
hist(Birthrate[Continent=="Africa"], breaks=seq(0,60,2), add=TRUE,
     col=rgb(0,0,1,.3), freq=FALSE)

lines(density(Birthrate[Continent=="Europe"], na.rm=TRUE), col="red", lwd=2)
lines(density(Birthrate[Continent=="Asia"], na.rm=TRUE), col="darkgreen", lwd=2)
lines(density(Birthrate[Continent=="Africa"], na.rm=TRUE), col="blue", lwd=2)

legend("topright", fill=rgb(c(1,0,0),c(0,1,0),c(0,0,1),.3),
       legend=c("Europe", "Asia", "Africa"), cex=1.5)
```

Note that I made the bin widths for Europe somewhat narrower, because the distribution is more concentrated.

(f) *Summarize the patterns in these distribution, commenting on the center, the spread, and the modality (i.e. number of humps).*

The centers of these distributions are clearly highest in Africa (around 40 children/1000 individuals), with, however, what appear to be several modes at lower birth rates. The center of the distribution is somewhat lower for Asia, with a very broad range from the lowest bin to the highest bin. Birth rates tend to be lowest in Europe (the mode is near 10 children/1000 individuals), with, additionally, a very narrow range. In no country do birth rates appears to be higher than 20.