Lab 7: Inference for Numerical Data

North Carolina births

In 2004, the state of North Carolina released a large data set containing information on births recorded in this state. This data set is useful to researchers studying the relation between habits and practices of expectant mothers and the birth of their children. We will work with a random sample of observations from this data set.

Exploratory analysis

Load the nc data set into our workspace.

```
download.file("http://www.openintro.org/stat/data/nc.RData", destfile =
"nc.RData")
load("nc.RData")
```

We have observations on 13 different variables, some categorical and some numerical. The meaning of each variable is as follows.

fage	father's age in years.
mage	mother's age in years.
mature	maturity status of mother.
weeks	length of pregnancy in weeks.
premie	whether the birth was classified as premature (premie) or full-term.
visits	number of hospital visits during pregnancy.
marital	whether mother is married or not married at birth.
gained	weight gained by mother during pregnancy in pounds.
weight	weight of the baby at birth in pounds.
lowbirthweight	whether baby was classified as low birthweight (low) or not (not low).
gender	gender of the baby, female or male.
habit	status of the mother as a nonsmoker or a smoker.
whitemom	whether mom is white or not white.

Exercise 1 What are the cases in this data set? How many cases are there in our sample?

As a first step in the analysis, we should consider summaries of the data. This can be done using the `summary` command:

```
summary(nc)
```

```
fage            mage            mature
 Min.   :14.00   Min.   :13   mature mom :133
 1st Qu.:25.00   1st Qu.:22   younger mom:867
 Median :30.00   Median :27
 Mean   :30.26   Mean   :27
 3rd Qu.:35.00   3rd Qu.:32
 Max.   :55.00   Max.   :50
 NA's   :171
     weeks             premie        visits
 Min.   :20.00   full term:846   Min.   : 0.0
 1st Qu.:37.00   premie   :152   1st Qu.:10.0
 Median :39.00   NA's     :  2   Median :12.0
 Mean   :38.33                   Mean   :12.1
 3rd Qu.:40.00                   3rd Qu.:15.0
 Max.   :45.00                   Max.   :30.0
 NA's   :2                       NA's   :9
       marital        gained          weight
 married    :386   Min.   : 0.00   Min.   : 1.000
 not married:613   1st Qu.:20.00   1st Qu.: 6.380
 NA's       :  1   Median :30.00   Median : 7.310
                   Mean   :30.33   Mean   : 7.101
                   3rd Qu.:38.00   3rd Qu.: 8.060
                   Max.   :85.00   Max.   :11.750
                   NA's   :27
 lowbirthweight    gender          habit         whitemom
 low    :111    female:503   nonsmoker:873   not white:284
 not low:889    male  :497   smoker   :126   white    :714
                             NA's     :  1   NA's     :  2
```

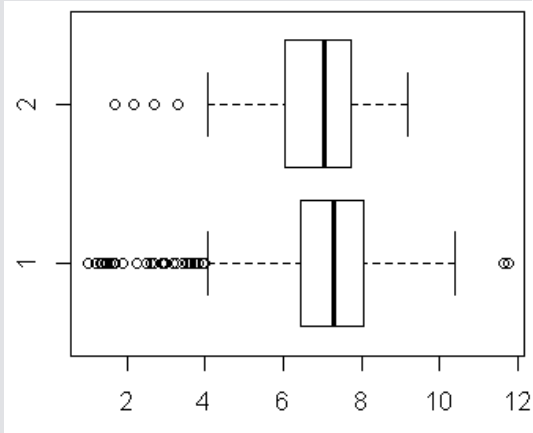
As you review the variable summaries, consider which variables are categorical and which are numerical. For numerical variables, are there outliers? If you aren't sure or want to take a closer look at the data, make a graph.

Consider the possible relationship between a mother's smoking habit and the weight of her baby. Plotting the data is a useful first step because it helps us quickly visualize trends, identify strong associations, and develop research questions.

Exercise 2 Make a side-by-side boxplots of habit (smokers vs nonsmokers) for variable weight. What does the plot highlight about the relationship between these two cases?

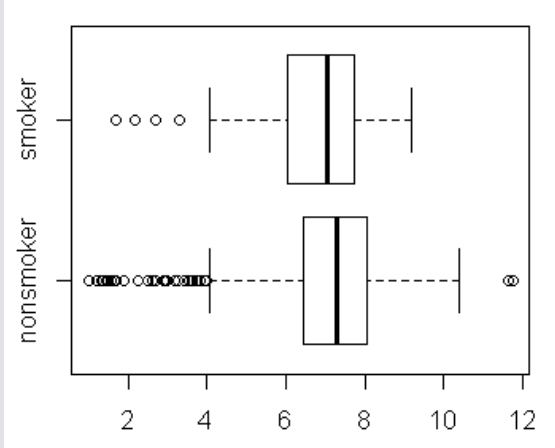
```
> boxplot (nc)
```

```
nsdata <- subset(nc, nc$habit == "nonsmoker")
sdata <- subset(nc, nc$habit == "smoker")
boxplot(nsdata$gained, sdata$gained, horizontal=TRUE)
```



A better way is

```
boxplot(nc$weight ~ nc$habit, horizontal=TRUE)
```



The box plots show how the medians of the two distributions compare, but we can also compare the means of the distributions using the following function to split the weight variable into the habit groups, then take the mean of each using the mean function.

```
by(nc$weight, nc$habit, mean)
nc$habit: nonsmoker
[1] 7.144273
------------------------------------------------------------
nc$habit: smoker
[1] 6.82873
```

There is an observed difference, but is this difference statistically significant? In order to answer this question we will conduct a hypothesis test.

Inference

Exercise 3 Check if the conditions necessary for inference are satisfied. Note that you will need to obtain sample sizes to check the conditions. You can compute the group size using the same by command above but replacing mean with length.

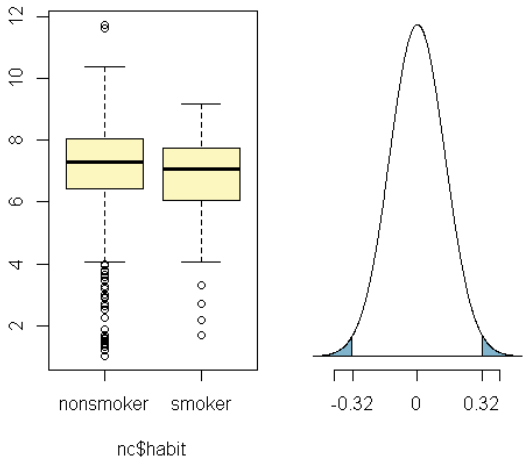
```
by(nc$weight, nc$habit, length)
nc$habit: nonsmoker
[1] 873
------------------------------------------------
nc$habit: smoker
[1] 126
```

Exercise 4 Write the hypotheses for testing if the average weights of babies born to smoking and non-smoking mothers are different. Next, we introduce a new function, inference, that we will use for conducting hypothesis tests and constructing confidence intervals.

```
inference(y = nc$weight, x = nc$habit, est = "mean", type = "ht", null = 0,
alternative = "twosided", method = "theoretical")
```

```
Summary statistics:
n_nonsmoker = 873, mean_nonsmoker = 7.1443, sd_nonsmoker = 1.5187
n_smoker = 126, mean_smoker = 6.8287, sd_smoker = 1.3862
Observed difference between means (nonsmoker-smoker) = 0.3155

H0: mu_nonsmoker - mu_smoker = 0
HA: mu_nonsmoker - mu_smoker != 0     # !=0 mean not equal to 0
Standard error = 0.134
Test statistic: Z =  2.359
p-value =  0.0184
```



Let's pause for a moment to go through the arguments of this custom function.

- The first argument is y, which is the response variable that we are interested in: nc$weight.
- The second argument is the explanatory variable, x, which is the variable that splits the data into two groups, smokers and non-smokers: nc$habit.
- The third argument, est, is the parameter we're interested in: "mean" (other options are "median", or "proportion".)
- Next we decide on the type of inference we want: a hypothesis test ("ht") or a confidence interval ("ci").
- When performing a hypothesis test, we also need to supply the null value, which in this case is 0, since the null hypothesis sets the two population means equal to each other.

• The alternative hypothesis can be "less", "greater", or "twosided".
• Lastly, the method of inference can be "theoretical" or "simulation" based.

Exercise 5 Change the type argument to "ci" to construct and record a confidence interval for the difference between the weights of babies born to smoking and non-smoking mothers.

```
> inference(y = nc$weight, x = nc$habit, est = "mean", type = "ci", null = 0,
+           alternative = "twosided", method = "theoretical")
Response variable: numerical, Explanatory variable: categorical
Difference between two means
Summary statistics:
n_nonsmoker = 873, mean_nonsmoker = 7.1443, sd_nonsmoker = 1.5187
n_smoker = 126, mean_smoker = 6.8287, sd_smoker = 1.3862
Observed difference between means (nonsmoker-smoker) = 0.3155

Standard error = 0.1338
95 % Confidence interval = ( 0.0534 , 0.5777 )
```

By default the function reports an interval for ($\mu_{\text{nonsmoker}} - \mu_{\text{smoker}}$). We can easily change this order by using the order argument:

```
inference(y = nc$weight, x = nc$habit, est = "mean", type = "ci", null = 0,
alternative = "twosided", method = "theoretical",
order = c("smoker","nonsmoker"))
Response variable: numerical, Explanatory variable: categorical
Difference between two means
Summary statistics:
n_smoker = 126, mean_smoker = 6.8287, sd_smoker = 1.3862
n_nonsmoker = 873, mean_nonsmoker = 7.1443, sd_nonsmoker = 1.5187
Observed difference between means (smoker-nonsmoker) = -0.3155

Standard error = 0.1338
95 % Confidence interval = ( -0.5777 , -0.0534 )
```

Lab 7: On Your Own

Name _____ **Score** _____

1. Calculate a 95% confidence interval for the average length of pregnancies (weeks) and interpret it in context. Note that since you're doing inference on a single population parameter, there is no explanatory variable, so you can omit the *x* variable from the function.

2. Calculate a new confidence interval for the same parameter at the 90% confidence level. You can change the confidence level by adding a new argument to the function: conflevel =0.90.

3. Conduct a hypothesis test evaluating whether the average weight gained by younger mothers is different than the average weight gained by mature mothers.

4. Now, a non-inference task: Determine the age cutoff for younger and mature mothers. Use a method of your choice, and explain how your method works.

5. Pick a pair of numerical and categorical variables and come up with a research question evaluating the relationship between these variables. Formulate the question in a way that it can be answered using a hypothesis test and/or a confidence interval. Answer your question using the inference function, report the statistical results, and also provide an explanation in plain language.