

Data606 Lab7 - Inference for numerical data

Lab Completed By Chad Bailey

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.

```
load("more/nc.RData")
```

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

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

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

```
## Student response to exercise 1
```

```
nrow(nc)
```

```
## [1] 1000
```

Each case/record represents a birth and gives characteristics associated with that event. There are 1,000 cases in this dataset.

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

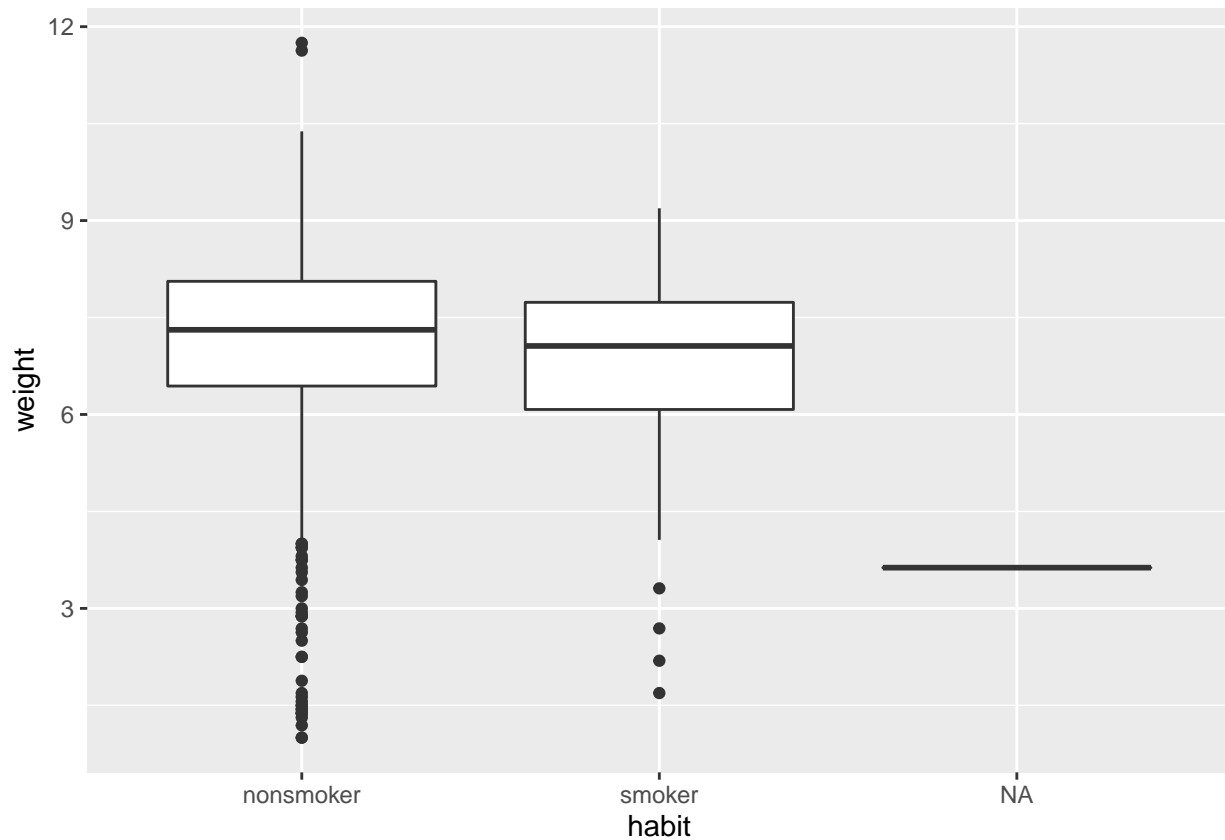
Consider the possible relationship between a mother's smoking habit and the weight of her baby. Plotting the data is a useful first step because it helps us quickly visualize trends, identify strong associations, and develop research questions.

2. Make a side-by-side boxplot of `habit` and `weight`. What does the plot highlight about the relationship between these two variables?

```
## Student response to exercise 2
```

```
library(ggplot2)
```

```
ggplot(nc, aes(x = habit, y = weight)) + geom_boxplot()
```



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

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.

```
## Student response to exercise 3
```

```
by(nc$weight, nc$habit, length)
```

```
## nc$habit: nonsmoker
```

```
## [1] 873
```

```
## -----
```

```
## nc$habit: smoker
```

```
## [1] 126
```

```
## conditions required for inference:
```

```
## 1. independence: Yes, each of the cases are independent.
```

```
## 2. Normality: both groups 'non-smokers' and 'smokers' have >30 cases  
## and neither has extreme outliers
```

4. Write the hypotheses for testing if the average weights of babies born to smoking and non-smoking mothers are different.

```
## Student response to exercise 4
```

```
## H0: There is no difference in average weight of babies born to smoking and  
## non-smoking mothers.
```

```
## HA: There is a difference in average weight of babies born to smoking and  
## non-smoking mothers.
```

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")
```

```
## 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
```

```
##
```

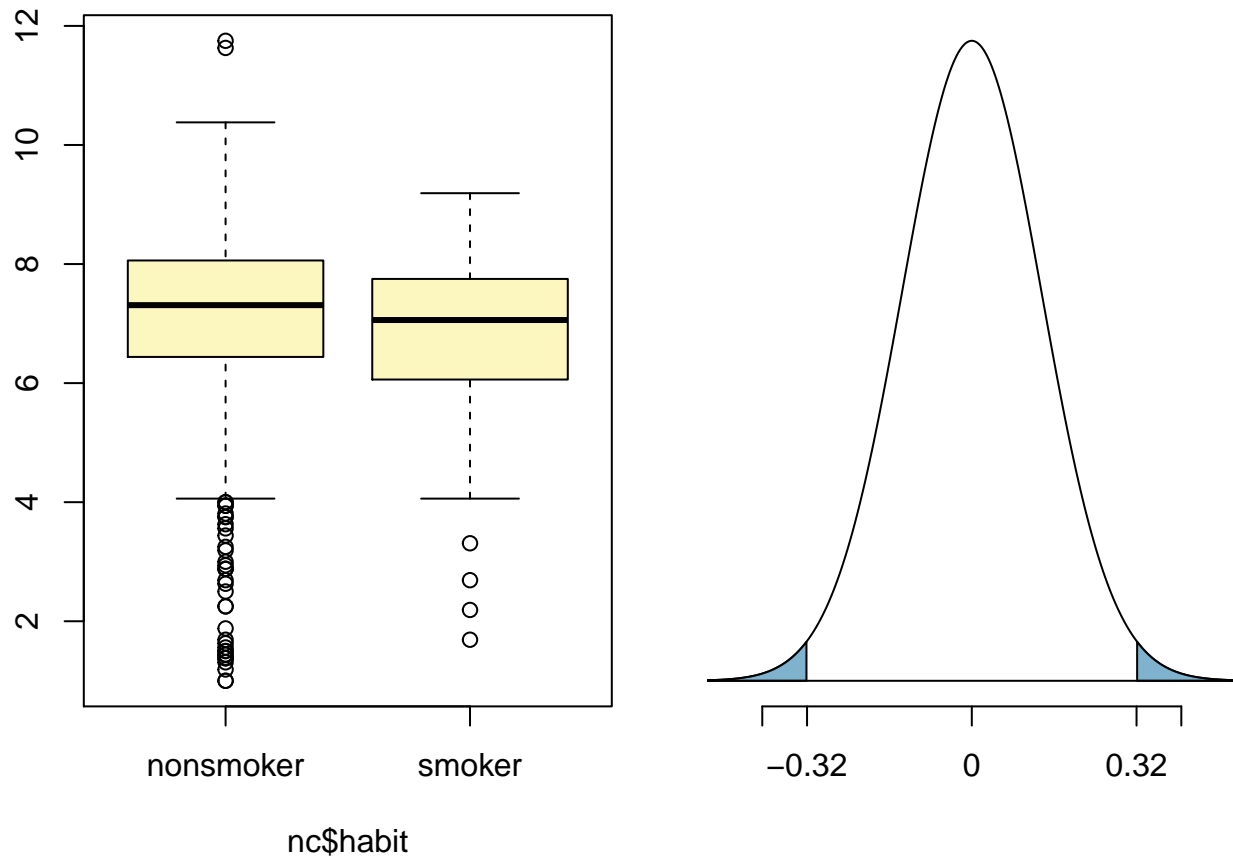
```
## H0: mu_nonsmoker - mu_smoker = 0
```

```
## HA: mu_nonsmoker - mu_smoker != 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.

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.

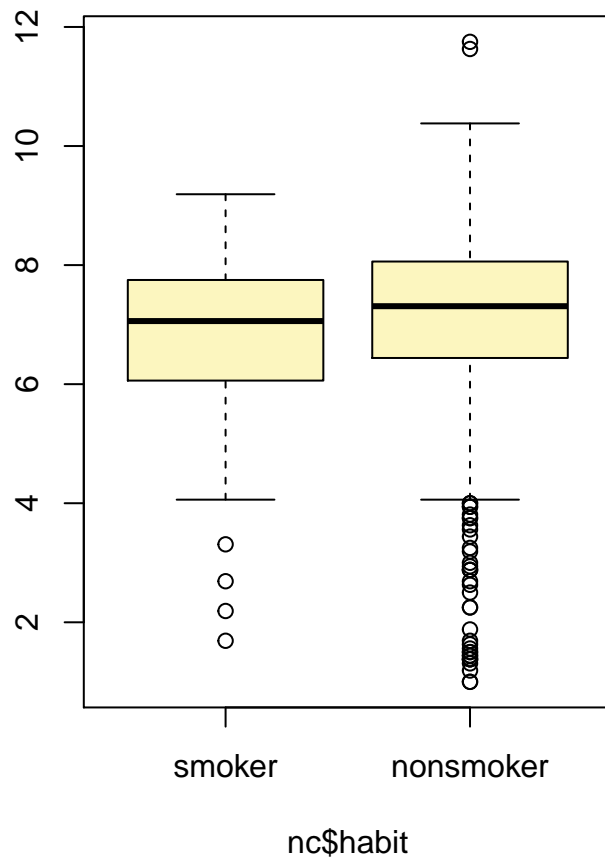
By default the function reports an interval for $(\mu_{nonsmoker} - \mu_{smoker})$. We can easily change this order by using the `order` argument:

```
## Student response to exercise 5
```

```
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 )
```

On your own

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

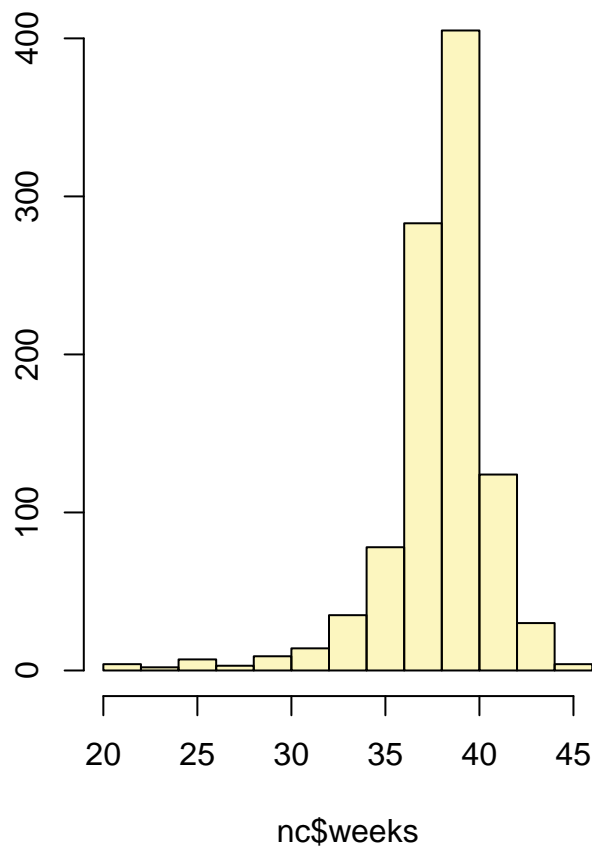
- Pick a pair of numerical and categorical variables and come up with a research question evaluating the relationship between these variables. Formulate the question in a way that it can be answered using a hypothesis test and/or a confidence interval. Answer your question using the `inference` function,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

```
## Student response to OnYourOwn 1
```

```
inference(y = nc$weeks, est = "mean", type = "ci", null = 0,
          alternative = "twosided", method = "theoretical")
```

```
## Single mean
```

```
## Summary statistics:
```



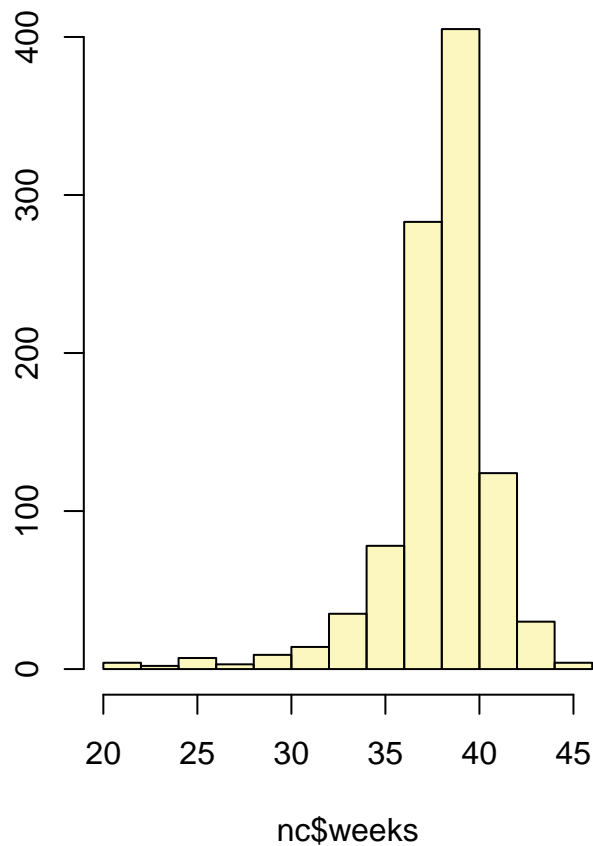
```
## mean = 38.3347 ; sd = 2.9316 ; n = 998
## Standard error = 0.0928
## 95 % Confidence interval = ( 38.1528 , 38.5165 )
```

```
## Based on this sample we can be 95% confident that the average length of
## pregnancy (in weeks) for the population is between 38.1528 and 38.5165 weeks.
```

```
## Student response to OnYourOwn 2
```

```
inference(y = nc$weeks, est = "mean", type = "ci", null = 0,
          alternative = "twosided", method = "theoretical", conflevel = 0.90)
```

```
## Single mean
## Summary statistics:
```



```
## mean = 38.3347 ; sd = 2.9316 ; n = 998
## Standard error = 0.0928
## 90 % Confidence interval = ( 38.182 , 38.4873 )
```

Based on this sample we can be 90% confident that the average length of pregnancy (in weeks) for the population is between 38.182 and 38.4873 weeks.

Student response to OnYourOwn 3

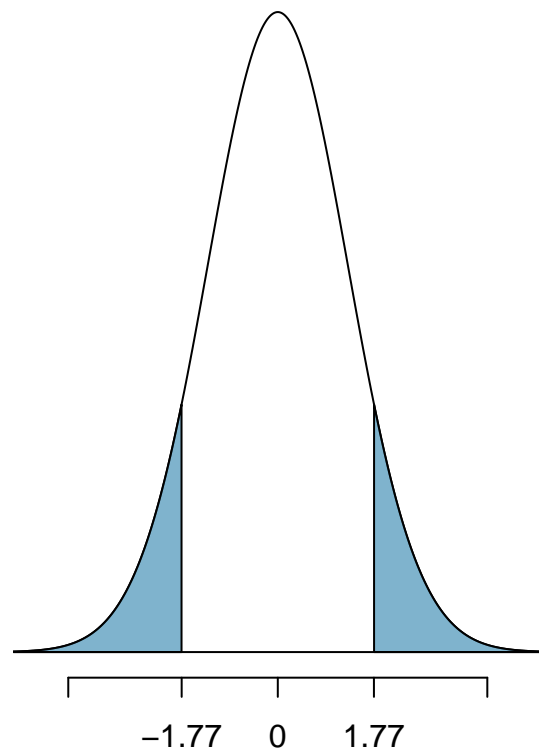
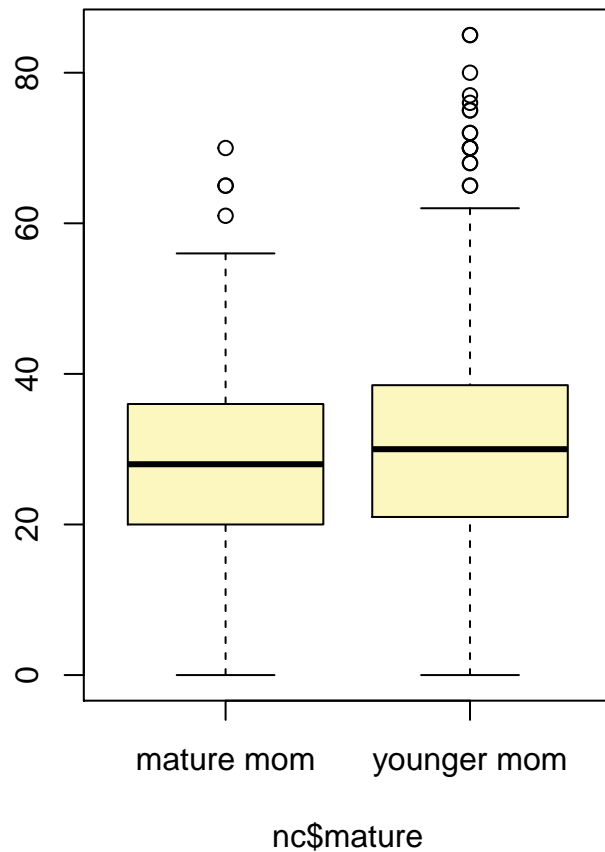
```
inference(y = nc$gained, x = nc$mature, est = "mean", type = "ht", null = 0,
          alternative = "twosided", method = "theoretical")
```

```
## Response variable: numerical, Explanatory variable: categorical
## Difference between two means
## Summary statistics:
## n_mature mom = 129, mean_mature mom = 28.7907, sd_mature mom = 13.4824
## n_younger mom = 844, mean_younger mom = 30.5604, sd_younger mom = 14.3469

## Observed difference between means (mature mom-younger mom) = -1.7697
##
## H0: mu_mature mom - mu_younger mom = 0
```



```
## HA: mu_mature mom - mu_younger mom != 0
## Standard error = 1.286
## Test statistic: Z = -1.376
## p-value = 0.1686
```



```
## H0: There is no difference in the average weight gained between young and
##       mature mothers
## HA: There is a difference in the average weight gained between young and
##       mature mothers
```

```
## Based on the outcomes of the hypothesis test, we fail to reject the null
## hypothesis. There is not significant enough evidence to determine if
## the observed difference is due to random variation or a true difference
## between groups.
```

```
## Student response to OnYourOwn 4
```

```
young <- nc[ which(nc$mature == 'younger mom'),]
mature <- nc[ which(nc$mature == 'mature mom'),]

range(young$mage, na.rm = TRUE)
```

```
## [1] 13 34
```

```
range(mature$mage, na.rm = TRUE)
```

```
## [1] 35 50
```

```
## The cutoff age for "younger mom" is 34 years old. The beginning of 'mature mom'  
## is 35 years old.
```

```
## Student response to OnYourOwn 5
```

```
## Using variables: gender & weight
```

```
## H0: There is no difference in average weight between female and male babies
```

```
## HA: There is a difference in average weight between female and male babies
```

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

```
## Response variable: numerical, Explanatory variable: categorical
```

```
## Difference between two means
```

```
## Summary statistics:
```

```
## n_female = 503, mean_female = 6.9029, sd_female = 1.4759
```

```
## n_male = 497, mean_male = 7.3015, sd_male = 1.5168
```

```
## Observed difference between means (female-male) = -0.3986
```

```
##
```

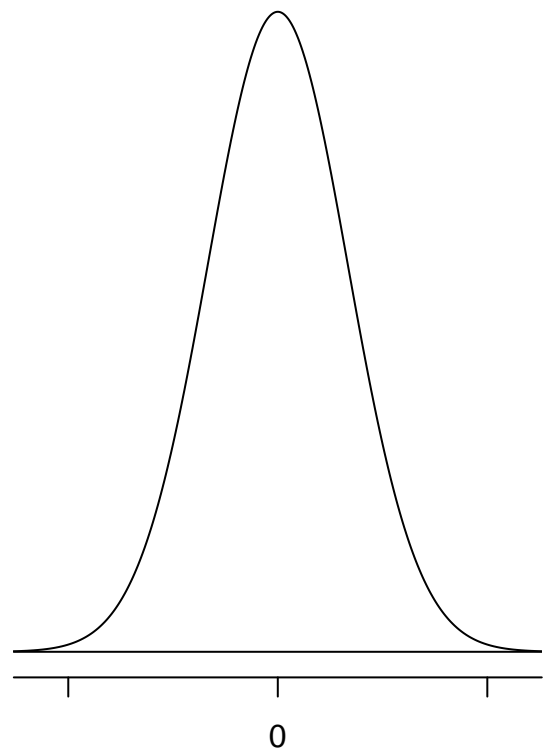
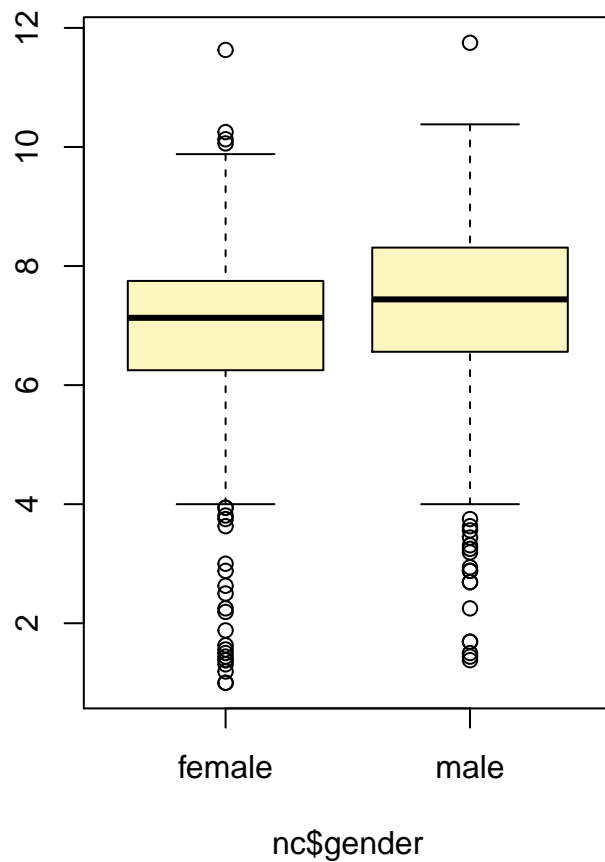
```
## H0:  $\mu_{\text{female}} - \mu_{\text{male}} = 0$ 
```

```
## HA:  $\mu_{\text{female}} - \mu_{\text{male}} \neq 0$ 
```

```
## Standard error = 0.095
```

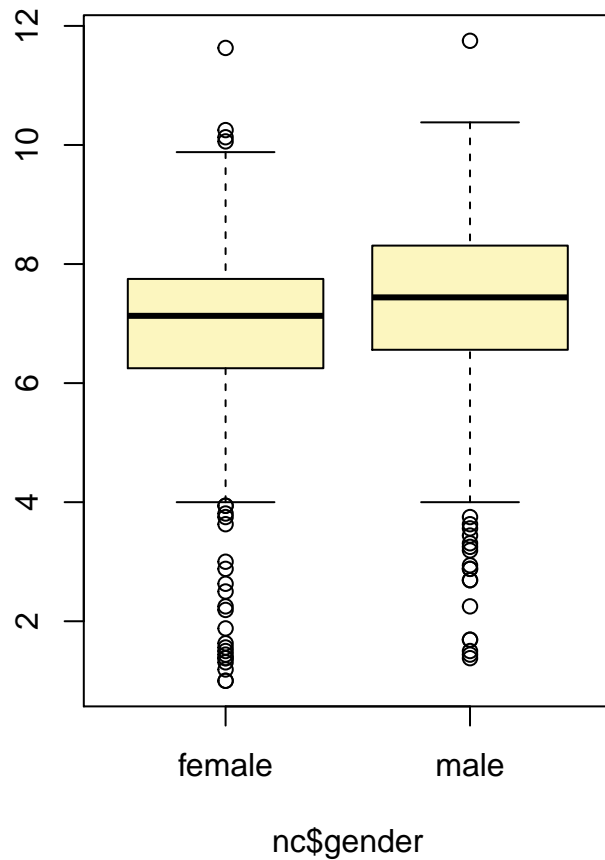
```
## Test statistic: Z = -4.211
```

```
## p-value = 0
```



```
inference(y = nc$weight, x = nc$gender, est = 'mean', type = 'ci', null = 0,
          alternative = 'twosided', method = 'theoretical')
```

```
## Response variable: numerical, Explanatory variable: categorical
## Difference between two means
## Summary statistics:
## n_female = 503, mean_female = 6.9029, sd_female = 1.4759
## n_male = 497, mean_male = 7.3015, sd_male = 1.5168
```



```
## Observed difference between means (female-male) = -0.3986
##
## Standard error = 0.0947
## 95 % Confidence interval = ( -0.5841 , -0.2131 )
```

```
## Based on the results of the hypothesis test, we would reject the null
## hypothesis. The means are far enough apart that we can say with 95% certainty
## that the difference is due to a real difference between the groups and not
## just random variation in the data.
```

```
## Using a confidence interval method, we can see that the confidence interval
## ( -0.5841 , -0.2131 ) is below zero (0) - the point of interest. This again
## shows that we can be 95% confident that there is a real difference between
## the average weight of male and female babies in the general population.
```