Inference for Paired Data

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Create a Word docx from this R Markdown file for the following exercise. Submit the R markdown file and resulting Word docx file via D2L Dropbox.

## Exercise 1

To reduce ankle injuries, restrictive appliances such as taping and spatting (applying tape over the shoe and sock) have been employed. As part of a study at UWL, subjects also completed a 5-point Likert-type scale survey regarding their perceptions of the movement of each ankle appliance during exercise.

Researchers would like to compare the central values for perceptions of the movement of taped ankles compared to spatted ankles using and to estimate the difference with 90% confidence.

### Part 1a

Load the data set AnkleMovement.rda from the DS705 package.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1a -|-|-|-|-|-|-|-|-|-|-|-

# Load the data AnkleMovement  
require(DS705data)

## Loading required package: DS705data

data("AnkleMovement")

### Part 1b

Create a new variable of the differences, with the perceptions of the spatted ankle (spat) subtracted from the perceptions of the taped ankle (tape).

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1b -|-|-|-|-|-|-|-|-|-|-|-

# Create variable of difference in perception.  
perception\_diff <- AnkleMovement$tape - AnkleMovement$spat

### Part 1c

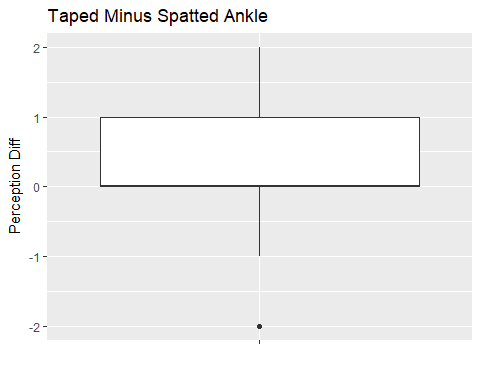
Create a boxplot and histogram for the sample of differences.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1c -|-|-|-|-|-|-|-|-|-|-|-

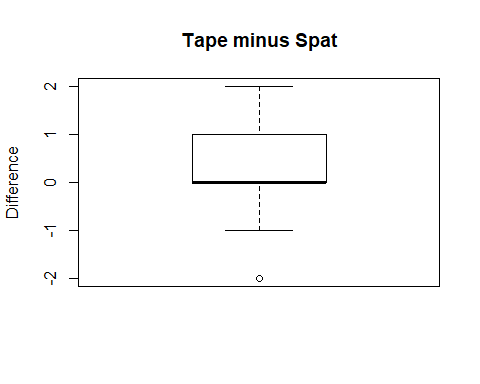
library(ggplot2)

## Warning: package 'ggplot2' was built under R version 3.4.4

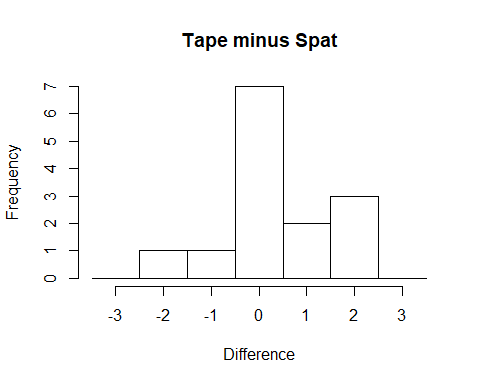
perception\_diff\_df <- data.frame(perception\_diff) # data from page 66  
ggplot(data = perception\_diff\_df, aes(x = "", y = perception\_diff)) +   
 geom\_boxplot() + labs(x="", y="Perception Diff") + ggtitle("Taped Minus Spatted Ankle")#+



#coord\_cartesian(ylim = c(0, 150)) # I set the y axis scale so the plot looks better.  
  
#ggplot(data = WormSheep, aes(x = treated, y = worms)) + geom\_boxplot() + labs(x = "")  
  
#ggplot(WormSheep, aes(x=worms)) +   
# geom\_histogram(binwidth=10, colour="black", fill="white") +   
# facet\_grid(. ~ treated)  
  
  
# Create Boxplots and Histograms for sample differences  
# https://www.r-bloggers.com/make-a-box-plot-with-single-column-data-using-ggplot2-tutorial/  
boxplot(perception\_diff, ylab = "Difference", main = "Tape minus Spat")



bins <- seq(-3.5,3.5,by=1)  
hist(perception\_diff, xlab = "Difference", main = "Tape minus Spat", breaks = bins)



### Part 1d

Comment on the suitability of this data for the paired t-test, the Wilcoxon signed rank test, and the sign test.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1d -|-|-|-|-|-|-|-|-|-|-|-

It is difficult to judge if the distribution is normal, which would be be the best time to use a paired t-test. Also based on the box plot, the data may be left skewed, which may be more evidence the distribution of differences not being normal. Also the sample size is small. There is also no explicit statement that the sample is random. We must assume that the sample is random. Although the Wilcoxon signed rank test is less powerful than the t-test, it is a better choice when samples are random, but non-normal. The population of differences should also be approximately symmetric about the median. Based on the boxplot, it appears this is the case.

Wilcox signed rank test is more powerful than sign test. The sign test only requires that the sample data be randomly sampled.

### Part 1e

Because the choice of test is somewhat unclear, as happens often in real life, try all three tests to compare the central values for subject’s perceptions of the movement of taped ankles compared to spatted ankles using .

Do the t-test first:

#### Step 1

Define the parameter in words in the context of the problem.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e.step1 -|-|-|-|-|-|-|-|-|-|-|-

Ho: Mu of d is Diff = Taped - Spat Mu of d = 0, Against alternative that Ha:Mu of d > 0. Hence perception of ankle movement is more for taping taping than spatting

#### Step 2

State the null and alternative hypotheses for the test using the symbol you defined previously.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e.step2 -|-|-|-|-|-|-|-|-|-|-|-

Replace this text with your answer here.

#### Step 3

Use R to generate the output for the test you selected.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e.step3 -|-|-|-|-|-|-|-|-|-|-|-

#   
t.test(AnkleMovement$tape, AnkleMovement$spat, alternative = "greater", paired = TRUE, conf.level = .90)

##   
## Paired t-test  
##   
## data: AnkleMovement$tape and AnkleMovement$spat  
## t = 1.1613, df = 13, p-value = 0.1332  
## alternative hypothesis: true difference in means is greater than 0  
## 90 percent confidence interval:  
## -0.0580957 Inf  
## sample estimates:  
## mean of the differences   
## 0.3571429

#### Step 4

State a statistical conclusion at and interpret it in the context of the problem.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e.step4 -|-|-|-|-|-|-|-|-|-|-|-

Given a significance level of 10%, we fail to reject the null hypothesis that for taped ankles the mean perceived ankle movement is equal to the mean for spatted ankles for the entire poplulation of athletes.

#### Step 5

Write an interpretation in the context of the problem for the 90% CI for the population mean difference.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e.step5 -|-|-|-|-|-|-|-|-|-|-|-

Taping and spatting lead to the same perception of movement on a 5 point Likert-type scale. The athletes did not notice a difference in ankle movement between the two methods.

#### Step 6

Perform the Wilcoxon Signed Rank Test.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e.step6 -|-|-|-|-|-|-|-|-|-|-|-

# Insert your R code here.  
wilcox.test(AnkleMovement$tape, AnkleMovement$spat, alternative = "greater", paired = TRUE, conf.level = .90)

## Warning in wilcox.test.default(AnkleMovement$tape, AnkleMovement$spat,  
## alternative = "greater", : cannot compute exact p-value with ties

## Warning in wilcox.test.default(AnkleMovement$tape, AnkleMovement$spat,  
## alternative = "greater", : cannot compute exact p-value with zeroes

##   
## Wilcoxon signed rank test with continuity correction  
##   
## data: AnkleMovement$tape and AnkleMovement$spat  
## V = 20.5, p-value = 0.149  
## alternative hypothesis: true location shift is greater than 0

Replace this text with your answer here.

#### Step 7

Perform the sign test.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e.step7 -|-|-|-|-|-|-|-|-|-|-|-

# Insert your R code here.  
library(signmedian.test)  
signmedian.test(perception\_diff, mu=0, alternative="greater", conf.level = .9)

##   
## Exact sign test  
##   
## data: perception\_diff  
## #(x>0) = 5, mu = 0, p-value = 0.2266  
## alternative hypothesis: the median of x is greater than mu  
## 87.5 percent confidence interval:  
## -1 2  
## sample estimates:  
## point estimator   
## 0

Replace this text with your answer here.

#### Step 8

Construct a bootstrap confidence interval at a 90% level of confidence for the mean difference in population mean perception of movement for taped and spatted ankles. Use a bootstrap sample size of 5000. Compare this interval with the results of the 90% *t*-interval.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e.step8 -|-|-|-|-|-|-|-|-|-|-|-

# Insert your R code here.  
  
library(boot)  
bootMean <- function(x, i) {  
 # x is a numeric vector  
 # i is a vector of indices for the resampled elements of x  
 mean(x[i])  
}  
set.seed(NULL)  
boot.object <- boot(perception\_diff, bootMean, R=5000)  
boot.ci(boot.object, conf = .9, type = "bca")$bca[4:5]

## [1] -0.2142857 0.7857143

Replace this text with your answer here.

#### Step 9

Compare the results of the three hypothesis tests and also whether or not the 90% bootstrap interval agrees with the result of each test. Which procedure should be reported and why?

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e.step9 -|-|-|-|-|-|-|-|-|-|-|-

Replace this text with your answer here.

## Exercise 2

In a nationwide study of insurance claims (in dollars) filed in the previous year, a random sample of 125 claims was selected from all claims for vehicles classified as small, meaning the gross vehicle weight rating (GVWR) is less than 4500 pounds.

For each claim, the insurance company’s estimate for the claim was also provided.

The data frame SmallAuto.rda contains the claims and estimates for each vehicle class.

### Part 2a

Load the data SmallAuto from the DS705 package.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 2a -|-|-|-|-|-|-|-|-|-|-|-

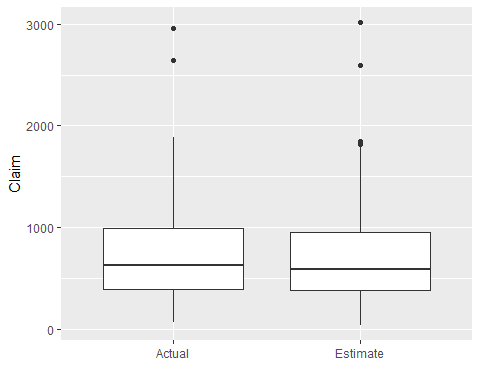
# Load the data.  
data("SmallAuto")

### Part 2b

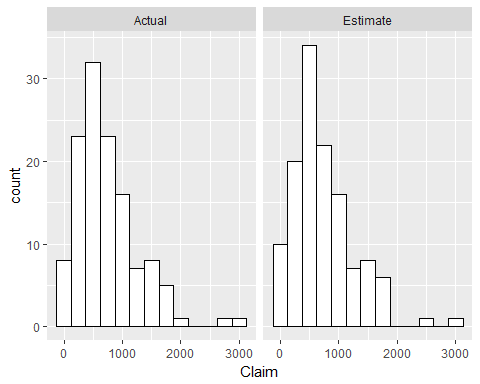
Construct histograms and boxplots for both the estimated claims and actual for the small class of vehicle. Describe the shapes of these distributions.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 2b -|-|-|-|-|-|-|-|-|-|-|-

# Insert your R code here.  
ggplot(data = SmallAuto, aes(x = Category, y = Claim)) + geom\_boxplot() + labs(x = "")



ggplot(SmallAuto, aes(x=Claim)) +   
 geom\_histogram(binwidth=250, colour="black", fill="white") +   
 facet\_grid(. ~ Category)



Both the estimate and actual distributions are right skewed.

### Part 2c

Create a new variable of the differences for small vehicles, with the difference being the estimated claim amount minus the actual claim amount. The estimated claim amounts in the first half of the vector are paired with the actual claim amounts in the second half of the vector so that row 1 and row 126 form a pair, rows 2 and 127, etc.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 2c -|-|-|-|-|-|-|-|-|-|-|-

# Insert your R code here.  
  
small\_auto\_est\_act\_diff <- SmallAuto[1:125,]$Claim - SmallAuto[126:250,]$Claim

### Part 2c

Create a boxplot, histogram, and normal probability plot for the sample of differences. Also, obtain the P-value for a Shapiro-Wilk normality test.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 2c -|-|-|-|-|-|-|-|-|-|-|-

# Insert your R code here.

### Part 2d

Comment on the shape of the distribution of differences and the suitability of this data for the paired *t*-test, the Wilcoxon signed rank test, and the sign test. Which test will you use?

### -|-|-|-|-|-|-|-|-|-|-|- Answer 2d -|-|-|-|-|-|-|-|-|-|-|-

Replace this text with your answer here.

### Part 2e

Conduct an appropriate test to see if the population central values for the estimated claim amount is less than for the actual claim amounts for vehicles in the small class using .

#### Step 1

Define the parameter in words in the context of the problem.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 2e.step1 -|-|-|-|-|-|-|-|-|-|-|-

Replace this text with your answer here.

#### Step 2

State the null and alternative hypotheses for the test using the symbol you defined previously.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 2e.step2 -|-|-|-|-|-|-|-|-|-|-|-

Replace this text with your answer here.

#### Step 3

Use R to generate the output for the test you selected. Pay close attention to the order of subtraction done behind the scenes in R.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 2e.step3 -|-|-|-|-|-|-|-|-|-|-|-

# Insert your R code here.

#### Step 4

State a statistical conclusion at and interpret it in the context of the problem.

#### -|-|-|-|-|-|-|-|-|-|-|- Answer 2e.step4 -|-|-|-|-|-|-|-|-|-|-|-

Replace this text with your answer here.

### Part 2f

Write an interpretation in the context of the problem for a 95% two-sided confidence interval.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 2f -|-|-|-|-|-|-|-|-|-|-|-

# Insert your R code here.

Replace this text with your answer here.

## Exercise 3

The data frame AutoIns is very similar to Small Auto.

In a nationwide study of insurance claims filed in the previous year, a random sample of 125 claims was selected from all claims for vehicles classified as small, meaning the gross vehicle weight rating (GVWR) is less than 4500 pounds A separate sample of 125 claims for vehicles classified as standard, meaning the GVWR is between 4500 and 8500 pounds.

For each claim, the insurance company’s estimate for the claim was also provided.

The data frame AutoIns.rda contains the claims and estimates for each vehicle class. The variables in the data frame are defined as follows:

claim.small = the actual claim amount in dollars for a vehicle in the small class

est.small = the estimated claim amount in dollars for a vehicle in the small class

claim.standard = the actual claim amount in dollars for a vehicle in the standard class

est.standard = the estimated claim amount in dollars for a vehicle in the standard class

### Part 3a

Load the data AutoIns from the DS705 package and look at the structure of the data in the file.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 3a -|-|-|-|-|-|-|-|-|-|-|-

# Load the data.  
data("AutoIns")

### Part 3b

Is the data “stacked” or “side-by-side” (“tall” or “wide”)?

### -|-|-|-|-|-|-|-|-|-|-|- Answer 3b -|-|-|-|-|-|-|-|-|-|-|-

The data is side by side.

### Part 3c

Which pairs of variables in the data frame are independent of each other? You can use the variable names to identify them.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 3c -|-|-|-|-|-|-|-|-|-|-|-

Replace this text with your answer here.

### Part 3d

Which pairs of variables in the data frame are paired (matched pairs)? You can use the variable names to identify them.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 3d -|-|-|-|-|-|-|-|-|-|-|-

Replace this text with your answer here.