Non-Parametric: Hypotheses Test

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PART 0. INTRODUCTION

In this project, I will perform an analysis using a non-parametric test. In the process of performing various tests, let's look at the conditions for each non-parametric test. I will also focus on which conditions tell us that it is correct to perform non-parametric tests. Through this, I will try to find out the questions I actually need to ask in the real-world analysis situation and how to answer them. In the process, I will understand each non-parametric test. Additionally, I will consider how to create a simulation loop.

Non-Parametric, Understanding:

1. The non-parametric test tells us that all the tests we have done so far are close to parametric tests. Parametric tests are those that assume that the sample data comes from a population that follows a probability distribution — the normal distribution — with a fixed set of parameters. Common parametric tests are focused on analyzing and comparing the mean or variance of data (Shubhangi, 2021).
2. On the other hand, non-parametric tests do not compare parameters. The analysis method using rank is mainly used. The reason for using rank is that the number of samples is too small. As a result, it is impossible to extract meaningful parameters. Also, the assumptions required for parametric tests are not satisfied. The method of non-parametric test is the same as hypothesis steps. The results are mainly derived using rank or association.

PART 1. ANALYSIS

PART 1-1. Sign Test

Sign test, Understanding:

1. The sign test for a single sample is a nonparametric test used to test the value of a population median. If the data value is above the conjectured median, it is assigned a plus sign. If the data value is below the conjectured median, it is assigned a minus sign. And if it is exactly the same as the conjectured median, it is assigned a 0.
2. Then the numbers of plus and minus signs are compared to determine if they are significantly different. If the null hypothesis is true, the number of plus signs should be approximately equal to the number of minus signs. If the null hypothesis is not true, there will be a disproportionate number of plus or minus signs (Bluman, 2017).

Section 13-2. 6 Game attendance

Step 0 Finding a Key-Metrics.

This is about number of attendances at local football game

An athletic director suggests the median number for the paid attendance at 20 local football games is 3000. The data for a random sample are shown. At α = 0.05, is there enough evidence to reject the claim? If you were printing the programs for the games, would you use this figure as a guide?

6210	3150	2700	3012	4875
3540	6127	2581	2642	2573
2792	2800	2500	3700	6030
5437	2758	3490	2851	2720

At α = 0.05, can it be concluded that the median of paid attendance is 3000?

Step 1 Hypothesis.

Null: Median is equal to 3000 (Claim)
Alternative: The median is not equal to 3000

- H0: Median=3000, H1: Median ≠ 3000

Step 2 Find the critical value.

- The p-value is α = 0.05

Step 3 Compute the test value.

Exact binomial test		
number of successes = 10	number of trials = 20	p-value = 1
95 percent confidence interval: 0.2719578 0.7280422		
sample estimates: probability of success 0.5		

Step 4 Make the decision.

- There is not enough evidence to reject null hypothesis since 1 (p-value) > 0.05

Step 5 Summarize the results.

- There is not enough evidence to reject the claim that the median of paid attendance is 3000.

Section 13-2. 10 Lottery Ticket Sales

Step 0 Finding a Key-Metrics.

This is about number of selling lottery tickets

A lottery outlet owner hypothesizes that she sells 200 lottery tickets a day.
She randomly sampled 40 days and found that on 15 days she sold fewer than 200 tickets.

At α =0.05, is there sufficient evidence to conclude that the median is below 200 tickets?

Step 1 Hypothesis.

Null: Median is equal to 200 (Claim)
Alternative: The median is fewer than

- H0: Median=200, H1: Median < 200

Step 2 Find the critical value.

- Critical.value <- qnorm(p=.05, lower.tail=TRUE)
- The Critical value of normal distribution alpha=0.05 and lower tail is true: -1.65

Step 3 Compute the test value.

- Sample size is >= 25, so I will use the equation
- R code= test.value={(15+0.5)-0.5*40}/(sqrt(40)/2)= -1.423025

$$z = \frac{(X+0.5)-0.5n}{\frac{\sqrt{n}}{2}}$$

Step 4 Make the decision.

- There is not enough evidence to reject null hypothesis since -1.423025 (test value) > -1.65 (critical value)

Step 5 Summarize the results.

- There is not enough evidence to reject the claim that median number of selling lottery tickets of a lottery outlet owner is 200.

APPENDIX
The reason why I did not use the binom.test ()

- There are only total numbers and positive numbers. I could assume that there is no equal value and suppose that total numbers are 40, positives are 25, and negatives are 15. However, I could not confirm that fact, so I used critical values to see if there is significant.
- And the sample number was also over 25, so I made a formular to calculate the values manually.

PART 1-2. The Wilcox Rank Sum Test

The Wilcox Rank Sum Test, Understanding:

1. The Wilcoxon rank sum test is a nonparametric test that uses ranks to determine if two independent samples were selected from populations that have the same distributions.
2. The assumptions for the Wilcoxon rank sum test are first, the samples are random and independent of one another. Second, the size of each sample must be greater than or equal to 10 (Bluman, 2017).

Section 13-3. 4 Lengths of Prison Sentences

Step 0 Finding a Key-Metrics.
This is about length of sentence in a certain type of crime by Gender

A random sample of men and women in prison was asked to give the length of sentence each received for a certain type of crime.

Male	8 12 6 14 22 27 32 24 26 19 15 13
Female	7 5 2 3 21 26 30 9 4 17 23 12 11 16

At α = 0.05, test the claim that there is no difference in the sentence received by each gender. The data (in months) are shown here.

Step 1 Hypothesis.

Null: There is no difference in a length of sentence in a certain crime by Gender.
Alternative: There is difference in a length of sentence in a certain crime by Gender.

Step 2 Find the critical value.

- The p-value is α = 0.05

Step 3 Compute the test value.

Wilcoxon rank sum test

data: males and females
W= 113, p-value = 0.1357
alternative hypothesis: true location shift is not equal to 0

Step 4 Make the decision.

- There is not enough evidence to reject null hypothesis since 0.1357 (p-value) > 0.05

Step 5 Summarize the results.

- There is not enough evidence to reject the claim that there is no difference in a length of sentence in a certain type of crime.

Section 13-3. 8 Winning Baseball Games

Step 0 Finding a Key-Metrics.

This is about number of wins of NL & AL (major league baseball)

For the years 1970–1993 the National League (NL) and the American League (AL) (major league baseball) were each divided into two divisions: East and West. Below are random samples of the number of games won by each league's Eastern Division

NL	89 96 88 101 90 91 92 96 108 100 95
AL	108 86 91 97 100 102 95 104 95 89 88 101

At α = 0.05, is there sufficient evidence to conclude a difference in the number of wins?

Step 1 Hypothesis.

Null: There is no difference in number of wins by league.
Alternative: There is difference in number of wins by league.

Step 2 Find the critical value.

- The p-value is α = 0.05

Step 3 Compute the test value.

Wilcoxon rank sum test	
data: NL and AL	
W= 59,	p-value = 0.6657
alternative hypothesis: true location shift is not equal to 0	

Step 4 Make the decision.

- There is not enough evidence to reject null hypothesis since 0.6657 (p-value) > 0.05

Step 5 Summarize the results.

- There is not enough evidence to reject the claim that there is no difference between the National League and the American League in number of wins.

PART 1-3. Wilcoxon Signed-Rank Test

Wilcoxon Signed-Rank Test, Understanding:

1. Wilcoxon rank-sum test is used to compare two independent samples, while Wilcoxon signed-rank test is used to compare two related samples, matched samples, or to conduct a paired difference test of repeated measurements on a single sample to assess whether their population mean ranks differ (Yinglin, 2020).

Section 13-4. 5 Ws=13, n=15, alpha=0.01, two-tailed

Step 0 Finding a Key-Metrics.

There is no Key-Metrics. I will Imagine the situation. Compare before & after in 15 days. Check the number of shoplifting incidents after increasing security guards.

Step 1 Hypothesis.

Null: There is no difference in the number of shoplifting incidents before and after the increase in security.
Alternative: There is difference in the number of shoplifting incidents before and after the increase in security.

Step 2 Find the critical value.

- The Ws is 13

Step 3 Compute the test value.

- When alpha=0.01, n=15 and two-tailed test, the critical value is 16 on the Table K

Step 4 Make the decision.

- There is enough evidence to reject null hypothesis
  since 13 (test value) < 16

Step 5 Summarize the results.

- There is enough evidence to reject the claim that there is no difference in the number of shoplifting incidents before and after the increase in security.

Section 13-4. 6 Ws=32, n=28, alpha=0.0025, one-tailed

Step 0 Finding a Key-Metrics.

There is no Key-Metrics. I will Imagine the situation. Compare before & after in 28 people. Check the number of pushups after eating protein supplement.

Step 1 Hypothesis.

Null: There is no difference in the number of pushups before and after eating protein supplements
Alternative: There is difference in the number of pushups before and after eating protein supplements

Step 2 Find the critical value.

- The Ws is 32

Step 3 Compute the test value.

- When alpha=0.0025, n=28 and one-tailed, the critical value is 117 on the Table K

Step 4 Make the decision.

- There is enough evidence to reject null hypothesis
  since 32 (test value) < 117

Step 5 Summarize the results.

- There is enough evidence to reject the claim that There is no difference in the number of pushups before and after eating protein supplements

Section 13-4. 7 Ws=65, n=20, alpha=0.05, one-tailed

Step 0 Finding a Key-Metrics.

There is no Key-Metrics. I will Imagine the situation. Compare before & after in 20 days. Check the number of consumers after changing a storefront sign

Step 1 Hypothesis.

Null: There is no difference in the number of customers before and after changing a storefront sign
Alternative: There is difference in the number of customers before and after changing a storefront sign

Step 2 Find the critical value.

- The Ws is 65

Step 3 Compute the test value.

- When alpha=0.05, n=20 and one-tailed test, the critical value is 60 on the Table K

Step 4 Make the decision.

- There is not enough evidence to reject null hypothesis
  since 65 (test value) > 60

Step 5 Summarize the results.

- There is not enough evidence to reject the claim that there is no difference in the number of customers before and after changing a storefront sign

Section 13-4. 8 Ws=22, n=14, alpha=0.1, two-tailed

Step 0 Finding a Key-Metrics.

There is no Key-Metrics. I will Imagine the situation. Compare before & after in 14 days. Check the number of paid tickets after changing a machine

Step 1 Hypothesis.

Null: There is no difference in the number of paid tickets after changing a machine
Alternative: There is difference in the number of paid ticket after changing a machine

Step 2 Find the critical value.

- The Ws is 22

Step 3 Compute the test value.

- When alpha=0.1, n=14 and two-tailed test, The critical value is 26 on the Table K

Step 4 Make the decision.

- There is enough evidence to reject null hypothesis
  since 22 (test value) < 26

Step 5 Summarize the results.

- There is enough evidence to reject the claim that there is no difference in the number of paid tickets after changing a machine

PART 1-4. The Kruskal-Wallis Test

The Kruskal-Wallis Test, Understanding:

1. The Kruskal-Wallis test (sometimes also called the "one-way ANOVA on ranks") is that can be used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable (Laerd, n.d.).
2. The Kruskal-Wallis test assesses the differences against the average ranks in order to determine whether or not they are likely to have come from samples drawn from the same population (Complete Dissertation, n.d.).

Section 13-5. 2 Mathematics Literacy Scores

Step 0 Finding a Key-Metrics.

Mathematics literacy scores by the regions

Through the Organization for Economic Cooperation and Development (OECD), 15-year-olds are tested in member countries in mathematics, reading, and science literacy. Listed are randomly selected total mathematics literacy scores (i.e., both genders) for selected countries in different parts of the world.

Western Hemisphere	Europe	Eastern Asia
527	520	523
406	510	547
474	513	547
381	548	391
411	496	549

Test, using the Kruskal-Wallis test, to see if there is a difference in means at α = 0.05.

Step 1 Hypothesis.

Null: There is no difference in mathematics literacy scores by the regions. Alternative: There is difference in mathematics literacy scores by the regions.

Step 2 Find the critical value.

- The p-value is α = 0.05

Step 3 Compute the test value.

Kruskal-Wallis rank sum test	
data: scores by part	
Kruskal-Wallis chi-squared = 4.1674	
df = 2	p-value = 0.1245

Step 4 Make the decision.

- Do not reject the null hypothesis, since p-value (0.1245) > 0.05

Step 5 Summarize the results.

- There is not enough evidence to reject the claim that there is no difference in mathematics literacy scores by the regions.

PART 1-5. Spearman Rank Correlation Coefficient

Spearman Rank Correlation Coefficient, Understanding:

1. Spearman rank correlation is a non-parametric test that is used to measure the degree of association between two variables (Complete Dissertation, n.d.).
2. The Spearman's rank correlation coefficient is a method of testing the strength and direction (positive or negative) of the correlation (relationship or connection) between two variables (QMUL, n.d.).
3. The fundamental difference between the two correlation coefficients is that the Pearson coefficient works with a linear relationship between the two variables whereas the Spearman Coefficient works with monotonic relationships as well (Juhi, 2020).

Section 13-5. 6 Subway and Commuter Rail Passengers

Step 0 Finding a Key-Metrics.

Finding a relationship between the subway and Rail daily passengers

Six cities are randomly selected, and the number of daily passenger trips (in thousands) for subways and commuter rail service is obtained.

City	1	2	3	4	5	6
Subway	845	494	425	313	108	41
Rail	39	291	142	103	33	38

At $\alpha = 0.05$,is there a relationship between the variables? Suggest one reason why the transportation authority might use the results of this study.

Step 1 Hypothesis.

Null: There is no association between the two variables.
Alternative: There is association between the two variables.

H0: p=0, H1: p≠0

Step 2 Find the critical value.

- The p-value is α = 0.05

Step 3 Compute the test value.

Spearman's rank correlation rho		
data: pass$subway and pass$rail		
S = 14		p-value = 0.2417
alternative hypothesis: true rho is not equal to 0		
sample estimates:	rho	0.6

Step 4 Make the decision.

- Do not reject the null hypothesis, since p-value (0.2417) > 0.05

Step 5 Summarize the results.

- There is not enough evidence to reject the claim that there is no association between the two variables.

PART 1-6. Simulation of the Experiments

Section 14-3. 16 Prizes in Caramel Corn Boxes

Step 0 Finding a Key-Metrics.

Randomly extract the values from Group (A, B, C, and D). If the sampling contains all value (A, B, C, and D), end the sequence and check the trial numbers

A caramel corn company gives four different prizes, one in each box. They are placed in the boxes at random. Find the average number of boxes a person needs to buy to get all four prizes. (40)

Step 1 Decision the main codes.

Main Code: sample() & while, if

Function	Purpose	Example
sample()	Extract the value	sample(data, size=1, replace=T)
while{, if … break}	Making loop	while(length() > 0) {… if(length() == 0 {… break}

Step 2 Choose the detailed value and output

sample()	data: c(A, B, C, D)/ size=1 (extract one a trial)/ replace=TRUE
cat()	check the exact value: “Extracted”, choice, “\n”
if()	delete the value from c(A, B, C, D) and if there is nothing, break

Step 3 Making the codes

```
{while (length(group1) > 0) {
  choice <- sample(group1, size=1, replace=T)
  cat("Extracted", choice, "\n")
  group2 <- group2[group2 != choice]
  count <- count + 1
    if (length(group2) == 0) {
    return(count)
    break}}}
```

Step 4 Checking the examples and prepare for replicating

Example of Result 1

Extracted A
Extracted D
Extracted B
Extracted A
Extracted C
All elements were extracted after 5 trial(s).

Delete the unnecessary function	the cat("Extracted", choice, "\n")
Add functions for reset the value	group2 <- c("A", "B", "C", "D")/ count <- 0
Making fuctions	function.name <- function() {while…}

Step 5 Checking the results

code	result
mean(replicate(40, prize.loop()))	**8.825**

- In the 40 trials, the mean of the number of trials to get all four prizes is 8.825

Section 14-3. 16 Lottery Winner

Step 0 Finding a Key-Metrics.

Randomly extract the values from Group (b, i and g). If the sampling contains all value (b, i, and g), end the sequence and check the trial numbers

To win a certain lotto, a person must spell the word big. Sixty percent of the tickets contain the letter b, 30% contain the letter i, and 10% contain the letter g. Find the average number of tickets a person must buy to win the prize. (30)

Step 1 Decision the main codes.

Main Code: sample() & while, if

Function	Purpose	Example
sample()	Extract values	sample(data, size=1, replace=T, prob=c(0.6, 0.3, 0.1)
while{, if … break}	Making loop	while(length() > 0) {… if(length() == 0 {… break}

Step 2 Choose the detailed value and output

sample()	data: c(b, i g). size=1 (extract one a trial)/ replace=TRUE/ prob=
cat()	check the exact value: “Extracted”, choice, “\n”
if()	delete the value from c(b, i g). and if there is nothing, break

Step 3 Making the codes

```
{while (length(group1) > 0) {
  choice <- sample(group3, size=1, replace=T, prob=c(0.6,0.3,0.1))
  cat("Extracted", choice, "\n")
  group4 <- group4[group4 != choice]
   count <- count + 1
    if (length(group4) == 0) {
    return(count)
    break}}}
```

Step 4 Checking the examples and prepare for replicating

Example of Result 1

Extracted b
Extracted i
Extracted b
Extracted b
Extracted i
Extracted g
All elements were extracted after 6 trial(s).

Delete the unnecessary function	cat("Extracted", choice, "\n")
Add functions for reset the value	group4 <- c ("b", "i", "g")/ count <- 0
Making fuctions	function.name <- function() {while…}

Step 5 Checking the results

code	result
mean(replicate(30, lottery.loop()))	**11.5666**

- In the 30 trials, the mean of the number of trials to get all four prizes is 11.5666

PART 2. RESULT & INTERPRETATIONS

1. In this project, I did a lot of non-parametric analysis and made loop code for simulating the experiments in R. I learn when I have to use the non-parametric tests. Furthermore, I think about the key-metrics which is related to real-world problems.
2. Non-parametric test is mostly used when the sample is not enough. Sign test is used to test the value of a population median with plus, minus, and 0 values. The Wilcox Rank Sum Test is the test to determine if two independent samples have the same distributions. Wilcoxon rank-sum test is used to compare a paired difference to assess whether their population mean ranks differ. The Kruskal-Wallis Test is executed to see if samples are drawn from the same population by checking the average ranks. Spearman Rank Correlation Coefficient is used to measure the degree of association between two variables. If I could not find the a linear relationship between the two variables, I can use the Spearman test.
3. I learned many ways to conduct non-parametric test in this module. I mostly used p-value to check if there is significant. I also checked the other critical values methods that I can use for non-parametric tests.
4. In the last part, I conducted the simulating the experiments. It was very difficult at the first time, after I checked several references, I could solve the problem.

PART 3. CONCLUSION

I learn how to execute the non-parametric tests and how to make a function loop for simulating experiments. Making a function loop for the simulating tests reminds me the first time that I decided to learn Analytics. I think about the possibility that the simulating test has. I imagined the situation that I’m in the medical field and take a tests for efficiency. And I also imagine the situation that I’m in the manufacturing company. I should check the defective proportion.

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R-Codes

```
# nonparametric statistical tests
# Step 1 - from the hypotheses
# step 2 - find the critical value
# step 3 - calculate the test value
# step 4 - make a decision
# Step 5 - state our conclusion


#### sign test 1
##############

# State the hypothesis for 13-2 6. game attendance
# The median of attendance = 3000
# The median of attendance != 3000

# Set significance level
alpha <- 0.05

# claim is that the number of for paid attendance at 20 local football games is 3000
median <- 3000

# 20 games attendance
attendance <- c(6210, 3150, 2700, 3012, 4875, 3540, 6127, 2581, 2642, 2573, 2792, 2800,
2500, 3700, 6030, 5437, 2758, 3490, 2851, 2720)

# Check the difference
difference <-  attendance - median

# Determine the number of attendance where the number was above 3000
# exclude 0 values; + sign if value is greater than median - sign is less
pos <- length(difference[difference > 0])

# Determine the number of where attendance was below 3000
neg <- length(difference[difference < 0])

# Rund the test and save the results to the result variable
result <- binom.test(x = c(pos, neg), alternative = "two.sided")
result

# View the p-value
result$p.value

# determine if we should reject the null hypothesis
ifelse(result$p.value > alpha, "fail to reject the null hypothesis", "reject the null hypothesis")
```

```
# Conclusion: there is not enough evidence to conclude that the median is not 3000 attendence
per day

#### sign test 2 simple
##############

# State the hypothesis for 13-2 10. Lottery Ticket Sales TOTAL = 40 minus = 25 plus = ? equal
= ?
# The median of attendance = 200
# The median of attendance < 200

# other function using binom.test
pos2

# Set significance level
alpha2 <- 0.05

# claim is that the selling of lottery tickets a day is 200
median2 <- 200

# we don't have specific numbers cannot check the difference
# test.value = {(X+0.5)-0.5*n}/(sqrt(n)/2)
test.value={(15+0.5)-0.5*40}/(sqrt(40)/2)

# Critical z value for alpha = 0.05 and n = 40 is
critical.value <- qnorm(p=.05, lower.tail=TRUE)

# determine if we should reject the null hypothesis
ifelse(test.value > critical.value, "fail to reject the null hypothesis", "reject the null hypothesis")

# Conclusion: there is not enough evidence to conclude that the median is not 200 sells per day

#### wilcox.test 1
##############

# State the hypothesis for 13-3 4. Length of Prison sentence
# H0: there is no difference in the sex to be given length of sentence
# H1: there is difference in the sex to be given length of sentence

# Set significance level
alpha3 <- 0.05

# Check the values of male/female
males <- c(8,12,6,14,22,27,32,24,26,19,15,13)
females <- c(7,5,2,3,21,26,30,9,4,17,23,12,11,16)
```

```
# Run the test and save the results to the result variable
result3 <- wilcox.test(x=males, y=females, alternative="two.sided", correct = FALSE)
result3

# View the p-value
result3$p.value

# determine if we should reject the null hypothesis
ifelse(result3$p.value > alpha, "fail to reject the null hypothesis", "reject the null hypothesis")

# Conclusion: there is not enough evidence to conclude that there is difference in length of
sentence between male and female

#### wilcox.test 2
##############

# State the hypothesis for 13-3 4. Length of Prison sentence
# H0: there is no difference in Leagues wining
# H1: there is difference in Leagues wining

# Set significance level
alpha4 <- 0.05

# Check the values of male/female
NL <- c(89,96,88,101,90,91,92,96,108,100,95)
AL <- c(108,86,91,97,100,102,95,104,95,89,88,101)

# Run the test and save the results to the result variable
result4 <- wilcox.test(x=NL, y=AL, alternative="two.sided", correct = FALSE)
result4

# View the p-value
result4$p.value

# determine if we should reject the null hypothesis
ifelse(result4$p.value > alpha, "fail to reject the null hypothesis", "reject the null hypothesis")

# Conclusion: there is not enough evidence to conclude that there is difference in winning
number between NL and AL

#### wilcox.test Section 13-4 5
############## Ws=13, n=15 alpha=0.01 two-tail

# State the hypothesis for 13-4 5
# H0: there is no difference in two
```

```
# H1: there is difference in two

# we don't have specific numbers cannot check the difference
# test.value = 13
test.value2 <- 13

# Critical value by Table K for n=15 alpha = 0.01, two-tailed is 16
critical.value2  <- 16

# determine if we should reject the null hypothesis
ifelse(test.value2 > critical.value2, "fail to reject the null hypothesis", "reject the null hypothesis")

# with code
qsignrank()

#### wilcox.test Section 13-4  6
############### Ws=32, n=28, alpha=0.0025 one-tailed

# State the hypothesis for 13-4 6
# H0: there is no difference in two
# H1: there is difference in two

# we don't have specific numbers cannot check the difference
# test.value = 32
test.value3=32

# Critical value by Table K for n=28 alpha = 0.025, one-tailed is 117
critical.value3  <- 117

# determine if we should reject the null hypothesis
ifelse(test.value3 > critical.value3, "fail to reject the null hypothesis", "reject the null hypothesis")

#### wilcox.test Section 13-4  7
############### Ws=65, n=20, alpha=0.05 one-tailed

# State the hypothesis for 13-4 7
# H0: there is no difference in two
# H1: there is difference in two

# we don't have specific numbers cannot check the difference
# test.value = 65
test.value4=65

# Critical value by Table K for n=20, alpha=0.05 one-tailed is 60
critical.value4  <- 60
```

```
# determine if we should reject the null hypothesis
ifelse(test.value4 > critical.value4, "fail to reject the null hypothesis", "reject the null hypothesis")

#### wilcox.test Section 13-4  8
############## Ws=22, n=14, alpha=0.10 two-tailed

# State the hypothesis for 13-4 8
# H0: there is no difference in two
# H1: there is difference in two

# we don't have specific numbers cannot check the difference
# test.value = 22
test.value5=22

# Critical value by Table K for n=14, alpha=0.10 two-tailed is 26
critical.value5  <- 26

# determine if we should reject the null hypothesis
ifelse(test.value5 > critical.value5, "fail to reject the null hypothesis", "reject the null hypothesis")

#### Kruskal-Wallis test 1
##############

# State the hypothesis for 13-5 2. Length of Prison sentence
# H0: there is no difference in total mathematics literacy scores by part of the world
# H1: there is difference in total mathematics literacy scores by part of the world

# Set significance level
alpha5 <- 0.05

# Input the value for each part as a data frame
WH.part <- data.frame(scores=c(527,406,474,381,411), part=rep("Western Hemisphere",5))
E.part <- data.frame(scores=c(520,510,513,548,496), part=rep("Europe",5))
EA.part <- data.frame(scores=c(523,547,547,391,549), part=rep("Eastern Asia",5))

# combine the data frames into one
scores <- rbind(WH.part, E.part, EA.part)

# Run the test and save the results to the result variable
result5 <- kruskal.test(scores ~ part, data=scores)
result5

# View the p-value
result5$p.value

# determine if we should reject the null hypothesis
```

```
ifelse(result5$p.value > alpha5, "fail to reject the null hypothesis", "reject the null hypothesis")

# Conclusion: there is not enough evidence to conclude that there is difference in scores by the
part of world


#### Spearman rank correlation coefficient test 1
##############

# State the hypothesis for 13-5 2. Length of Prison sentence
# H0: rho = 0
# H1: rho != 0

# Set significance level
alpha6 <- 0.05

# Input the value for each part as a data frame
city <- c(1:6)
subway <- c(845,494,425,313,108,41)
rail <- c(39,291,142,103,33,38)

# combine the data frames into one
pass <- data.frame(city=city, subway=subway, rail=rail)
pass

# Run the test and save the results to the result variable
result6 <- cor.test(pass$subway, pass$rail, method = "spearman")
result6

# View the p-value
result6$p.value

# determine if we should reject the null hypothesis
ifelse(result6$p.value > alpha6, "fail to reject the null hypothesis", "reject the null hypothesis")

# Conclusion: there is not enough evidence to conclude that there is a relationship between the
passengers of subway and passengers of rail in each city.

# Set up a vector with elements A, B, C, and D
group1 <- c("A", "B", "C", "D")
group2 <- c("A", "B", "C", "D")

# Set up a counter for the number of times sampling has been done
count <- 0

### first simulation
```

```
# making and checking loop
while (length(group1) > 0) {

  # Randomly choose an element to extract
  choice <- sample(group1, size=1, replace=T)

  # Print the choice to the console
  cat("Extracted", choice, "\n")

  # Remove the chosen element from the group
  group2 <- group2[group2 != choice]

  # Increment the counter
  count <- count + 1

  # Check if all elements have been extracted at least once
  if (length(group2) == 0) {
    # If so, end the loop and print the number of extractions to the console
    # If so, end the loop and print the number of extractions to the console
    cat("All elements were extracted after", count, "trial(s).")
    break
}
}

# Set up a vector with elements A, B, C, and D
group1 <- c("A", "B", "C", "D")
group2 <- c("A", "B", "C", "D")

# Set up a counter for the number of times sampling has been done
count <- 0

# Set up a loop that will keep running until al(l elements have been extracted at least once
prize.loop <- function() {while (length(group1) > 0) {

  # Randomly choose an element to extract
  choice <- sample(group1, size=1, replace=T)

  # Remove the chosen element from the group
  group2 <- group2[group2 != choice]

  # Increment the counter
  count <- count + 1

  # Check if all elements have been extracted at least once
  if (length(group2) == 0) {
```

```
    # If so, end the loop and print the number of extractions to the console
    return(count)
    group2 <- c("A", "B", "C", "D")
    count <- 0
    break}
}
}
prize.loop()
mean(replicate(40, prize.loop()))

### Second simulation
# Making and Chekcing loop
# Set up a vector with elements A, B, C, and D
group3 <- c("b", "i", "g")
group4 <- c("b", "i", "g")
sample(group3, size=1, replace=T, prob=c(0.6,0.3,0.1))

# Set up a counter for the number of times sampling has been done
count <- 0

while (length(group3) > 0) {

  # Randomly choose an element to extract
  choice <- sample(group3, size=1, replace=T, prob=c(0.6,0.3,0.1))

  # Print the choice to the console
  cat("Extracted", choice, "\n")

  # Remove the chosen element from the group
  group4 <- group4[group4 != choice]

  # Increment the counter
  count <- count + 1

  # Check if all elements have been extracted at least once
  if (length(group4) == 0) {
    # If so, end the loop and print the number of extractions to the console
    cat("All elements were extracted after", count, "trial(s).")
    break
}
}

# Set up a vector with elements A, B, C, and D
group3 <- c("b", "i", "g")
group4 <- c("b", "i", "g")
sample(group3, size=1, replace=T, prob=c(0.6,0.3,0.1))
```

```
# Set up a counter for the number of times sampling has been done
count <- 0

# Set up a loop that will keep running until al(l elements have been extracted at least once
lottery.loop <- function() {while (length(group3) > 0) {

 # Randomly choose an element to extract
 choice <- sample(group3, size=1, replace=T, prob=c(0.6,0.3,0.1))

 # Remove the chosen element from the group
 group4 <- group4[group4 != choice]

 # Increment the counter
 count <- count + 1

 # Check if all elements have been extracted at least once
 if (length(group4) == 0) {
  # If so, end the loop and print the number of extractions to the console
  return(count)
  group4 <- c("b", "i", "g")
  count <- 0
  break}
}
}
lottery.loop()


mean(replicate(30, lottery.loop()))
```