Statistics 140 Winter 17

Final Exam Part 2

Version 1 Yellow

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1. Xin-Ru, Shahan, and Zixiang were recently hired by a major ice cream company to conduct a survey to determine whether there is a relationship between gender and ice cream flavor preferred. They selected a random sample of ice cream enthusiasts and cross-classified them as follows. Preform the appropriate test to determine whether there is a relationship between gender and ice cream flavor preference.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Preference | | |
| Gender | Chocolate | Vanilla | Strawberry |
| Male | 100 | 120 | 90 |
| Female | 130 | 85 | 75 |

**H0: Gender is independent of preference of ice cream flavor.**

**Ha: There is a relationship between gender and ice cream flavor preference.**

R Code for X2 Test for Independence:

> icecream<-matrix(c(100,120,90,130,85,75),2,3,byrow=TRUE)

> icecream

[,1] [,2] [,3]

[1,] 100 120 90

[2,] 130 85 75

> ice<-as.table(icecream)

> rownames(ice)<-c("Male","Female")

> colnames(ice)<-c("Chocolate","Vanilla","Strawberry")

> ice

Chocolate Vanilla Strawberry

Male 100 120 90

Female 130 85 75

> chisq.test(ice)

Pearson's Chi-squared test

data: ice

X-squared = 10.597, df = 2, p-value = 0.004998

**TS: X2 = 10.597 with p-value = 0.004998**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.004998 is less than α = 0.05, we reject H0**

**There is sufficient evidence to conclude a relationship between gender and ice cream flavor preference.**

1. Rebecca and Cindy are avid runners. They were interested in examining the amount of water, measured in ounces that runners drink per day. They select a random sample of 20 runners and record the amount of water ingested per day as follows. Perform the appropriate test to determine whether there is sufficient evidence that the median amount of water ingested by runners per day is more than 45 ounces.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 30 | 32 | 35 | 37 | 38 | 40 | 41 | 43 | 44 | 46 |
| 47 | 49 | 52 | 54 | 55 | 56 | 59 | 61 | 62 | 63 |

**H0: Median amount of water ingested ≤ 45 ounces**

**Ha: Median amount of water ingested > 45 ounces**

R Code for Quantile Test:

> binom.test(x=11,n=20,alternative="greater")

Exact binomial test

data: 11 and 20

number of successes = 11, number of trials = 20, p-value = 0.4119

alternative hypothesis: true probability of success is greater than 0.5

95 percent confidence interval:

0.3469314 1.0000000

sample estimates:

probability of success

0.55

**TS: n= 20, number of observations above 45 = 11, p-value = 0.4119**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.4119 is greater than α = 0.05, we do not reject H0**

**There is insufficient evidence to indicate the median amount of water ingested is significantly greater than 45 ounces.**

1. Refer to question 2. Sarah K and Amber were interested in testing whether the 70th percentile is 50 ounces. Perform the appropriate test.

**H0: The 70th percentile = 50 ounces**

**Ha: The 70th percentile ≠ 50 ounces**

**TS: Using the quantile test:**

**T1: # of observations ≤ 50 = 12**

**T2: # of observations < 50 = 12**

**T = T1 = T2 = 12 so α1 = α2 = α/2 = 0.05/2 = 0.025**

**RR:**

**T ≤ t1 where P(Y ≤ t1) = α1 = 0.025**

**P(Y ≤ 9) = 0.017 P(Y ≤ 10) = 0.048**

**T > t2 where P(Y ≤ t2) = 1 - α2 = 1 - 0.025 = 0.975**

**P(Y ≤ 17) = 0.965 P(Y ≤ 18) = 0.992**

**Reject H0 if T ≤ 9 or T > 17**

**Since T = 12 is not ≤ 9 or T > 17, we do not reject H0**

**There is sufficient evidence to indicate that the 70th percentile is 50 ounces.**

1. Historically a factor has been able to produce very specialized nano-technology component with 80% reliability, i.e. 80% of the components passed its quality assurance requirements. They have now changed their manufacturing process and hope that this has improved the reliability. To test this, Jirashuddhi, Nathan, and Siddarth took a sample of 25 components produced using the new process and found that 21 components passed the quality assurance test. Perform the appropriate test to determine whether the new process provides sufficient improvement over the old process?

**P = the proportion of components that pass the quality assurance test**

**H0: p ≤ 0.80**

**Ha: p > 0.80**

R Code for Binomial Test:

> prop.test(x=21,n=25,p=0.80,alternative="greater")

1-sample proportions test with continuity correction

data: 21 out of 25, null probability 0.8

X-squared = 0.0625, df = 1, p-value = 0.4013

alternative hypothesis: true p is greater than 0.8

95 percent confidence interval:

0.6646938 1.0000000

sample estimates:

p

0.84

**TS: n = 25, T = 21, α = 0.05, X2 = 0.0625 with p-value = 0.4013**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.4013 is greater than α = 0.05, we do not reject H0**

**There is insufficient evidence to indicate that the proportion of components that pass the quality assurance test is significantly greater than 80%.**

1. In a study of diagnostic processes, Amy and Minh are working on a psychology project. Entering clinical graduate students are shown a 20-minute videotape of children’s behavior and asked to rank order 10 behavioral events on the tape in the order of importance each has for a behavioral assessment. (1 = most important) The process was repeated using experienced clinicians. They recorded the following data. Conduct the appropriate test to determine whether there is a positive association between the student ranks and clinician ranks.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Event | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Student | 2 | 4 | 1 | 6 | 5 | 3 | 10 | 8 | 7 | 9 |
| Clinician | 1 | 3 | 2 | 7 | 5 | 4 | 8 | 6 | 9 | 10 |

**H0: Student rank and clinician rank are independent**

**Ha: Student rank and clinician rank are positively correlated.**

R Code for Kendall’s Tau:

> clinic<-read.table("C:\\Users\\Sarah\\Downloads\\clinic1d.dat",header=TRUE)

> clinic #Print as check

> attach(clinic)

> names(clinic)

[1] "S" "C"

> cor.test(S,C,method="kendall",alternative="greater")

Kendall's rank correlation tau

data: S and C

T = 39, p-value = 0.001106

alternative hypothesis: true tau is greater than 0

sample estimates:

tau

0.7333333

**TS: Tau = 0.733333 with p-value = 0.001106**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.001106 is less than α = 0.05, we reject H0**

**There is sufficient evidence to indicate that student rank and clinician rank are positively associated.**

1. Daniel, Yongjae, and Nicholas were interested in whether accidents occur with the same frequency during the work week in Southern California. They recorded the following data for one work week selected at random. Perform the appropriate test of hypothesis to see if it is reasonable to assume the accidents occur with the same frequency per day.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Day | Mon | Tues | Wed | Thurs | Fri |
| # of Accidents | 23 | 18 | 17 | 19 | 23 |

**P = number of accidents**

**H0: The data follows a multinomial distribution with the certain proportions**

**(p1 = p2 = p3 = p4 = p5 = 0.20)**

**Ha: The data does not follow a multinomial distribution with certain proportions**

**(at least 2 proportions are incorrect)**

SAS Code for X2 Goodness of Fit Test:

options ls = 78 ps = 55 formdlim = '#' nocenter nodate;

ods graphics off;

data q1;

input users $ observed1 prop1;

n = 100;

expected1 = n\*prop1;

chisq1 = (observed1 - expected1)\*\*2/expected1;

datalines;

mon 23 0.2

tues 18 0.2

wed 17 0.2

thurs 19 0.2

fri 23 0.2

;

proc print noobs;

proc means sum noprint;

var chisq1;

output out = a1 sum = chisq\_sum;

proc print noobs;

data pvalue1;

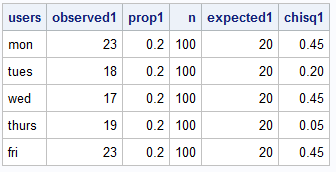
set a1;

pvalue = 1 - probchi(chisq\_sum,3);

proc print noobs;

run;

quit;





**TS: X2 = 1.6 with p-value = 0.65939**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.65939 is greater than α = 0.05, we do not reject H0**

**There is sufficient evidence to indicate that accidents occur with the same frequency per day. (p = 0.20)**

1. Brandon obtained a random sample of one hundred people and asked them their opinion about capital punishment. Brandon then had them watch a short debate regarding the subject and repeated the survey. He recorded the following summary data. Perform the appropriate test to determine whether the video changed people’s response to the original question.

|  |  |  |
| --- | --- | --- |
|  | After Viewing Debate | |
| Before Viewing Debate | Oppose | Favor |
| Oppose | 59 | 11 |
| Favor | 6 | 24 |

**H0: The video has not altered opinion.**

**Ha: The video has altered opinion.**

R Code for McNemar’s Test:

> punish<-matrix(c( 59,11,6,24),2,2,byrow=TRUE)

> punish

[,1] [,2]

[1,] 59 11

[2,] 6 24

> mcnemar.test(punish)

McNemar's Chi-squared test with continuity correction

data: punish

McNemar's chi-squared = 0.94118, df = 1, p-value = 0.332

**TS: X2 = 0.94118 with p-value = 0.332**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.332 is greater than α = 0.05, we do not reject H0**

**There is insufficient evidence to indicate that the video has altered people’s opinion.**

1. Brandon was interested in comparing the performance in two sections of an upper division course in Statistics. He obtains the following information. Perform the appropriate test to determine whether there is a significant relationship between performance and course section.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Course Performance | | |
| Section | Pass | Fail | Total |
| Section 1 | 19 | 3 | 22 |
| Section 2 | 21 | 5 | 26 |
| Total | 40 | 8 | 48 |

**H0: Section number and course performance are independent**

**Ha: Section number and course performance are not independent (relationship)**

R Code for Fisher’s Exact Test:

> stats<-matrix(c(19,3,21,5),2,2,byrow=TRUE)

> stats

[,1] [,2]

[1,] 19 3

[2,] 21 5

> fisher.test(stats)

Fisher's Exact Test for Count Data

data: stats

p-value = 0.7102

alternative hypothesis: true odds ratio is not equal to 1

95 percent confidence interval:

0.2507512 10.9412136

sample estimates:

odds ratio

1.495263

**TS: p-value = 0.7102**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.7102 is greater than α = 0.05, we do not reject H0**

**There is insufficient evidence to indicate that section number and course performance are not independent or have a relationship.**

1. Karina, Mirella, and Tina, owners of a marketing research firm, have been asked to test the effectiveness of a new flavoring for a beverage. They selected a sample of 20 people and randomly assigned 10 to taste the beverage with the old flavoring and 10 to taste the beverage with the new flavoring. The people in the study were then given a questionnaire which evaluates the enjoyability of the beverage. The results are shown below. Perform the appropriate test to determine whether the distributions of flavor perceptions are the same except for possible differences in mean or median enjoyability.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| New | 13 | 12 | 19 | 11 | 20 | 15 | 18 | 9 | 12 | 16 |
| Old | 12 | 8 | 6 | 16 | 12 | 19 | 10 | 18 | 4 | 11 |

**H0: Distribution functions do not differ (Cannot conclude a difference in flavor perceptions between the two groups)**

**Ha: Distribution functions do differ with respect to location (Can conclude a difference in flavor perceptions between the two groups)**

R Code for Mann-Whitney Test:

> flavor<-read.table("C:/Users/Sarah/Downloads/flavor1d.dat",header=TRUE)

> flavor #Print as check

> attach(flavor)

> names(flavor)

[1] "New" "Old"

> wilcox.test(New,Old)

Wilcoxon rank sum test with continuity correction

data: New and Old

W = 69, p-value = 0.1598

alternative hypothesis: true location shift is not equal to 0

Warning message:

In wilcox.test.default(New, Old) : cannot compute exact p-value with ties

**TS: W = 69 with p-value = 0.1598**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.1598 is greater than α = 0.05, we do not reject H0**

**There is insufficient evidence to indicate a difference in flavor perceptions between the two groups.**

1. Refer to question 9. Alfred and Bianca thought it might be useful to test whether the flavor enjoyability distributions differ at all.
2. Perform the appropriate nonparametric test.

**H0: Distribution functions of flavor perceptions are the same**

**Ha: Distribution functions of flavor perceptions are significantly different.**

SAS Code for Cramer von Mises Test:

options ls= 78 ps= 55 nocenter nodate;

ods graphics off;

data flavor;

input beverage flavor @@;

datalines;

1 13 1 12 1 19 1 11 1 20 1 15 1 18 1 9 1 12 1 16

2 12 2 8 2 6 2 16 2 12 2 19 2 10 2 18 2 4 2 11

;

proc sort;

by beverage flavor;

proc print;

proc npar1way edf;

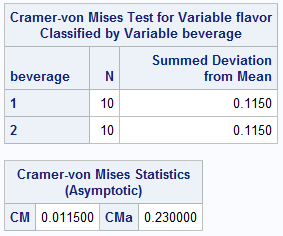
class beverage;

var flavor;

exact ks;

run;

quit;



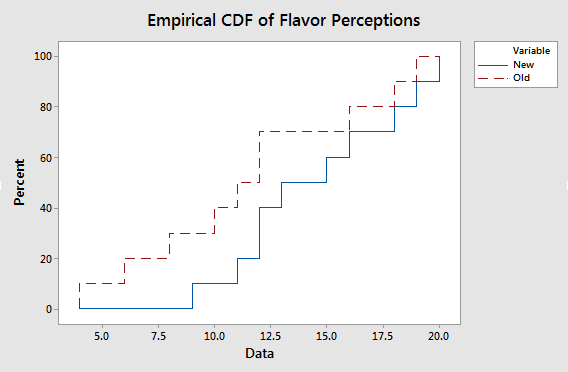
**TS: CMa = 0.230000**

**RR: Reject H0 if CMa > 0.461**

**Since the CMa = 0.230000 is less than 0.461, we do not reject H0**

**There is insufficient evidence to indicate that the distribution functions of flavor perceptions are significantly different.**

1. Create a graph of the two empirical distribution functions associated with the enjoyability of the two flavors.



1. CJ and Kevin, civil engineers for the Department of Transportation in a Midwestern state, were concerned about the ability of the road surfaces to withstand the harsh climate conditions. They decided to test four types of surfaces for durability. They selected 8 observations from each type of surface and placed them on “life test.” The following data was recorded. Perform the appropriate test to determine whether one can conclude that at least one road surface has a different median durability.

|  |  |  |  |
| --- | --- | --- | --- |
| Concrete | Composite | Brick | Gravel |
| 8.8 | 10.1 | 11.9 | 13.4 |
| 9.6 | 10.1 | 11.1 | 13.0 |
| 8.3 | 10.3 | 11.0 | 11.9 |
| 9.3 | 9.8 | 12.1 | 12.6 |
| 9.1 | 9.9 | 12.6 | 12.7 |
| 8.3 | 10.6 | 10.9 | 13.0 |
| 8.4 | 10.8 | 11.8 | 13.5 |
| 8.0 | 10.3 | 12.9 | 12.3 |

**H0: All four types of road surface have the same median durability**

**Ha: At least one road surface has a significantly different median durability**

SAS Code for Median Test:

options nocenter nodate nonumber ls = 78 ps =55 formdlim = '#';

ods graohics off;

data raod;

infile 'C:\Users\Sarah\Downloads\ROAD1D.DAT' firstobs =2;

do rows = 1 to 8;

do road\_type = 1 to 4;

if road\_type = 1 then level = 'Concrete ';

else if road\_type = 2 then level = 'Composite';

else if road\_type = 3 then level = 'Brick ';

else level = 'Gravel ';

input durability @@;

output;

end;

end;

proc print;

proc sort;

by level;

proc print;

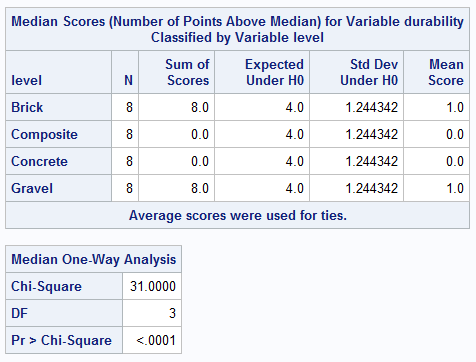
proc npar1way median;

class level;

var durability;

run;

quit;



**TS: X2 = 31.0000 with p-value < 0.0001**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value < 0.0001 is less than 0.05, we reject H0**

**There is sufficient evidence to indicate that at least one road surface has a significantly different median durability.**

1. Refer to Question 11:
2. Sarah R and Maher believe it might be useful to determine whether one can conclude that at least the durability of the surfaces have the same distribution function. Perform the appropriate test.

**H0: All four road surfaces have identical distribution functions.**

**Ha: At least one of the four road surfaces does not have the same median durability.**

R Code for Kruskal Wallis Test:

> road<-read.table("C:/Users/Sarah/Downloads/road1d.dat",header=TRUE)

> road #Print as check

> attach(road)

> names(road)

[1] "Con" "Comp" "Brick" "Gravel"

> kruskal.test(road)

Kruskal-Wallis rank sum test

data: road

Kruskal-Wallis chi-squared = 27.849, df = 3, p-value = 3.907e-06

**TS: X2 = 27.849 with p-value = 3.907 x 10-6**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 3.907 x 10-6 is less than α = 0.05, we reject H0**

**There is sufficient evidence to indicate that at least one of the four road surfaces does not have the same median durability.**

1. If appropriate, perform multiple comparisons to determine which surfaces are significantly different.

**Since we rejected the null above, we can perform a test to determine which road surface has a significantly different distribution function.**

R Code for Multiple Comparisons:

**>** library(dunn.test)

> dunn.test(road)

Kruskal-Wallis rank sum test

data: road and group

Kruskal-Wallis chi-squared = 27.8488, df = 3, p-value = 0

Comparison of road by group

(No adjustment)

Col Mean |

Row Mean | 1 2 3

--------------+------------------------------------------

2 | -1.706544

| 0.0440

|

3 | -3.626406 -1.919862

| 0.0001 0.0274

|

4 | -4.906314 -3.199770 -1.279908

| 0.0000 0.0007 0.1003

|  |  |  |  |
| --- | --- | --- | --- |
| Comparison | p-value | p-value < α (0.05)  (Yes or No) | Sign. Difference?  (Yes or No) |
| Concrete vs. Composite | 0.0440 | Yes | Yes |
| Concrete vs. Brick | 0.0001 | Yes | Yes |
| Concrete vs. Gravel | 0.0000 | Yes | Yes |
| Composite vs. Brick | 0.0274 | Yes | Yes |
| Composite vs. Gravel | 0.0007 | Yes | Yes |
| Brick vs. Gravel | 0.1003 | No | No |

**Concrete vs. Composite, Concrete vs. Brick, Concrete vs. Gravel, Composite vs. Brick, and Composite vs. Gravel have significantly different distribution functions.**

1. Dog obedience competitions have become popular in the United States and Canada. Participating in dog obedience has provided a venue for both dogs and their handlers to maintain top physical condition. Linda and Brandon, dog obedience enthusiasts have developed an obedience training course and are concerned as to whether the training course actually improves dog performance in competition. They obtain a random sample of 8 dogs and record the following data. Perform the appropriate test of hypothesis to test whether the training course significantly improves performance on the average.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Dog | Dexter | Dusty | Cody | Shadow | Lakota | Kali | Abby | Mercedes |
| Before | 81.2 | 87.5 | 85.5 | 87.2 | 83.2 | 83.3 | 82.4 | 83.3 |
| After | 81.0 | 90.5 | 86.4 | 89.2 | 83.8 | 83.5 | 83.1 | 83.2 |

**H0: Cannot conclude the training course significantly improves performance**

**Ha: Can conclude the training course significantly improves performance**

R Code for Wilcox Signed Rank Test:

> obey<-read.table("C:/Users/Sarah/Downloads/obey1d.dat",header=TRUE)

> obey #Print as check

> attach(obey)

> names(obey)

[1] "Dog" "Before1" "After1"

> wilcox.test(Before1,After1,paired=TRUE,alternative="less")

Wilcoxon signed rank test with continuity correction

data: Before1 and After1

V = 3.5, p-value = 0.02483

alternative hypothesis: true location shift is less than 0

Warning message:

In wilcox.test.default(Before1, After1, paired = TRUE, alternative = "less") :

cannot compute exact p-value with ties

**TS: p-value = 0.02483**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.02483 is less than α = 0.05, we reject H0**

**There is sufficient evidence to conclude that the training course significantly improves performance.**

1. Brandon, a quality control engineer claims that the life length of a particular battery follows an exponential distribution with mean of 2.5. Brandon obtains a random sample of the 10 batteries and places them on life test with the following results.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0.406 | 2.343 | 0.538 | 5.088 | 5.587 | 2.563 | 0.023 | 3.334 | 3.491 | 1.267 |

1. Perform the appropriate test.

**H0: The life length of batteries follows an exponential distribution with a mean of 2.5**

**Ha: The life length of batteries does not follow an exponential distribution with a mean of 2.5.**

R Code for Kolmogorov-Smirnov Test (1 sample):

> battery<-read.table("C:/Users/Sarah/Downloads/battery1d.dat",header=TRUE)

> battery

> attach(battery)

> names(battery)

[1] "life1"

> ks.test(life1,"pexp",rate=1/2.5)

One-sample Kolmogorov-Smirnov test

data: life1

D = 0.20828, p-value = 0.7055

alternative hypothesis: two-sided

**TS: D = 0.20828 with p-value = 0.7055**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.7055 is greater than α = 0.05, we do not reject H0**

**There is sufficient evidence to indicate the life length of the batteries follow an exponential distribution with mean of 2.5.**

1. Create a graph of the empirical distribution function and the cumulative distribution function.



1. Liu, Derick, and Patrick were interested in determining whether the quiz scores in a large introductory statistics class follow a normal distribution. They obtained the following random sample of data of the quiz scores.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 9.1 | 5.0 | 7.3 | 7.4 | 5.5 | 8.6 | 7.0 | 4.3 | 4.7 | 8.0 |
| 4.0 | 8.5 | 6.4 | 6.1 | 5.8 | 9.5 | 5.2 | 6.7 | 8.3 | 9.2 |

1. Perform the appropriate test.

**H0: The quiz scores are normally distributed**

**Ha: The quiz scores are not normally distributed**

R Code for Lilliefor’s Test:

> quiz<-read.table("C:/Users/Sarah/Downloads/quizzes1d.dat",header=TRUE)

> quiz #Print as check

> attach(quiz)

> names(quiz)

[1] "scores"

> mu\_est=mean(scores)

> mu\_est

[1] 6.83

> sd\_est=sd(scores)

> sd\_est

[1] 1.723552

> ks.test(scores,"pnorm",mean=mu\_est,sd=sd\_est)

One-sample Kolmogorov-Smirnov test

data: scores

D = 0.10314, p-value = 0.9687

alternative hypothesis: two-sided

**TS: D = 0.10314 with p-value = 0.9687**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.9687 is greater than α = 0.05, we do not reject H0**

**There is sufficient evidence to indicate that the quiz scores follow a normal distribution.**

1. Create a graph of the empirical distribution function and the cumulative distribution function.



1. Students in a late evening MWF statistics generally exhibit two types of behavior: energetic (1) and tired (0). The professor was interested in determining whether at least one of the days was significantly different with respect to student behavior. She had the students fill out an online survey form where they indicated their behavior for each of the three days. The professor took a random sample of 10 students and recorded the following information. Perform the appropriate test.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Day | | | |
| Student | Monday | Wednesday | Friday | Ri Totals |
| 1 | 1 | 1 | 0 | 2 |
| 2 | 1 | 0 | 0 | 1 |
| 3 | 1 | 1 | 1 | 3 |
| 4 | 1 | 1 | 0 | 2 |
| 5 | 1 | 1 | 0 | 2 |
| 6 | 0 | 0 | 1 | 1 |
| 7 | 1 | 1 | 0 | 2 |
| 8 | 1 | 1 | 0 | 2 |
| 9 | 1 | 0 | 1 | 2 |
| 10 | 1 | 1 | 0 | 2 |
| Cj Totals | 9 | 7 | 3 | 19 |

**H0: The students have the same behavior on each day**

**Ha: At least one of the days the students have a different behavior**

Cochran’s Test was performed.

Blocks: Students

N = 19

c = 3

r = 10

**TS = X2 with c-1 df = 3-1 = 2 df**

**= = 6.2222**

**RR: Reject H0 if T > X20.05,2 = 5.992**

**Since T = 6.2222 is greater than X20.05,2 = 5.992, we reject H0**

**There is sufficient evidence to indicate that at least one of the days the students have a different behavior.**

1. Zi-yue, Andy, and Pedro conducted an experiment to determine the effect of four different chemicals on the strength of fabric. These chemicals were used as part of a permanent press finishing process. Five fabric samples were selected, and a portion of each was tested with each of five chemicals. The following data was recorded. Perform the appropriate nonparametric test to determine whether there is a significant chemical effect.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Chemical  Type | Fabric Samples | | | | |
| 1 | 2 | 3 | 4 | 5 |
| 1 | 1.3 | 1.6 | 0.30 | 1.2 | 1.1 |
| 2 | 2.2 | 2.4 | 0.40 | 2.0 | 1.8 |
| 3 | 1.8 | 1.7 | 0.60 | 1.5 | 1.3 |
| 4 | 3.9 | 4.4 | 2.0 | 4.1 | 3.4 |

**H0: Each ranking within a block is equally likely. There is no difference in fabrics and no chemical effect**

**Ha: At least one of the fabrics is different with a chemical effect**

**Blocks = chemical type = 4**

**Treatments = fabric samples = 5**

R Code for Friedman’s Test:

> fabric<-read.table("C:/Users/Sarah/Downloads/fabric1d.dat",header=TRUE)

> fabric #Print as check

> fabrics<-as.matrix(fabric)

> fabrics #Print as check

> library(stats)

> library(PMCMR)

> friedman.test(fabrics)

Friedman rank sum test

data: fabrics

Friedman chi-squared = 14.6, df = 4, p-value = 0.005607

**TS: X2 = 14.6 with p-value = 0.005607**

**RR: Reject H0 if p-value < α = 0.05**

**Since the p-value = 0.005607 is less than α = 0.05, we reject H0**

**There is sufficient evidence to indicate that at least one of the fabrics is different and there is a chemical effect.**