Name: James Tsai
Section: MSDS6371-401
Date: 10/17/15

MSDS 6371: Midterm Exam 1 (FALL 2015)

1. (2pts each) Circle all that are true:

a. For a left tailed test, if the test statistic is less than the critical value, the correct conclusion is to fail to reject the Ho.
b. If you increase alpha, the power will increase.
c. All other things equal, if you increase the confidence, the interval will get wider.
d. The 2 Sample T-Test is resistant to outliers.
e. A Rank-Sum test is a good test to use with censored data.
f. For a fixed alpha, $t_{\alpha/2}$ will never be bigger than $Z_{\alpha/2}$, no matter what the sample size.
g. If the effect size increases (the distance between the null mean and assumed actual mean) the power will decrease.
h. For a two sample confidence interval for the difference in means (μ_1-μ_2), if both limits are positive, that is evidence that the two population means are not equal **and** that μ_1 is bigger.
i. The F-Test for Equality of variance is assumption free.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model					
Error	13	61.5500000			
Corrected Total	16	238.0000000			

2. (2 pts each) Given the ANOVA table above, find:
   a. The Mean Square Error: **4.735**
   b. The F Value: **12.422**
   c. R^2: **0.7414**
   d. How many degrees of freedom were used in estimating the MSE? **13**

3. **(2 pts each) Circle all** that are true about the Central Limit Theorem (CLT) assuming n > 30.
   a. The sampling distribution of the sample standard deviation will be normally distributed.
   b. The mean of the sampling distribution of the mean will be the same as the mean of the original distribution the sample was pulled from.
   c. The sampling distribution of the sample mean will be normally distributed.
   d. The sampling distribution of the sample mean will be the same as the original distribution.
   e. The standard deviation of the sampling distribution of the sample mean (the standard error) will be the same as the standard deviation of the original distribution.

4. S.W. Laagakos and F. Mosteller of Harvard University fed 38 randomly chosen female mice different doses of red dye number 40 and recorded the time of death in weeks. To decide which mouse receives which treatment, a random number from 1 to 4 is drawn for each mouse. The mouse receives the treatment based on this number:
   1. Control Group: No Dosage
   2. Low Dosage
   3. Medium Dosage

4. High Dosage

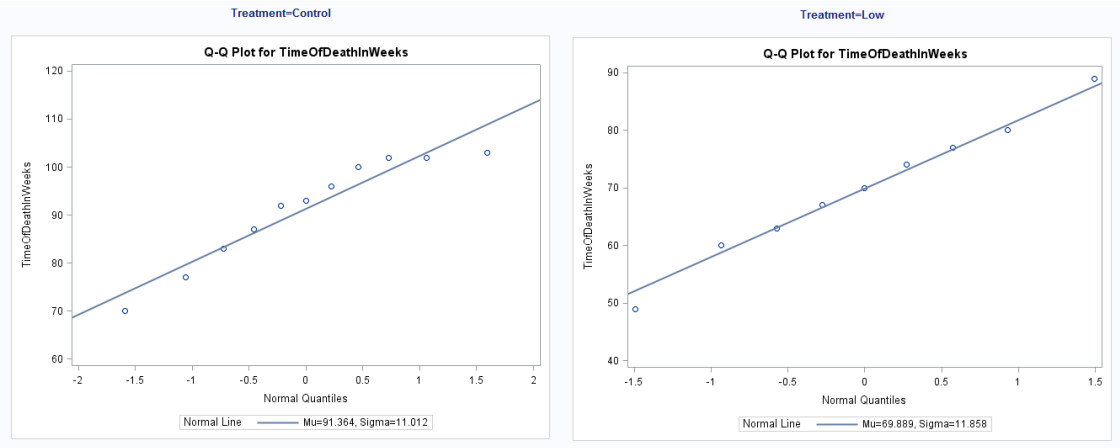
Dosage and time of death are shown in the data file red40.csv.

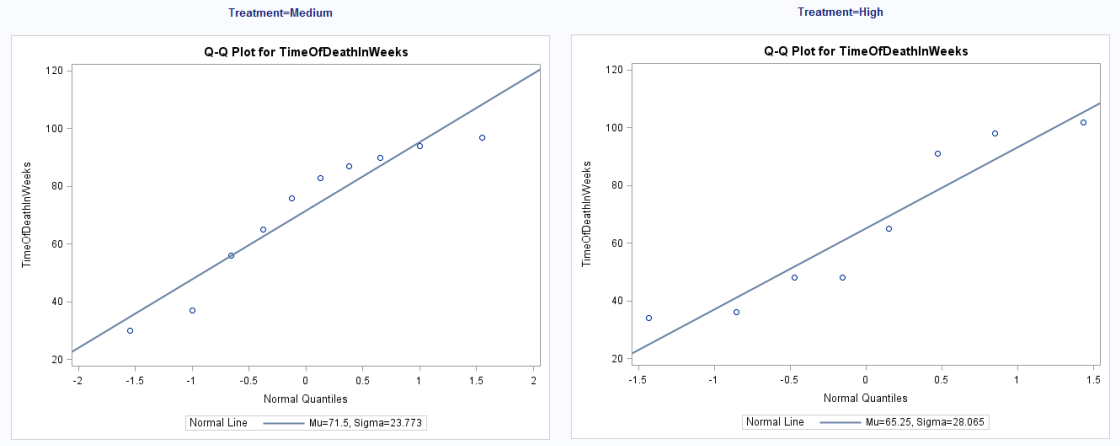
a. (9pts) Test the claim that there are any differences in location (mean or median) between the 4 groups. Perform a complete analysis.

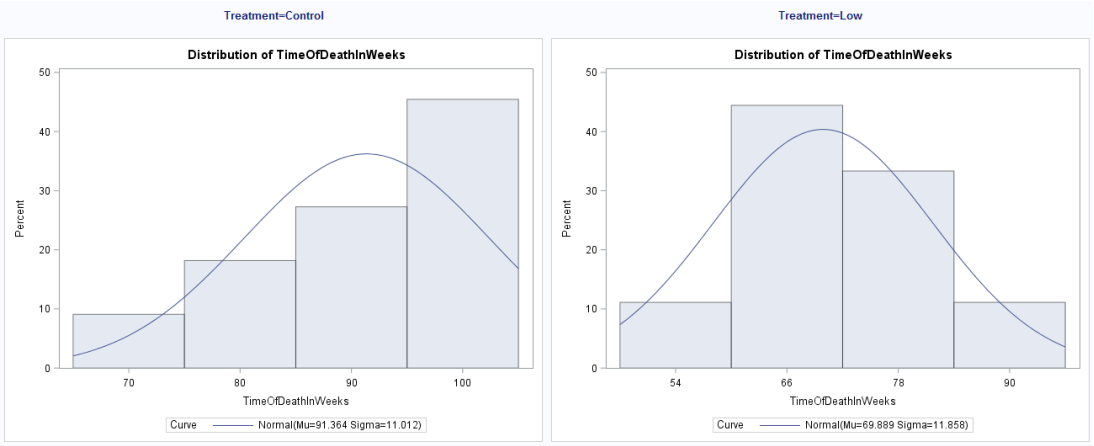
Assumptions

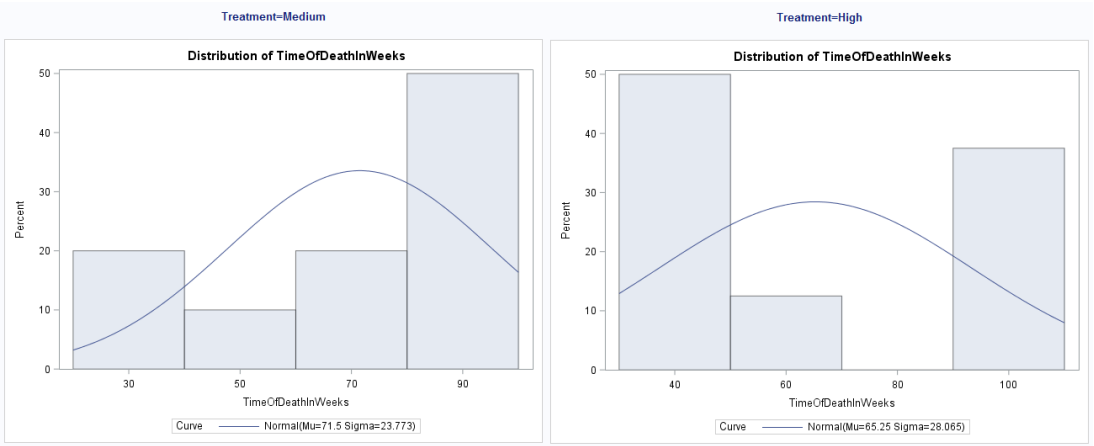
For this test, we would like to run an ANOVA test, as we want to see if there is a difference in means. First we must check for Normality, Equality of Variances, and Independent Observations.

We first perform a visual examination of the QQ plots and histograms of the 4 groups to determine if there is evidence against Normality. Judging from the 4 QQ plots and 4 histograms, there is no evidence to suggest that the data from the four groups are not Normal.

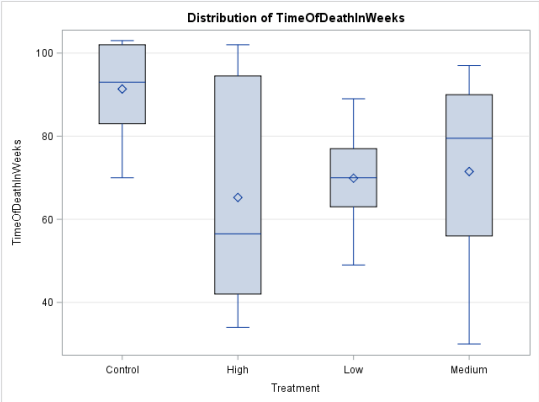








Next we perform a visual examination of the box plots of the 4 groups to determine if there is evidence against equal standard deviations. Judging from the box plots, the High dosage group and the Medium dosage group differ from the Control group and the Low dosage group. We also confirm with the descriptive statistics that the standard deviation for High and Medium dosage groups are about double that of the Control and Low dosage groups.



Level of Treatment	N	TimeOfDeathInWeeks Mean	Std Dev
Control	11	91.3636364	11.0115642
High	8	65.2500000	28.0649756
Low	9	69.8888889	11.8579556
Medium	10	71.5000000	23.7732342

Both the box plots and the calculated standard deviations reveal evidence against equality of variances across the 4 groups, with no serious outliers. For this reason, we can proceed with the Welch's ANOVA. We assume independence between and within the groups.

Welch's ANOVA for Weeks			
Source	DF	F Value	Pr > F
Group	3.0000	6.71	0.0035
Error	16.8887		

1. H_0: $\mu_{control} = \mu_{high} = \mu_{medium} = \mu_{low}$
   H_A: At least one pair of the groups has different means.
2. F-statistic: 6.71
3. p-value = .0035
4. Reject H_0 since .0035 < .05.
5. Conclusion: Welch's ANOVA suggests there is sufficient evidence at the alpha = .05 level of significance (p-value = 0.0035) that at least one pair of the groups have different mean time of death in weeks.

b. (9 pts) If the results of the above analysis provide evidence of a difference in mean or median time to death, which of the dosage treatments have significantly different mean or median times to death than the control (no dosage)? For this problem, make sure and state the problem, address any assumptions, provide the appropriate visual aids (tables, plots, etc), provide a clear and concise conclusion as well as the scope. Individual analysis may vary but should at least contain the above.

We have concluded that there is at least one pair of means that are different from the Welch's ANOVA test. We should run a Welch's T-Test for the difference in means from the control group to each of the treatment groups: high, medium, and low, respectively. We choose Satterthwaite methods for all 3 pairs of tests to use in our calculations to correspond to Welch's T-Test since we cannot assume the standard deviations are the same. As a side note, the differences in mean from the control group to the low dosage treatment group, either Pooled or Satterthwaite should suffice, as there is no violation of equality of variances between the control group and the low dosage group.

Control/High Group T-Test

Variable: TimeOfDeathInWeeks

Treatment	N	Mean	Std Dev	Std Err	Minimum	Maximum
Control	11	91.3636	11.0116	3.3201	70.0000	103.0
High	8	65.2500	28.0650	9.9225	34.0000	102.0
Diff (1-2)		26.1136	19.8909	9.2425		

Treatment	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
Control		91.3636	83.9660	98.7613	11.0116	7.6940	19.3246
High		65.2500	41.7871	88.7129	28.0650	18.5558	57.1199
Diff (1-2)	Pooled	26.1136	6.6136	45.6137	19.8909	14.9259	29.8194
Diff (1-2)	Satterthwaite	26.1136	2.2664	49.9609			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	17	2.83	0.0117
Satterthwaite	Unequal	8.5799	2.50	0.0353

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	7	10	6.50	0.0089

Step 1: Set up H_0 and H_A

We are conducting a two-tail test to the claim that the mean time of death for the control group is different than the mean time of death for the high dosage treatment group. Therefore, we will construct our null hypothesis to assume $\mu_{control}$ equals μ_{high}.

H_0: $\mu_{control} = \mu_{high}$

H_A: $\mu_{control} \neq \mu_{high}$

Step 2: Identify alpha and the critical value

The critical value has to be found from t-distribution calculator or lookup table, it's not part of the SAS output. Our hypothesis test is with a significance level (alpha) of .05. We are conducting a two-tail test; therefore we need to divide the alpha by 2 when calculating our t-score.

DF = 8.5799 (using the DF from Satterthwaite)

Critical Value = $t_{.05/2,8.5799} = \pm 2.279$

Step 3: Identify the test Statistic

The test statistic is outputted by SAS. We use the Satterthwaite value since this is a Welch's T-Test.

t = 2.50

Step 4: Find p-value

The p-value is outputted by SAS. We use the Satterhwaite value since this is a Welch's T-Test.

p-value = .0353

Step 5: Reject H_0 if the p-value is less than the significance level (alpha). Fail to reject if H_0 if it is not

Reject H_0 since .0353 < .05

Step 6: Conclusion

There is sufficient evidence at alpha = .05 level of significance (p-value = .0353) to suggest that the mean time of death in weeks of the control group is different than that of the high dosage treatment group. A 95% confidence interval for the mean time of death in weeks is (2.2664, 49.9609). Since zero is not within the confidence interval, it is consistent with our finding that the means are not equal. These findings are only valid for this study only, as the female mice were not randomly selected from a broader population.

Control/Medium Group T-Test

Variable: TimeOfDeathInWeeks

Treatment	N	Mean	Std Dev	Std Err	Minimum	Maximum
Control	11	91.3636	11.0116	3.3201	70.0000	103.0
Medium	10	71.5000	23.7732	7.5178	30.0000	97.0000
Diff (1-2)		19.8636	18.2079	7.9556		

Treatment	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
Control		91.3636	83.9660	98.7613	11.0116	7.6940	19.3246
Medium		71.5000	54.4937	88.5063	23.7732	16.3521	43.4007
Diff (1-2)	Pooled	19.8636	3.2123	36.5149	18.2079	13.8470	26.5940
Diff (1-2)	Satterthwaite	19.8636	2.0257	37.7016			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	19	2.50	0.0219
Satterthwaite	Unequal	12.428	2.42	0.0319

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	9	10	4.66	0.0246

Step 1: Set up H_0 and H_A

We are conducting a two-tail test to the claim that the mean time of death for the control group is different than the mean time of death for the medium dosage treatment group. Therefore, we will construct our null hypothesis to assume $\mu_{control}$ equals μ_{medium}.

H_0: $\mu_{control} = \mu_{medium}$

H_A: $\mu_{control} \neq \mu_{medium}$

Step 2: Identify alpha and the critical value

The critical value has to be found from t-distribution calculator or lookup table, it's not part of the SAS output. Our hypothesis test is with a significance level (alpha) of .05. We are conducting a two-tail test; therefore we need to divide the alpha by 2 when calculating our t-score.

DF = 12.428 (using the DF from Satterthwaite)

Critical Value = $t_{.05/2,12.428} = \pm 2.171$

Step 3: Identify the test Statistic

The test statistic is outputted by SAS. We use the Satterthwaite value since this is a Welch's T-Test.

t = 2.42

Step 4: Find p-value

The p-value is outputted by SAS. We use the Satterhwaite value since this is a Welch's T-Test.

p-value = .0319

Step 5: Reject H_0 if the p-value is less than the significance level (alpha). Fail to reject if H_0 if it is not
Reject H_0 since .0319 < .05

Step 6: Conclusion
There is sufficient evidence at alpha = .05 level of significance (p-value = .0319) to suggest that the mean time of death in weeks of the control group is different than that of the medium dosage treatment group. A 95% confidence interval for the mean time of death in weeks is (2.0257, 37.7016). Since zero is not within the confidence interval, it is consistent with our finding that the means are not equal. These findings are only valid for this study only, as the female mice were not randomly selected from a broader population.

Control/Low Group T-Test

Variable: TimeOfDeathInWeeks

Treatment	N	Mean	Std Dev	Std Err	Minimum	Maximum
Control	11	91.3636	11.0116	3.3201	70.0000	103.0
Low	9	69.8889	11.8580	3.9527	49.0000	89.0000
Diff (1-2)		21.4747	11.3955	5.1219		

Treatment	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
Control		91.3636	83.9660	98.7613	11.0116	7.6940	19.3246
Low		69.8889	60.7741	79.0037	11.8580	8.0095	22.7171
Diff (1-2)	Pooled	21.4747	10.7140	32.2355	11.3955	8.6106	16.8519
Diff (1-2)	Satterthwaite	21.4747	10.5660	32.3835			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	18	4.19	0.0005
Satterthwaite	Unequal	16.643	4.16	0.0007

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	8	10	1.16	0.8100

Step 1: Set up H_0 and H_A
We are conducting a two-tail test to the claim that the mean time of death for the control group is different than the mean time of death for the low dosage treatment group. Therefore, we will construct our null hypothesis to assume $\mu_{control}$ equals μ_{low}.

H_0: $\mu_{control} = \mu_{low}$
H_A: $\mu_{control} \neq \mu_{low}$

Step 2: Identify alpha and the critical value
The critical value has to be found from t-distribution calculator or lookup table, it's not part of the SAS output. Our hypothesis test is with a significance level (alpha) of .05. We are conducting a two-tail test; therefore we need to divide the alpha by 2 when calculating our t-score.

DF = 16.643
Critical Value = $t_{.05/2,16.643} = \pm 2.113$

Step 3: Identify the test Statistic
The test statistic is outputted by SAS. We use the Satterthwaite value since this is a Welch's T-Test.

t = 4.16

Step 4: Find p-value
The p-value is outputted by SAS. We use the Satterthwaite value since this is a Welch's T-Test.

p-value = .0007

Step 5: Reject H_0 if the p-value is less than the significance level (alpha). Fail to reject if H_0 if it is not

Reject H_0 since .0007 < .05

Step 6: Conclusion
There is sufficient evidence at alpha = .05 level of significance (p-value = .0007) to suggest that the mean time of death in weeks of the control group is different than that of the low dosage treatment group. A 95% confidence interval for the mean time of death in weeks is (10.566, 32.3835). Since zero is not within the confidence interval, it is consistent with our finding that the means are not equal. These findings are only valid for this study only, as the female mice were not randomly selected from a broader population.

c. (9pts) Would you feel comfortable using a contrast to test for a significant difference between the mean times to failure of the control and low dosage groups? If so perform this contrast. If not explain why?

Yes, a contrast to test for a significant difference between the mean times to failure of the control and low dosage groups would be possible. The control and low dosage groups can be assumed to have equal variances.

The GLM Procedure

Dependent Variable: TimeOfDeathInWeeks

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	4051.96039	1350.65346	3.55	0.0245
Error	34	12937.43434	380.51277		
Corrected Total	37	16989.39474			

R-Square	Coeff Var	Root MSE	TimeOfDeathInWeeks Mean
0.238499	25.81874	19.50674	75.55263

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	4051.960393	1350.653464	3.55	0.0245

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treatment	3	4051.960393	1350.653464	3.55	0.0245

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
CONTROL GROUP VS. LOW DOSAGE GROUP	1	2282.765657	2282.765657	6.00	0.0196

Step 1: Summary statistics
Sp = Root MSE = 19.50674; 34 d.f.

Step 2: Specify the coefficients for the linear combination

	Control	High	Low	Medium
n:	11	8	9	10
Average:	91.3636	65.2500	69.8889	71.5000
C:	1	0	-1	0

Step 3: Estimate the linear combination
g = (1)(91.3636) + (-1)(69.8889) = 21.4747

Step 4: Find the standard error of the estimate
SE(g) = 19.50674 $\sqrt{((1^2/11)+(-1^2/9))}$ = 8.7676

Step 5: Construct the 95% confidence interval
$t_{34}(0.975)$ = 2.0322
21.4747 ± (2.0322)(8.7676)
(3.657, 39.2922)

Step 6: Reject or fail to reject null hypothesis
H_0: $\gamma = 0$
H_A: $\gamma \neq 0$
$t = (g-\gamma)/SE(g) = 21.4747/8.7676 = 2.4493$
$p \approx .0196$
At α =0.05, Reject Null Hypothesis.

Conclusion
There is sufficient evidence at alpha = 0.05 level of significance (p-value = 0.0196) to suggest that there is a difference between the mean to failure of the control and low dosage groups. A 95% confidence interval for the mean to failure is (3.657, 39.2922). Since zero is not in the interval, it is consistent with the rejection of the null hypothesis.

5. (2 pts) Only two more to go! You're half way done! For this question simply identify the first Department Chair of Statistics at SMU. Google search SMU STATISTICS.

Paul Minton is the first Department Chair of Statistics at SMU.

6. (8 pts) Assume Merck Pharmaceuticals wanted to test a new cancer drug. In order to do so they tested it first on rats. 40 rats with the same cancer were selected (not at random from any bigger population) for the study and 20 were randomly selected to be administered the drug and 20 were not given any drug at all. The response variable is a cancer score in which the higher the number the more cancers cells are present in the rat. Histograms and QQ plots revealed evidence against the data coming from a normal distribution as well as visual evidence against equal standard deviations. Therefore, since only 20 samples were taken, the researchers were skeptical that they could use a pooled t test to test for difference in mean cancer score between the two groups. They also noticed that the sample with the bigger sample mean had the bigger sample standard deviation. For this reason a log transformation was performed. The researchers were satisfied that the log transformed data met the assumptions to perform a pooled t test. They performed the test on the logged data and the results are below. Assume all the assumptions of the pooled ttest are met with the logged data. Use the test results to interpret the test results for the researchers. Your answer should consist of a step 6 conclusion and scope discussion; all inference should be on

the original scale (cancer_score units, not logged units.). Just provide Step 6 (Conclusion) and the Scope. You **do not** need to do State the problem, address any assumptions or do Steps 1 – 5.

Variable: logcancer_score

Treatment	N	Mean	Std Dev	Std Err	Minimum	Maximum
Control	20	4.4032	0.3530	0.0789	3.8067	4.9416
Drug	20	3.6653	0.4497	0.1006	2.9957	4.3820
Diff (1-2)		0.7380	0.4043	0.1278		

Treatment	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
Control		4.4032	4.2380	4.5684	0.3530	0.2684	0.5155
Drug		3.6653	3.4548	3.8758	0.4497	0.3420	0.6569
Diff (1-2)	Pooled	0.7380	0.4792	0.9968	0.4043	0.3304	0.5210
Diff (1-2)	Satterthwaite	0.7380	0.4787	0.9972			

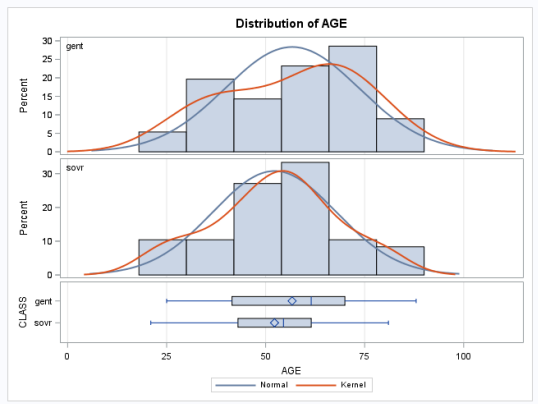
Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	38	5.77	<.0001
Satterthwaite	Unequal	35.968	5.77	<.0001

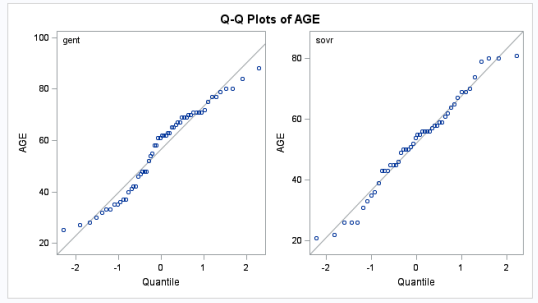
Step 6: Conclusion

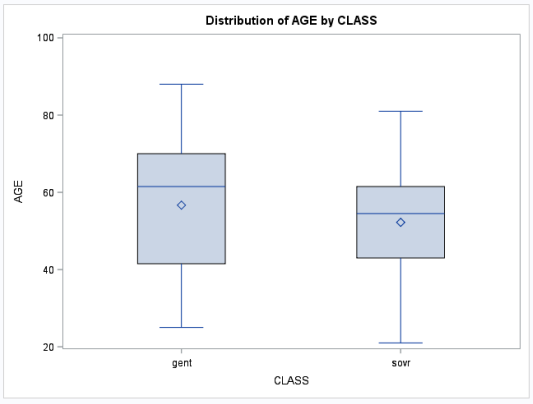
There is sufficient evidence at alpha = .05 level of significance (p-value < 0.0001) to suggest that the mean cancer score for the mice that were administered the drug is higher than the mice not given any drug at all. We have an estimate of the difference in means at 2.092. A 95% confidence interval for the mean score is (1.6148, 2.7096). Since zero is not within the confidence interval, it is consistent with our finding that the means are not equal. We cannot establish causality to the general population as the 40 rats were not selected randomly from a bigger population, but findings for this study can be accepted.

7. A researcher wants to test the hypothesis that life expectancy between the classes (sovereignty, gentry, aristocracy) in mid 1800's Europe was significantly different. To do this the researcher obtained a sample of the ages at death of 48 sovereignty, 56 gentry and 65 aristocracy members. These were obtained by looking at the first few pages of extensive records kept for families of each class. The records were in alphabetical order by first name. These data are in EuroDeathAge.csv.
    a. (9 pts) Test the claim that the mean or median life expectancy for the sovereignty is less than that of the gentry. Conduct a complete analysis.

Assumptions







Judging from the histograms and QQ plots from above, there is not sufficient evidence to suggest that the data does not come from a normal distribution, therefore we can assume they do. Furthermore, the histograms and boxplots do not provide evidence to suggest the standard deviations are different, thus we will assume they both have same standard deviations. Lastly, we assume that the observations are independent of each other. We can proceed with a Student's T-Test and make inferences to the mean life expectancy.

The TTEST Procedure

Variable: AGE

CLASS	N	Mean	Std Dev	Std Err	Minimum	Maximum
gent	56	56.6786	16.8934	2.2575	25.0000	88.0000
sovr	48	52.2292	15.5567	2.2454	21.0000	81.0000
Diff (1-2)		4.4494	16.2911	3.2044		

CLASS	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
gent		56.6786	52.1545	61.2026	16.8934	14.2424	20.7662
sovr		52.2292	47.7120	56.7464	15.5567	12.9504	19.4860
Diff (1-2)	Pooled	4.4494	-0.8697	Infty	16.2911	14.3295	18.8798
Diff (1-2)	Satterthwaite	4.4494	-0.8361	Infty			

Method	Variances	DF	t Value	Pr > t
Pooled	Equal	102	1.39	0.0840
Satterthwaite	Unequal	101.45	1.40	0.0827

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	55	47	1.18	0.5653

Step 1: Set up H_0 and H_A

We are conducting a one-tail test to the claim that the mean life expectancy for the sovereignty is less than that of the gentry. Therefore, we will construct our null hypothesis to assume $\mu_{sovereignty}$ is greater than or equal μ_{gentry}.

H_0: $\mu_{sovereignty} >= \mu_{gentry}$
H_A: $\mu_{sovereignty} < \mu_{gentry}$

Step 2: Identify alpha and the critical value
Our hypothesis test is with a significance level (alpha) of .05.

We are conducting a one-tail test; therefore we do not need to divide the alpha in 2 when calculating our t-score. We are only concerned about the area under the distribution curve on the right side.

$t_{102}(.95) = 1.66$

Step 3: Identify the test Statistic
t = 1.39

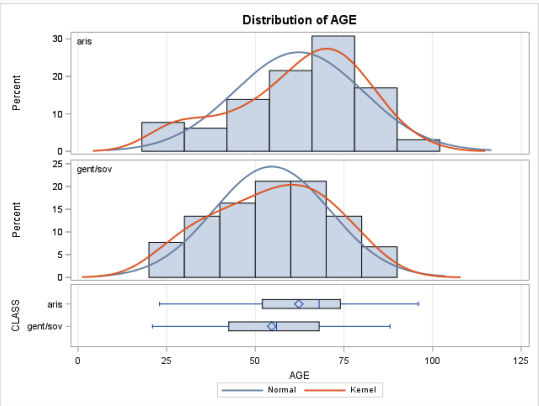
Step 4: Find p-value
p-value = 0.0840

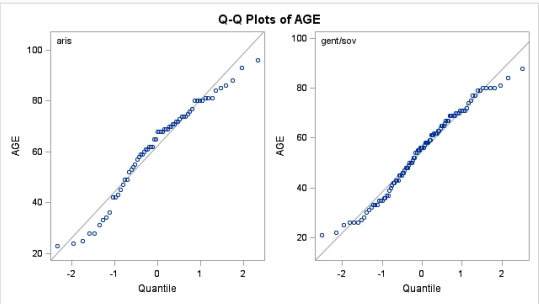
Step 5: Reject H0 if the p-value is less than the significance level (alpha). Fail to reject if H0 if it is not
Fail to reject H_0 since 0.0840 > .05.

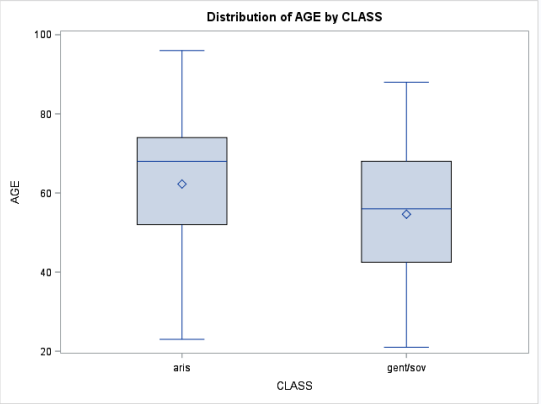
Step 6:
There is not sufficient evidence to suggest at alpha = .05 level of significance (p-value = .0840) that the mean life expectancy of the sovereignty group is greater than or equal to the mean life expectancy of the gentry. A 95% confidence interval is (-0.8697, infinity). As zero is contained in this interval, it is consistent with our conclusions of failing to reject the null hypothesis.

b. (9 pts) Next the researcher wants to test if the aristocracy has a greater mean life expectancy than the average of the sovereignty and gentry classes. Would a contrast be appropriate here? Why would you want to use a contrast if possible?

Assumptions







CLASS	N	Mean	Std Dev	Std Err	Minimum	Maximum
aris	65	62.2615	18.1050	2.2456	23.0000	96.0000
gent/sov	104	54.6250	16.3643	1.6047	21.0000	88.0000
Diff (1-2)		7.6365	17.0524	2.6962		

When we look at the histogram and qq plots for the group aristocracy and the combined sovereignty/gentry groups, we find that there is no evidence against equivalent standard deviations. Furthermore, we find that the standard deviations are almost the same and there are no outliers. Since we have met the requirements for a contrast test, running a contrast would be appropriate here. We would want to run a contrast here because there maybe a commonality between the sovereignty and gentry groups that is not in the aristocracy group leading to shorter life spans.

c. (9 pts) If appropriate, use a contrast to perform the analysis. Conduct a complete analysis.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	2844.35033	1422.17517	4.91	0.0085
Error	166	48049.24730	289.45330		
Corrected Total	168	50893.59763			

R-Square	Coeff Var	Root MSE	AGE Mean
0.055888	29.55646	17.01333	57.56213

Source	DF	Type I SS	Mean Square	F Value	Pr > F
CLASS	2	2844.350335	1422.175167	4.91	0.0085

Source	DF	Type III SS	Mean Square	F Value	Pr > F
CLASS	2	2844.350335	1422.175167	4.91	0.0085

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
ARISTOCRACY CLASS VS. SOVEREIGNTY AND GENTRY CLASS	1	2432.818428	2432.818428	8.40	0.0042

Step 1: Summary statistics

Sp = Root MSE = 17.013; 166 d.f.

Step 2: Specify the coefficients for the linear combination

	Aristocracy	Sovereignty	Gentry
n:	65	48	56
Average:	62.262	52.229	56.679
C:	2	-1	-1

Step 3: Estimate the linear combination

g = (2)(62.262) + (-1)(52.229) + (-1)(56.679) = 15.616

Step 4: Find the standard error of the estimate

$SE(g) = 17.013 \sqrt{((-2^2/65)+(1^2/48)+(1^2/56))} = 5.386$

Step 5: Construct the 95% confidence interval

$t_{166}(0.95) = 1.654$

$15.616 \pm (1.654)(5.386)$

(6.708, 24.524)

Step 6: Reject or fail to reject null hypothesis

H_0: $\gamma = 0$

H_A: $\gamma \neq 0$

$t = (g-\gamma)/SE(g) = 15.616/5.386 = 2.899$

$p \approx .0042$

At α =0.05, Reject Null Hypothesis.

Conclusion

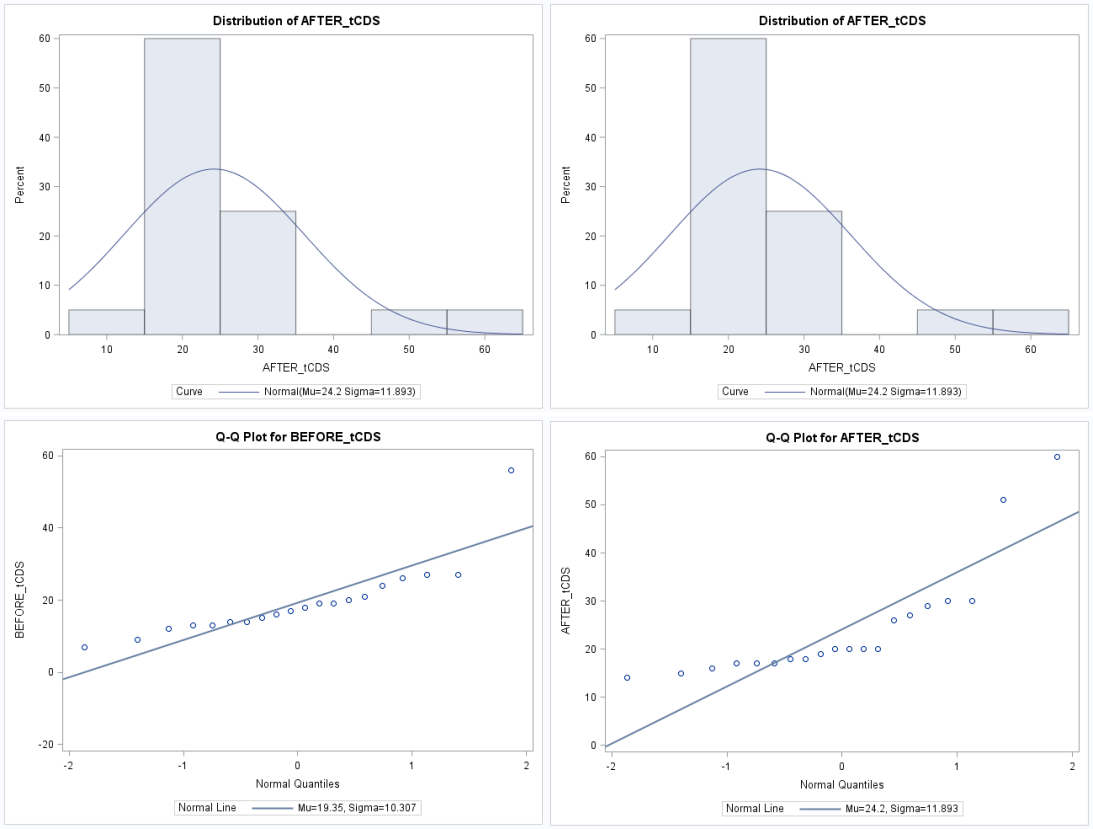
There is sufficient evidence at alpha = 0.05 level of significance (p-value = 0.0042) to suggest that the aristocracy class has a greater mean life expectancy than the combined groups of sovereignty and gentry class. A 95% confidence interval for the mean life expectancy is (6.708, 24.524). Since zero is not in the interval, it is consistent with the rejection of the null hypothesis.

8. BONUS TO COME!!!!

1. (3 pts) This data is the result of a quick test performed on a set of volunteers at SMU. There is a such things as tCDS (Transcranial direct current stimulation.) The theory is that by wearing a helmet that applies an electrical current to certain regions of the brain a subject may encounter an enhancement in memory. A group of researchers built a device to administer the current and wanted to test the phenomenon quickly and cheaply … which is wear the college students come in. So the researchers were able to find 20 volunteers and first had them try and memorize as many words as possible from a list of commonly used words in three minutes. The researchers then placed the helmet and administered the tCDS and asked them to try and memorize as many words as possible form a similar but different list of words. They were again given three minutes. The data show the number of words each subject memorized before and after tCDS. Perform a complete analysis to determine If there is evidence that the tCDS treatment worked. Again, please provide a complete yet efficient complete analysis. The data are below:

Subject	Before tCDS	After tCDS
1	24	26
2	18	17
3	27	30
4	16	20
5	19	18
6	27	30
7	13	16
8	26	27
9	19	20
10	56	51
11	12	20
12	9	29
13	15	17
14	21	20
15	14	15
16	7	60
17	14	17
18	17	18
19	13	14
20	20	19

<u>Assumptions</u>



When we look at the histograms and QQplots, we find evidence against normality. The data is right-skewed and contains outliers, which do not conform to the normal curve. Therefore, we rule out the standard t-tests and opt for a rank-sum test. Since these observations are dependent, meaning that the observations for “Before tCDS” and “After tCDS” are from the same subject, we have to use the Wilcoxon signed rank sum test since our assumption is that difference between the variables will not be normally distributed and the observations are paired. We use the “proc univariate” procedure in SAS to calculate the Wilcoxon signed rank result.

Tests for Location: Mu0=0				
Test	Statistic		p Value	
Student's t	t	1.756681	Pr > |t|	0.0951
Sign	M	5	Pr >= |M|	0.0414
Signed Rank	S	68	Pr >= |S|	0.0082

1. H_0 : $Median_{BeforetCDS} >= Median_{AftertCDS}$
   H_A: $Median_{BeforetCDS} < Median_{AftertCDS}$
2. Skip
3. S = 68
4. p-value = 0.0082
5. Reject H_0

6. There is sufficient evidence to suggest at the alpha = .05 level of significance (p-value = 0.0082) to support the claim that the subjects after tCDS was administered had higher median words memorized than before they had tCDS administered. We cannot establish causality to the general population as the 20 college students were not selected randomly from a bigger population, but findings for this study show that the tCDS treatment had an effect.

2. Use the permutation code we used earlier to generate an "exact" pvalue for the test performed in question

Goodness-of-Fit Tests for Normal Distribution				
Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.01803002	Pr > D	<0.010
Cramer-von Mises	W-Sq	0.29735018	Pr > W-Sq	<0.005
Anderson-Darling	A-Sq	1.85825288	Pr > A-Sq	<0.005

After running the tCDS data thru the permutation code, the result from the p-value from the permutation distribution are <0.010 or <0.005 depending on the goodness-of-fit test used. While the p-values differ slightly, they are consistent with the reject of our null hypothesis at our alpha = .05 level of significance.