R Tutorial for STAT 350 Lab 7

Author: Leonore Findsen, Chunyan Sun, Sarah H. Sellke, Jeremy Troisi

Example 1: (Data Set: eduproduct.txt – website)
Evaluation of a New Educational Product Your company markets educational materials aimed at parents of young children. You are planning a new product that is designed to improve children's reading comprehension. Your product is based on new ideas from educational research, and you would like to claim that children will acquire better reading comprehension skills utilizing these new ideas than with the traditional approach. Your marketing material will include the results of a study conducted to compare two versions of the new approach with the traditional method.[5] The standard method is called Basal, and the two variations of the new method are called DRTA and Strat.
Education researchers randomly divided 66 children into three groups of 22. Each group was taught by one of the three methods. The response variable is a measure of reading comprehension called COMP that was obtained by a test taken after the instruction was completed.

a) Make side-by-side boxplots and an effects plot of the data. Also, make a table giving the sample size, mean, and standard deviation for each treatment group. From this information, do you think that all of the means are the same? Be sure to comment on each of the plots.
b) Examine the assumptions necessary for ANOVA. Is it appropriate to continue the analysis? Be sure to state each of the assumptions and comment on each of them using the appropriate plots/data. Remember, you need to generate the normal probability plots and histograms for each population.
c) Run the ANOVA and report the results of the significance test (4 steps) using a significance level of 0.05. Are you results in this step consistent with part 1?.
d) Use an appropriate multiple-comparison method to determine if the different types of educational methods affects reading comprehension. Explain why you chose this method. Present a graphical representation of the results if appropriate for your method. Write a short statement on your conclusion.
e) Write a short report explaining the effect of this study. Be sure to answer the question posed in this question and how far this study can be generalized. This paragraph should be written in complete English sentences and should be understandable to someone who has not taken a course in Statistics.

Solution:

First you need to read in the data as before.

a) Make side-by-side boxplots and an effects plot of the data. Also, make a table giving the sample size, mean, and standard deviation for each treatment group. From this information, do you think that all of the means are the same? Be sure to comment on each of the plots.

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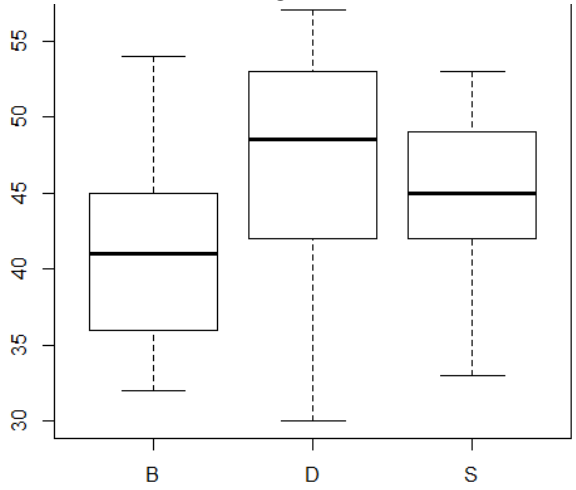
Solution:

side-by-side boxplots:

```
> boxplot(Comp~Group,ed)
```

(numeric variable ~ categorical variable, data frame)



Although there appears to be a reasonable enough departure of the majority of B from the majority of D, the departure visually is not significant enough to make a claim without a more rigorous mathematical test.

effects plot:

```
# the first line generates a dummy variable of the correct length with
value 1
# the second line generates the Effect Plot for the mean
> trace <- rep(1,length(ed$Group))
> interaction.plot(ed$Group,trace,ed$Comp,fun=mean,legend=F)
```

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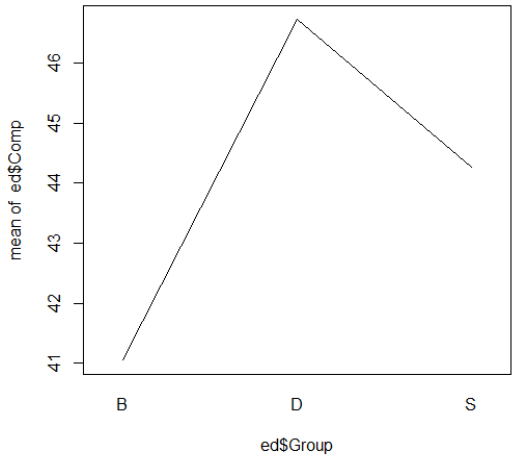

Maybe group D is higher.

Calculating the sample size, mean and standard deviation per category:

sample size:

```
> attach(ed)
> tapply(Comp, Group, length)
 B  D  S
22 22 22
```

mean:

```
> tapply(Comp, Group, mean)
       B        D        S
41.04545 46.72727 44.27273
```

standard deviation:

```
> tapply(Comp, Group, sd)
       B        D        S
5.635578 7.388420 5.766750
```

Group	n	sample mean	sample standard deviation
B	22	41.04545	5.635578
D	22	46.72727	7.388420
S	22	44.27273	5.766750

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It does not appear there is a significant departure of any of the means from one another observing their values and sample standard deviations (s). However, before such a claim can be made with any assertion, an ANOVA test is necessary and before such a test can be run, we must validate the assumptions for such a test are met.

b) Examine the assumptions necessary for ANOVA. Is it appropriate to continue the analysis? Be sure to state each of the assumptions and comment on each of them using the appropriate plots/data. Remember, you need to generate the normal probability plots and histograms for each population.

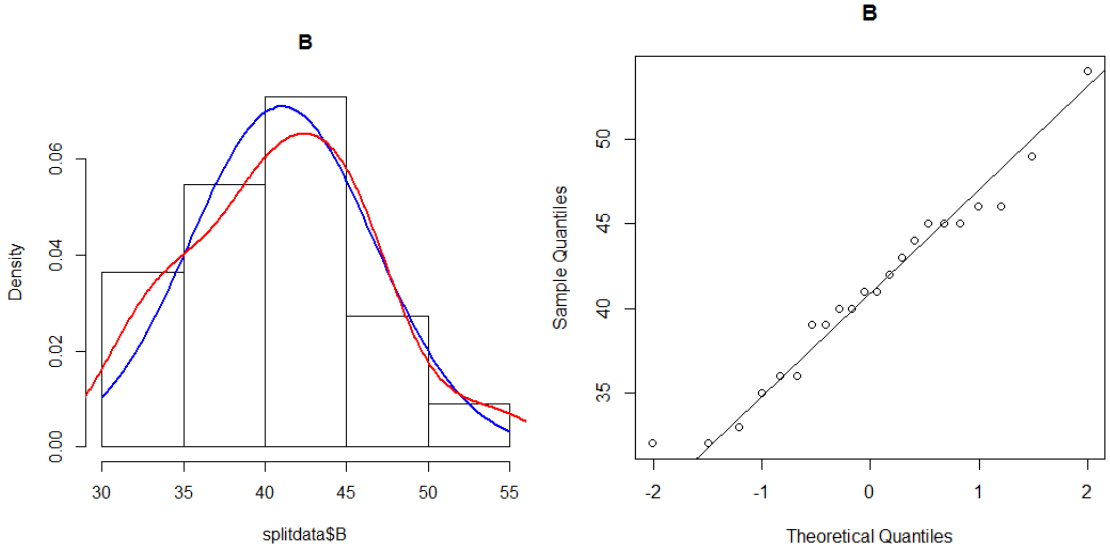
Solution:

qqnorm plots conditioned by group can easily be obtained in Lattice Graphics:

```
> library(lattice)
> qqmath(~Comp | Group, data = ed, layout = c(3, 1),
            panel = function(x){
               panel.qqmath(x)
               panel.qqmathline(x)
            })
```

However, last semester the plots were done in the base R package, so they will more than suffice in drawing our conclusions here.

Normality:



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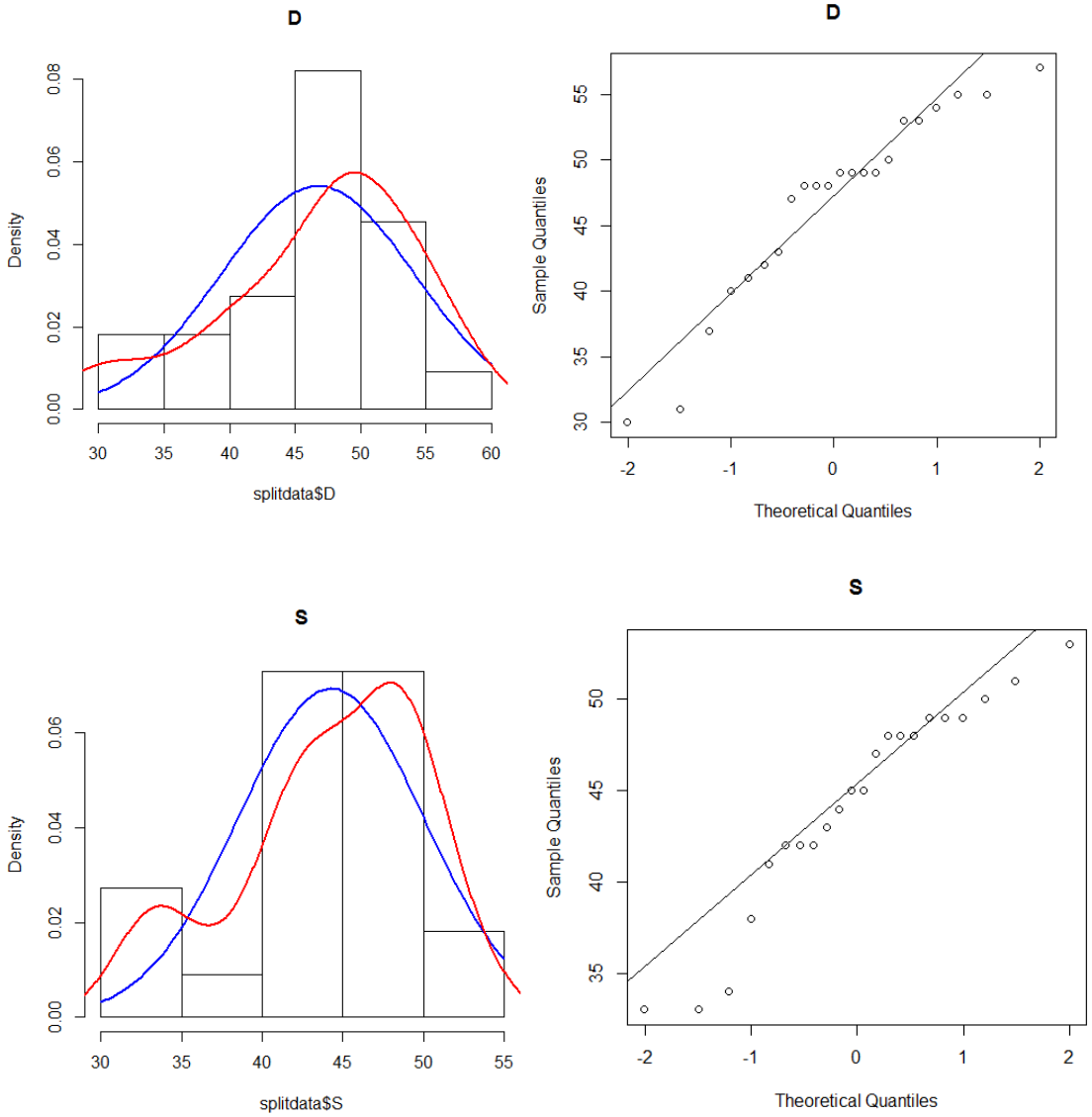


With a sample size of 22 *3 = 66, these qqnorm plots do not show a significant enough departure from normality for us not to be able to consider them normal.

Constant standard deviation

Twice the smallest s (s_B = 5.6) is greater than the largest s (s_D = 7.4), so the assumption of constant variance is met.

c) Run the ANOVA and report the results of the significance test (4 steps) using a significance level of 0.05. Are you results in this step consistent with part 1?.

Solution:

```
#ANOVA
# the command is aov(quant~qual, data = name above)
#  to print out the results, you need to use the summary command
#  note: this does not print out the 'total' line, you may calculate it
#     by hand or via R (BONUS).
fit <- aov(Comp ~ Group, data=ed)
summary(fit)

            Df Sum Sq Mean Sq F value Pr(>F)
Group        2  357.3  178.65   4.481 0.0152 *
Residuals   63 2511.7   39.87
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Step 0: Definition of the terms
μ_B is the population mean COMP score for the Basal method.
μ_D is the population mean COMP score for the DRTA method.
μ_S is the population mean COMP score for the Strat method.

Step 1: State the hypotheses
H_0: $\mu_B = \mu_D = \mu_S$
H_a: at least one μ_i is different.

Step 2: Find the *Test Statistic, report DF*.
$F_t = 4.481$
DF1 = p - 1 = 3 - 1 = 2, DF2 = n - p = 66 - 3 = 63

Step 3: Find the *p-value:*
P-value = 0.0152

Step 4: Conclusion:
$\alpha = 0.05$
Since 0.0152 < 0.05, we should reject H_0
The data provides sufficiently strong evidence (P-value = 0.0152) to the claim that the population mean values of at least one of the education methods is different from the rest.

d) Use an appropriate multiple-comparison method to determine if the different types of educational methods affects reading comprehension. Explain why you chose this method. Present a graphical representation of the results if appropriate for your method. Write a short statement on your conclusion.

Solution:

Bonferroni:

This method was chosen because we want to compare all of the means in a pairwise fashion.

```
> pairwise.t.test(ed$Comp,ed$Group,p.adjust="bon")

        Pairwise comparisons using t tests with pooled SD

data:  ed$Comp and ed$Group

  B     D
D 0.012 -
S 0.285 0.606

P value adjustment method: bonferroni
```

If the value in the table is greater than 0.05 (or your chosen value of α), then they are the same; otherwise, they are different.

This is stating that D/B are different and B/S and D/S are the same. This is easily seen using the following procedure:
1) Order the means in descending (or ascending order)
2) Draw a line when the groups are the same:

D (46.727) S (44.273) B (41.045)

Therefore the best method would be D and/or S.

Tukey:

This method was chosen because we want to compare all of the means in a pairwise fashion.

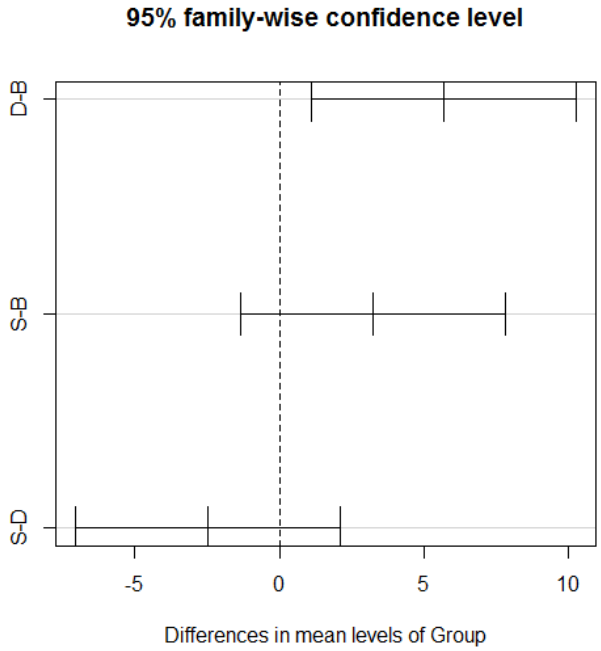
```
> test.Tukey<-TukeyHSD(fit,conf.level=0.95)
> test.Tukey

  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = Comp ~ Group, data = ed)

$Group
         diff       lwr       upr     p adj
D-B  5.681818  1.112137 10.251499 0.0111135
S-B  3.227273 -1.342408  7.796953 0.2149995
S-D -2.454545 -7.024226  2.115135 0.4064363

> plot(test.Tukey)
```



This graph easily indicates which of the pairs are the same (when the interval contains 0), but it is difficult for me to see the answer. So again, I would do this by hand:

This is stating that D/B are different and B/S and D/S are the same.

This is easily seen using the following procedure:
1) Order the means in descending (or ascending order)
2) Draw a line when the groups are the same:

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D (46.727) S (44.273) B (41.045)

Therefore the best method would be D and/or S.

e) Write a short report explaining the effect of this study. Be sure to answer the question posed in this question and how far this study can be generalized. This paragraph should be written in complete English sentences and should be understandable to someone who has not taken a course in Statistics.

From the original question, we want to determine if the new methods D and S are better than the traditional method, B. From the results in the study, method S is the same as method B, therefore the study did show that method D is better than the original method. Note that you do need to know whether a better score are a worse score is better.