How can I perform Tukey’s test in SAS?

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Tukey's test is a statistical method used to compare the means of multiple groups. In order to perform Tukey's test in SAS, you will need to follow these steps:

1. Import your data into SAS and make sure it is in a format suitable for analysis.
2. Use the PROC ANOVA statement to run an Analysis of Variance (ANOVA) test to determine if there are significant differences between the means of the groups.
3. If the ANOVA test indicates significant differences, use the LSMEANS statement to obtain the estimated means for each group.
4. Use the DIFF statement to specify the groups you want to compare and request the Tukey's test.
5. Run the code and examine the results to determine which groups have significant differences in means.

In summary, to perform Tukey's test in SAS, you will need to use the PROC ANOVA, LSMEANS, and DIFF statements to run the appropriate tests and obtain the results. This method can help you identify which groups have significantly different means and further analyze the differences between them.

Perform Tukey's Test in SAS

A one-way ANOVA is used to determine whether or not there is a statistically significant difference between the means of three or more independent groups.

If the overall p-value from the ANOVA table is less than some significance level, then we have sufficient evidence to say that at least one of the means of the groups is different from the others.

However, this doesn't tell us *which* groups are different from each other. It simply tells us that not all of the group means are equal.

In order to find out exactly which groups are different from each other, we must conduct a post hoc test.

One of the most commonly used post hoc tests is Tukey's Test, which allows us to make pairwise comparisons between the means of each group while controlling for the family-wise error rate.

The following example shows how to perform Tukey's Test in R.

Example: Tukey's Test in SAS

Suppose a researcher recruits 30 students to participate in a study. The students are to use one of three studying methods to prepare for an exam.

The exam results for each student are shown below:

Method A	Method B	Method C
78	81	84
81	83	88
82	83	88
82	85	89
85	86	90
88	88	93
88	90	95
90	91	98

We can use the following code to create this dataset in SAS:

```
/*create dataset*/
data my_data;
input Method $ Score;
datalines;
A 78
A 81
A 82
A 82
A 85
A 88
A 88
A 90
B 81
B 83
B 83
B 85
B 86
B 88
B 90
B 91
C 84
```

C 88
C 88
C 89
C 90
C 93
C 95
C 98
;
run;

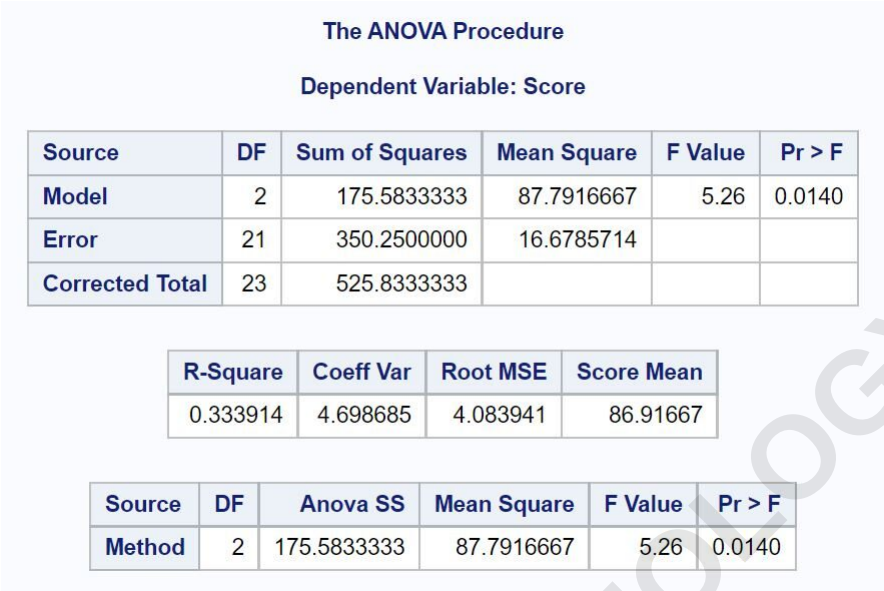
Next, we'll use proc ANOVA to perform the one-way ANOVA:

```
/*perform one-way ANOVA*/
proc ANOVAdata=my_data;
class Method;
model Score = Method;
means Method / tukey cldiff;
run;
```

Note: We used the means statement along with the tukey and cldiff options to specify that a Tukey post-hoc test should be performed (with confidence intervals) if the overall p-value of the one-way ANOVA is

statistically significant.

First, we'll analyze the ANOVA table in the output:



The ANOVA Procedure

Dependent Variable: Score

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	175.5833333	87.7916667	5.26	0.0140
Error	21	350.2500000	16.6785714		
Corrected Total	23	525.8333333			

R-Square	Coeff Var	Root MSE	Score Mean
0.333914	4.698685	4.083941	86.91667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Method	2	175.5833333	87.7916667	5.26	0.0140

The overall F Value: 5.26The corresponding p-value: 0.0140

Recall that a one-way ANOVA uses the following null and alternative hypotheses:

H0: All group means are equal.HA: At least one group mean is different from the rest.

Since the p-value from the ANOVA table (0.0140) is less than α = .05, we reject the null hypothesis.

This tells us that the mean exam score is not equal between the three studying methods.

To determine exactly which group means are different, we must refer to the final table in the output that shows the results of the Tukey post-hoc tests:

The ANOVA Procedure

Tukey's Studentized Range (HSD) Test for Score

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	21
Error Mean Square	16.67857
Critical Value of Studentized Range	3.56462
Minimum Significant Difference	5.1469

Comparisons significant at the 0.05 level are indicated by ***.

Method Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
C - B	4.750	-0.397	9.897	
C - A	6.375	1.228	11.522	***
B - C	-4.750	-9.897	0.397	
B - A	1.625	-3.522	6.772	
A - C	-6.375	-11.522	-1.228	***
A - B	-1.625	-6.772	3.522	

To tell which group means are different, we must look at which pairwise comparisons have stars (***) next to them.

From the table we can see there is a statistically significant difference in mean exam scores between group A and group C.

There are no statistically significant differences between any other group means.

The following tutorials provide additional information about ANOVA models:

A Guide to Using Post Hoc Tests with ANOVA