

Extra sum of squares: testing equality in a subset of groups

Example dataset: case 0502.jmp

Question: whether the six other judges (not Spock's) have the same mean percentage of women on their venires?

$H_0: \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7$

H_1 : at least one " \neq "

group	1	2	3	4	5	6	7
Full model	μ_1	μ_2	μ_3	μ_4	μ_5	μ_6	μ_7
Reduced model	μ_1	μ_0	μ_0	μ_0	μ_0	μ_0	μ_0

Steps:

- 1) generate a new column (group ids) for the reduced model
- 2) run ANOVA for the full model \rightarrow [fit y by x]
- 3) run ANOVA for the reduced model \rightarrow [fit y by x]
- 4) calculate the difference between error sum of squares, and find the p-value for the F statistic.

Linear Combinations and Multiple Comparisons of Means

1. Using JMP to specify and solve linear combinations: dataset: feed.jmp

Launch *Fit Model* platform, specify the appropriate variables for the ANOVA, including the response variable Y (mass) and explanatory effects X (feed type).

Running the model generates the F -statistic that test the null hypothesis of equal means which we reject.

To examine the more specific questions with linear combinations, click the triangle next to the effect of interest and select *LS Means Contrast...* which yields a “Contrast Specification” dialog box where you click + or - to specify the contrast of interest. The appropriate orthogonal coefficients are generated automatically.

Contrast

Contrast Specification

Feed Grp

1	0	+	-
2	0	+	-
3	0	+	-
4	0	+	-

Click on + or - to make contrast values.

Contrast

Test Detail

1	1	0	0
2	0	1	0
3	0	0	1
4	-1	-1	-1
Estimate	-25.62	-16.94	14.11
Std Error	1.85	1.85	1.9623
t Ratio	-13.85	-9.157	7.1907
Prob> t	6e-10	1.6e-7	3.1e-6
SS	1641	717.41	442.43

Sum of Squares	4226.3478947
Numerator DF	3
Denominator DF	15
F Ratio	164.64152297
Prob > F	1.061311e-11

2. Using JMP for Unplanned Comparisons

Choose the *Fit Y to X* platform, the appropriate *Y* and *X* variables, then *Compare Means*. JMP offers:

- **Compare Each Pair:** LSD procedure; computes pairwise comparisons among means using Student's *t* test. This procedure does not control the familywise error rate;
- **Compare All Pairs:** Tukey or Tukey-Kramer HSD procedure; controls the familywise error rate; exact test if sample sizes are the same; conservative if sample sizes differ.
- **Compare with Best:** Hsu MCB procedure; tests whether means are < the unknown maximum or >the unknown minimum.
- **Compare with Control:** Dunnett's procedure; tests whether means are different from the mean of a control group.

You can adjust the α -level used by these procedures (default is 5%) if you choose *Set Alpha Level* from the menu within the *Fit Y by X* platform.

LSD and Tukey are also available in the Fit Model Platform.

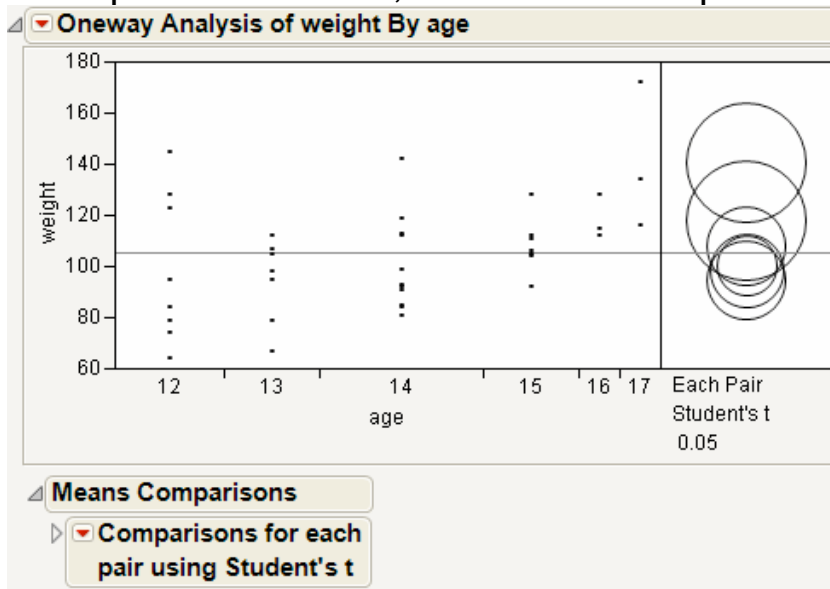
Example of the Each Pair, Student's t Test

This example uses the Big Class.jmp sample data table. It shows a one-way layout of weight by age, and shows the group comparison using comparison circles that illustrate all possible t-tests.

1. Open the Big Class.jmp sample data table.
2. Select Analyze > Fit Y by X.
3. Select weight and click Y, Response.
4. Select age and click X, Factor.
5. Click OK.

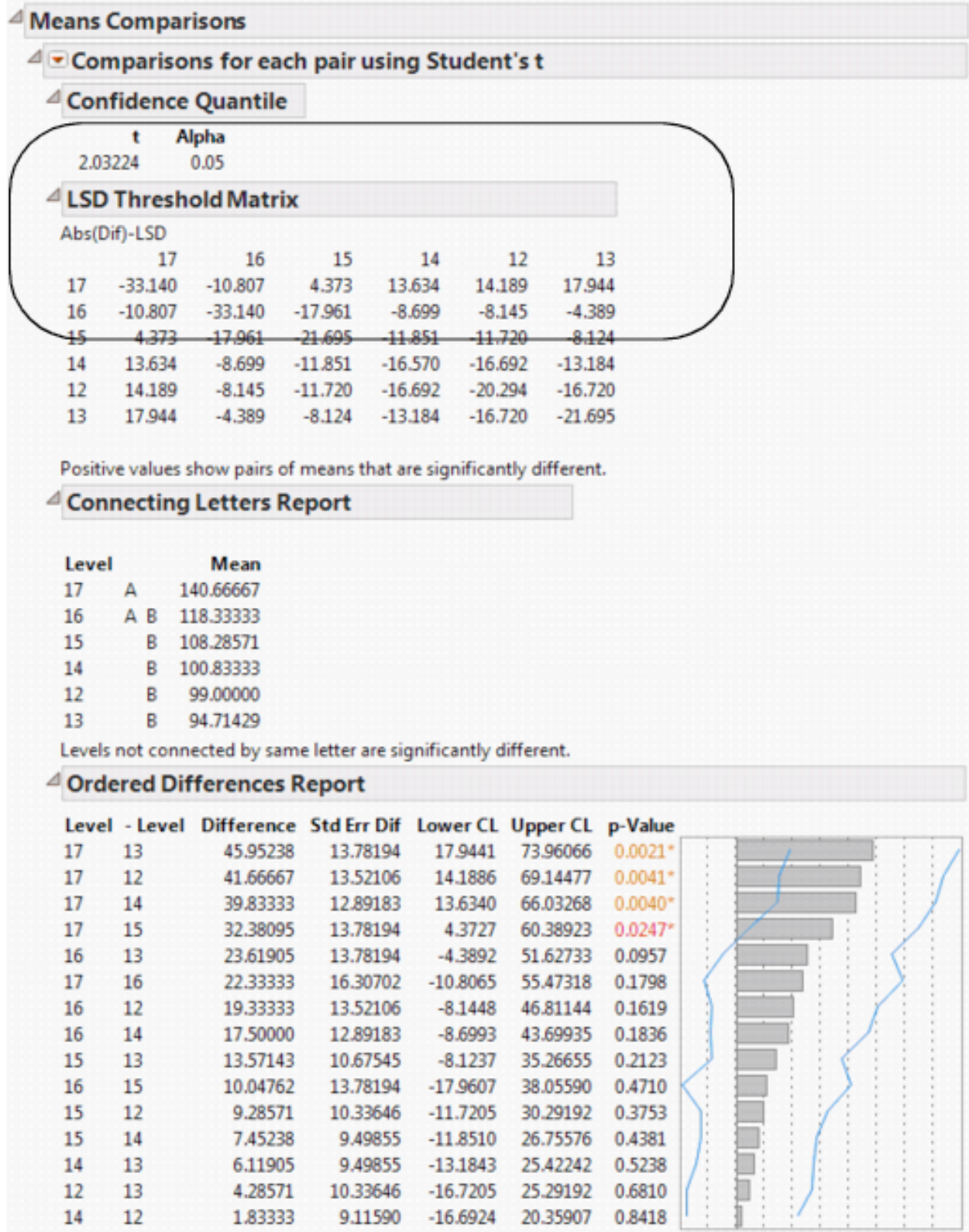
From the red triangle menu, select Compare Means > Each Pair, Student's t.

Example of Each Pair, Student's t Comparison Circles



The means comparison method can be thought of as seeing if the actual difference in the means is greater than the difference that would be significant. This difference is called the LSD (least significant difference). The LSD term is used for Student's t intervals and in context with intervals for other tests. In the comparison circles graph, the distance between the circles' centers represent the actual difference. The LSD is what the distance would be if the circles intersected at right angles.

Example of Means Comparisons Report for Each Pair, Student's t



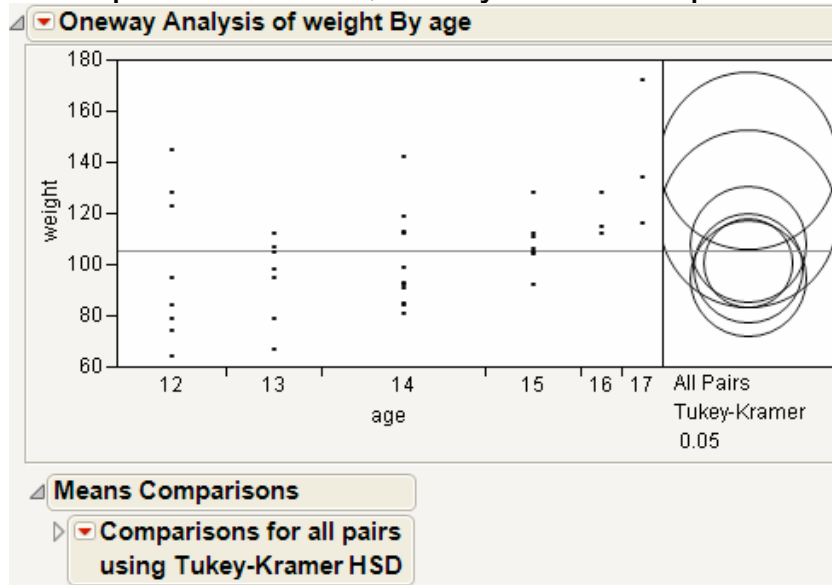
In Example of Means Comparisons Report for Each Pair, Student's t, the LSD threshold table shows the difference between the absolute difference in the means and the LSD (least significant difference). If the values are positive, the difference in the two means is larger than the LSD, and the two groups are significantly different.

Example of the All Pairs, Tukey HSD Test

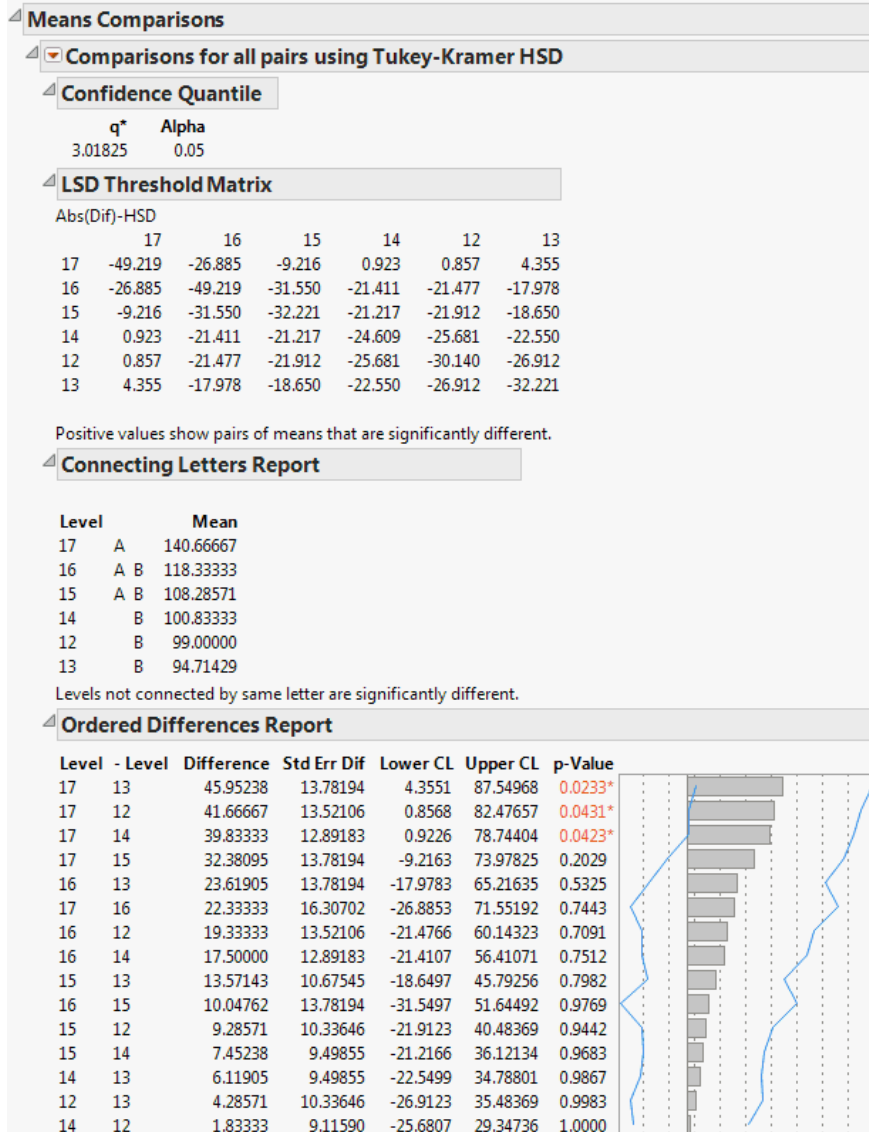
1. Open the Big Class.jmp sample data table.
2. Select Analyze > Fit Y by X.
3. Select weight and click Y, Response.
4. Select age and click X, Factor.
5. Click OK.

From the red triangle menu, select Compare Means > All Pairs, Tukey HSD.

Example of All Pairs, Tukey HSD Comparison Circles



Example of Means Comparisons Report for All Pairs, Tukey HSD



In Example of Means Comparisons Report for All Pairs, Tukey HSD, the Tukey-Kramer HSD Threshold matrix shows the actual absolute difference in the means minus the HSD, which is the difference that would be significant. Pairs with a positive value are significantly different. The q^* (appearing above the HSD Threshold Matrix table) is the quantile that is used to scale the HSDs. It has a computational role comparable to a Student's t .

Example of the With Best, Hsu MCB Test

1. Open the Big Class.jmp sample data table.
2. Select Analyze > Fit Y by X.

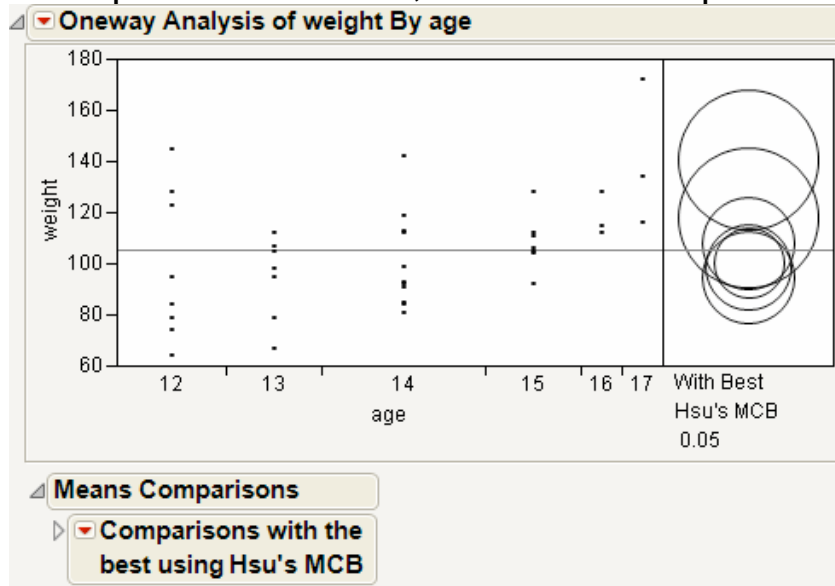
3. Select weight and click Y, Response.

4. Select age and click X, Factor.

5. Click OK.

From the red triangle menu, select Compare Means > With Best, Hsu MCB.

Examples of With Best, Hsu MCB Comparison Circles



Example of Means Comparisons Report for With Best, Hsu MCB

Comparisons with the best using Hsu's MCB

Confidence Quantile

d	Alpha
2.23157	0.05
2.23157	
2.34056	
2.38159	
2.35278	
2.34056	

Comparison vs. Min/Max

Level	vs. Max p-Value	vs. Min p-Value
17	.	0.0039*
16	0.2162	0.1268
15	0.0441*	0.2978
14	0.0075*	0.6416
12	0.0080*	0.7071
13	0.0036*	0.9365

LSD Threshold Matrix

Mean[i]-Mean[j]-LSD

	17	16	15	14	12	13
17	-36.390	-14.057	0.124	9.130	9.855	13.695
16	-58.724	-36.390	-22.210	-13.203	-12.479	-8.638
15	-63.136	-40.803	-24.987	-15.169	-15.034	-11.415
14	-68.602	-46.269	-29.684	-19.418	-19.614	-16.113
12	-71.840	-49.507	-33.479	-23.544	-23.495	-19.907
13	-76.708	-54.374	-38.558	-28.741	-28.605	-24.987

If a column has any positive values, the mean is significantly less than the max.

Mean[i]-Mean[j]+LSD

	17	16	15	14	12	13
17	36.390	58.724	64.638	70.536	73.479	78.210
16	14.057	36.390	42.305	48.203	51.145	55.876
15	-1.626	20.708	24.987	30.074	33.605	38.558
14	-11.064	11.269	14.780	19.418	23.281	28.351
12	-11.493	10.840	14.907	19.877	23.495	28.479
13	-15.197	7.136	11.415	16.503	20.034	24.987

The Comparison vs. Min/Max report compares each level to the minimum and the maximum level. For example, level 17 is the only level that is significantly different from the minimum level.

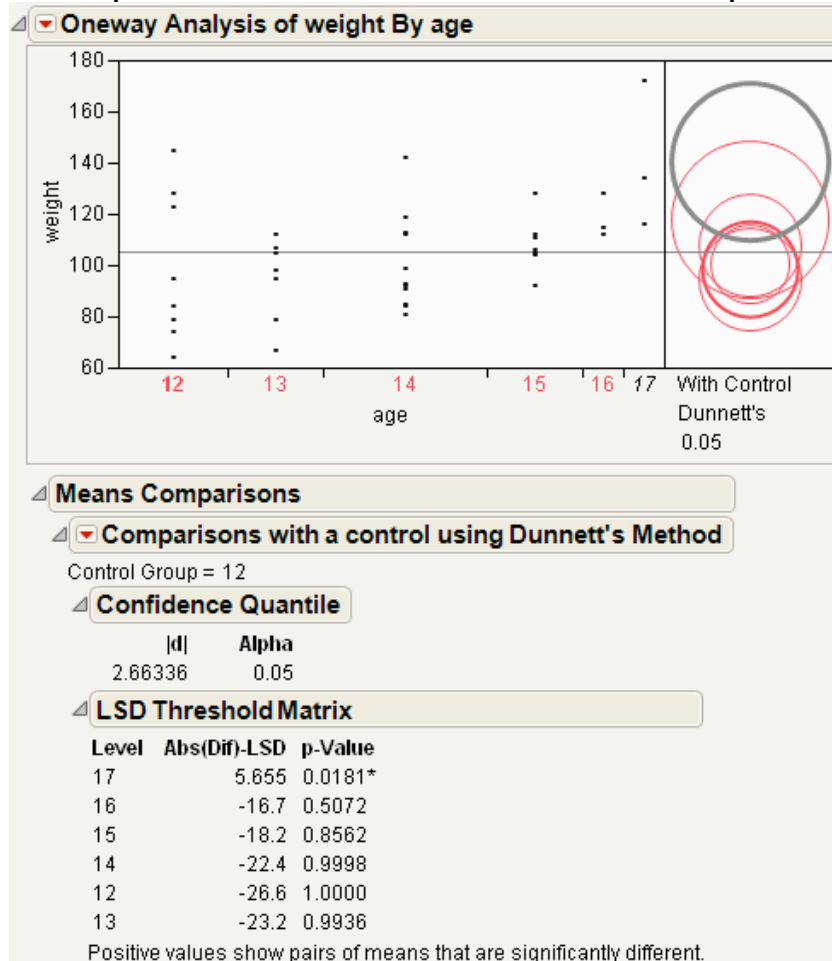
Example of the With Control, Dunnett's Test

1. Open the Big Class.jmp sample data table.
2. Select Analyze > Fit Y by X.
3. Select weight and click Y, Response.
4. Select age and click X, Factor.
5. Click OK.

From the red triangle menu, select Compare Means > With Control, Dunnett's.

Select the group to use as the control group. In this example, select age 12.

Example of With Control, Dunnett's Comparison Circles



Using the comparison circles in Example of With Control, Dunnett's Comparison Circles, you can conclude that level 17 is the only level that is significantly different from the control level of 12.

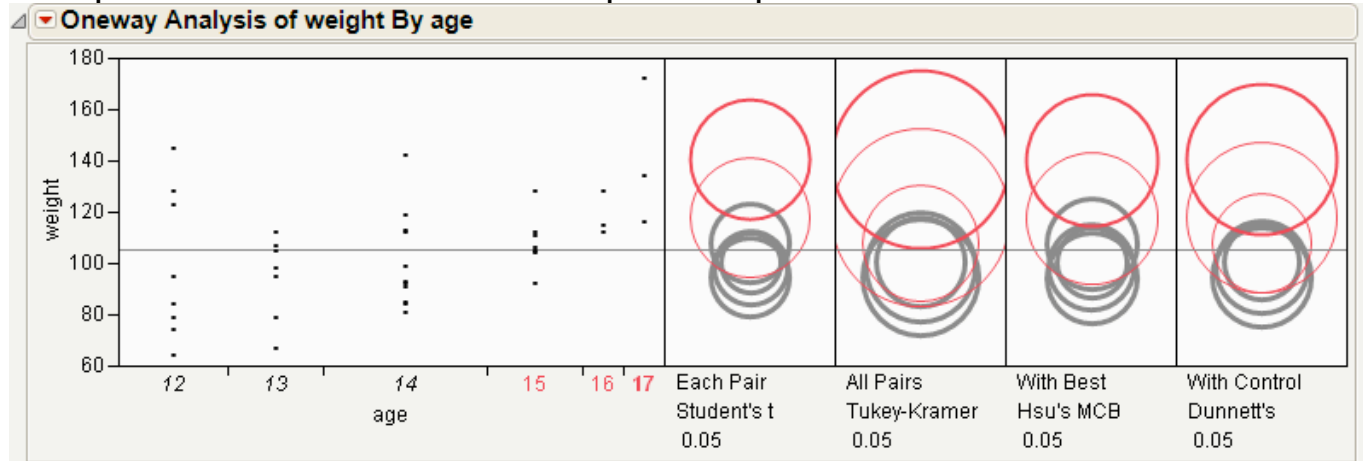
Example Contrasting All of the Compare Means Tests

1. Open the Big Class.jmp sample data table.
2. Select Analyze > Fit Y by X.
3. Select weight and click Y, Response.
4. Select age and click X, Factor.
5. Click OK.
6. From the red triangle menu, select each one of the Compare Means options.

Although the four methods all test differences between group means, different results can occur. Comparison Circles for Four

Multiple Comparison Tests shows the comparison circles for all four tests, with the age 17 group as the control group.

Comparison Circles for Four Multiple Comparison Tests



From Comparison Circles for Four Multiple Comparison Tests, notice that for the Student's t and Hsu methods, age group 15 (the third circle from the top) is significantly different from the control group and appears gray. But, for the Tukey and Dunnett method, age group 15 is not significantly different, and appears red.