The ANOVA for Independent Groups — Analysis of k-Between-Group Data with a Quantitative DV

Application: To compare means of a quantitative variable obtained from 2 or more independent groups.

Research Hypothesis: The researcher hypothesized that Coop stores would have the most fish on display, Chain stores would display the least, and Private pet stores would display an intermediate amount.

H0: for this analysis: The three different types of pet shops have the mean number of fish displayed.

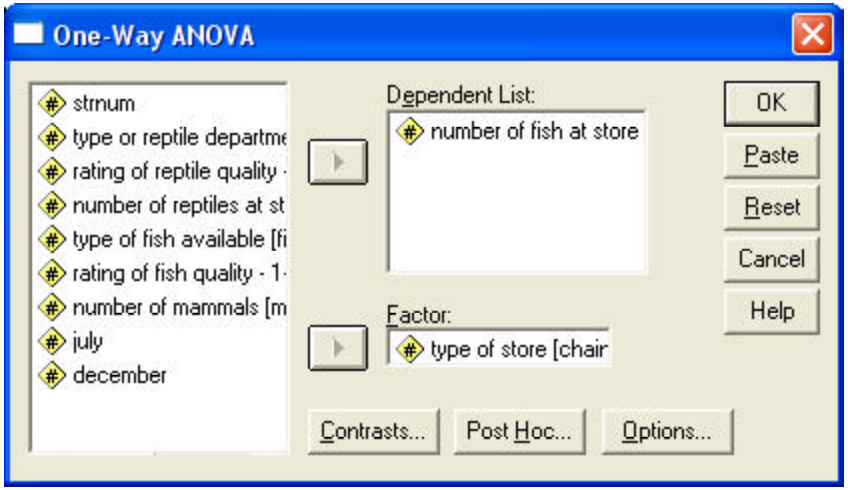
Research Design: The IV is Type of Pet Store, with the conditions Chain, Private & Coop
The DV is the number of fish

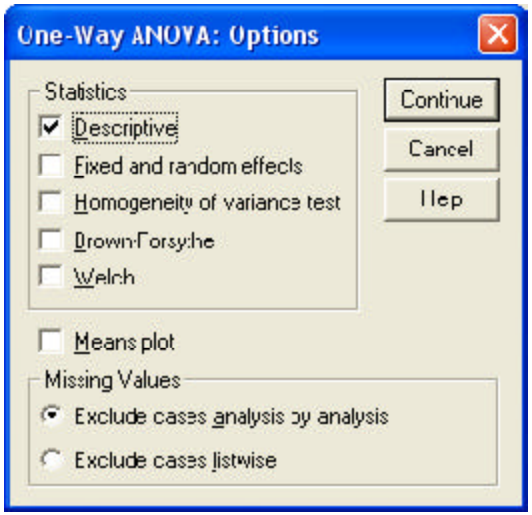
Variables in the Analysis: In a BG design the variables in the analysis are the IV (Type of Pet Store) and the DV (number of Fish)

Type of Pet Store		
Chain	**Private**	**Coop**

Analyze ➔ Compare Means ➔ One-way ANOVA

- highlight the "Dependent" variable (be sure it is **quantitative**) and click the arrow
- highlight the "Factor" (IV, grouping) variable (be sure it is **qualitative**) and click the arrow
- click "Options" — in the **One-Way ANOVA: Options** window check that you want "Descriptive Statistics





Descriptives

number of fish at store

	N	Mean	Std. Deviation	Std. Error
chain store	5	17.40	5.030	2.249
privately owned	3	19.33	4.041	2.333
coop	4	35.50	4.796	2.398
Total	12	23.92	9.605	2.773

The univariate statistics for each IV condition.

ANOVA

number of fish at store

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	812.050	2	406.025	18.013	.001
Within Groups	202.867	9	22.541		
Total	1014.917	11			

p-value There is a significant difference among the mean of the three types of store

This is the "error term" -- the MSE (mean square error)

This is the df error

Steps for computing and interpreting LSD minimum mean difference

1. Dermine df(error) for the analysis **df(error) = 9**
2. Use the attached t-table to determine the critical value of t (at p = .05) for this df(error) with df = 9, **t-critical = 2.26**
3. Determine the MSerror for the analysis **MSerror = 22.54**
4. Determine the average number of participants in each group -- ave of 5, 3 & 4 = 4 **n = 4**
5. Apply the LSD formula to obtain the minimum mean difference

$$d_{LSD} = \frac{t * \sqrt{(2 * MS_{Error})}}{\sqrt{n}} = \frac{2.26 * \sqrt{(2 * 22.54)}}{\sqrt{4}} = \mathbf{7.58}$$

6. Compare the minimum mean difference (7.58) with each pairwise mean difference
   -- if the pairwise mean difference is larger than the minimum mean difference, then those two conditions have means that are "significantly different"
   -- if the pairwise mean difference is smaller than the minimum mean difference, then those two conditions have means that are "statistically equivalent"

For this analysis -- compare the minimum mean difference of 4.89 with each of the pairwise differences

The average number of fish at Chain (M=17.40) and Private (M=19.33) store was not statistically different (the mean difference of 1.93 is less than the min mean dif of 7.58). Coop stores (M=35.50) had more fish than either Chain stores (both pairwise differences were larger than the min mean dif.)

Reporting the Results

The number of fish displayed at each type of store is summarized in Table 1. There were significant mean differences in the number of fish displayed among the three types of stores, F(2,9) = 18.01, Mse = 22.54, p <.05. Pairwise comparisons using LSD (with a minimum mean difference = 7.58) revealed that, consistent with the research hypothesis, Coop stores displayed more fish than either Private or Chain stores. However, contrary to the research hypothesis, there was no difference between the average number of fish displayed by Chain and Private pet stores.

Table 1.
Summary of fish displayed by each of the three types of stores

	Store Type		
	Chain	Privately	Coop
Number of Fish Displayed	Store	Owned	Store
Mean	17.40	19.33	35.50
Standard deviation	5.03	4.04	4.80

t-table Critical values of t for α = .05 & α = .01

df	α = .05	α = .01
1	12.71	63.66
2	4.30	9.92
3	3.18	5.84
4	2.78	4.60
5	2.57	4.03
6	2.45	3.71
7	2.36	3.50
8	2.31	3.36
9	2.26	3.25
10	2.23	3 17
11	2.20	3.11
12	2.18	3.06
13	2.16	3.01
14	2.14	2.98
15	2.13	2.95
16	2.12	2.92
17	2.11	2.90
18	2.10	2.88
19	2.09	2.86
20	2.09	2.84
21	2.08	2.83
22	2.07	2.82
23	2.07	2.81
24	2.06	2.80
25	2.06	2.79
26	2.06	2.78
27	2.05	2.77
28	2.05	2.76
29	2.04	2.76
30	2.04	2.75
40	2.02	2.70
60	2.00	2.66
120	1.98	2.62
∞	1.96	2.58

Steps for computing and interpreting HSD minimum mean difference

1. Determine the MSerror for the analysis **MSerror = 22.54**
2. Determine the average number of participants in each group -- ave of 5, 3 & 4 = 4 **n = 4**
3. Determind k, the nubmer of IV conditions in the designm **k = 3**
4. Dermine df(error) for the analysis **df(error) = 9**
5. Use the table of Q values to determine the value of Q with df = 9 and k = 3 means **Q = 3.95**
6. Apply the HSD formula to obtain the minimum mean difference

$$d_{HSD} = Q * \frac{\sqrt{MS_{Error}}}{\sqrt{n}} = \frac{3.95 * \sqrt{22.54}}{\sqrt{4}} = \mathbf{9.36}$$

6. Compare the minimum mean difference (9.36) with each pairwise mean difference
   -- if the pairwise mean difference is larger than the minimum mean difference, then those two conditions have means that are "significantly different"
   -- if the pairwise mean difference is smaller than the minimum mean difference, then those two conditions have means that are "statistically equivalent"

By the Way: Sometimes LSD and HSD analyses will produce different results for one or more of the pairwise comparisons. If so, the difference will always be that you have rejected H0: based on the LSD test (the more sensitive test) and retained H0: based on the HSD test (the more conservative test). When this happens you should consider the general trend among statisticians (and journal editors) towards "statistical conservatism". More importantly, you should remember that rejecting the null for a particular analysis is not a guarantee that the effect is "really there" . Replication (finding the effect in several different studies) is a much better indicator of the "reality" of an effect.

Reporting the Results

The number of fish displayed at each type of store is summarized in Table 1. There were significant mean differences in the number of fish displayed among the three types of stores, F(2,9) = 18.01, Mse = 22.54, p <.05. Pairwise comparisons using HSD (with a minimum mean difference = 9.36) revealed that, consistent with the research hypothesis, Coop stores displayed more fish than either Private or Chain stores. However, contrary to the research hypothesis, there was no difference between the average number of fish displayed by Chain and Private pet stores.

Table 1.
Summary of fish displayed by each of the three types of stores

	Store Type		
Number of Fish Displayed	Chain Store	Privately Owned	Coop Store
Mean	17.40	19.33	35.50
Standard deviation	5.03	4.04	4.80

Studentized Range Statistic Table
Values of Q for α = .05

Denominator df	k = number of means 2	3	4	5	6
5	3.64	4.60	5.22	5.67	6.03
6	3.46	4.34	4.90	5.30	5.63
7	3.34	4.16	4.68	5.06	5.36
8	3.26	4.04	4.53	4.89	5.17
9	3.20	3.95	4.41	4.76	5.02
10	3.15	3.88	4.33	4.65	4.91
11	3.11	3.82	4.26	4.57	4.82
12	3.08	3.77	4.20	4.51	4.75
13	3.06	3.73	4.15	4.45	4.69
14	3.03	3.70	4.11	4.41	4.64
15	3.01	3.67	4.08	4.37	4.59
16	3.00	3.65	4.05	4.33	4.56
17	2.98	3.63	4.02	4.30	4.52
18	2.97	3.61	4.00	4.28	4.49
19	2.96	3.59	3.98	4.25	4.47
20	2.95	3.58	3.96~	4.23	4.45
24	2.92	3.53	3.90	4.17	4-37
30	2.89	3.49	3.85	4.10	4.30
40	2.86	3.44	3.79	4.04	4.23
60	2.83	3.40	3.74	3.98	4.16
120	2.80	3.36	3.68	3.92	4.10
∞	2.77	3.31	3.63	3.86	4.03