

3-Way Between Groups Factorial ANOVA

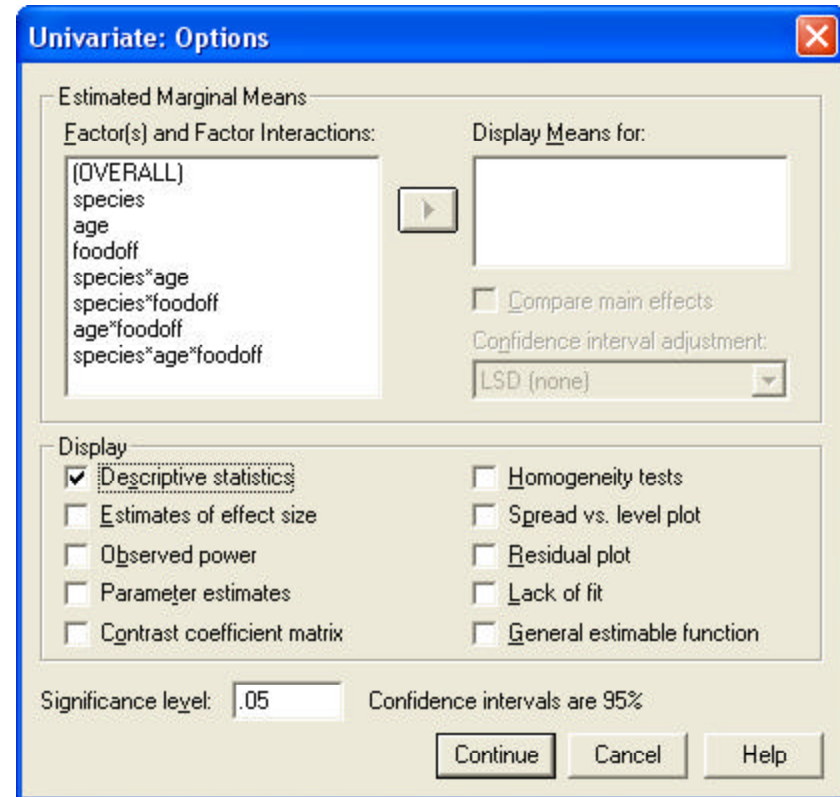
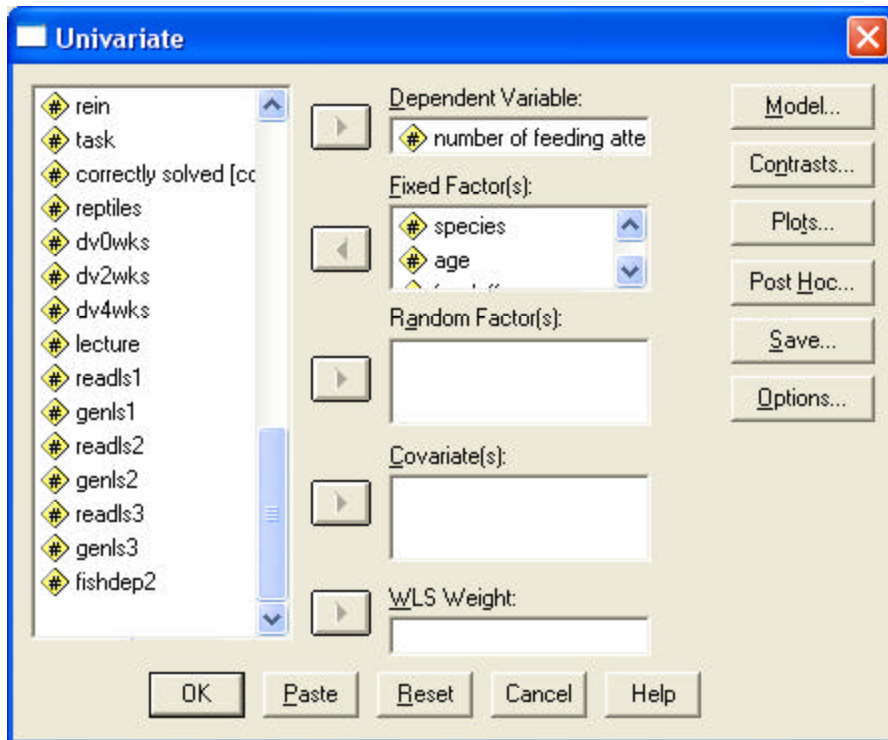
Application: Examination of main effects and interactions relating three IVs (with 2 or more conditions each) to a single quantitative DV.

Research Hypothesis: As is often the case, the researcher had hypotheses about some of the possible effects of this design, including:

- a 3-way interaction -- interaction of food and age will be different for the two species, because 3-day painted turtles prefer only crickets whereas 3-day snappers prefer both crickets and ground meat, while 30-day turtles of both species will have no food preference.
- a 2-way interaction of age and species -- 3 month olds will make more feeding strikes than 3 day olds, and this pattern will be stonger for painted than snapping turtles
- a main effect for type of food offered -- live crickets and ground meat will be equivalent and both will be preferred to lettuce

Analyze → General Linear Model → Univariate

- highlight the DV and press the arrow to put it in the “Dependent Variables” window
- highlight the all three IVs and press the arrow to put them into the “Fixed Factor(s)” window
- “Options” — check that you want “Descriptives”



SPSS Output:

Here are the univariate statistics and the ANOVA summary table.

Tests of Between-Subjects Effects

Dependent Variable: number of feeding attempts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2519.833 ^a	11	229.076	60.511	.000
Intercept	11180.167	1	11180.167	2953.252	.000
SPECIES	620.167	1	620.167	163.818	.000
AGE	864.000	1	864.000	228.226	.000
FOODOFF	236.396	2	118.198	31.222	.000
SPECIES * AGE	204.167	1	204.167	53.931	.000
SPECIES * FOODOFF	116.896	2	58.448	15.439	.000
AGE * FOODOFF	364.187	2	182.094	48.100	.000
SPECIES * AGE * FOODOFF	114.021	2	57.010	15.059	.000
Error	318.000	84	3.786		
Total	14018.000	96			
Corrected Total	2837.833	95			

a. R Squared = .888 (Adjusted R Squared = .873)

Note that there is a single error term for all of the F-tests. This error term df and MS will be used when computing all LSD minimum mean difference values.

Descriptive Statistics

Dependent Variable: number of feeding attempts

species of turtle	age when turtle	type of food offered	Mean	Std. Deviation	N
painted	3 days	live crickets	9.0000	1.30931	8
		ground meat	1.1250	1.12599	8
		lettuce	1.2500	1.03510	8
		Total	3.7917	3.92294	24
	3 months	live crickets	12.6250	1.84681	8
		ground meat	12.2500	1.83225	8
		lettuce	13.2500	1.83225	8
		Total	12.7083	1.80529	24
	Total	live crickets	10.8125	2.42813	16
		ground meat	6.6875	5.92980	16
		lettuce	7.2500	6.36134	16
		Total	8.2500	5.42453	48
snapper	3 days	live crickets	14.7500	3.19598	8
		ground meat	15.2500	1.38873	8
		lettuce	5.3750	1.50594	8
		Total	11.7917	5.09031	24
	3 months	live crickets	14.5000	2.56348	8
		ground meat	14.5000	2.87849	8
		lettuce	15.6250	1.40789	8
		Total	14.8750	2.32776	24
	Total	live crickets	14.6250	2.80179	16
		ground meat	14.8750	2.21736	16
		lettuce	10.5000	5.47723	16
		Total	13.3333	4.21413	48
Total	3 days	live crickets	11.8750	3.79254	16
		ground meat	8.1875	7.39566	16
		lettuce	3.3125	2.46897	16
		Total	7.7917	6.04578	48
	3 months	live crickets	13.5625	2.36555	16
		ground meat	13.3750	2.60448	16
		lettuce	14.4375	1.99896	16
		Total	13.7917	2.33346	48
	Total	live crickets	12.7188	3.22525	32
		ground meat	10.7813	6.05744	32
		lettuce	8.8750	6.06816	32
		Total	10.7917	5.46552	96

There was a significant 3-way interaction -- but did it have the hypothesized pattern?

We will need to

- organize the data to examine this pattern
- compute the LSDmmd appropriate to compare cell means
- determine the pattern of the 2-ways that make up the 3-way and
- check if the data pattern is as hypothesized

For the 3-way interaction

based on $df(\text{error}) = 84$, $t = 2.00$ also $n = N/k = 96/12 = 8$ **MS(error) = 3.786**

$$d_{LSD} = \frac{t * \sqrt{(2 * MS_{\text{Error}})}}{\sqrt{n}} = \frac{2.00 * \sqrt{(2 * 3.79)}}{\sqrt{8}} = 1.95$$

Painted Turtles

Age	Food Offered		
	Crickets	Ground Meat	Lettuce
3 days	9.00	1.125	1.25
3 months	12.63	12.25	13.25

Applying this LSDmmd, we get the following data pattern...

For painted turtles...

3-day cric > gm cric > lett gm = lett
 3-months cric = gm cric = lett gm = lett

Snapping Turtles

Age	Food Offered		
	Crickets	Ground Meat	Lettuce
3 days	14.75	15.25	5.38
3 months	14.50	14.50	15.63

For snapping turtles...

3-day cric = gm cric > lett gm > lett
 3-months cric = gm cric = lett gm = lett

We can see that each part of the hypothesized 3-way interaction pattern matches the pattern of the cell means.

- 3-day painted turtles preferred crickets to ground meat and lettuce
- 3-day snappers preferred crickets and ground meat to lettuce
- 30-day turtles of both species showed no preference

There was a significant 2-way interaction of age and species -- but did it have the hypothesized pattern & is it descriptive or potentially misleading??

We will need to

- organize the data to examine the pattern of this 2-way
- compute the LSDmmd appropriate to compare cell means for this 2-way
- determine the pattern of the 2-ways & check if the data pattern fits the RH:
- determine if the pattern of the 2-way is descriptive or misleading by comparing it to the corresponding simple 2-ways of the 3-way

For the Age x Species 2-way interaction

based on $df(\text{error}) = 84$, $t = 2.00$ also $n = N/k = 96/4 = 24$ $MS(\text{error}) = 3.786$

$$d_{LSD} = \frac{t * \sqrt{(2 * MS_{\text{Error}})}}{\sqrt{24}} = \frac{2.00 * \sqrt{(2 * 3.79)}}{\sqrt{24}} = 1.12$$

Species

Age	Painted	Snapper
3 days	3.79	11.79
3 months	12.71	14.88

Applying this LSDmmd, we get the following data pattern

for Painted 3-months >>> 3-day

for Snappers 3-month > 3-day data pattern matches the RH:

Now we have to check whether this 2-way is descriptive or potentially misleading. In order to check this we have to examine the simple 2-way interaction of age x species for each of the three food conditions. This will require us to rearrange the cell means as follows...

Crickets

Species

Age	Painted	Snapper
3 days	9.00	14.75
3 months	12.63	14.50

Ground Meat

Species

Age	Painted	Snapper
3 days	1.13	15.25
3 months	12.25	14.50

Lettuce

Species

Age	Painted	Snapper
3 days	1.25	5.38
3 months	13.25	15.63

We will use the LSDmmd from the 3-way interaction to identify the pattern of these cell means (1.95 -- since these are all the cells of the 3-way, just rearranged from how they were shown on the last page). The rearrangement above clearly shows that this 2-way is not descriptive. The basic 2-way Age x Species interaction pattern looks to be consistent only for when lettuce is the food being offered,

There is a main effect for food type - but does it have the hypothesized pattern, and is it descriptive or potentially misleading?

For the Main Effect of Food Offered

based on $df(\text{error}) = 84$, $t = 2.00$ also $n = N/3 = 96/3 = 32$ $MS(\text{error}) = 3.786$

$$d_{LSD} = \frac{t * \sqrt{(2 * MS_{\text{Error}})}}{\sqrt{32}} = \frac{2.00 * \sqrt{(2 * 3.79)}}{\sqrt{32}} = .97$$

Applying this LSDmmd, we get the following data pattern...

cric > gm cric > lett gm > lett

As hypothesized, crickets were preferred to ground mean and lettuce, but contrary to the hypothesis ground meat was preferred to lettuce.

Also, examination of the simple effect of Food Offered for each combination of age and species (shown on p. 2), reveals that this main effect pattern is descriptive for none of those simple effects, and so is a “misleading main effect pattern”.

Food Offered

Crickets	Ground Meat	Lettuce
12.72	10.78	8.86

Reporting the Results -- including only the three effects explicated in this example -- usually all effects would be described.

A 3-way between groups ANOVA was used to examine the main effects and interactions of Food Offered, Species and Age as they relate to the number of feeding strikes made. Figure 1 shows the mean number of feeding strikes for each of the design conditions.

There was a significant 3-way interaction, $F(2, 84) = 15.059$, $p < .001$, $MSe = 3.79$. Examination of the cell means (using LSDmmd = 1.95) reveals that, as hypothesized, the pattern of this interaction was that 3-day painted turtles preferred crickets to ground meat and lettuce, 3-day snappers preferred crickets and ground meat to lettuce, while 30-day turtles of both species showed no preference

There was also a significant 2-way interaction of Age and Species, $F(1, 84) = 53.931$, $p < .001$. The pattern of this interaction (using LSDmmd = 1.12) was that, as hypothesized, 30-day turtles made more strikes than 3-day turtles, and this effect was stronger for painted turtles than for snapping turtles. This 2-way pattern was also descriptive for each food type.

There was a main effect for Food Offered, $F(2, 84) = 31.222$, $p < .001$. As hypothesized, crickets were preferred to ground mean and lettuce, but contrary to the hypothesis ground meat was preferred to lettuce (based on LSDmmd = .97). Also, examination of the simple effect of Food Offered for each combination of age and species, reveals that this main effect pattern is descriptive for none of those simple effects.