Alternative Statistical Analyses for Quasi-Experimental Designs

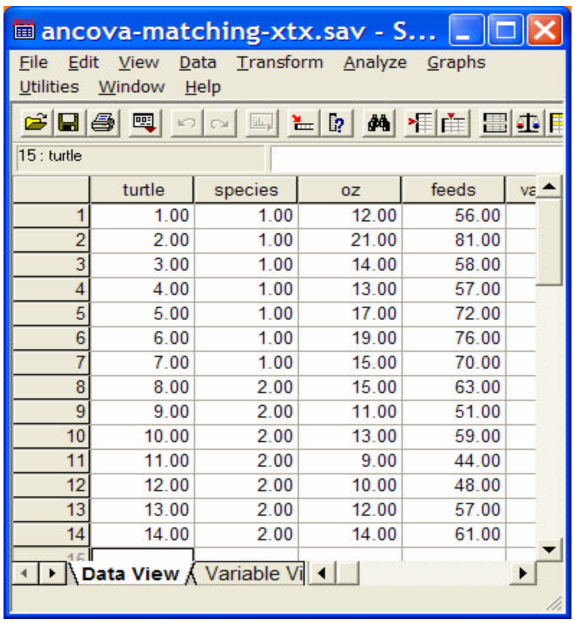
Walk-through

The purpose of the study was to explore the differences is feeding vigor of species of Nebraska turtles, as part of larger ecological study. It was expected that Blanding's would be the more vigorous feeder, based on the greater competition they experienced in their ecological niche.

Seven each of Painted turtles (code = 1) and Blanding's turtles (code = 2)were trapped out of a single pond in central Nebraska. Each was weighed and then placed in a 50 gallon aquarium with 6 inch water depth for 24 hours. Then 50 earth worms were placed in the tank and the number of feeding strikes was recorded for each turtle.

Here are the resulting data – the SPSS database is shown below:

Turtle#	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Species	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Weight	12	21	14	13	17	19	15	15	11	13	9	10	12	14
	56	81	58	57	72	76	70	63	51	59	44	48	57	61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	turtle	species	oz	feeds
1	1.00	1.00	12.00	56.00
2	2.00	1.00	21.00	81.00
3	3.00	1.00	14.00	58.00
4	4.00	1.00	13.00	57.00
5	5.00	1.00	17.00	72.00
6	6.00	1.00	19.00	76.00
7	7.00	1.00	15.00	70.00
8	8.00	2.00	15.00	63.00
9	9.00	2.00	11.00	51.00
10	10.00	2.00	13.00	59.00
11	11.00	2.00	9.00	44.00
12	12.00	2.00	10.00	48.00
13	13.00	2.00	12.00	57.00
14	14.00	2.00	14.00	61.00

ANOVA

The main question was whether there was a species difference in feeding vigor. However, the researcher knew that feeding vigor, as measured by number of feeding attempts, is usually related to size. She also knew that there was a size difference between these turtle species. So, the size differences among the turtles might be acting in two ways, statistically…

1) as a confound between the species – the larger Blanding's turtles may make more feeding strikes either because they are "more vigorous feeders" or because they are larger

2) to increase the within-condition variation – weakening the power of the between groups comparison

Descriptives

number of feeding attempts

	N	Mean	Std. Deviation
blandings	7	67.1429	10.10657
painted	7	54.7143	7.13476
Total	14	60.9286	10.59364

ANOVA

number of feeding attempts

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	540.643	1	540.643	7.065	.021
Within Groups	918.286	12	76.524		
Total	1458.929	13			

As expected – Blanding's had more feeding attempts.

Descriptives

weight of the turte

	N	Mean	Std. Deviation
blandings	7	15.8571	3.28778
painted	7	12.0000	2.16025
Total	14	13.9286	3.33891

ANOVA

weight of the turte

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	52.071	1	52.071	6.729	.023
Within Groups	92.857	12	7.738		
Total	144.929	13			

However, there was a size confound

Correlations

	weigl of th turt
number of feeding attemp	.97
	.0C
	1

And there was a correlation between and feeding attempt

So, some form of mechanical or statistical control is necessary to get a better idea of what variables are operating here.

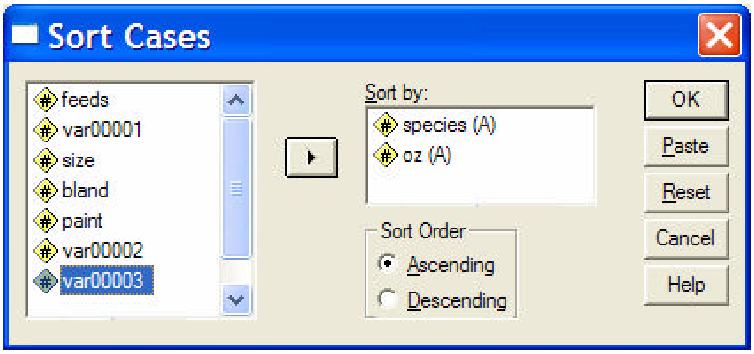
Remember – causal interpretation is shot!! We're now struggling to understand the associations among these variables.

Post-Hoc Matching

One approach is to engage in post-hoc matching – forming matched pairs of turtles from the two species that have "the same" value on the confounding variable. The data are then analyzed using a within-groups model, with each "case" being a matched pair of turtles.

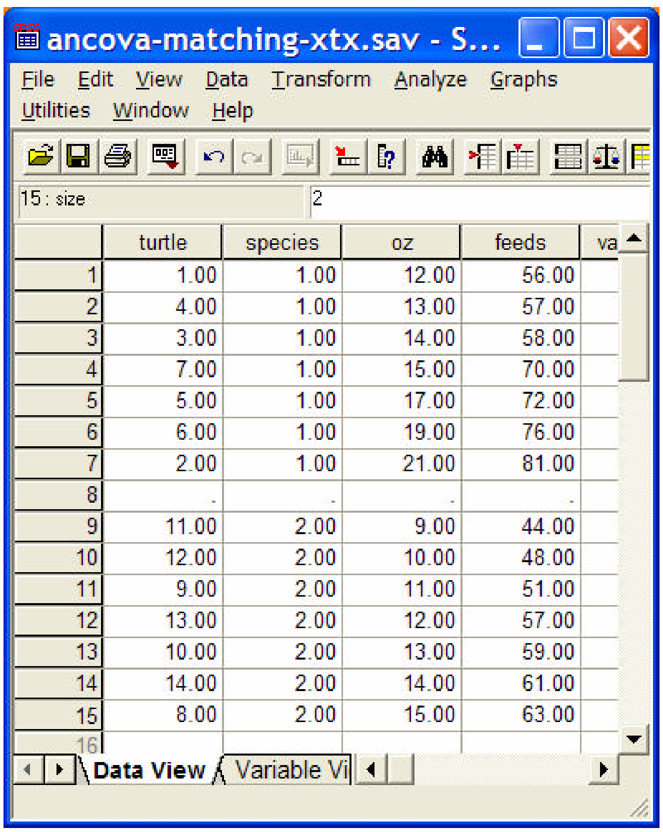
We can sort the data in SPSS to make the matching easier.

Data → Sort Cases



Move the sorting variables into the "Sort by:" window in the order you want them sorted – the order shown will sort by species first, and then oz-values within each species.

The resulting sorted dataset is shown below.



	turtle	species	oz	feeds	va
1	1.00	1.00	12.00	56.00	
2	4.00	1.00	13.00	57.00	
3	3.00	1.00	14.00	58.00	
4	7.00	1.00	15.00	70.00	
5	5.00	1.00	17.00	72.00	
6	6.00	1.00	19.00	76.00	
7	2.00	1.00	21.00	81.00	
8	.	.	.	.	
9	11.00	2.00	9.00	44.00	
10	12.00	2.00	10.00	48.00	
11	9.00	2.00	11.00	51.00	
12	13.00	2.00	12.00	57.00	
13	10.00	2.00	13.00	59.00	
14	14.00	2.00	14.00	61.00	
15	8.00	2.00	15.00	63.00	
16					

If we make exact post-hoc matches using "oz" as the matching variable, we can only match some of the turtles from each species. This is consistent with the mean difference between species on this v ariable that we found earlier.

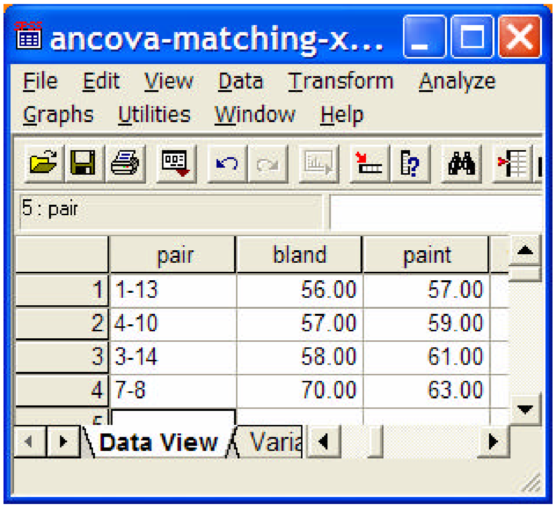
This is a common problem when using post-hoc matching to control confounding variables -- we end up using only part of each sample. This limits the external validity of our results, because we are using only the smaller Blanding's turtles and the larger Painted turtles.

While many consider this an improper analysis in this situation, I want you to know how to do it, in case it is ever requested of you (be sure to be polite when pointing out the possible problems with using this approach to your boss, advisor, editor, etc!!!)

We'd end up with the following four pairs of animals (oz.)

1 & 13 (12)   4 & 10 (13)   3 & 14 (14)   7 & 8 (15)

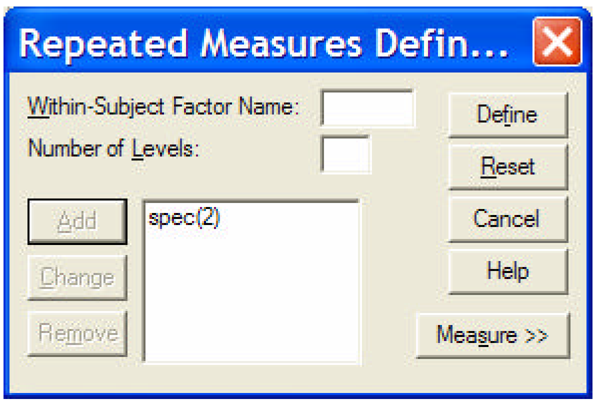
Matched groups designs use within-groups ANOVA. So, we are going to have to create a new data set using each matched-pair as a "case" and then perform a within-groups analysis. Here is the resulting SPSS dataset.

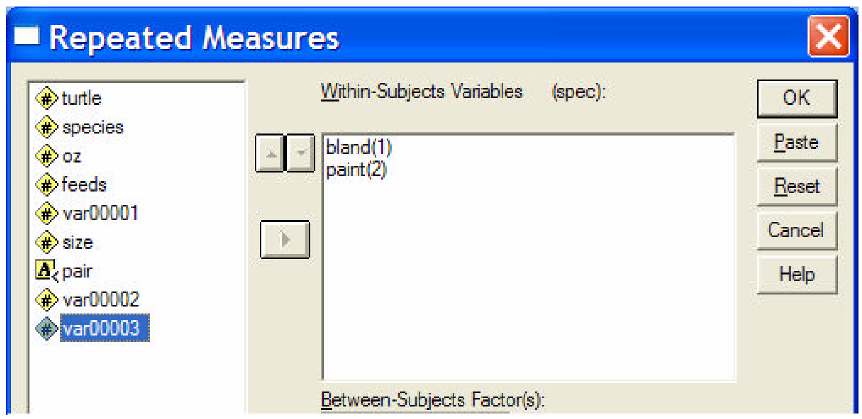


Notice that there are now only 4 “cases” and that each case is made up of a matched pair from above.

Now we perform a within-groups (repeated measures) ANOVA to test the mean difference between the groups

Analyze ➔ GLM ➔ Repeated Measures (be sure to get Descriptives from the Option window)





Here’s the output:

Descriptive Statistics

	Mean	Std. Deviation	N
BLAND	60.2500	6.55108	4
PAINT	60.0000	2.58199	4

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
SPEC	Sphericity Assumed	.125	1	.125	.012	.920
Error(SPEC)	Sphericity Assumed	31.375	3	10.458		

Based on the matched pairs, there is no difference between the groups. However, notice that the mean of each group is different from the means in the original ANOVA analysis. The difference between these means the original means is because we got rid of the heavier Blanding’s turtles (who had more feeding strikes) and we got rid of the lighter Painted turtles (who had more feeding strikes).

How should we interpret this analysis? Two parts –report the findings and then mention the “concern”!

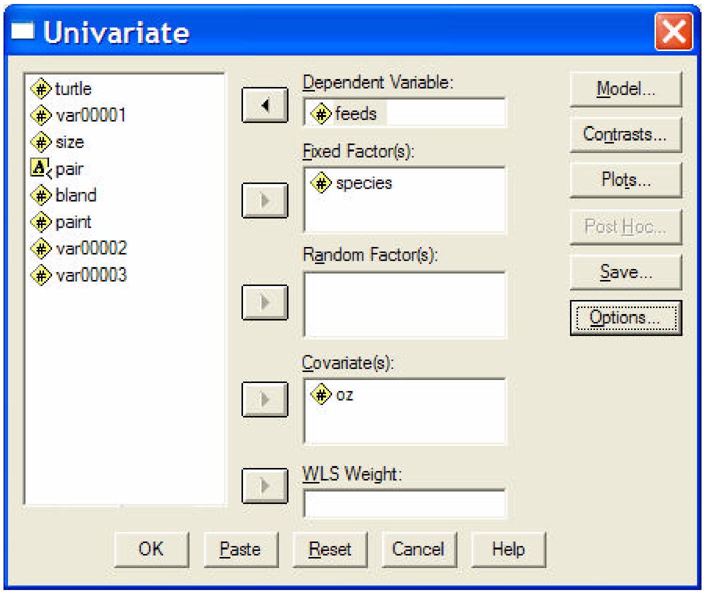
There is no mean difference between the feeding attempts of Blanding’s and Painted feeding turtles, after controlling for group weight differences using post hoc matching, $F(1, 3) = .012$, $p=.920$, $MSe=10.458$. However, this matching process led to the exclusion of the heavier Painted turtles and the lighter Blanding’s turtles, and so utility of this analysis as a meaningful comparison of the species is limited.

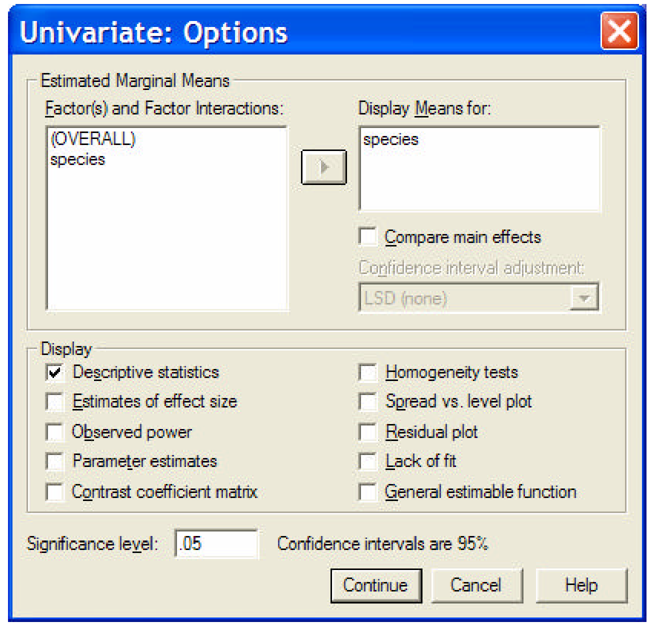
ANCOVA

One disadvantage of post-hoc matching is that “controlling” for a between group difference often requires that only part of the data (“good matches”) can be used. ANCOVA accomplishes much the same “controlling for” but uses all of the data.

For these data, the IV will be Species, the DV will be the number of feeding attempts and the covariate will be the confounding variable – body weight of the animals (oz).

Analyze ➔ GLM ➔ Univariate





The output:

Tests of Between-Subjects Effects

Dependent Variable: number of feeding attempts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1397.923[a]	2	698.962	126.03	.000
Intercept	160.237	1	160.237	28.893	.000
OZ	857.280	1	857.280	154.58	.000
SPECIES	1.127	1	1.127	.203	.661
Error	61.005	11	5.546		
Total	53431.000	14			
Corrected Total	1458.929	13			

a. R Squared = .958 (Adjusted R Squared = .951)

SPECIES

Dependent Variable: number of feeding attempts

SPECIES	Mean	Std. Error
blandings	61.283[a]	1.007
painted	60.574[a]	1.007

a. Covariates appearing in the model are evaluated at the following values: weight of the turte = 13.9286.

The ANOVA shows that there is no mean difference between the groups for number of feeding strikes, after controlling for weight, $F(1, 13) = .203$, $p=.661$, MSe=5.546.

Notice that the corrected means are very close to the means from the post-hoc matching analysis (and the mean difference was non-significant for both).

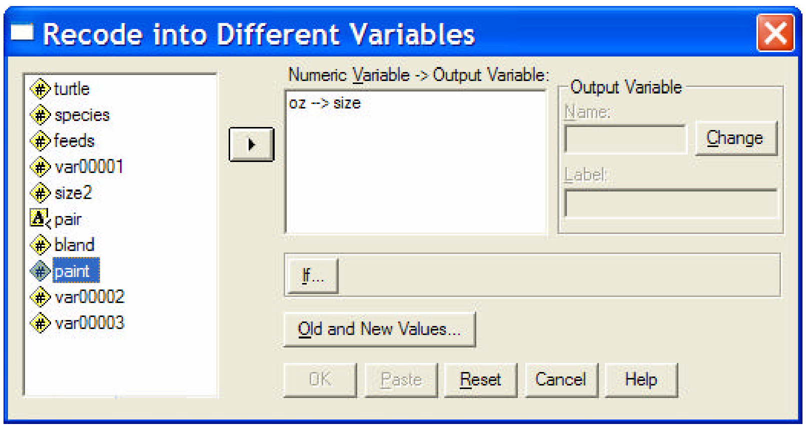
Treatment x Subjects Design

A third approach to "controlling for" a between groups difference is to make the variable on which the groups differ a "second IV" in a factorial design. What does this do for you?

1. Like ANCOVA, you can look at how the variable relates to the dependent variable
2. Like ANCOVA & post-hoc matching, the factorial ANOVA controls for the effect of the variable on the IV-DV relationship
3. Bonus: Allows you to look at the possibility of an interaction between the IV and the "confound" as they relate to the DV -- this interaction may be the most interesting effect in the analysis !!

We need to transform the "control variable" (here oz.) into a grouping variable. As we do this we need to assure that there are at least 2 cases in each condition of the factorial ANOVA. For these data splitting the oz variable between 13 – 14 accomplishes this. The transformation is accomplished using a recode.

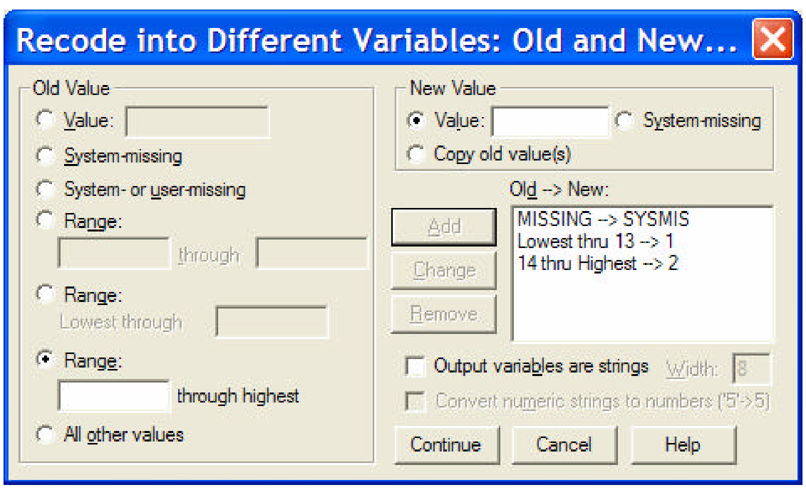
Transform ➔ Recode ➔ Into Different Variables



You will need to create a variable name for the new categorical variable – I used "size"

Enter that name in the "Output Variable" window.

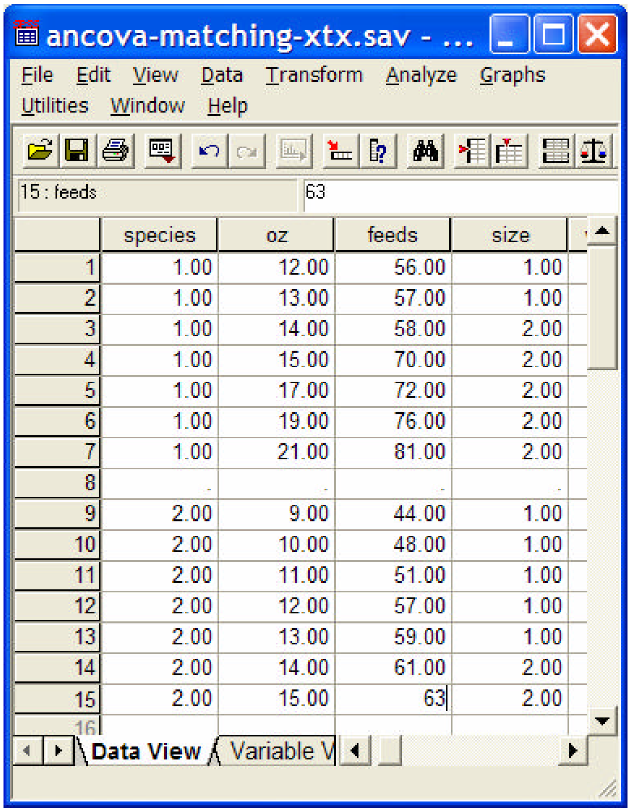
Then click the "Old and New Values" button.



Using the Range options, set the Old -> New assignments.

Be sure to start with the Missing values assignment!

After finishing the Recode, the dataset looks like this…

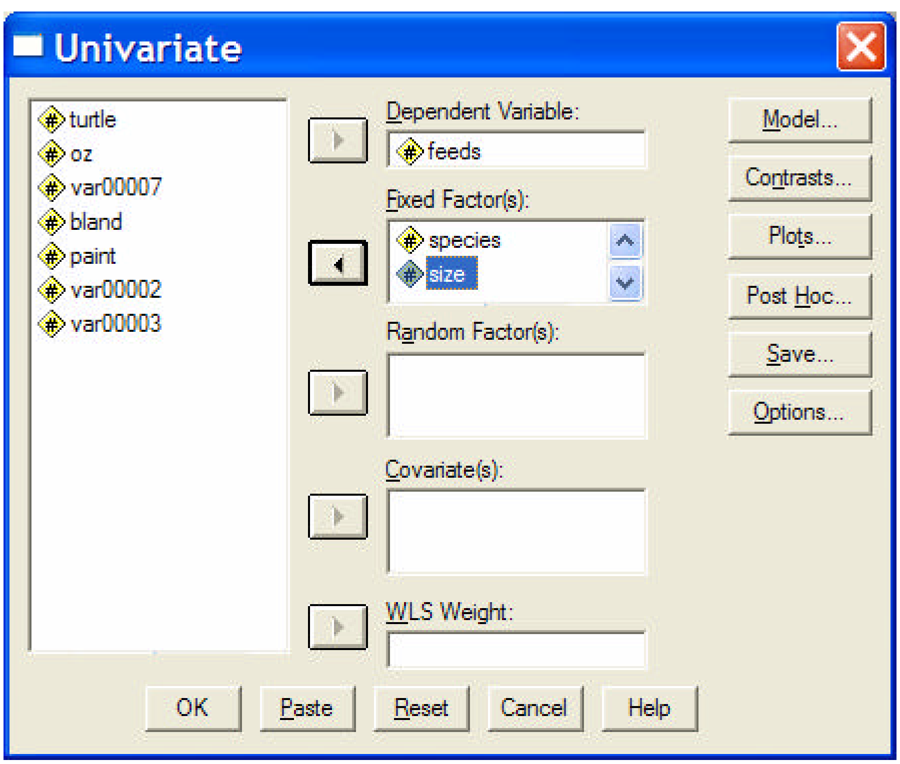


Remember, we have to have at least 2 cases in each IV x Confound condition of the factorial design.

The greater the disparity between the groups on the confound the greater the difficulty of accomplishing this – same as the difficulty of finding "lots of good post-hoc matches".

Then we perform a factorial ANOVA of these data…

Analyze → GLM → Univariate (remember to get Descriptive from the Options window)



Here's the output…

Descriptive Statistics

Dependent Variable: number of feeding attempts

SPECIES	SIZE	Mean	Std. Deviation	N
blandings	1.00	56.5000	.70711	2
	2.00	71.4000	8.59069	5
	Total	67.1429	10.10657	7
painted	1.00	51.8000	6.22093	5
	2.00	62.0000	1.41421	2
	Total	54.7143	7.13476	7
Total	1.00	53.1429	5.58058	7
	2.00	68.7143	8.40068	7
	Total	60.9286	10.59364	14

Tests of Between-Subjects Effects

Dependent Variable: number of feeding attempts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1006.429[a]	3	335.476	7.414	.007
Intercept	41727.779	1	41727.779	922.161	.000
SPECIES	42.007	1	42.007	.929	.889
SIZE	450.007	1	450.007	9.945	.010
SPECIES * SIZE	215.779	1	215.779	5.110	.043
Error	452.500	10	45.250		
Total	53531.000	14			
Corrected Total	1458.929	13			

a. R Squared = .690 (Adjusted R Squared = .597)

As we saw in the ANOVA and the ANCOVA, there are species weight differences .

Like the other analyses, there is no difference between the mean number of feeding attempts of the species, after accounting for species weight differences.

However, this analysis shows that there is an interaction of Species and Weight as they relate to the number of feeding attempts.

There is a larger difference between the number of feeding attempts made by "light" and "heavy" Blanding's turtles (56.6 vs. 71.4) and a smaller difference between the number of feeding attempts made by "light" and "heavy" Painted turtles (51.8 vs. 62.7).

This interaction is probably more important than would be a main effect of species (if one were found after controlling for weight.

Summary

1. None of these analyses is very difficult – matching and using the factorial ANOVA require some decisions and attention to detail, but nothing tricky!
2. None of these analyses is a substitute for a true experiment (though such isn't possible when comparing species or other intact natural groups.
3. The three analyses won't always produce the same results

Which is best? There probably is no "clear winner"! I want you able to do any of these and to be able to compare the results from each, however which you will do in your future probably depends upon the content area in which you are working and when & by whom whoever you are working for was trained.