

7.10. Factorial three-way parametric analysis of variance

EXAMPLE 7.7. Lead levels in soil samples taken at various depths, distances, and bearings from a smelter

BOX 7.10. How to carry out a three-way factorial parametric anova without replicates

Step 1: Set up the variables.

When SPSS starts up, select 'Variable View' using the tabs at the bottom left. You should get something like this:

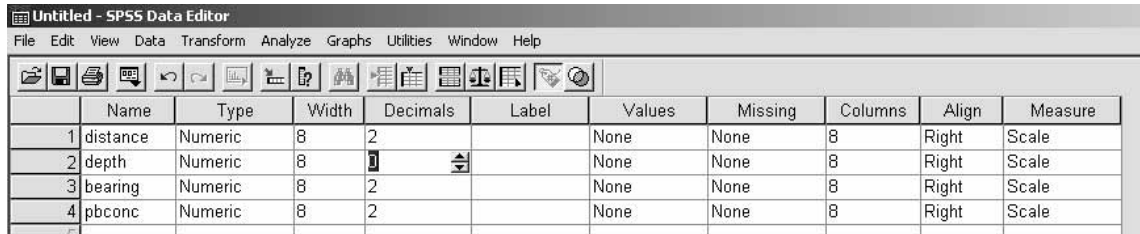
	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
1										
2										
3										
4										
5										

For the first variable name, type in 'distance', and for the second 'depth'. The third will be 'bearing', and the fourth will be the lead concentration, for which we use 'Pbconc' (SPSS doesn't accept variable names with more than eight characters). Default properties will be set for each variable.

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
1	distance	Numeric	8	2		None	None	8	Right	Scale
2	depth	Numeric	8	2		None	None	8	Right	Scale
3	bearing	Numeric	8	2		None	None	8	Right	Scale
4	pbconc	Numeric	8	2		None	None	8	Right	Scale
5										
6										

We need two decimal places of km for the 'distance' variable, but depths are whole numbers of cm, and concentrations are whole numbers of $\mu\text{g/g}$. Change the decimal places for 'depth' by clicking in the 'decimals' cell in

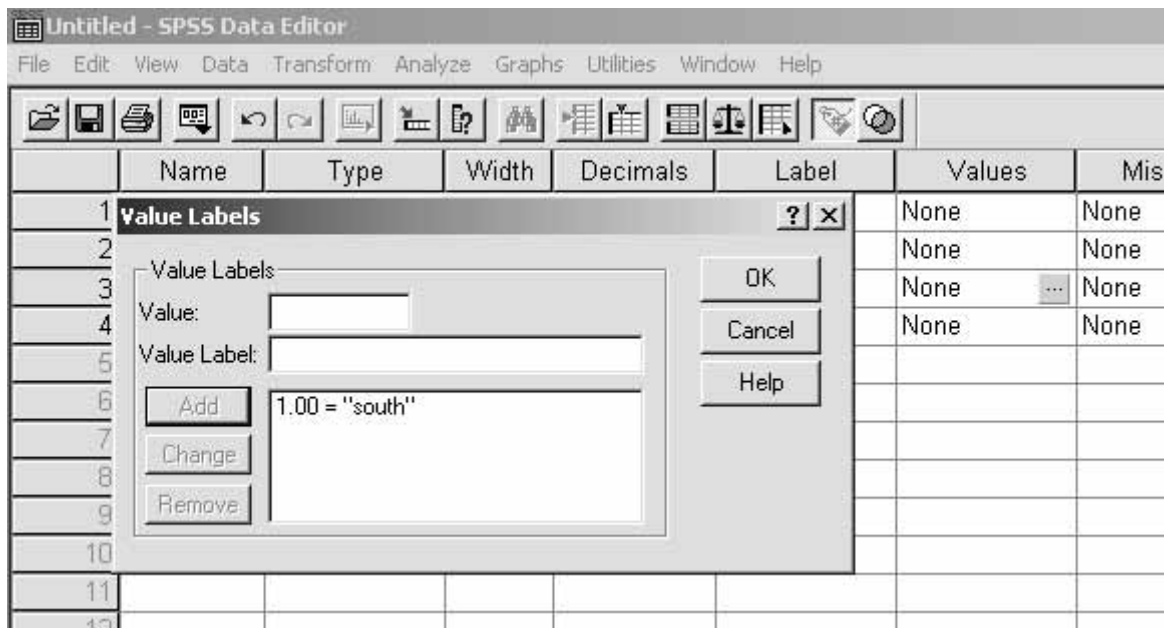
row 2, and using the ‘up’ and ‘down’ arrows that appear to adjust the number of decimal places to zero.



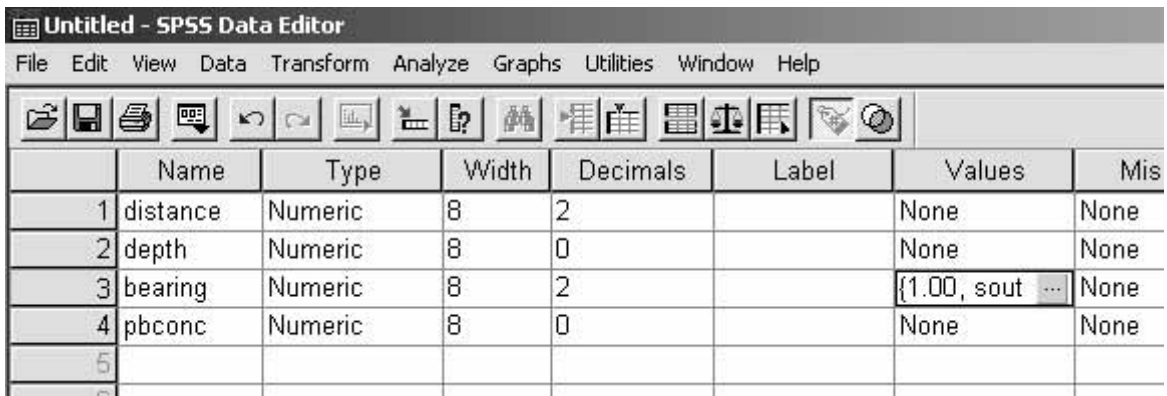
	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
1	distance	Numeric	8	2		None	None	8	Right	Scale
2	depth	Numeric	8	0		None	None	8	Right	Scale
3	bearing	Numeric	8	2		None	None	8	Right	Scale
4	pbconc	Numeric	8	2		None	None	8	Right	Scale

Repeat the process for ‘pbconc’.

While we could measure it in degrees (clockwise from north), ‘bearing’ is a categoric variable – but SPSS doesn’t like such things, so we have to use value labels. Click in the ‘Values’ cell in row 3, and then click in the grey area that appears at the right-hand side of the cell. This will give a dialogue window. In the ‘Value’ window, type ‘1’, and in the ‘Value Label’ window, type ‘south’. Click on ‘Add’ to enter this value–label pair into the system.



Repeat for value–label pairs of 2, south-east, and 3, south-west. Click on ‘OK’.



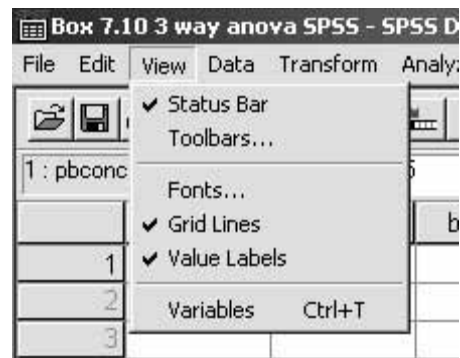
Untitled - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

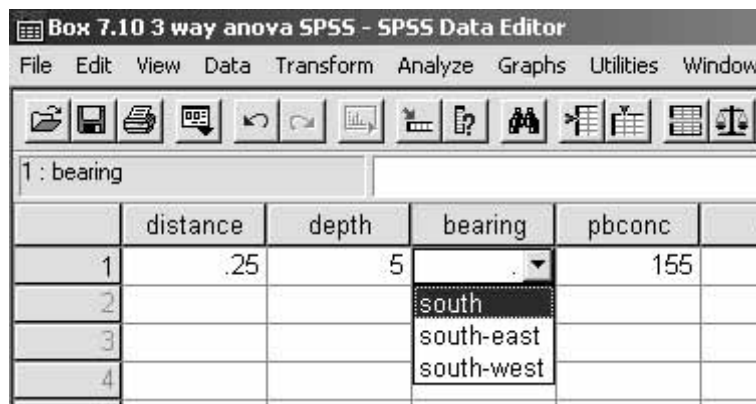
	Name	Type	Width	Decimals	Label	Values	Mis
1	distance	Numeric	8	2		None	None
2	depth	Numeric	8	0		None	None
3	bearing	Numeric	8	2		{1.00, sout ...	None
4	pbconc	Numeric	8	0		None	None
5							
6							

Change the 'Decimals' property of 'bearing' to zero, and then transfer to data view using the tabs at bottom-left.

Enter the distance, depth, and concentration numbers for the first measurement into the appropriate columns. Make sure that value labels are enabled by going to 'View' and, if necessary, selecting 'Value Labels'.



Click in the 'bearing' cell in row 1. A drop-down menu will be enabled at the right-hand side of the cell, from which you should select 'south'.



Box 7.10 3 way anova SPSS - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window

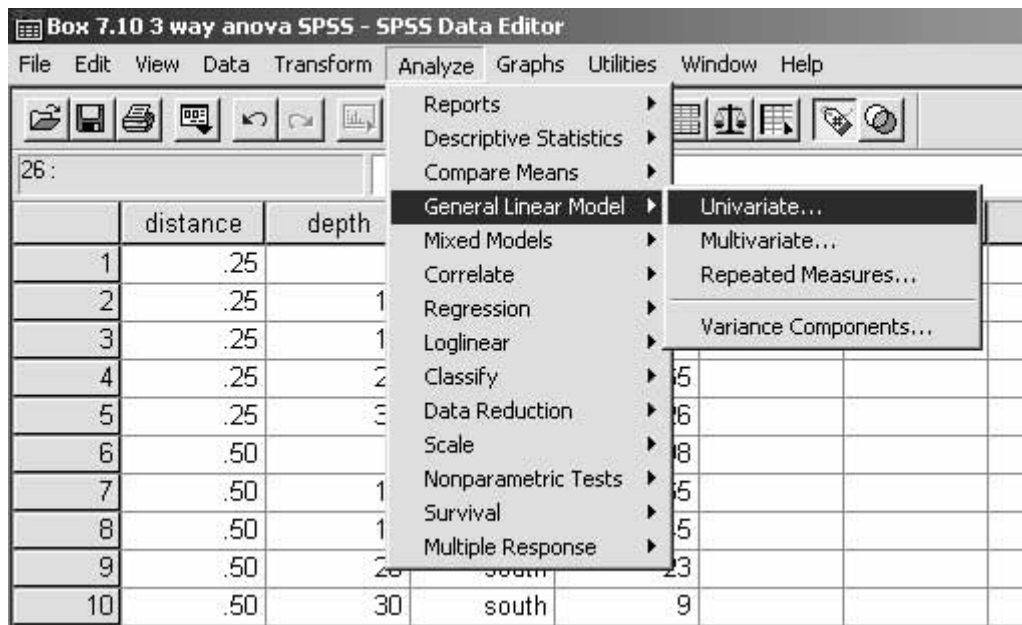
	distance	depth	bearing	pbconc	v
1	.25	5	▼	155	
2			south		
3			south-east		
4			south-west		

Enter all the other data in the same way. For much of it, you can ‘cut-and-paste’ from a Word table.

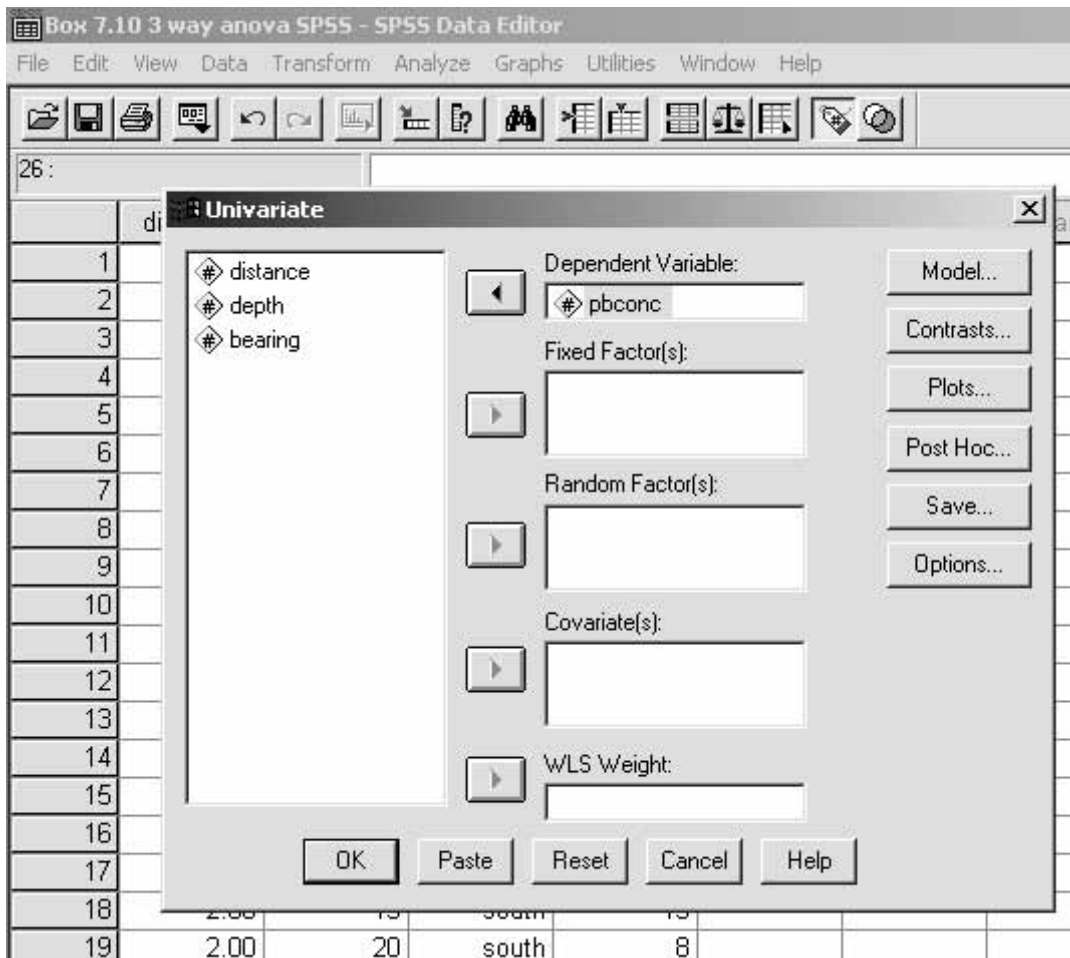
	distance	depth	bearing	pbconc	v
1	.25	5	south	155	
2	.25	10	south	102	
3	.25	15	south	77	
4	.25	20	south	65	
5	.25	30	south	26	
6	.50	5	south	98	
7	.50	10	south	65	
8	.50	15	south	45	
9	.50	20	south	23	
10	.50	30	south	9	
11	1.00	5	south	55	
12	1.00	10	south	36	
13	1.00	15	south	22	
14	1.00	20	south	12	
15	1.00	30	south	9	
16	2.00	5	south	25	
17	2.00	10	south	18	
18	2.00	15	south	15	
19	2.00	20	south	8	
20	2.00	30	south	7	
21	.25	5	south-east	96	
22	.25	10	south-east	73	
23	.25	15	south-east	23	
24	.25	20	south-east	12	

Step 2. Perform the test.

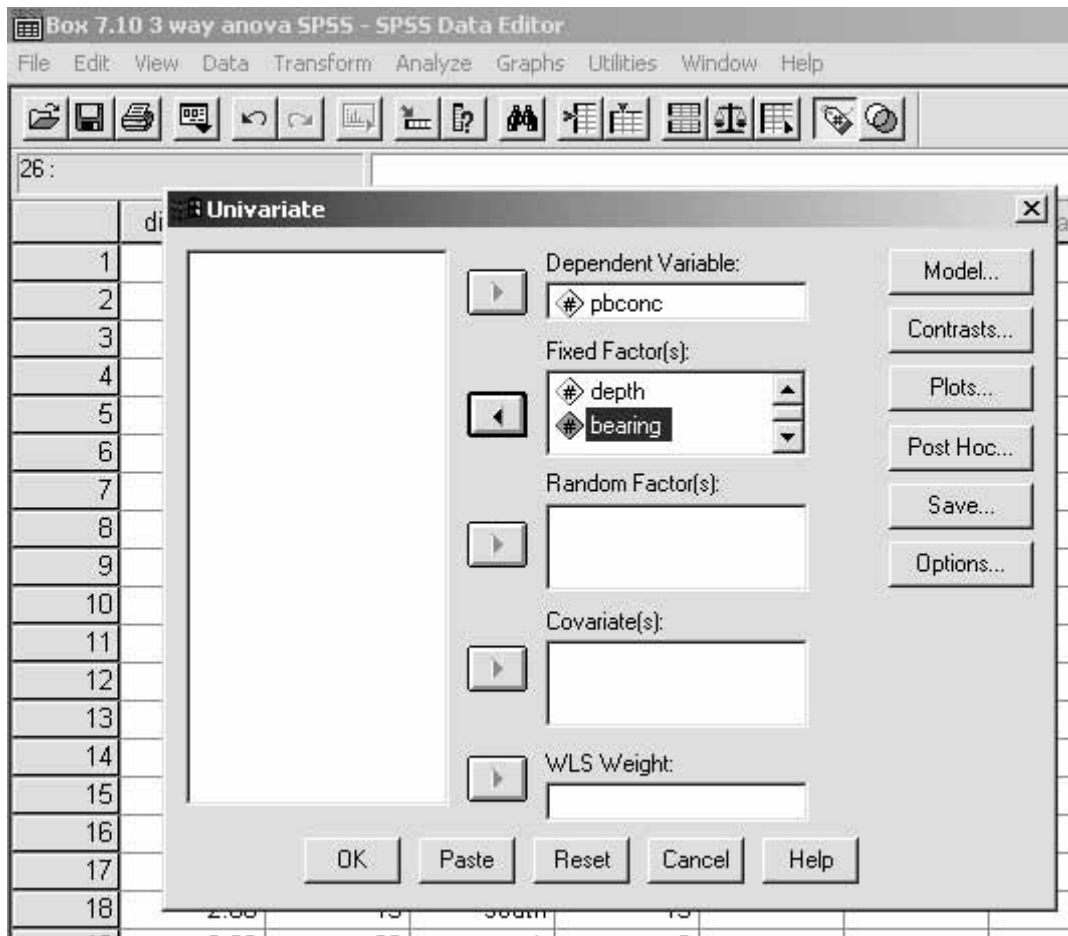
Go to ‘Analyze’, ‘General Linear Model’, ‘Univariate’.



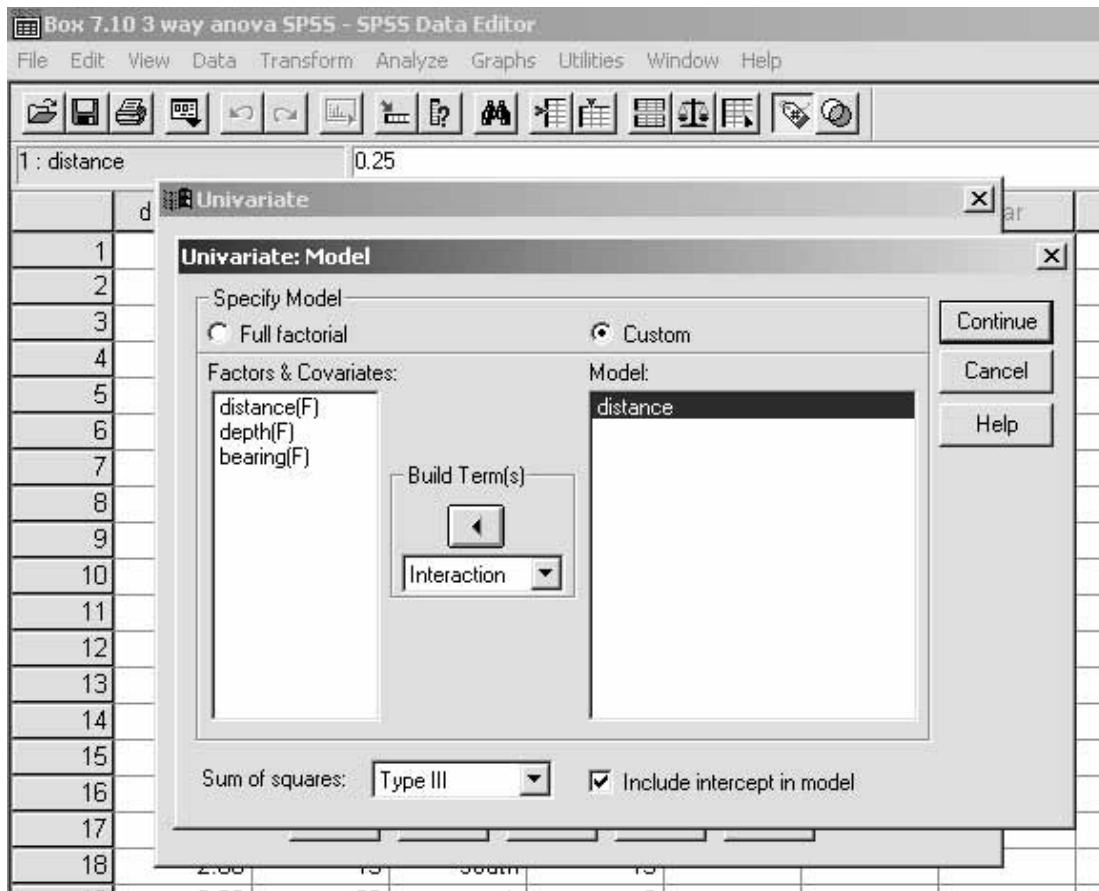
The lead concentration 'pbconc' is the dependent variable, so click on it to highlight it, then click on the appropriate arrow to transfer it to the 'Dependent Variable' box.



The independent factors are 'distance', 'depth', and 'bearing', so highlight each in turn and transfer them all to the 'Fixed Factor(s)' window.

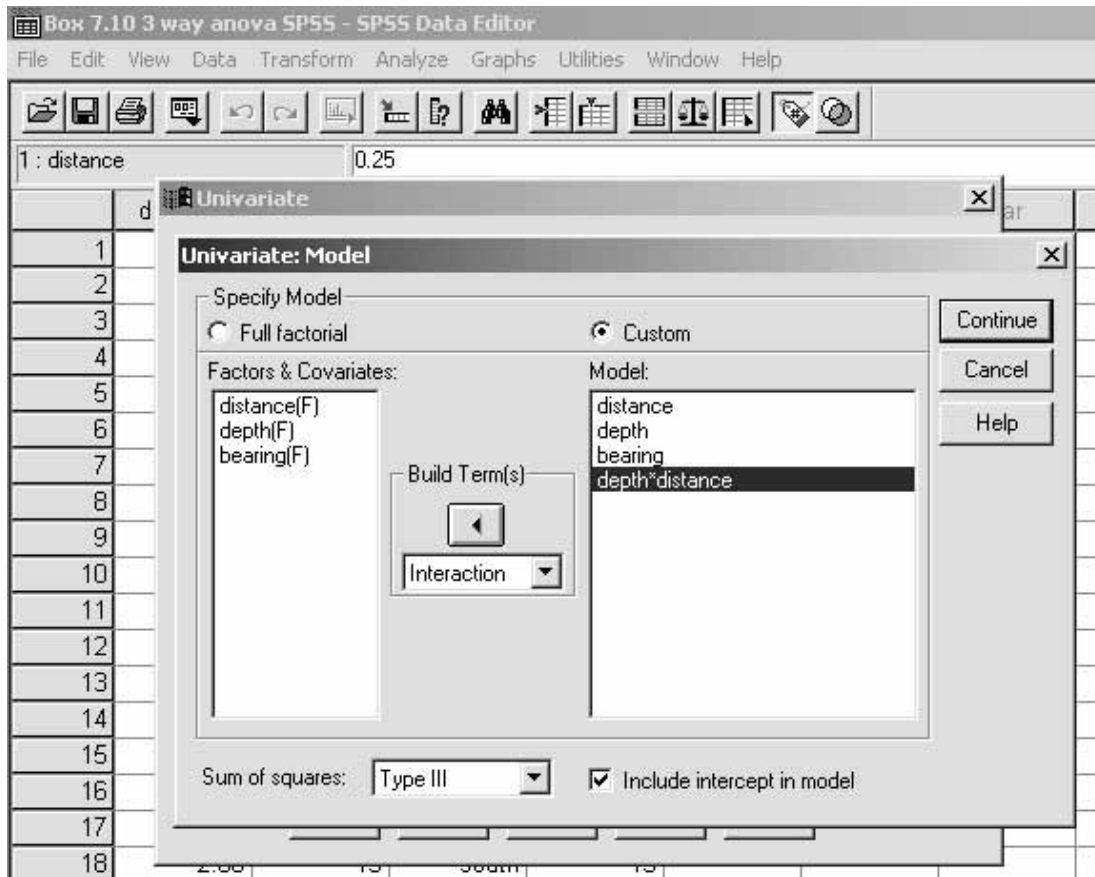


Click on 'Model'. Click on the 'Custom' radio button. Click on 'distance' to highlight it, then click on the 'Build Term(s)' arrow to transfer it to the 'Model' window.



Repeat the process to transfer 'depth' and 'bearing' to the 'Model' window.

Use the drop-down menu in 'Build Term(s)' to highlight 'Interaction'. Click on 'distance' and then on 'depth', then click on the 'Build Term(s)' arrow. This should transfer 'distance*depth' to the 'Model' window.



Repeat the procedure to model the interactions 'distance*bearing' and 'depth*bearing'. Click on 'Continue'. In the 'Univariate' dialogue box, click on 'OK'. The results will appear in a separate window.

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
DISTANCE	.25		15
	.50		15
	1.00		15
	2.00		15
DEPTH	5		12
	10		12
	15		12
	20		12
	30		12
BEARING	1	south	20
	2	south-east	20
	3	south-west	20

Tests of Between-Subjects Effects

Dependent Variable: PBCONC

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	458040.900(a)	35	13086.883	56.136	.000
Intercept	316536.067	1	316536.067	1357.787	.000
DISTANCE	67477.000	3	22492.333	96.481	.000
DEPTH	103956.433	4	25989.108	111.481	.000
BEARING	188872.133	2	94436.067	405.085	.000
DISTANCE * DEPTH	12921.167	12	1076.764	4.619	.001
DISTANCE * BEARING	27792.800	6	4632.133	19.870	.000
DEPTH * BEARING	57021.367	8	7127.671	30.574	.000
Error	5595.033	24	233.126		
Total	780172.000	60			
Corrected Total	463635.933	59			

a. R Squared = .988 (Adjusted R Squared = .970)

Step 3. Decide what the results mean.

The 'Sig.' values for all three interactions (distance*depth, distance*bearing and depth*bearing) are all significant at $p = 0.01$ or better, and so investigating any one of them separately is problematic because of the interactions.