

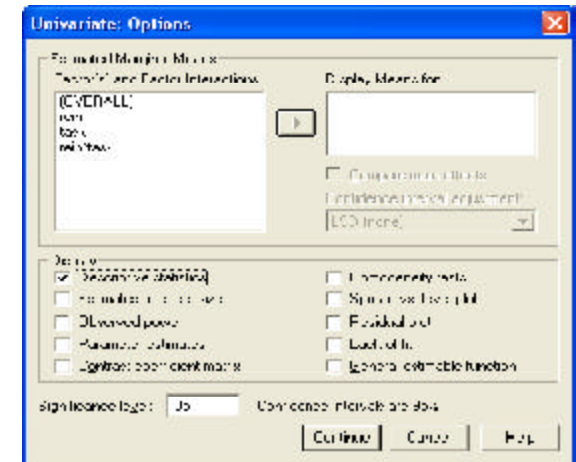
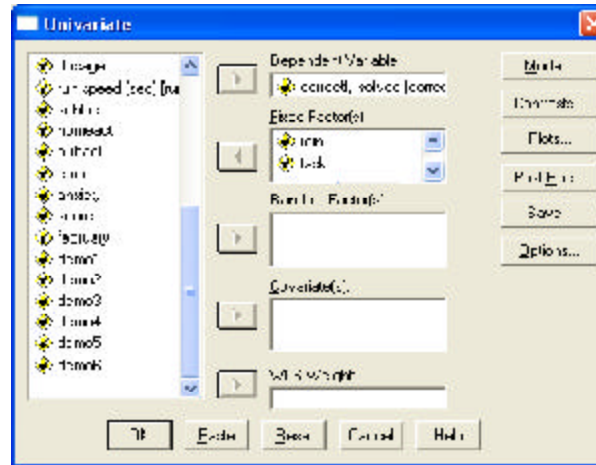
kxk Between Groups Factorial ANOVA

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

Research Hypothesis: The researcher hypothesized that there would be an interaction between Type of Task and Type of Reinforcement. Specifically, the expected pattern was that scores in the praise and criticism conditions would be higher than those in the silence condition when the task was simple, but that scores in the criticism and silence conditions would work be lower than those in the praise condition if the task was complex. The researcher also hypothesized that there would be a main effect for Type of Reinforcement. It was expected that overall there would be more correctly solved problems in the praise condition than in the criticism condition and the least correctly solved problems in the Silence condition. A main effect of Type of Task was also expected, with more overall correct solutions of simple problems than of complex problems.

Analyze → General Linear Model → Univariate

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



Descriptive Statistics

Dependent Variable: # correctly solved reasoning problems - DV

type of reinforcement	type of task	Mean	Std. Deviation	N
praise	simple	7.6000	1.5166	5
	complex	7.0000	2.0000	5
	Total	7.3000	1.7029	10
criticism	simple	7.2000	2.1679	5
	complex	2.0000	1.5811	5
	Total	4.6000	3.2728	10
silence	simple	4.4000	1.9494	5
	complex	3.2000	1.9235	5
	Total	3.8000	1.9322	10
Total	simple	6.4000	2.2928	15
	complex	4.0667	2.7894	15
	Total	5.2333	2.7753	30

Type of Reinforcement	Type of Task		
	Simple	Complex	
Praise	7.6	7.0	7.3
Criticism	7.2	2.0	4.6
Silence	4.4	3.2	3.8
	6.4	4.1	

Above is a table of the type commonly used in research reports which was composed from the SPSS output table on the left -- be sure you know where each cell and marginal means came from !!

Tests of Between-Subjects Effects

Dependent Variable: # correctly solved reasoning problems - DV

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	139.367 ^a	5	27.873	7.964	.000
Intercept	821.633	1	821.633	234.752	.000
REIN	67.267	2	33.633	9.610	.001
TASK	40.833	1	40.833	11.667	.002
REIN * TASK	31.267	2	15.633	4.467	.022
Error	84.000	24	3.500		
Total	1045.000	30			
Corrected Total	223.367	29			

a. R Squared = .624 (Adjusted R Squared = .546)

This column shows the p-values for the various effects,

There is a significant main effect for Type of Reinforcement (but because there are three conditions we don't know the pattern for the mean difference, and so can't test the RH: -- also be sure to check the corresponding simple effects to determine if this main effect is descriptive or potentially misleading).

There is a significant main effect for Type of Task (must inspect the marginal means to test the main effect RH: -- also be sure to check the corresponding simple effects to determine if this main effect is descriptive or potentially misleading).

There is a significant interaction of Type of Task and Type of Reinforcement as they related to the # of correctly solved reasoning problems (must examine the simple effects to determine the pattern of this interaction - see below).

This is the error term for the model -- the Mean Square Error or MSe

We will use LSD minimum mean differences to further analyze the data. There are three significant effects (main effect of Reinforcement, main effect of Task and the interaction), so we might need as many as three d_{LSD} values. However, since the main effect of Task has only two conditions (Simple vs. Complex), we will not need any type of follow-up analyses to compare the marginal means -- we need only compare the direction of the significant mean difference with the RH:.

For the Interaction

based on $df(\text{error}) = 24$, $t = 2.06$ also $n = 5$ $MS(\text{error}) = 3.50$

$$d_{LSD} = \frac{t * \sqrt{(2 * MS_{\text{Error}})}}{\sqrt{n}} = \frac{2.06 * \sqrt{(2 * 3.50)}}{\sqrt{5}} = 2.44$$

Remember: n is based on the average number of data points making up each mean -- $N = 30$ and there are 6 conditions in the design, so $n = N/k = 30/6 = 5$

Applying this d_{LSD} to the cell means ...

SE for Type of Task:

When praise is used Simple (7.6) = Complex (7.0)
 When criticism is used Simple (7.2) > Complex (2.0)
 When silence is used Simple (4.4) = Complex (3.2)

SE of Reinforcement:

For simple tasks Pr (7.6) = Cr(7.2) Cr > Sil (4.4) Pr > Sil
 For complex tasks Pr (7.0) > Cr (2.0) Cr = Si (3.2) Pr > Sil

For the main effect of Type of Reinforcement

based on $df(\text{error}) = 24$, $t = 2.06$ also $n = 10$ $MS(\text{error}) = 3.50$

$$d_{LSD} = \frac{t * \sqrt{(2 * MS_{\text{Error}})}}{\sqrt{n}} = \frac{2.06 * \sqrt{(2 * 3.50)}}{\sqrt{10}} = 1.72$$

Remember: n is based on the average number of data points making up each mean -- $N = 30$ and there are 3 conditions of the Type of Reinforcement IV, so $n = N/k = 30/3 = 10$

Applying this d_{LSD} to the marginal means for Type of Reinforcement ...

Pr(7.3) > Cr (4.6) Cr (4.6) = Sil(3.8) Pr > Sil

We need to compare this pattern to those of the simple effects for Type of Reinforcement, to determine if the main effect is descriptive or potentially misleading.

As you can see, the main effect pattern corresponds only with the simple effect for Complex Tasks, and so, is misleading as a general statement.

Reporting the Results:

A between groups factorial ANOVA with follow-up analyses using the LSD procedure ($p = .05$) was performed to examine the effects of Reinforcement Type and Task Type upon performance on the decision making task. Table 1 shows the means for each condition of the design.

There was an interaction of Task Type and Reinforcement Type as they relate to performance ($F(2,24) = 4.467$, $p = .022$, $Mse = 3.5$). The pattern of this interaction was that, as hypothesized, for simple tasks praise and criticism conditions had equivalent performance, both of which were better than silence, whereas for complex tasks praise was better than criticism, which was equivalent to silence (LSD minimum mean difference = 2.44).

There was a main effect of Task Type ($F(1,24) = 11.67$, $p = .002$), with better overall performance on the simple than the complex task, as hypothesized. However, this effect was descriptive for only the criticism condition. There was also a main effect of Reinforcement Type ($F(2,24) = 9.610$, $p = .001$). The pattern of the mean differences was that, as hypothesized, the best performance was obtained using praise, while poorer performance was obtained using criticism and silence which, contrary to the research hypothesis, were equivalent to each other (LSD minimum mean difference = 1.72; however, the pattern of differences across the Reinforcement types was different for the simple and complex tasks).

An alternative presentation of the interaction pattern (using the simple effect of Reinforcement Type for each Task Type would read...

The pattern of this interaction was that when Criticism was used performance was better on the simple task than the complex task, whereas there were not Task Type effects when either praise or silence were used (LSD minimum mean difference = 2.44).

t-table Critical values of t for $\alpha = .05$

df	$\alpha = .05$	df	$\alpha = .05$
1	12.71	18	2.10
2	4.30	19	2.09
3	3.18	20	2.09
4	2.78	21	2.08
5	2.57	22	2.07
6	2.45	23	2.07
7	2.36	24	2.06
8	2.31	25	2.06
9	2.26	26	2.06
10	2.23	27	2.05
11	2.20	28	2.05
12	2.18	29	2.04
13	2.16	30	2.04
14	2.14	40	2.02
15	2.13	60	2.00
16	2.12	120	1.98
17	2.11	∞	1.96