## 2x2 Between Groups Factorial ANOVA

**Application:** Examination of main effects and interaction relating two IVs (each with 2 conditions) 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 the two types of reinforcement would work equally well for simple tasks, whereas for complex tasks, praise would lead to more correctly solved problems than would criticism. The researcher also hypothesized that there would be main effects for Type of Reinforcement (praise would lead to more correctly solved problems than would criticism) and of Type of Task (more simple problems would be solved correctly than complex problems).

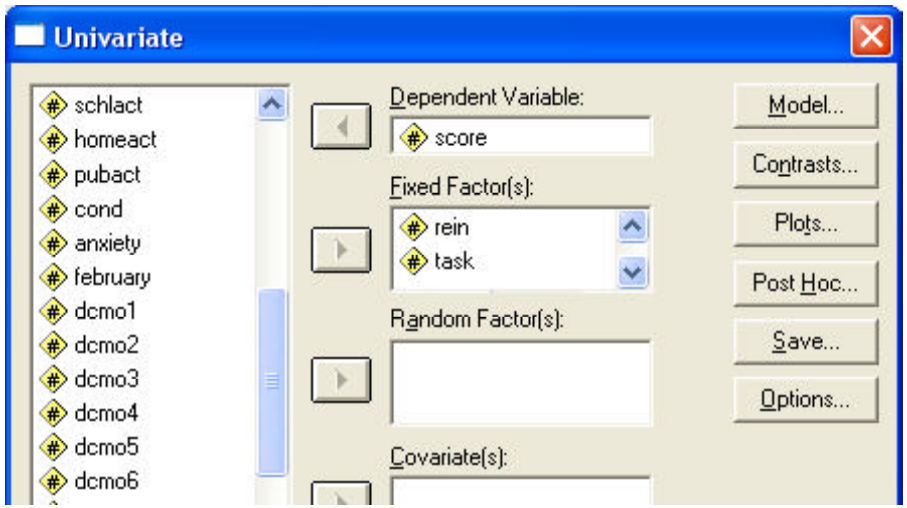
**Research Design:** The IVs are Type of Task, with the conditions Simple & Complex and Type of Reinforcement with the conditions Praise & Criticism
The DV is the number of correctly solved problems

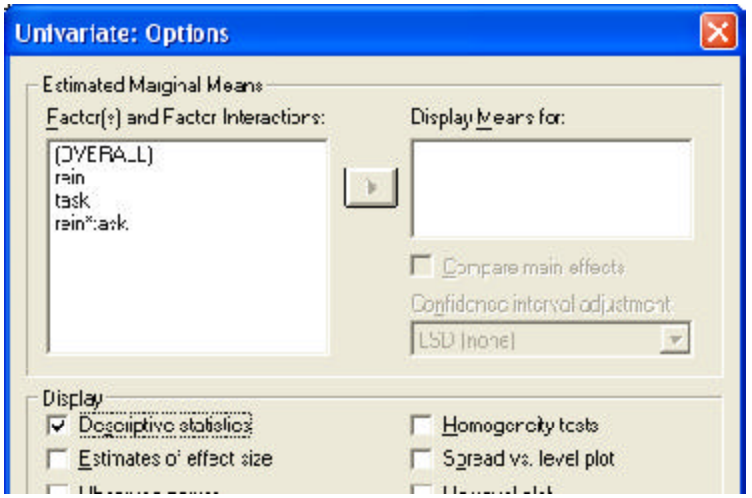
| Type of Reinforcement | Type of Task: Simple | Type of Task: Complex |
|---|---|---|
| Praise | | |
| Criticism | | |

**Variables in the Analysis:** In a BG factorial design the variables in the analysis are the 2 IVs (Type of Task & Type of Reinforcement) & the DV(number of correctly solved problems)

Analyze ➔ General Linear Model ➔ Univariate

- highlight the DV and press the arrow to put it in the "Dependent Variables" box
- highlight the two IVs and press the arrow to put them into the "Fixed Factor(s)" box
- click "Options" — in the **Univariate: Options** window check that you want "Descriptives"



## Output

**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 |
| Total | simple | 7.4000 | 1.7764 | 10 |
| | complex | 4.5000 | 3.1358 | 10 |
| | Total | 5.9500 | 2.8924 | 20 |

Below 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 !!

| Type of Reinforcement | Type of Task: Simple | Type of Task: Complex | |
|---|---|---|---|
| Praise | 7.6 | 7.0 | 7.3 |
| Criticism | 7.2 | 2.0 | 4.6 |
| | 7.4 | 4.5 | |

**Tests of Between-Subjects Effects**

Dependent Variable: '# correctly solved reasoning problems - DV'

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Mode | 104.950[a] | 3 | 34.983 | 10.365 | .000 |
| Intercept | 708.050 | 1 | 708.050 | 209.793 | .000 |
| REIN | 36.450 | 1 | 36.450 | 10.800 | .005 |
| TASK | 42.050 | 1 | 42.050 | 12.459 | .003 |
| REIN * TASK | 26.450 | 1 | 26.450 | 7.837 | .013 |
| Error | 54.000 | 16 | 3.375 | | |
| Total | 867.000 | 20 | | | |
| Corrected Total | 158.950 | 19 | | | |

a. R Squared = .660 (Adjusted R Squared = .597)

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

There is a significant main effect for Type of Reinforcement (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 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 -- often called the Mean Square Error (MSe).

**Using LSD to describe the pattern of the Interaction**

From the F-test we know that there is an interaction, but we don't know if pattern predicted by the interaction RH:

To do this we need to calculate the $d_{LSD}$ for the cell means -- then we can evaluate the simple effects and test the interaction RH:

based on df(error) = 16, **t = 2.12** also **n = 5** **MS(error) = 3.38**

$$d_{LSD} = \frac{t * \sqrt{(2 * MS_{Error})}}{\sqrt{n}} = \frac{2.12 * \sqrt{(2 * 3.38)}}{\sqrt{5}} = \mathbf{2.47}$$

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

SE of Reinforcement:

| | | |
|---|---|---|
| For simple tasks | **Praise (7.6)** | **=** Criticism (7.2) |
| For complex tasks | Praise (7.0) | **>** Criticism (2.0) |

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) |

Remember, we need only one set of SEs to describe the pattern of the interaction, but we need each set to evaluate the descriptiveness of the corresponding main effect.

**t-table**

| df | $\alpha$=.05 |
|---|---|
| 10 | 2.23 |
| 11 | 2.20 |
| 12 | 2.18 |
| 13 | 2.16 |
| 14 | 2.14 |
| 15 | 2.13 |
| 16 | 2.12 |
| 17 | 2.11 |
| 18 | 2.10 |
| 19 | 2.09 |
| 20 | 2.08 |
| 22 | 2.07 |
| 24 | 2.06 |
| 26 | 2.06 |
| 28 | 2.05 |
| 30 | 2.04 |
| 40 | 2.02 |
| 60 | 2.00 |
| 120 | 1.98 |
| ∞ | 1.96 |

**Reporting the Results:**

Task performances under the various conditions of the study are summarized in Table 1. As hypothesized, there was an interaction of Type of Task and Type of Reinforcement, as they related to the number of reasoning tasks solved correctly ($F(1,16) = 7.837$, $p = .013$, $MSe = 3.375$). Further analysis based on LSD follow-ups of the cell means (minimum mean difference = 2.47) revealed the pattern of this interaction was that the two types of reinforcement worked equally well for simple tasks, whereas for complex tasks, praise led to more correctly solved problems than did criticism.

There was a main effect of Type of Task ($F(1, 16) = 12.459$, $p = .003$). As hypothesized, more simple problems were solved correctly overall than were complex problems. However, there was no simple effect of Type of Task for those who received praise.

Also, there was a main effect of Type of Reinforcement ($F(1, 16) = 10.80$, $p = .005$). As hypothesized, praise led to more correctly solved problems than did criticism, overall, however there was no simple effect of Type of Reinforcement for those who completed the simple task.

Table 1 would look like the on the earlier page, but with standard deviations.