Factorial ANOVA Example¹

SPSS Syntax

MEANS VARS=memory by violence by training.

GLM memory BY violence training
   /plot = profile (violence*training)
   /print = etasq.

Menus
Analyze → General Linear Model, then drag the dependent variable over to the appropriate box and add both independent variables to Fixed Factors. Under the Plots button, choose which independent variables you want for the horizontal axis and for separate lines, then click the Add button. Under Options button, check Estimates of Effect Size

Output²:

General Linear Model

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type II Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>120,000*</td>
<td>3</td>
<td>40,000</td>
<td>32,000</td>
<td>.000</td>
<td>.857</td>
</tr>
<tr>
<td>Intercept</td>
<td>320,000</td>
<td>1</td>
<td>320,000</td>
<td>256,000</td>
<td>.000</td>
<td>.041</td>
</tr>
<tr>
<td>violence</td>
<td>80,000</td>
<td>1</td>
<td>80,000</td>
<td>64,000</td>
<td>.000</td>
<td>.800</td>
</tr>
<tr>
<td>training</td>
<td>20,000</td>
<td>1</td>
<td>20,000</td>
<td>16,000</td>
<td>.001</td>
<td>.500</td>
</tr>
<tr>
<td>violence * training</td>
<td>20,000</td>
<td>1</td>
<td>20,000</td>
<td>16,000</td>
<td>.001</td>
<td>.500</td>
</tr>
<tr>
<td>Error</td>
<td>20,000</td>
<td>16</td>
<td>1,250</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>460,000</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>140,000</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

² R Squared = .857 (Adjusted R Squared = .830)

¹ The data analyzed in this example are hypothetical. The memory interference effect of witnessing a violent incident was shown by Loftus, E. F., & Burns, T. E. (1982). Mental shock can produce retrograde amnesia. Memory & Cognition, 10, 318-323. Mindfulness training to reduce emotional interference effects has been conducted by several researchers, such as Ortner, C. N., Kilner, S. J., & Zelazo, P. D. (2007). Mindfulness meditation and reduced emotional interference on a cognitive task. Motivation and emotion, 31, 271-283, among others.
² You may notice that the variances are pretty unequal, which may be problematic with this small n. SPSS unfortunately does not have a Welch’s test that can be used with factorial ANOVA. The UNIANOVA command has added several versions of a robust approach (Huber-White sandwich estimator) that has been shown to be useful in regression models (I illustrate HC3 below, which Long & Ervin, 2000, recommend for small samples). The UNIANOVA syntax is very similar to the GLM syntax. In this example the p-values were very similar and there were no differences in conclusions when the robust method was used.

UNIANOVA memory BY violence training
   /plot = profile (violence*training)
   /print = etasq
   /robust=hc3.
The car package is used in my example, because most approaches to factorial ANOVA in R will use Type I sum of squares. Although this example has equal n in all cells, Type I, II and III sums of squares values will be different if that is not the case. Type III sum of squares is the default in SPSS and what I typically recommend for an unbalanced n design. There are a couple of tricks to getting the correct results using the car package though. An options function must be used and the IVs must be designated as categorical variables in R (“factors”). To check variable type, use str(d), where d is the dataframe name. If you use haven to read in SPSS data, for instance, you will need to convert the IVs to factors. In lessR, you can use the Transform function.

```R
library(lessR)
d <- Transform(violence = factor(violence))
d <- Transform(training = factor(training))

# Must use a different package to get Type III SS for unbalanced design (install car on first use)
library(car)
mymodel = lm(memory ~ violence + training + violence:training, data=d)
# this contrast statement is needed for correct results and is always the same
options(contrasts=c(unordered="contr.sum", ordered="contr.poly"))
Anova(mymodel, type = "III")

# to obtain partial eta squared values, install lsr package
library(lsr)
etasquared(mymodel, type = 3, anova = FALSE)

# interaction plot-- x.factor is x axis and trace.factor is separate lines, response is dv
# all other options can remain the same
interaction.plot(x.factor = d$violence, trace.factor = d$training,
                 response = d$memory, fun = mean, type = "b",
                 col = c("black", "red", "green"), pch = c(19, 17, 15),
                 fixed = TRUE, leg.bty = "o")
```

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>memory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>80</td>
<td>80.00</td>
<td>64</td>
<td>0.0000000555</td>
</tr>
<tr>
<td></td>
<td>training</td>
<td>20</td>
<td>20.00</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>violence:training</td>
<td>20</td>
<td>20.00</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Residuals</td>
<td>16</td>
<td>1.25</td>
<td></td>
</tr>
</tbody>
</table>

eta.sq eta.sq.part
violence 0.5714286         0.8
training 0.1428571         0.5
violence:training 0.1428571 0.5

lessR only allows balanced designs (equal n in each cell), but it is convenient if you have balanced n. For my analysis with n=5 in each cell I could use:

```R
av.brief(memory ~ violence * training)
```
A 2 X 2 (film × mindfulness training) factorial analysis of variance tested the effects of the violent film incident and the mindfulness training program on memory for the assailant. Results indicated a significant main effect for the violence factor, $F(1,16) = 64.00$, $p < .001$, partial $\eta^2 = .80$. As hypothesized, those who saw the violent segment in the film showed a memory deficit ($M = 2.00$) compared to those who had not seen the violent segment ($M = 6.00$). There was also a significant main effect for the training program, $F(1,16) = 16.00$, $p = .001$, partial $\eta^2 = .50$. Officers in the training program had better memory overall ($M = 5.00$) than those who had no training ($M = 3.00$). The two main effects were qualified, however, by a significant interaction between the two factors, $F(1,16) = 16.00$, $p = .001$, partial $\eta^2 = .50$, indicating that the training program effects were not the same for two different film conditions.

(Note that these analyses are incomplete, and I strongly recommend that a significant interaction be followed by additional analyses to probe the nature of the interaction. See the subsequent handout "Simple Effects Test Following a Significant Interaction" for additional information. In addition, although APA recommends inclusion of eta-squared values for each effect, I dislike this the partial eta-squared effect size measure, because the values typically do not total 100% of the variance, even though the F-values are computed such that the effects are partitioned. The term "partial" refers to the fact that only part of the total variance is counted in the denominator, making the values appear larger than if the total variance was used in the denominator).

References