

EXERCISE 16

Mixed ANOVA: three-factor experiment

Before you start

Before proceeding with this Exercise, you should study Section 10.3. From the procedural point of view, the analysis of mixed experiments with three factors is a fairly simple extension of the command for two-factor mixed experiments. In general, however, the interpretation of data from factorial experiments becomes increasingly problematic as more factors are added. In particular, where there is a complex experiment with repeated measures on some factors but not on others, the naming of the factors in the SPSS ANOVA dialog must be carried out with special care.

A three-factor mixed factorial experiment with two within subjects factors and one between subjects factor

While some languages, such as English, have a written form which is read from left to right, others, such as Japanese, consist of columns of characters (pictograms) which are read from the top down. A cognitive psychologist has run an experiment to investigate the effects of linguistic history upon ability to recall items presented either in rows or in columns. Two groups of participants were tested: one whose first language was English and another, whose first language was Japanese.

It was hypothesised that participants would find it easier to recall material presented in a manner consistent with their first language: for example, a Japanese participant should find it easier to recall items presented in a vertical array or column than a row containing the same items; whereas an English participant should find a row of items easier to memorise. This positive effect, however, might be specific to materials resembling the characters in the participant's written language. Thus a Japanese participant might show better recall of vertical arrays of pictorial patterns than horizontal arrays of the same patterns; but this effect might not obtain with words. Conversely, an English participant might be expected to show better recall of words presented in horizontal arrays than those in vertical arrays; but there might be no effect with pictorial patterns. The experiment included an additional control condition in which the participant was asked to recall material presented in random positions on the screen. The two groups were expected to show intermediate levels of recall under this random orientation condition.

Each participant was tested under six presentation conditions, each being a combination of the levels of two factors, one of which was the *Orientation* of the presentation (horizontal, vertical or random orientation), the other the *Type* of presentation (pictures or words). The between subjects variable was the language group to which the participants belonged. The dependent variable was the number of items correctly recalled over a fixed series of trials. We have, therefore, an experiment of mixed factorial design, with one between subjects factor (Language group) and two within subjects factors: Orientation of Array (with 3 levels) and Type of Material (with 2 levels). In the usual notation, the design is of type $A \times (B \times C)$, the brackets indicating that factors B and C are within subjects.

The results are shown in Table 1.

Table 1. Three-factor mixed factorial experiment with two within subjects treatment factors

Orientation of array: Type of material:		Vertical		Horizontal		Random	
		Verbal	Pictorial	Verbal	Pictorial	Verbal	Pictorial
Participant	Language						
1	English	28	17	38	32	32	18
2	English	30	20	42	30	30	23
3	English	32	22	40	27	34	17
4	Japanese	27	37	18	26	18	30
5	Japanese	30	40	23	30	23	26
6	Japanese	33	43	20	31	21	32

Preparing the SPSS data set

In **Variable View**, in addition to a case variable, it will be necessary to name one grouping variable *Language*. In **Data View**, we shall require 6 variables (one for each combination of the *Orientation* and *Type* factors) to contain the results. We suggest that you name the variables in the systematic fashion described in Section 10.3.1.

The ANOVA

The command for running the **Repeated Measures ANOVA** is outlined in Section 10.3.1. The procedure is a straightforward extension of the routine for the two-factor mixed experiment. Name and specify the numbers of levels of two within subjects factors (*Orientation* and *Type*). Enter the **Measure Name** as *RecallScore*. (Note that in the ANOVA dialog box, spaces between characters are not allowed.) Transfer the between subjects variable *Language* to the **Between-Subjects Factor(s)**: box. To request the profile plots, click the **Plots...** button to open the **Repeated Measures: Profile Plots** dialog box. Enter *Orientation* in the **Horizontal Axis**: box, *Type* in the **Separate Lines**: box and *Language* in the **Separate Plots**: box. Click **Add**, then **Continue**, to return to the original dialog box. Select **Options...** to request **Descriptive Statistics**, **Estimates of Effect Size** and **Bonferroni Pairwise Comparisons** for the *Orientation* factor. Click **Continue** and **OK** to run the analysis.

The output

When answering the bullet point relating to effect size, use the following ranges of partial eta-squared (η_p^2) for deciding whether its value is Small, Medium or Large: Small: $.01 \leq \eta_p^2 < .06$; Medium: $.06 \leq \eta_p^2 < .14$; Large: $\eta_p^2 \geq .14$. Note that these are the ranges of values given for omega squared in Table 5 on page 236. While omega squared corrects for positive bias, there are problems with that statistic in experiments of mixed factorial design and we must use eta squared as an equivalent measure of effect size.

Check the **Within-Subjects Factors** table and **Between-Subjects Factors** table to make sure that the details of the experimental design have been communicated correctly to SPSS. Inspect the table of **Descriptive Statistics** to see if you can discern a pattern in the means. Delete the table of **Multivariate Tests**. The **Mauchly** tests will appear in the table **Mauchly's Test of Sphericity**. The Mauchly test only applies to within subjects factors that have more than two levels. In this case, there will be Mauchly tests for the *Orientation* factor and the

Orientation × *Type* interaction. Are the p-values are greater than 0.05? If not, more conservative tests must be made and you must read the appropriate lines in the output table.

The within subjects tests are given in the table **Tests of Within-Subjects Effects**. If the relevant Mauchly test is not significant, you need study only the rows in the ANOVA table labelled **Sphericity Assumed** and you can delete the rows for the conservative tests. Delete the **Tests of Within-Subjects Contrasts** table. The next table is **Tests of Between-Subjects Effects** for the factor *Language*.

- Write down the F ratios (and p-values) for the three factors *Orientation*, *Type* and *Language*, their two-way interactions and the three-way interaction. Do the values of F confirm the patterns among the treatment means you have observed in the table of Descriptive Statistics and the Profile Plots?
- Write down the corresponding Partial Eta Squared values along with whether the effect sizes are ‘small’, ‘medium’ or ‘large’ (see note above).

Look at the table of **Pairwise Comparisons**.

- Are any of the pairs significantly different? Does this add any further information to the result of the F test for the *Orientation* factor?

Finally inspect the **Profile Plots** again. Compare the pattern of lines in both plots.

- Does the ANOVA confirm the appearance of the graphs?
- Has the experimenter’s hypothesis been confirmed? In your answer, refer to the relevant features of the results.

Finishing the session

Close down SPSS and any other windows before logging off.