EXERCISE 12

Between subjects factorial ANOVA (two-way ANOVA)

Before you start

Before proceeding with this practical, please read Chapter 8. The following Exercise assumes a knowledge of the standard **factorial ANOVA** terminology.

An experiment on the memories of chess players

'Must have a marvellous memory!' This is something often said of a good chess player; but do good chess players necessarily have better short-term memories than those who are mediocre? To find out, a psychologist tested chess players at three levels of proficiency on their ability to reconstruct board positions they had just been shown. Some of the positions used were from real games selected from tournaments; but others were merely random placings of the same pieces. The psychologist predicted that whereas the better players would show superior reconstructions of real board positions, this superiority would disappear when they tried to reproduce random placements. The dependent variable in this experiment was a participant's *score* on reconstruction. There were two independent variables (factors):

Competence (Novice, Average, Good).

Position (Real, Random).

An important feature of the design of this experiment was that a different sample of participants performed under each of the six treatment combinations: that is, each group of players at a given level was subdivided into those reconstructing Real positions and those reconstructing Random positions.

What the psychologist is predicting is that, when performance is averaged over Random and Real positions, the better players will achieve higher performance means; but this will turn out to be because of their superior recall of Real board positions only, and the beginners will be just as good at reconstructing Random positions. The **two-factor ANOVA**, therefore, should show a significant interaction between the factors of Competence and Position, as well as (possibly) a main effect of Competence. The latter might be expected to arise because the better players' much superior performance in reconstructing real board positions pulls up the mean value of their performance over both Real and Random positions, even though they may not outperform beginners on the Random task.

The results of the experiment are shown in Table 1.

Table 1. Results of the experiment on the reconstruction of positions by chess players

Position	Competence														
	Novice					Average					Good				
Real	38	39	42	40	40	65	58	70	61	62	88	95	86	89	89
	42	37	38	40	38	58	63	66	62	65	88	90	85	92	86
Random	50	53	40	41	36	50	40	43	37	38	41	40	50	42	41
	42	44	46	44	45	42	44	38	37	43	43	46	41	44	45

Opening SPSS

Open SPSS and select the **Type in data** radio button in the opening window. If **Data View** opens first, click the **Variable View** tab to open **Variable View**.

Preparing the SPSS data set

Recast the data of Table 1 into a form suitable for entry into SPSS along the lines of the description in Section 8.4.1. You will need a variable for cases (there are 60 participants) as well as two grouping variables, *Competence* and *Position*, with appropriate values and value labels specified in the **Values** column, and one dependent variable, *Score*. Ensure that the values in the **Decimals** column have been reduced to 0. We also recommend you to use the **Label** column to assign fuller labels to the variables: e.g. Case Number, Competence, Position of Pieces. Ensure that you have selected the appropriate type of measure for each variable in the **Measure** column. Switch to **Data View** and enter the data, leaving the values for *case* until last, when you can use **Compute** to enter them automatically, making *case* the **Target Variable** and *$casenum* the **Numeric Expression**.

As always, save the data set with a suitable name.

Exploring the data

Before proceeding with the ANOVA, it is important to explore the data. Look at the boxplots (see Section 8.4.2) using **Graphs➔Chart Builder…** and select **Boxplot** from the gallery. Drag the **Clustered Boxplot** image to the **Chart preview** and fill in the variable names with *Score* in the **Y-Axis** box, *Position* in the **X-Axis** box and *Competence* in the **Cluster: set pattern** box. Click **OK** to plot the clustered boxplots.

- **What do you notice about the distribution of data among the three levels of *Competence* for each of the levels of *Position*?**

Although means can be requested in the dialog box for the ANOVA, it is recommended to include the calculation of the means at the exploration of data stage. Do this using the **Means** command (see Section 4.3.2) and layering the two classificatory variables *Position* and *Competence*.

- **What do you notice about the values of the means for the two levels of *Position* across the three levels of *Competence*?**

Procedure for the two-way ANOVA

Choose **Analyze➔General Linear Model➔Univariate…** to open the **Univariate** dialog box. Then complete the dialog box as described in Section 8.4.3, specifying a plot of the means using the **Plots…** dialog box, selecting **Descriptive statistics** and **Estimates of effect size** using the **Options…** dialog box, and a **Tukey** Post Hoc test for *Competence* (ignore *Position* since it has only two levels) using the **Post Hoc…** dialog box.

Output for the two-way ANOVA

[In answering the bullet point relating to effect size, use the following ranges of eta-squared (η^2) for deciding whether its value is Small, Medium or Large:
Small: $.01 \le \eta^2 < .06$; Medium: $.06 \le \eta^2 < .14$; Large: $\eta^2 \ge .14$]

Tables listing the levels of the factors and descriptive statistics will appear first. The ANOVA summary table gives F ratios for the main effects of *Competence* and *Position* and also for the interaction between the two factors, as well as the values of partial eta squared.

- **Write down the report of the results in the form shown in Section 8.2.1 e.g. "The mean scores for the Real and Random conditions of the Position factor …." including the values of F and partial eta squared (stating whether these are large, medium or small) for the main effect and interaction tests.**

- **Do these results confirm your predictions from inspection of the output from the Means procedure?**

- **Relate these results to the experimental hypothesis about the short-term memory of chess players.**

Post hoc comparisons among the levels of competence

Inspect the output for the post hoc comparisons of the levels of competence.

- **Construct your own table showing clearly which pairs of Competence levels are significantly different and which (if any) are not.**

Graph of cell means

Note that the zero point of the vertical scale does not appear on the axis. Always be suspicious of such a graph, because it can give the appearance of a strong effect when actually there is very little happening. The difficulty can easily be remedied by double-clicking on the graph to bring it into the **Chart Editor**, double-clicking on the vertical axis and specifying zero as the minimum point on the vertical scale.

Inspect the graph.

- **What do you conclude from the plot?**

Simple main effects

To tease out the interaction, use the SPSS syntax. Open the Syntax Editor as described in Section 8.5 and then enter subcommands similar to those in Figure 9 but amended for the variable names and factor names of this example (e.g. the /DESIGN subcommand would be /DESIGN=Competence WITHIN Position(1) Competence WITHIN Position(2)). Ensure that there is a period (.) after the /DESIGN subcommand and then run the three-line command as described in Section 8.5.

- **Does the F ratio for Competence within Position (1) differ from that for Competence within Position(2)? Explain what this means.**

Finishing the session

Close down SPSS and any other windows before logging out of the computer.