EXERCISE 9

Comparing the averages of two related samples of data

Before you start

The methods described in the previous Exercise, (the **independent samples *t* test** and the **Mann-Whitney** test), are appropriate for data from a between subjects experiment, that is, one with independent samples of participants in the two groups. Suppose, however, that the data had come from an experiment in which the same participants had been tested under both the experimental and control conditions. Such a within subjects experiment would yield a set of paired (or related) data. In this Exercise, we shall consider some methods for comparing the averages of the scores obtained under the experimental and control conditions when we have a set of paired data (SPSS calls such sets **paired samples**), rather than independent samples. Before proceeding with this exercise, the reader should review the material in Section 6.2.5.

THE PAIRED-SAMPLES T TEST

An experiment on hemispherical specialisation

In an experiment investigating the relative ease with which words presented in the left and right visual fields were recognised, participants were instructed to fixate a spot in the centre of the field. They were told that, after a short interval, a word would appear to the left or the right of the spot and they were to press a key as soon as they recognised it. In the trials that followed, each word was presented an equal number of times in each field, though the order of presentation of the words was, of course, randomised. From the results, a table of median decision times was constructed from the participants' reactions to presentations of 40 words in each of the two visual fields (Table 1).

Table 1. Median decision times for words presented to the right and left visual fields

Case	Right visual field	Left visual field	Case	Right visual field	Left visual field
1	323	324	8	439	442
2	493	512	9	682	683
3	502	503	10	703	998
4	376	385	11	598	600
5	428	453	12	456	462
6	343	345	13	653	704
7	523	543	14	652	653

The question is whether these data support the experimental hypothesis that there is a difference between the response times for words in the left and right visual fields? Before

proceeding with this Exercise, we suggest you read Section 6.2.5, which describes the procedure for a paired-samples *t* test.

Opening SPSS

In the opening window of SPSS, select the **Type in data** radio button. If **Data View** appears first, click the tab labelled **Variable View** to open **Variable View**.

Preparing the SPSS data set

In the data set for the independent samples *t* test, one of the variables must be a grouping variable, showing which participants performed under which conditions. With the paired-samples *t* test, however, there are no groups, so no coding variable is needed.

After naming a variable *Case*, name two more variables: *RVF* with the label *Right Visual Field* in the **Label** column, and *LVF* with the label *Left Visual Field* in the **Label** column. Since there are no decimals in the data, ensure that the values in the **Decimals** column are all 0.

Select **Data View** and enter the data in the usual way, as described in Section 3.1.2.

Exploring the data

As always, it is wise to explore the data, rather than automatically pressing ahead with a formal test. Select **Graphs➔Chart Builder…** (see Section 5.7) and then **Scatter/Dot…** in the gallery so that the **Simple Scatter** diagram becomes visible. Click and drag it to the **Chart preview** and then click and drag in turn the variable names to the X-Axis and Y-Axis dotted boxes. Click **OK** to plot the scatterplot.

From inspection of the scatterplot, it is quite clear that there is a glaringly obvious outlier. It is instructive to ascertain the effect of its presence upon the results of the *t* test, in comparison with the nonparametric **Wilcoxon** and **Sign** tests.

Running the paired-samples *t* test

Run the **paired-samples *t* test** by following the procedure described in Section 6.2.5.

Output for the paired-samples *t* test

From the details given in the *t* test output, it is clear that there are contraindications against the use of the paired-samples *t* test for the data in the present experiment. There is marked discrepancy between the standard deviations of the scores obtained under the *Right Visual Field* and *Left Visual Field* conditions, which arises from the presence of an outlier, which showed up dramatically in the scatterplot.

- **Write down the value of *t* and its p-value. Is *t* significant? Write down, in terms of the research hypothesis, the meaning of this result.**
- **Calculate the effect size using the formula at the end of Section 6.2.5. Is the effect size small, medium or large according to Cohen's table?**

What has happened here? You should find the *t* test result puzzling to say the least. You might find another clue by examining the distribution of differences between the scores. Use **Compute** to calculate a difference between *Left Visual Field* and *Right Visual Field*, putting the answer in a variable called *Differences*.

- **What do you notice about the values in *Differences*? Is there a discernible pattern? (What about the directions of the differences?) Relate this to the scientific hypothesis.**

NONPARAMETRIC ALTERNATIVES TO THE PAIRED-SAMPLES T TEST

The Wilcoxon matched pairs test

Now carry out the **Wilcoxon matched pairs** test, following the procedure described in Section 6.4.4.

- **Write down the value of the statistic and its p-value. Compare the p-value with that for the *t* test. Do the results of the test support the scientific hypothesis?**

The Sign test

This test is based very simply on how many positive and negative differences there are between pairs of data, assuming that the value of one variable is consistently subtracted from the value of the other. It is a straightforward application of the **binomial test** to paired data, such as the results of the visual field experiment above. To merely record the signs (rather than the magnitudes) of the differences between the times for the left and right visual fields is certainly to lose a considerable amount of information.

When paired data show no contraindications for using a parametric test, the ***t* test** is preferable to the **Sign test** because the latter would incur a needless sacrifice of statistical power. The great advantage of the **Sign test** is its robustness to the influence of outliers and no assumptions about bivariate normality in the original paired data. The procedure is very similar to that for the **Wilcoxon test** except that within the **Test Type** box, the **Wilcoxon** check box should be clicked off and the **Sign** check box clicked on. Click **OK** to run the test.

- **Write down the results of the Sign test, including the p-value. Is the result significant? Compare this with the result of the paired samples *t* test and explain any discrepancy.**

Eliminating the outliers

When there are contraindications for the ***t* test**, the use of a nonparametric test is not the only alternative available. Another approach is to consider the possibility of deselecting some of the data. In the present set of paired data, there is one difference between scores value in the variable *Differences* that is much larger than all the others. This may have arisen because *Case 10* had special difficulty in recognising words in the left visual field. At any rate, that participant's performance is quite atypical, and certainly calls into question the claim that he or she was drawn from the same population as the others. It is instructive to re-analyse the data after excluding the scores of *Case 10*. This is done by using the **Select Cases…** procedure (Section 3.3.1). Follow the procedure described in that section to eliminate *Case 10* from the data. (Hint: give the instruction to select cases if *case* ~= 10. The sign ~= means 'not equal to'.)

Now re-run the **paired-samples *t* test**, and run both the **Wilcoxon** and the **Sign** test on the reduced data set. Examine the new output.

- **Write down the value of *t* and its tail probability. Write down your interpretation of this new result. Similarly give the statistics and**

their p-values for the Sign and Wilcoxon tests. Explain your findings.

Finishing the session

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