

### 3: Nonparametric tests

#### 3.1. Mann-Whitney Test

The Mann-Whitney test is used in experiments in which there are two conditions and different subjects have been used in each condition, but the assumptions of parametric tests are not tenable. For example, a psychologist might be interested in the depressant effects of certain recreational drugs. Twenty clubbers were used in all: 10 were given an ecstasy tablet to take on a Saturday night and ten were only allowed to drink alcohol. Levels of depression were measured using the Beck Depression Inventory (BDI) the day after and midweek. When we have collected data using different subjects in each group, we need to input the data using a coding variable (see Handout 1). So, the spreadsheet will have three columns of data. The first column is a coding variable (called something like **drug**), which, in this case, will have only two codes (for convenience I suggest 1 = Ecstasy group, and 2 = alcohol group). The second column will have values for the dependent variable (BDI) measured the day after (call this variable **sunbdi**) and the third will have the midweek scores on the same questionnaire (call this variable **wedbdi**). The data are in Table 3.1 in which the group codes are shown (rather than the group names). When you enter the data into SPSS remember to tell the computer that a code of 1 represents the group that were given ecstasy, and that a code of 2 represents the group that were restricted to alcohol. There were no specific predictions about which drug would have the most effect so the analysis should be 2-tailed.

Table 3.1: Data for spider experiment

Subject	Drug	BDI (Sunday)	BDI (Wednesday)
1	1	15	28
2	1	14	35
3	1	23	35
4	1	26	24
5	1	24	39
6	1	22	32
7	1	16	27
8	1	18	29
9	1	30	36
10	1	17	35
11	2	16	5
12	2	15	24
13	2	20	6
14	2	15	14
15	2	16	9
16	2	13	7
17	2	14	17
18	2	19	6
19	2	18	3
20	2	18	10

##### 3.1.1. Running the Analysis

First, we would run some exploratory analysis on the data (see Handout 2). If you do this you should find that the data are not normally distributed for either variable according to the Shapiro-Wilk statistic. This finding would alert us to the

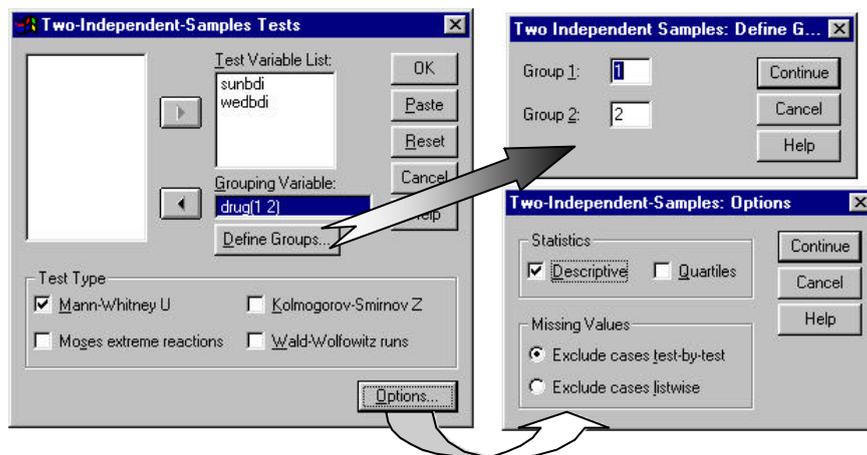
	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Beck Depression Inventory (Sunday)	.190	20	.057	.896	20	.037
Beck Depression Inventory (Wednesday)	.161	20	.185	.893	20	.033

a. Lilliefors Significance Correction

fact that a nonparametric test should be used. Next we need to access the main dialogue box by using the **Analyze > Nonparametric Tests > 2 Independent Samples ...** menu pathway (see Figure 3.1). Once the dialogue box is activated, select both dependent variables from the list (click on **sunbdi** then, holding the mouse button down, drag over **wedbdi**) and transfer them to the box labelled **Test Variable**

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List by clicking on . Next, we need to select an independent variable (the grouping variable). In this case, we need to select **drug** and then transfer it to the box labelled *Grouping variable*. When your grouping variable has been selected the **Define Groups...** button will become active and you should click on it to activate the *define groups* dialogue box. SPSS need to know what numeric codes you assigned to your two groups, and there is a space for you to type the codes. In this example, we coded our ecstasy group as 1, and our alcohol group as 2 and so these are the codes that we type. When you have defined the groups, click on **Continue** to return to the main dialogue box. If you click on **Options...** then another dialogue box appears that gives you options as for the analysis. However, these options are not particularly useful because, for example option that provides descriptive statistics does so for the entire data set (so doesn't break down values according to group membership). For this reason, I recommend obtaining descriptive statistics using the methods we learnt about in week 2. To run the analyses return to the main dialogue box and click on **OK**.



**Figure 3.1:** Dialogue boxes for the Mann-Whitney test

### 3.1.2. Output from the Mann-Whitney Test

The Mann-Whitney test works by looking at differences in the ranked positions of scores in different groups. Therefore, the first part of the output summarises the data after it has been ranked. Specifically, SPSS tells us the average and total

Ranks				
	Type of Drug	N	Mean Rank	Sum of Ranks
Beck Depression Inventory (Sunday)	Ecstasy	10	12.75	127.50
	Alcohol	10	8.25	82.50
	Total	20		
Beck Depression Inventory (Wednesday)	Ecstasy	10	15.45	154.50
	Alcohol	10	5.55	55.50
	Total	20		

ranks in each condition. Now, the Mann-Whitney test relies on scores being ranked from lowest to highest, therefore, the group with the lowest mean rank is the group with the greatest number of lower scores in it. Similarly, the group with the highest mean rank should have greater number of high scores within it. Therefore, this initial table can be used to ascertain which group had

the highest scores, which is useful in case we need to interpret a significant result. Although we can ascertain a lot from the table of ranks, it is worth looking at some descriptive statistics as well. The second table provides the actual test statistics for the Mann-Whitney test. There are many variations on the Mann-Whitney test; in fact, Mann, Whitney and Wilcoxon all came up with statistically comparable techniques for analysing ranked data. The form of the test commonly taught is that of the Mann-Whitney test, however, Wilcoxon provided a different version of this statistic, which can be converted into a Z score and can, therefore, be compared against critical values of the normal distribution. SPSS provides both statistics and the Z score for the Wilcoxon statistic. The table has a column for each variable (one for **sunbdi**

Test Statistics <sup>b</sup>		
	Beck Depression Inventory (Sunday)	Beck Depression Inventory (Wednesday)
Mann-Whitney U	27.500	.500
Wilcoxon W	82.500	55.500
Z	-1.709	-3.750
Asymp. Sig. (2-tailed)	.087	.000
Exact Sig. [2*(1-tailed Sig.)]	.089 <sup>a</sup>	.000 <sup>a</sup>

a. Not corrected for ties.

b. Grouping Variable: Type of Drug

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and one for **wedbdi**) and in each column there is the value of Mann-Whitney's U statistic<sup>1</sup>, the value of Wilcoxon's statistic and the associated z approximation. The important part of the table is the significance value of the test (look at the exact significance and halve its value to obtain the one-tailed significance if you have made a directional prediction). For these data, the Mann-Whitney test is nonsignificant (2-tailed) for the depression scores taken on the Sunday. This finding indicates that ecstasy is no more of a depressant, the day after taking it, than alcohol. Both groups report comparable levels of depression. However, for the mid-week measures the results are highly significant ( $p < 0.001$ ). The value of the mean rankings indicates that the Ecstasy group was significantly more depressed mid-week than the alcohol group.

It is worth noting that nonparametric tests generally have less *statistical power* than their parametric counterparts. This means that there is an increased chance of a Type II error (i.e. there is more chance of accepting that there is no difference between groups when, in reality, a difference exists). To see what I mean, run an independent t-test on these data: how do the conclusions differ?

## 3.2. The Wilcoxon Signed-Rank Test

### 3.2.1. Running the Analysis

Imagine the experimenter was now interested in the change in depression levels, within subjects, for each of the two drugs. We now want to compare the BDI scores on Sunday to those on Wednesday. We can use the same data as before, but because we want to look at the change for each drug separately, we need to use the split file command (see Handout 2) and ask SPSS to split the file by the variable drug. This will ensure that any analysis we do is repeated for the Ecstasy group and the alcohol group separately.

Once the file has been split, select the Wilcoxon test dialogue box by using the file path **Analyze** **Nonparametric Tests** **2 Related Samples ...** (Figure 3.2). Once the dialogue box is activated, select two variables from the list (click on the first variable with the mouse and then the second). The first variable you select (**sunbdi**) will be named as *Variable 1* in the box labelled *Current Selections*, and the second variable you select (**wedbdi**) appears as *Variable 2*. When you have selected two variables, transfer them to the box labelled *Test Pair(s)* by clicking on . If you want to carry out several Wilcoxon tests then you can select another pair of variables, transfer them to the variable list, and then select another pair and so on. In this case, we want only one test. If you click on  then another dialogue box appears that gives you the chance to select descriptive statistics. Unlike the Mann-Whitney test, the descriptive statistics here are worth having, because it is the change across variables (columns in the spreadsheet) that are relevant. To run the analysis, return to the main dialogue box and click on .

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<sup>1</sup> The value of U is calculated using the equation  $U = N_1 N_2 + \frac{N_1(N_1+1)}{2} - R_1$  in which  $N_1$  and  $N_2$  are the samples sizes of groups 1 and 2 respectively, and  $R_1$  is the sum of ranks for group 1. Therefore, for the Sunday BDI scores  $U = (10 \times 10) + \frac{10(11)}{2} - 127.50 = 27.50$  and for the Wednesday BDI scores  $U = (10 \times 10) + \frac{10(11)}{2} - 154.50 = .50$ .

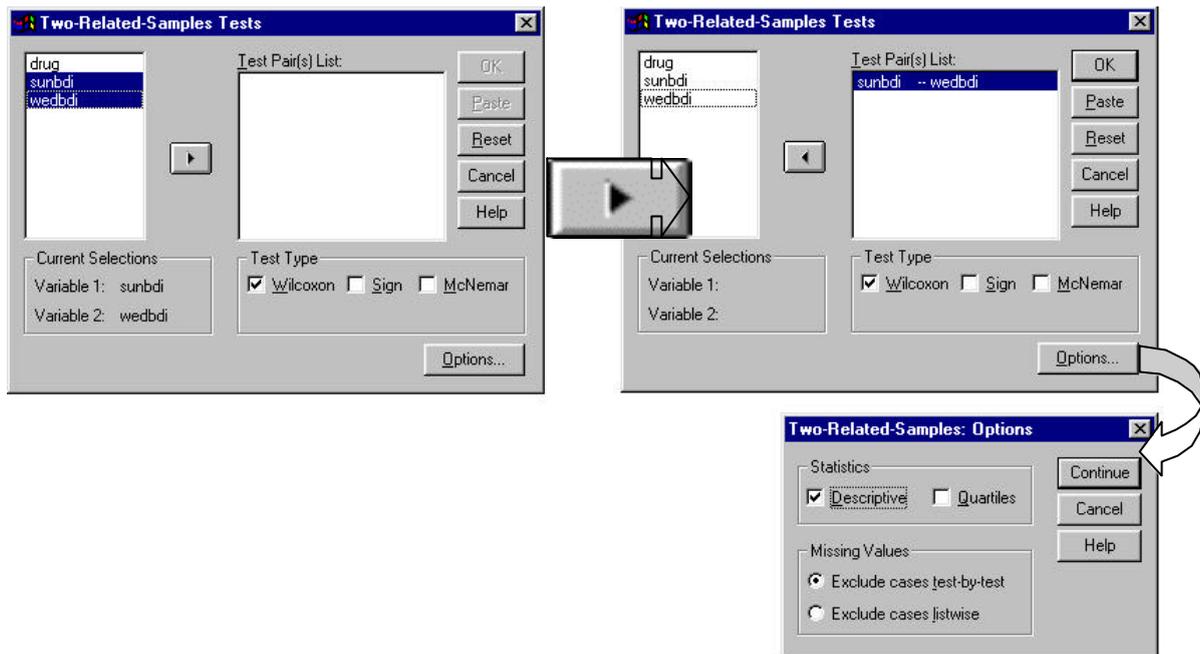


Figure 3.2: Dialogue boxes for the Wilcoxon Test.

### 3.2.2. Output from SPSS

#### 3.2.2.1. Ecstasy Group

If you split the file, then the first set of results obtained will be for the Ecstasy group. The first table provides information about the ranked scores. It tells us the number of negative ranks (these are ranks for which the Sunday score was greater than the Wednesday score) and the number of positive ranks (subjects for whom the Wednesday score was greater than the Sunday score). The table shows that for 9 of the 10 subjects, their score on Wednesday was greater than on Sunday, indicating greater depression Midweek compared to the morning after. There were no tied ranks. The table also shows the average number of negative and positive ranks and the sum of positive and negative ranks. Below the table are footnotes which tell us what the positive and negative ranks relate to (so provide the same kind of explanation as I've just made—see, I'm not clever, I just read the footnotes!). If

Ranks <sup>a</sup>				
		N	Mean Rank	Sum of Ranks
Beck Depression Inventory (Wednesday) - Beck Depression Inventory (Sunday)	Negative Ranks	1 <sup>a</sup>	1.00	1.00
	Positive Ranks	9 <sup>b</sup>	6.00	54.00
	Ties	0 <sup>c</sup>		
Total		10		

- a. Beck Depression Inventory (Wednesday) < Beck Depression Inventor (Sunday)
- b. Beck Depression Inventory (Wednesday) > Beck Depression Inventor (Sunday)
- c. Beck Depression Inventory (Sunday) = Beck Depression Inventory (Wednesday)
- d. Type of Drug = Ecstasy

Test Statistics <sup>b,c</sup>	
	Beck Depression Inventory (Wednesday) - Beck Depression Inventory (Sunday)
Z	-2.703 <sup>a</sup>
Asymp. Sig. (2-tailed)	.007

- a. Based on negative ranks.
- b. Wilcoxon Signed Ranks Test
- c. Type of Drug = Ecstasy

we were to look up the significance of Wilcoxon's test by hand, we would take the lowest value of the two types of ranks, so our test value would be the number of negative ranks (e.g. 1). However, this value can be converted to a Z score and this is what SPSS does. The advantage of this approach is that it allows exact significance values to be calculated based on the normal distribution. This table tells us that the statistic is based on the negative ranks, that the z-score is -2.703 and that this value is significant at  $p = 0.007$ . Therefore, because this value is based on the negative ranks, we should conclude that when taking Ecstasy there was a significant increase in depression (as measured by the BDI) from the

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morning after to mid-week. The remainder of the output should contain the same two tables but for the alcohol group (if it does not, then you probably forgot to split the file).

### 3.2.2.2. Alcohol Group

As before, the first table provides information about the ranked scores. It tells us the number of negative ranks (these are ranks for which the Sunday score was greater than the Wednesday score) and the number of positive ranks (subjects for whom the Wednesday score was greater than the Sunday score). The table shows that for 8 of the 10 subjects, their score on Sunday was greater than on Wednesday, indicating greater depression the morning after compared to mid-week. There were no tied ranks. The table also shows the average number of negative and positive ranks and the sum of positive and negative ranks. Below the table are footnotes that tell us to what the positive and negative ranks relate. As before, the lowest value of ranked scores converted to a Z score and this is what SPSS does. The next table tells us that the statistic is based on the positive ranks, that the z-score is  $-1.988$  and that this value is significant at  $p = 0.047$ . Therefore, we should conclude, based on the fact that positive ranks were used) that when taking alcohol there was a significant decline in depression

	N	Mean Rank	Sum of Ranks
Beck Depression Inventory (Wednesday) - Beck Depression Inventory (Sunday) Negative Ranks	8 <sup>a</sup>	5.88	47.00
Beck Depression Inventory (Sunday) Positive Ranks	2 <sup>b</sup>	4.00	8.00
Ties	0 <sup>c</sup>		
Total	10		

- a. Beck Depression Inventory (Wednesday) < Beck Depression Inventor (Sunday)
- b. Beck Depression Inventory (Wednesday) > Beck Depression Inventor (Sunday)
- c. Beck Depression Inventory (Sunday) = Beck Depression Inventory (Wednesday)
- d. Type of Drug = Alcohol

	Beck Depression Inventory (Wednesday) - Beck Depression Inventory (Sunday)
Z	-1.988 <sup>a</sup>
Asymp. Sig. (2-tailed)	.047

- a. Based on positive ranks.
- b. Wilcoxon Signed Ranks Test
- c. Type of Drug = Alcohol

(as measured by the BDI) from the morning after to mid-week. From these two results, we can see that there is an opposite effect when alcohol is taken, to when ecstasy is taken. Alcohol makes you slightly depressed the morning after but this depression has dropped by Midweek. Ecstasy also causes some depression the morning after consumption, however, this depression increases towards the middle of the week. Of course, to see the true effect of the morning after we would have had to take measures of depression before the drugs were administered! This opposite effect, is known as an interaction (i.e. you get one effect under certain circumstances, and a different effect under other circumstances) and you'll be learning about them in your second year (so remember this session well!).

## 3.3. Graphing Mixed Designs

In the examples in this handout, we had one variable measured with different subjects (drug), but each subject was also given measures on two separate days (so, this variable was repeated measures). The situation in which there are two variables and one has been measured between-groups and the other is a repeated measure is known as a mixed design. This situation is interesting to illustrate how to draw complex graphs. To draw this graph, first remember to switch off the split file command so that we are analysing all cases (see handout 2). Then select the main bar chart dialogue box by using the **Graphs > Bar...** menu path. In this dialogue box, click on the picture labelled *Clustered* (this option allows us to plot the between-groups variable) and then select *Summaries for separate variables* (this option allows us to plot the repeated measure). When these options have been selected, click on **Define**. The next dialogue box has two spaces. The first asks what you want the bars to represent. You should select the variables representing different levels of the repeated measures variable (in this case **sunbdi** and **wedbdi**), and transfer them to the box labelled *Bars Represent*. A second space is labelled *Category Axis*, and you should transfer the between-groups variable (**drug**) into this space. By default, SPSS will display mean values of the selected variables; however, you can display other values by clicking on **Change Summary...** When all of the options have been selected click on **OK** to draw the graph. The resulting graph is shown in Figure 3.3. It is pretty clear that the clusters of bars represent the two groups (the between-groups variable) while the

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bars within each cluster represent the different days (the repeated measures variable). If you double click on the graph you can edit it in a separate window and make it pretty (like I have!).

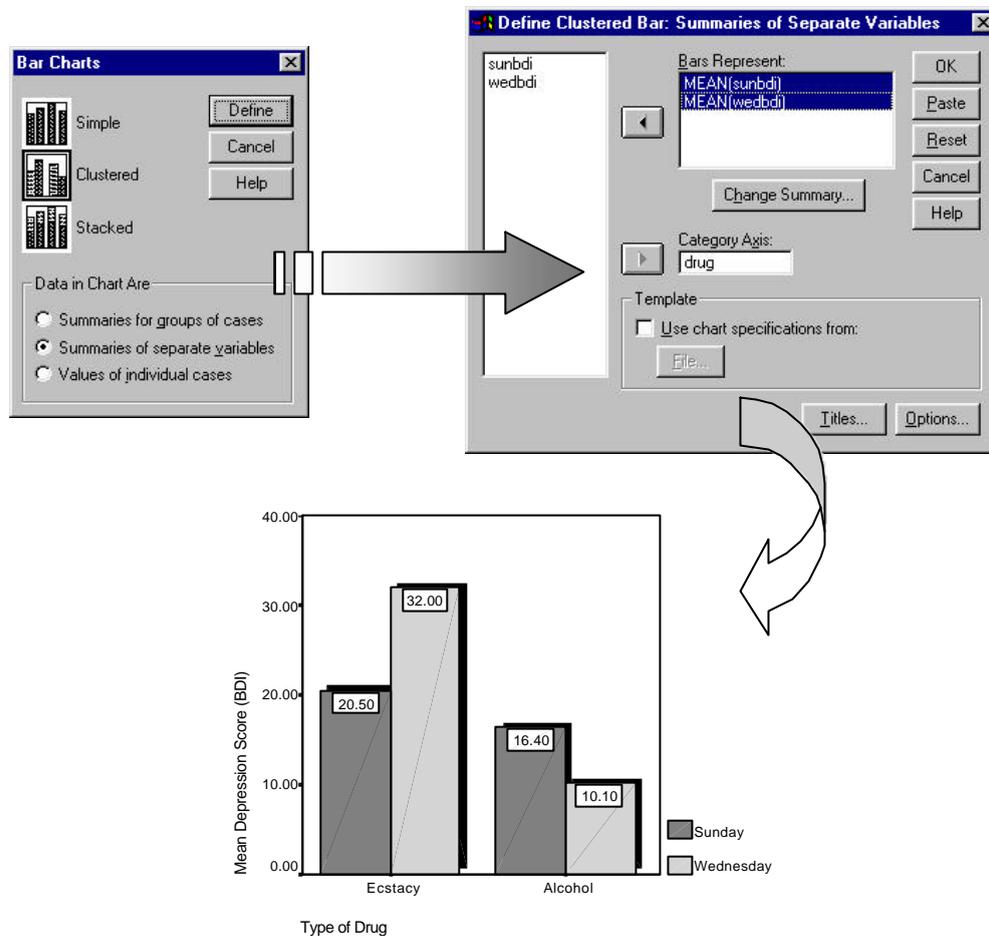


Figure 3.3: Plotting graphs of mixed designs.

This handout contains large excerpts of the following text (so copyright exists!)

**Field, A. P. (2000). *Discovering statistics using SPSS for Windows: advanced techniques for the beginner*. London: Sage.**

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