

## Non-Parametric Tests

These questions are for you to complete in your own time. Please use them for extra revision of the concepts discussed in lectures and practised in tutorials. For help with these questions, you can ask any of your tutorial leaders or visit Maths-Aid. Maths-Aid can be found in Room 1.16 on Level 1 of the Marjorie Robinson Library and can be contacted at [mathsaid@ncl.ac.uk](mailto:mathsaid@ncl.ac.uk).

### Non-parametric testing

On previous question sheets you were asked to analyse data using two sample and paired  $t$  tests. These types of tests are referred to as parametric tests and can only be used if the data to be analysed does not significantly deviate from a normal distribution. We do not know that this is true for any of the data sets analysed in the previous weeks. For data sets that we do not know to be normally distributed (meaning we do not know that a parametric test is required) we must perform hypothesis tests using an equivalent non-parametric test. The equivalent non-parametric tests that we will use here are listed in the table below.

Parametric Test	Non-Parametric Test
Two sample t-test	Mann-Whitney U test
Paired t-test	Wilcoxon signed ranks test

### Mann-Whitney U Test

1. Recall the data from question 1 on the 2-sample t-test worksheet, where researchers were interested in differences in heart rate of men and women whilst waiting for an interview. Use a Mann-Whitney U test to test if heart rate differs between men and women at the 95% level.

Heart rate women (bmp)	Heart rate men (bmp)
84	80
81	74
80	73
70	72
72	78
69	75
65	70
74	74
80	69

- a) State  $H_0$  and  $H_1$

- b) Identify  $n_{1,2}$  and use these to calculate  $R_1, R_2$  and  $U$ .
- c) Compare  $U$  to the critical value in the table that corresponds to  $n_1, n_2$  to determine if the test is significant. Interpret the result.
2. Recall the data from question 3 on the 2-sample t-test worksheet, where we considered the effect that different types of music had on mood. Apply a Mann-Whitney U test to this data to see if there is any difference in mood between the two music conditions.

Mood score classical music	Mood score rap music
7.98	6.74
6.31	6.12
4.76	7.89
6.02	5.84
5.66	3.87
6.75	3.1
5.73	4.55
6.86	6.32
7.09	7.02
4.98	

### Wilcoxon Signed Ranks Test

3. A lecturer believes that students in his class are not getting enough sleep to perform to the best of their ability on tests. To test this theory, he asks 10 students in his class to keep sleep diaries over a four week period. He tells the students to ensure they sleep for 8 hours per night. At the beginning and end of the four weeks, all the students take a standard IQ test. Scores on the test at the beginning and end of the four week period are below. Is there any evidence to support the researcher's theory that longer periods of sleep improve performance?

Participant	First Test Score	Second Test Score
1	92	102
2	97	100
3	76	74
4	87	85
5	80	83
6	79	89
7	99	100
8	111	112
9	103	99
10	93	97

- a) State  $H_0$  and  $H_1$
- b) Calculate  $W_-$  and  $W_+$
- c) Compare the smallest of  $W_-$  and  $W_+$  to the appropriate value in the table and interpret the result.

## Solutions

### Mann Whitney U Test

- 1) a)  $H_0$ : no difference in heart rate between the sexes in stressful situations  
 $H_1$ : some difference in heart rate between the sexes in stressful situations  
b)  $n_1 = 9, n_2 = 9, R_1 = 89.5, R_2 = 81.5, U = 36.5$   
c) At the 95% level,  $U_{crit} = 17$ , so  $U > U_{crit}$  and the result is not significant. There is no evidence to suggest there is a difference in heart rate between the sexes in stressful situations.
  
- 2)  $H_0$ : no difference in the effects of the different music types on mood  
 $H_1$ : some difference in the effects of the different music types on mood  
 $n_1 = 10, n_2 = 9, R_1 = 107, R_2 = 83, U = 38$   
At the 95% level,  $U_{crit} = 20$ , so  $U > U_{crit}$  and the result is not significant. There is no evidence to suggest there is a difference in the effects of the different music types on mood.

### Wilcoxon Signed Ranks Test

3. a)  $H_0$ : no effect of music on mood  
 $H_1$ : some effect of music on mood  
b)  $W_- = 14.5, W_+ = 40.5$   
c)  $W_{crit} = 8, W_- > W_{crit}$  so  $p > 0.05$  and the result is not significant  
d) The result is not significant so there is no evidence to reject the null hypothesis. Hence, there is no evidence to suggest sleep had an effect on performance.