Chapter 4
Non-Parametric Tests

Wilcoxon Test

The t-tests reviewed in the previous chapter are suitable for studies with normally distributed results. However, if there are outliers, then the t-tests are not sensitive and non-parametric tests have to be applied. We should add that non-parametric are also adequate for testing normally distributed data. And, so, these tests are, actually, universal, and are, therefore, absolutely to be recommended.

Calculate the p-value with the paired Wilcoxon test.

Observation 1:

6.0,	7.1,	8.1,	7.5,	6.4,	7.9,	6.8,	6.6,	7.3,	5.6

Observation 2:

5.1,	8.0,	3.8,	4.4,	5.2,	5.4,	4.3,	6.0,	7.3,	6.2

Individual differences:

0.9,	–0.9,	4.3,	3.1,	1.2,	2.5,	2.5,	0.6,	3.6,	–0.6

Rank number:

3.5,	3.5,	10,	7,	5,	8,	6,	2,	9,	1

A. not significant
B. $0.05 < p < 0.10$
C. $p < 0.05$
D. $P < 0.01$

Is there a significant difference between observation 1 and 2? Which significance level is correct?

The individual differences are given a rank number dependent on their magnitude of difference. If two differences are identical, and if they have for example the rank numbers 3 and 4, then an average rank number is given to both of them, which

T.J. Cleophas and A.H. Zwinderman, *Statistical Analysis of Clinical Data on a Pocket Calculator: Statistics on a Pocket Calculator*, DOI 10.1007/978-94-007-1211-9_4,

means 3.5 and 3.5. Next, all positive and all negative rank numbers have to be added up separately. We will find 4.5 and 50.5. According to the Wilcoxon table underneath the smaller one of the two add-up numbers must be smaller than 8 in order to be able to speak of a p-value <0.05. This is true in our example.

Be careful with type of data
Unless suffer serious damage!!!!!

Wilcoxon test table

Number of pairs	P<0.05	P<0.01
7	2	0
8	2	0
9	6	2
10	8	3
11	11	5
12	14	7
13	17	10
14	21	13
15	25	16
16	30	19

Mann-Whitney Test

Like the Wilcoxon test, being the non-parametric alternative for the paired t-test, the Mann-Whitney test is the non-parametric alternative for the unpaired t-test. Also this test is applicable for all kinds of data, and, therefore, particularly, to be recommended for investigators with little affection for medical statistics.

Calculate the p-value of the difference between two groups of ten patients with the help of this test.

Group 1:

6.0	7.1,	8.1,	7.5,	6.4,	7.9,	6.8,	6.6,	7.3,	5.6

Group 2:

5.1,	8.0,	3.8,	4.4,	5.2,	5.4,	4.3,	6.0,	3.7,	6.2

A. not significant
B. $0.05 < p < 0.10$
C. $p < 0.05$
D. $p < 0.01$

Is there a significant difference between the two groups? What significance level is correct?

All values are ranked together in ascending order of magnitude. The values from group 1 are printed thin, those from group 2 are printed fat. Add a rank number to each value. If there are identical values, for example, the rank numbers 9 and 10, then replace those rank numbers with average rank numbers, 9.5 and 9.5.

Subsequently, all fat printed rank numbers are added up, and so are the thin printed rank numbers. We will find the values 142.5 for fat print, and 67.5 for thin print.

According to the Mann-Whitney table of page 13, the difference should be larger than 71 in order for the significance level of difference to be <0.05. We find a difference of 75, which means that there is a p-value <0.05 and that the difference between the two groups is, thus, significant.

3.7	1
3.8	2
4.3	3
4.4	4
5.1	5
5.2	6
5.4	7
5.6	**8**
6.0	**9.5**
6.0	9.5
6.2	11
6.4	**12**
6.6	**13**
6.8	**14**
7.1	**15**
7.3	**16**
7.5	**17**
7.9	**18**
8.0	19
8.1	**20**

Mann-Whitney test

$P < 0.01$ levels

$n_1 \rightarrow$ $n_2 \downarrow$	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4			10											
5		6	11	17										
6		7	12	18	26									
7		7	13	20	27	36								
8	3	8	14	21	29	38	49							
9	3	8	15	22	31	40	51	63						
10	3	9	15	23	32	42	53	65	78					
11	4	9	16	24	34	44	55	68	81	96				
12	4	10	17	26	35	46	58	71	85	99	115			
13	4	10	18	27	37	48	60	73	88	103	119	137		
14	4	11	19	28	38	50	63	76	91	106	123	141	160	
15	4	11	20	29	40	52	65	79	94	110	127	145	164	185
16	4	12	21	31	42	54	67	82	97	114	131	150	169	
17	5	12	21	32	43	56	70	84	100	117	135	154		
18	5	13	22	33	45	58	72	87	103	121	139			
19	5	13	23	34	46	60	74	90	107	124				
20	5	14	24	35	48	62	77	93	110					
21	6	14	25	37	50	64	79	95						
22	6	15	26	38	51	66	82							
23	6	15	27	39	53	68								
24	6	16	28	40	55									
25	6	16	28	42										
26	7	17	29											
27	7	17												
28	7													

The values are the minimal differences that are statistically significant with a p-value <0.01. The upper row gives the size of Group 1, the left column the size of Group 2

Mann-Whitney test

P<0.05 levels

$n_1 \rightarrow$														
$n_2 \downarrow$	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5				15										
6			10	16	23									
7			10	17	24	32								
8			11	17	25	34	43							
9		6	11	18	26	35	45	56						
10		6	12	19	27	37	47	58	71					
11		6	12	20	28	38	49	61	74	87				
12		7	13	21	30	40	51	63	76	90	106			
13		7	14	22	31	41	53	65	79	93	109	125		
14		7	14	22	32	43	54	67	81	96	112	129	147	
15		8	15	23	33	44	56	70	84	99	115	133	151	171
16		8	15	24	34	46	58	72	86	102	119	137	155	
17		8	16	25	36	47	60	74	89	105	122	140		
18		8	16	26	37	49	62	76	92	108	125			
19	3	9	17	27	38	50	64	78	94	111				
20	3	9	18	28	39	52	66	81	97					
21	3	9	18	29	40	53	68	83						
22	3	10	19	29	42	55	70							
23	3	10	19	30	43	57								
24	3	10	20	31	44									
25	3	11	20	32										
26	3	11	21											
27	4	11												
28	4													

The values are the minimal differences that are statistically significant with a p-value <0.01. The upper row gives the size of Group 1, the left column the size of Group 2