Nonparametric Statistics

(SignTest) Hemoglobin levels (in g/dL) sampled from 10 female vegetarians. Is the median hemoglobin level less than 13.0

x	diff	| diff |	Rank	Signed Rank	η=	13
12.3	-0.7	0.7	3.5	-3.5		
13.1	0.1	0.1	1.0	1.0		8.0
11.3	-1.7	1.7	7.0	-7.0		-47.0
10.1	-2.9	2.9	10.0	-10.0		
14.0	1.0	1.0	5.0	5.0		
13.3	0.3	0.3	2.0	2.0		
10.5	-2.5	2.5	9.0	-9.0		
12.3	-0.7	0.7	3.5	-3.5		
10.9	-2.1	2.1	8.0	-8.0		
11.9	-1.1	1.1	6.0	-6.0		

	Ranks	
	1	0.1
	2	0.3
3.5	3	0.7
3.5	4	0.7
	5	1
	6	1.1
	7	1.7
	8	2.1
	9	2.5
	10	2.9

$H_0: \ \eta = 13$

$H_a: \ \eta < 13$

$\sum - \ = 47$

$\sum + \ = 8$

$TS: \ \min\left(\sum -, \sum +\right) = 8 \qquad (\text{for } n \le 25)$

$$\frac{(\eta + 0.5) - \frac{n}{2}}{\sqrt{\frac{n}{2}}} \qquad (\text{for } n > 25)$$

$CV: \ S_{n,\alpha} = S_{10,\ 0,05} = 1 \qquad \text{for } n \le 25$

$z_{\alpha} \qquad \text{for } n > 25$

Nonparametric Statistics

(Wilcoxin-Signed Rank Test) Aluminum concentration in fresh water samples.

Sample No.	August	November	difference	| difference |	Rank
1	18.3	12.7	-5.6	5.6	8
2	13.3	11.1	-2.2	2.2	5
3	16.5	15.3	-1.2	1.2	3
4	12.6	12.7	0.1	0.1	1
5	9.5	10.5	1	1	2
6	13.6	15.6	2	2	4
7	8.1	11.2	3.1	3.1	6
8	8.9	16.2	7.3	7.3	7
9	10	16.2	6.2	6.2	9
10	8.3	15.5	7.2	7.2	10
11	7.9	19.9	12	12	11
12	8.1	20.4	12.3	12.3	12
13	13.6	36.8	23.2	23.2	13

$\sum -\ = 16$

$\sum +\ = 75$

```
Ryan-Joiner Test
Test statistic, Rp:                          0.8402
Critical value for 0.05 significance level:  0.931
Critical value for 0.01 significance level:  0.9

Reject normality with a 0.05 significance level.
Reject normality with a 0.01 significance level.
```

$H_0: \ \mu_{November} - \mu_{August} = 0$

$H_a: \ \mu_{November} - \mu_{August} \neq 0$

$\alpha = 0.05$

$n = 13$

$TS: \ \min\left(\sum -, \sum +\right) = 16$ (for $n \leq 30$)

$$\frac{\min\left(\sum -, \sum +\right) - \frac{n(n+1)}{4}}{\sqrt{\frac{n(n+1)(2n+1)}{24}}}$$ (for $n > 30$)

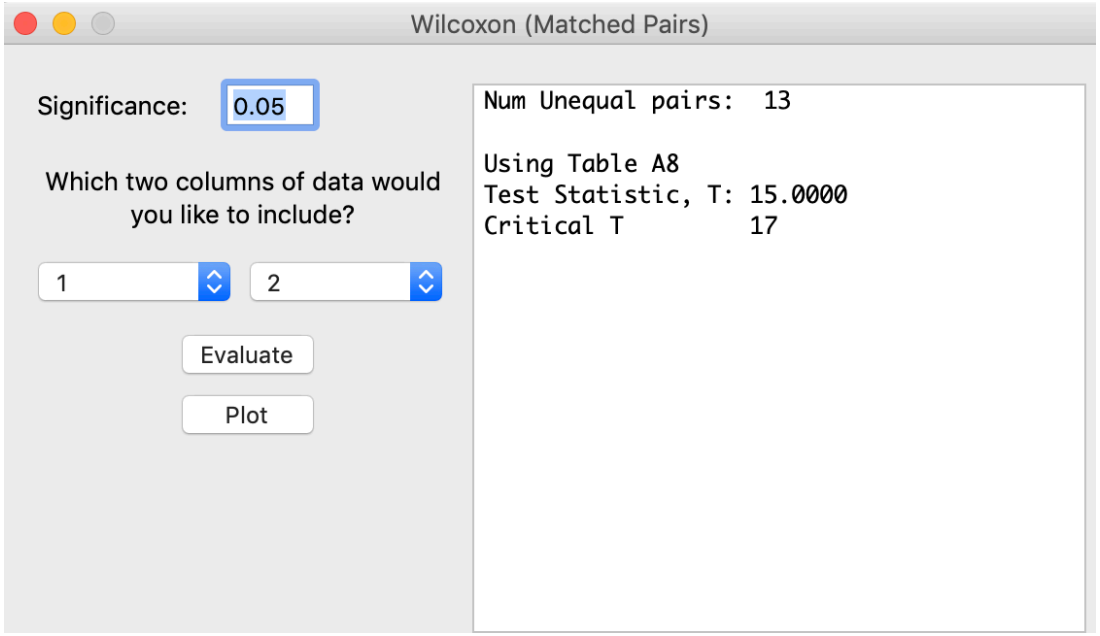
$CV: \ W_{n,\alpha} = W_{13,0.05} = 17$

Nonparametric Statistics

(Wilcoxin-Signed Rank Test)

- **Reject H_0 when the test statistic is less than the critical value !**

Row	1	2
1	18.3	12.7
2	13.3	11.1
3	16.5	15.3
4	12.6	12.7
5	9.5	10.5
6	13.6	15.6
7	8.1	11.2
8	8.9	16.2
9	10	16.2
10	8.3	15.5
11	7.9	19.9
12	8.1	20.4
13	13.6	36.8



Nonparametric Statistics

(Mann Whitney U- Test) - Comparing ratings or ranks for two(2) independent samples.

- **Reject H_0 when the test statistic is less than the critical value !**

Treatment	A	B
	3	9
	4	7
	2	5
	6	10
	2	6
	5	8

	Ranks	
1.5	1	2
1.5	2	2
	3	3
	4	4
5.5	5	5
5.5	6	5
7.5	7	6
7.5	8	6
	9	7
	10	8
	11	9
	12	10

Treatment		A		B
	3	3	11	9
	4	4	9	7
	1.5	2	5.5	5
	7.5	6	12	10
	1.5	2	7.5	6
	5.5	5	10	8
Sums ->	23		55	

$$H_0 : \mu_A - \mu_B = 0$$
$$H_a : \mu_A - \mu_B \neq 0$$
$$\alpha = 0.05$$

$$TS: \min \begin{cases} RankSum_A - \dfrac{n(n+1)}{2} = 2 \\ RankSum_B - \dfrac{n(n+1)}{2} = 34 \end{cases} = 2$$

$$CV: U_{n_1, n_2, \alpha} = U_{6, 6, 0.05} = 5$$

Nonparametric Statistics

(Kruskal Wallis Test) - Nonparametric version of ANOVA.
Here we are told the the populations are not normally distributed.

Row	1	2	3
1	8.2	10.2	13.5
2	10.3	9.1	8.9
3	9.1	13.9	9.6
4	12.6	14.5	13.8
5	11.4	9.1	17.4
6	13.2	16.4	15.3