Comparing groups using continuous not-Normal data (Some non-parametric tests)



Gabriela Czanner PhD CStat Department of Biostatistics Department of Eye and Vision Science



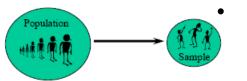
29 May 2013

MERSEY POSTGRADUATE TRAINING PROGRAMME

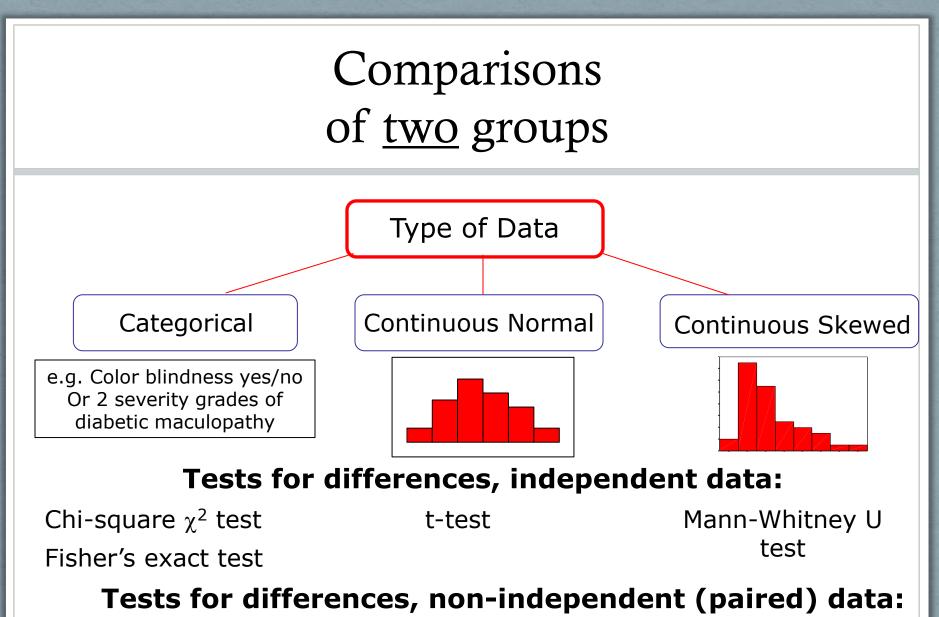
Workshop Series: Basic Statistics for Eye Researchers and Clinicians

How to compare several groups?

- Research question
 - Is Visual Acuity same across three <u>patients groups</u> e.g. diabetic retinopathy, diabetic maculopathy and healthy?
 - Is the degree of staining in conjuctivial tissues same across 5 different storage <u>methods</u>?
 - Is contrast sensitivity different at two different <u>time points e.g.</u> before and after a treatment?

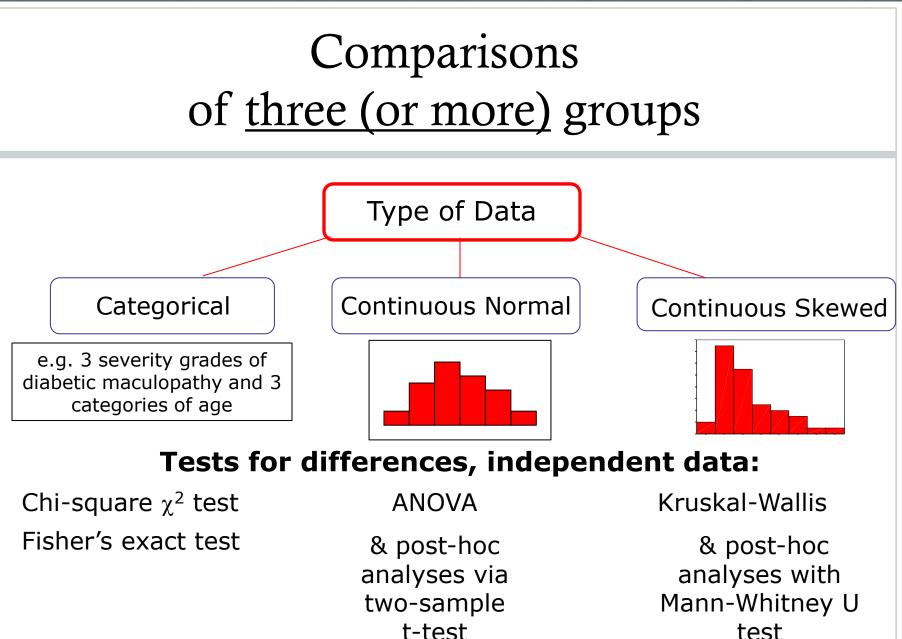


- A strategy
- To collect data on samples in each group
- Then use the data to compare the groups via an appropriate data analysis method



McNemar's test Paired (single sample) t-test Wilcoxon signed

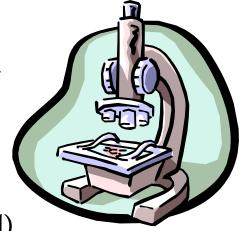
rank test

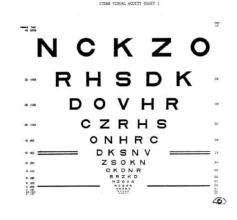


t-test

Outline

- Comparison for 2 groups using data that are continuous, paired (non-independent) and skewed (not-Normal)
 - Wilcoxon test
- Comparisons for 2 groups using data that are continuous, independent and skewed (not-Normal)
 - Mann-Whitney's test





Nonparametric methods of groups comparison for continuous data

- Parametric methods (such as t-test, ANOVA) for continuous (interval) data assume response measurement is approximately Normally distributed. Assumption may not be justifiable, or difficult to check because of small amount of data.
- **Nonparametric** (or **distribution-free**) techniques do not require the Normality assumption where numerical data are replaced by rank values.

For paired continuous data: Wilcoxon signed rank

For independent continuous data: Mann-Whitney U test

Wilcoxon signed rank test

- The non-parametric equivalent of the paired (one sample) *t-test is the Wilcoxon signed rank test*.
- For n pairs of observations the procedure is:
 - Calculate the difference between the pairs of observations.
 - Rank the differences in order of magnitude, ignoring the signs.
 - Sum the ranks of the negative differences to give *T*[⊥] and those of the positive differences to give *T*⁺
 - Set *T* to be the smaller of T^- and T^+
- The distribution of *T* is tabulated for *n* < 50. A normal approximation can be used for large *n*.

- 13 patients of early diabetic retinopathy are seen twice: at a baseline and at six moths.
- Has their visual acuity (BCVA in letters) changed across the two time point?

BCVAbaseline	BCVAat6months	
94	93	NT. 11 1 (1 '
90	95	Null hypothesis ???
90	84	H0:
81	85	Alternative hypothesis???
70	80	Alternative hypothesis??? H1:
85	83	111.
87	79	
82	75	
86	95	
73	84	

- 13 patients of early diabetic retinopathy are seen twice: at a baseline and at six moths.
- Has their visual acuity (BCVA in letters) changed across the two time point?

BCVAbaseline	BCVAat6months	
94	93	NT. 11 1
90	95	Null hypothesis
90	84	H0: <u>The distribution of BCVA is same</u>
81	85	at the two time points.
70	80	Alternative hypothesis
85	83	H1: the distribution is different
87	79	111. the distribution is <u>different</u>
82	75	Data are too short to check Normality,
86	95	so we will use Wilcoxon test.
73	84	

9

BCVAbaseline	BCVAat6months	Difference	Abs Diff	Rank	Rank +	Rank -
94	93	1				
90	95	-5				
90	84	6				
81	85	-4				
70	80	-10				
85	83	2				
87	79	8				
82	75	7				
86	95	-9				
73	84	-11				

1 step Calculate the difference between the pairs of observations.

BCVAbaseline	BCVAat6months	Difference	Abs Diff	Rank	Rank +	Rank -
94	93	1	1	1		
90	95	-5	5	4		
90	84	6	6	5		
81	85	-4	4	3		
70	80	-10	10	9		
85	83	2	2	2		
87	79	8	8	7		
82	75	7	7	6		
86	95	-9	9	8		
73	84	-11	11	10		

2 step Rank the differences in order of magnitude, ignoring the signs.

Example: Visual acuity and Wilcoxon signed rank test ... manually

BCVAbaseline	BCVAat6months	Difference	Abs Diff	Rank	Rank +	Rank -
94	93	1	1	1	1	
90	95	-5	5	4		4
90	84	6	6	5	5	
81	85	-4	4	3		3
70	80	-10	10	9		9
85	83	2	2	2	2	
87	79	8	8	7	7	
82	75	7	7	6	6	
86	95	-9	9	8		8
73	84	-11	11	10		10
				SUM	21	34
Here T- equals	34					
Here T+ equals	21					

Step 3 Find ranks in each group: Rank + and Rank-; and sum them up.

Example: Visual acuity and Wilcoxon signed rank test ... manually

BCVAbaseline	BCVAat6months	Difference	Abs Diff	Rank	Rank +	Rank -
94	93	1	1	1	1	
90	95	-5	5	4		4
90	84	6	6	5	5	
81	85	-4	4	3		3
70	80	-10	10	9		9
85	83	2	2	2	2	
87	79	8	8	7	7	
82	75	7	7	6	6	
86	95	-9	9	8		8
73	84	-11	11	10		10
				SUM	21	34

Step 4 Test statistic.

Here T- equals	34
Here T+ equals	21

- Hence test statistic T = min(T- and T+) = 21
- Under hypothesis of equality of distributions at 0 and 6 months, what value of T we expect ?
 - (a) Small and close to 0?
 - (b) Large and close to max rank which is 55?
 - (b) Or the average value of 1, 2, 3,....10 which is 55/2=27.5?

BCVAbaseline	BCVAat6months	Difference	Abs Diff	Rank	Rank +	Rank -
94	93	1	1	1	1	
90	95	-5	5	4		4
90	84	6	6	5	5	
81	85	-4	4	3		3
70	80	-10	10	9		9
85	83	2	2	2	2	
87	79	8	8	7	7	
82	75	7	7	6	6	
86	95	-9	9	8		8
73	84	-11	11	10		10
				SUM	21	34

Here T- equals	34
Here T+ equals	21

- Hence test statistic T = min(T- and T+) = 21
- Under hypothesis of equality of distributions at 0 and 6 months, what value of T we expect?
 - (a) Small and close to 0? NO
 - (b) Large and close to max rank which is 55? NO
 - (b) Or the average value of 1, 2, 3,....10 which is 55/2=27.5? **YES**

BCVAbaseline	BCVAat6months	Difference	Abs Diff	Rank	Rank +	Rank -
94	93	1	1	1	1	
90	95	-5	5	4		4
90	84	6	6	5	5	
81	85	-4	4	3		3
70	80	-10	10	9		9
85	83	2	2	2	2	
87	79	8	8	7	7	
82	75	7	7	6	6	
86	95	-9	9	8		8
73	84	-11	11	10		10
				SUM	21	34

Here T- equals Here T+ equals 34

21

- Hence test statistic T= min(T- and T+) =21
- Is value 21 small enough to reject H0?
- The 5% quantile of Wilcoxon test is **8** (from stats tables) i.e. we would reject null hypothesis of equality **if T**<=**8**.
 - Conclusion? Do we reject null hypothesis of equality of BCVA distribution across the two time points?

BCVAbaseline	BCVAat6months	Difference	Abs Diff	Rank	Rank +	Rank -
94	93	1	1	1	1	
90	95	-5	5	4		4
90	84	6	6	5	5	
81	85	-4	4	3		3
70	80	-10	10	9		9
85	83	2	2	2	2	
87	79	8	8	7	7	
82	75	7	7	6	6	
86	95	-9	9	8		8
73	84	-11	11	10		10
				SUM	21	34

Here T- equals Here T+ equals 34

21

- Hence test statistic T = min(T- and T+) =21
- Is value 21 small enough to reject H0?
- The 5% quantile of Wilcoxon test is **8** (from stats tables) i.e. we would reject null hypothesis of equality **if T**<=**8**.

• Conclusion? Do we reject null hypothesis of equality of distribution of BCVA across the two time points? The answer is "NO"

Example: Visual acuity and Wilcoxon test manually

- From statistics tables the 5% quantile (critical value) is 8, hence T>8 i.e. 21>8, hence the result is NOT significant at the 5% significance level.
- The conclusion is that we do not have strong evidence of change in BCVA across the 6 months.
- Note that:
 - Zero differences are discounted and *n* is decreased accordingly.
 - Tied values are assigned the average of the ranks covered.

Wilcoxon test in SPSS software: data supplied in two columns

		ning session3						
1] -	1] - ta *Untitled1 [DataSet0] - IBM SPSS Statistics Data Editor							
ata	<u>F</u> ile <u>E</u> dit	<u>V</u> iew <u>D</u> ata <u>T</u>	ransform <u>A</u> nalyze	<u>G</u> raphs <u>U</u> tilitie				
d	🗁 🗄			🖹 📥				
	11 : BCVAat6r	nonths						
		BCVAbaseline	BCVAat6months	var				
	1	94.00	93.00					
	2	90.00	95.00					
	3	90.00	84.00					
	4	81.00	85.00					
	5	70.00	80.00					
	6	85.00	83.00					
	7	87.00	79.00					
	8	82.00	75.00					
	9	86.00	95.00					
	10	73.00	84.00					
	11							
	12	-						

Wilcoxon test in SPSS software: where to find the test

7	Ten	gional teaching session3	Paste	B I	<u>U</u> - abe	X ₂ X ² A	<u>▶</u> - <u>A</u> - [∎∎≣I	■ \$≣• 2	*	1 Normal	¶ No Spaci	Heading 1
	[DataSet0] - IBM SPSS Statis		10000		_	148	<u> </u>			X			• X
<u>F</u> ile <u>E</u> dit	<u>V</u> iew <u>D</u> ata <u>T</u> ransform	<u>Analyze</u> <u>G</u> raphs <u>U</u> tilities Ad	d- <u>o</u> ns <u>W</u> indo										
	🖨 🛄 🗠	Reports ▶ Descriptive Statistics ▶	*5			▲ (1 €		ABG					
15 :		Tables 🕨										Visible: 2 o	f 2 Variables
	BCVAbaseline BCVAat	Co <u>m</u> pare Means	var	var	var	var	var	var	var	var	var	var	var
1	94.00	<u>G</u> eneral Linear Model											
2	90.00	Generali <u>z</u> ed Linear Models ♪											
3	90.00	Mixed Models											
4	81.00	<u>C</u> orrelate ►											
5	70.00	Regression •											
6	85.00	L <u>o</u> glinear 🕨											
7	87.00	Classify 🕨											
8	82.00	Dimension Reduction											
9	86.00	Sc <u>a</u> le ♪											
10	73.00	Nonparametric Tests		ample									
11		Forecasting •			_								
12		Survival		ndent Sample	S								
13				d Samples									
14 15		 Wissing Value Analysis	Legac	/ Dialogs	•	<u>/// C</u> hi-square							
15		Multiple Imputation				0/1 <u>B</u> inomial							
17		Complex Samples				**** <u>R</u> uns							
17		Quality Control				<u> 1</u> -Sample k	-S						
10		ROC Curve				2 Independ	ent Samples						
20						K Independ							
20						2 Related S							
22													<u>_</u> _
	1					🔣 K Related S	ampies						4
Data View 2 Related Sa	Variable View				***				IBM SPS	S Statistics Pr	ocessor is re	ady	
<u> </u>			5	-	_		_	_	_		_		
			-										

Wilcoxon test in SPSS software: defining variables

15: Visible 2 of 2 Variables BCVAatements var				SPSS Statistics Data Ed		Utilities A	dd-ons Wind	ow Hel	D										1.1
15: Visible 2 of 2 Variables BCVAatements var	ta									4 2 1	A		ABS						Γ
1 94 00 93 00 93 00 90 00 95 00 3 90 00 96 00 <td></td> <td>15 :</td> <td></td> <td>Visible: 2 o</td> <td>f 2 Variables</td> <td></td>		15 :															Visible: 2 o	f 2 Variables	
2 90.00 95.00 3 90.00 84.00 4 81.00 85.00 5 70.00 80.00 6 85.00 83.00 7 87.00 79.00 8 82.00 75.00 9 86.00 95.00 10 73.00 84.00 11 Test Type V Wiccoon 90/elsenar 13 Wiccoon 14 Wiccoon 15 Wiccoon 16 Wiccoon 19 Wiccoon 19 Wiccoon 19 Wiccoon 19 Wiccoon 19 Wiccoon 10 73.00 11 OK Easte Reset Cancel Hep 12 Visible Weemar 13 Wiccoon 14 Wiccoon 15 Wiccoon 16 Wiccoon 19 Wiccoon 20 Wiccoon 21 Wiccoon 22 <td< td=""><td></td><td></td><td>BCVAbaseline</td><td>BCVAat6months</td><td>var</td><td>var</td><td>var</td><td>Va</td><td>ır</td><td>var</td><td>var</td><td>var</td><td>var</td><td>var</td><td>var</td><td>var</td><td>var</td><td>var</td><td></td></td<>			BCVAbaseline	BCVAat6months	var	var	var	Va	ır	var	var	var	var	var	var	var	var	var	
3 90.00 84.00 4 81.00 85.00 5 70.00 80.00 6 85.00 83.00 7 87.00 79.00 8 82.00 75.00 9 86.00 95.00 10 73.00 84.00 11		1	94.00	93.00															
4 81:00 85:00 5 70:00 80:00 6 85:00 83:00 7 87:00 79:00 9 86:00 95:00 10 73:00 84:00 11 BCV/Astemonths Image: Control of the second		2	90.00	95.00			_	_	_										L
5 70.0 80.00 6 85.00 83.00 7 87.00 79.00 9 86.00 95.00 10 73.00 84.00 11 12 Image: Statistic Processor is ready 13 Image: Statistic Processor is ready 16 Image: Statistic Processor is ready 17 Image: Statistic Processor is ready		3				Two-Relat	ed-Samples Tes	ts						x					
5 700 80.00 6 65.00 83.00 7 87.00 79.00 9 66.00 95.00 10 73.00 84.00 11 1 1 12									Test	Pairs:			- Frank						
7 87.00 79.00 8 82.00 75.00 9 86.00 95.00 10 73.00 84.00 11										Variable									
1 17.50 9 86.00 9 86.00 10 73.00 11 Image: statistic processor is ready 12 Image: statistic processor is ready 13 Image: statistic processor is ready 16 Image: statistic processor is ready 17 Image: statistic processor is ready						SCVA:	at6months				/Ab 🔗 [BC	VAat	<u>Option</u>	S					
9 86.00 95.00 10 73.00 84.00 11								•	2				+						
10 73.00 84.00 11 Test Type 12 Wilcoxon 13 Wilcoxon 14 Wilcoxon 16 Marginal Homogeneity 16 Marginal Homogeneity 18 Marginal Homogeneity 20 Marginal Homogeneity 21 Marginal Homogeneity 22 Marginal Homogeneity																			
11 12 13 13 14 15 16 17 18 19 20 21 22 1 Data View IBM SPSS Statistics Processor is ready																			
12 13 14 15 16 17 16 17 18 19 20 21 22 22 1 Data View Variable View IBM SPSS Statistics Processor is ready			13.00	04.00					Tes	t Type									
13 14 15 16 17 18 19 20 21 22 22 22 23 24 15 16 17 18 19 20 11 12 13 14 15 16 17 18 19 20 21 22 23 24 15 16 17 18 19 20 21 22 23 24 16 17 18 19 10 10 10 11 12 13 14 15 16 17 18 19 19 10 10 11 12 13 14 15 16 17 18 19 19 10 10																			
14 Marginal Homogeneity 15 Marginal Homogeneity 16 Marginal Homogeneity 17 OK Paste Reset Cancel Help 18 Marginal Homogeneity 20 Marginal Homogeneity 21 Marginal Homogeneity 22 Marginal Homogeneity 19 Marginal Homogeneity 20 Marginal Homogeneity 21 Marginal Homogeneity 22 Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity 20 Marginal Homogeneity 21 Marginal Homogeneity 22 Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity 21 Marginal Homogeneity 22 Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity 22 Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity Marginal Homogeneity 10 Marginal Homogeneity 10 Marginal Homogeneity 11 Marginal Homogeneity 12 Marginal Homogeneity 13																			
15 16 17 0K Paste Reset Cancel Help 18 19 20 21 22 22 1 Data View Variable View IBM SPSS Statistics Processor is ready																			
17 18 19 20 21 22 22 1 Data View IBM SPSS Statistics Processor is ready		15									nogeneity								
18 19 20 21 22 22 23 24 25 26 27 28 29 20 21 22 23 24 25 26 27 28 29 20 21 22 23 24 25 26 27 28 29 20 20 21 22 23 24 25 26 27 28 29 29 20 20 21 22 23 24 25 26 27 28 29 29 20 20 20 21 22 24 25 26 27 28 29 29 29 29 20 20 20 20 20 21 22 23 24 25 26 27 28 29 29 29 29 20 <td></td> <td>16</td> <td></td>		16																	
19 20 21 21 22 1 22 1 Data View Variable View IBM SPSS Statistics Processor is ready		17					(ок	<u>P</u> aste	<u>R</u> eset	Cancel H	elp							
20 21 22 22 1 Data View Variable View IBM SPSS Statistics Processor is ready		18			Ľ				_				-						
21 22 1																			
22 Data View Variable View IBM SPSS Statistics Processor is ready IBM SPSS Statistics Processor																			
Data View Variable View IBM SPSS Statistics Processor is ready IBM SPSS Statistics Processor is ready																			
Data View Variable View IBM SPSS Statistics Processor is ready IBM SPSS Statistics Processor is ready			4																
IBM SPSS Statistics Processor is ready									_	***								F	
		Data view												IBM SPSS	Statistics Pro	ressor is rea	dv		
Ber (PE) Stadia Punase is wait in the second se	_[_	_	111-1		_			Variable View			, otalion of the		-,		J
Page 1 and 3 and 5							2 - 1			Page 1 of 1 Words			Colora and Color)0x 5*55 5aloh	a Processaria made	See Consider		
							-				11-11-		anany Par				needs - Halding		

Wilcoxon test in SPSS software: results

Wilcoxon Signed Ranks Test

Ranks								
		N	Mean Rank	Sum of Ranks				
	Negative Ranks	5 ^a	4.20	21.00				
DOV/Actomenthe DOV/Abaseline	Positive Ranks	5^{b}	6.80	34.00				
BCVAat6months - BCVAbaseline	Ties	0 ^c						
	Total	10						

a. BCVAat6months < BCVAbaseline

b. BCVAat6months > BCVAbaseline

c. BCVAat6months = BCVAbaseline

Test Statistics ^a						
	BCVAat6months -					
	BCVAbaseline					
Z	663 ^b					
Asymp. Sig. (2-tailed)	.508					

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

From SPSS: p-value 0.508. Do we reject null hypothesis at 5% significance level?

The conclusion is that we do not have strong evidence of change in BCVA across the 6 months.

Non-parametric group-comparison test for <u>independent</u> continuous non-Normal data

• Suppose we have two groups of individuals, with *n*₁ in the first group and *n*₂ in the second.

• We observe a response measurement for each individual in each group and wish to compare the measurements between the two groups.

• If response cannot be assumed to be normally distributed: means (or, the difference in means) are not an adequate summary of the data.

Example: Contrast sensitivity

- Contrast sensitivity (CS, in letters) was measured on 6 normal healthy subjects and 7 subjects with diabetic maculopathy ($n_1 = 6$, $n_2 = 7$).
- The distributions in each group are skewed, so a non-parametric test is preferable to the two-sample *t-test:*

Normals	DM
CS	CS
38	24
39	25
40	25
42	27
42 42	35
42	37
	41

Mann-Whitney U test

For two distinct groups, we use the **Mann-Whitney U test and proceed as follows:**

- Rank all the measurements (from low to high)
- To those ranks that are tied assign the average of the tied ranks.
- Sum the ranks of group 1, giving T_1
- Calculate $U_1 = n_1 n_2 + \frac{1}{2} n_1(n_1 + 1) T_1$ and $U_2 = n_1 n_2 U_1$
- Set *U* to be the smaller of U_1 and U_2
- The distribution of U is tabulated for n_1 and n_2 less than <u>20</u>. For larger values of *n*, a normal approximation can be used.

Example: Contrast Sensitivity

• We are interested if there is a difference between normal healthy subjects and subjects with diabetic maculopahty in terms of contrast sensitivity.

Normals	DM			
CS	CS			
38	24			
39	25			
40	25			
42	27			
42	35			
42	37			
	41			

H0: healthy and diabetic maculopathy subjects have <u>same distribution</u> of contrast sensitivity

H1: the distributions are <u>different</u>

We shall use Mann-Whitney U test because of independent continuos data, and because data are skewed.

Example: Contrast Sensitivity and Mann-Whitney U test

Normals	DM	Normals	DM					
CS	CS	Ranks	Ranks					
38	24	7	1					
39	25	8	2.5					
40	25	9	2.5					
42	27	12	4					
42	35	12	5					
42	37	12	6					
	41	1	10					
Total T1= Total T2=								
n1=	6							
n2=	7							
U1=	3							
U2=	U2= 39							
Test statistic U = smaller of U1 and U2 = 3 From stats tables the quantile (critical value) is = 6								

Example: Contrast Sensitivity and Mann-Whitney U test

- Remember that tied values are assigned the average of the ranks covered.
- Thus here:

 $U_1 = n_1 n_2 + \frac{1}{2} n_1(n_1 + 1) - T_1 = 6 \times 7 + \frac{1}{2} \times 6 \times 7 - 60 = 3$

$$U_2 = n_1 n_2 - U_1 = 6 \times 7 - 3 = 39$$

- Test statistic $U = \min(U_1, U_2) = 3$
- From tables, we have quantile (critical value of 6), hence it is seen that the result is significant at the 5% significance level, because U < 6.

There is strong evidence to suggest that contrast sensitivity differs between the two groups.



Mann-Whitney U test in SPSS software: contrast sensitivity data supplied in one column, another column for groups

🖬 *Untitled2 [DataSet1] - IBM	SPSS Statistics [Data Editor	-									
<u>F</u> ile <u>E</u> dit	<u>v</u> iew <u>D</u> ata <u>1</u>	<u>T</u> ransform <u>A</u> n	nalyze <u>G</u> rapi	hs <u>U</u> tilitie:									
😑 🗄													
13 : CS	41.0												
	CS	Group	var	var									
1	38.00	1.00											
2	39.00	1.00	ta *Untitled2 [[DataSet1] - IBM :	SPSS Statist	ics Data Editor	-	_	_	-	-	_	
3	40.00	1.00	<u>F</u> ile <u>E</u> dit	<u>V</u> iew <u>D</u> ata <u>T</u>	ransform	<u>Analyze</u> <u>G</u> raphs <u>U</u> tilities A	Add- <u>o</u>	ons <u>W</u> indow <u>H</u>	lelp				
4	42.00	1.00	- 😑 ല	🚔 🛄	5	Reports	•		- 4			A	
5	42.00	1.00				Descriptive Statistics	•				IA 🔨		
6	42.00	1.00	8 :			Ta <u>b</u> les	•						
7	24.00	2.00		CS	Group	Compare Means	•	var	var	var	var	var	var
8	25.00	2.00	1	38.00	1.0	<u>G</u> eneral Linear Model	•						
9	25.00	2.00	2	39.00	1.0	Generalized Linear Models	•						
10	27.00	2.00	3	40.00	1.0	Mixed Models	•						
11	35.00	2.00	4	42.00	1.0	<u>C</u> orrelate	•						
12	37.00	2.00	5	42.00	1.0	Regression	•						
13	41.00	2.00	6	42.00	1.0	Logimear							
14			7	24.00	2.0	Classify	•						
15			8	25.00	2.0	Dimension Reduction	•						
16			9	25.00	2.0	Scale							
17			10	27.00	2.0	Nonparametric Tests		🛕 One Sample.					
18			11	35.00	2.0	Forecasting	•	A Independent					
19			12	37.00	2.0	Cupringl							
20			13 14	41.00	2.0	— M <u>u</u> ltiple Response		A Related Sam					1
21			14			Missing Value Analysis	Ļ	Legacy Dialo	gs 🕨	<u> </u>	square		
			15			Multiple Imputation	•			0/1 <u>B</u> ino	mial		
			17			Complex Samples				aaat <u>R</u> un	s		
			18			Quality Control				🔼 <u>1</u> -Sa	mple K-S		
			19			ROC Curve				2 Inc	lependent Sa	amples	
			20								dependent Sa		
			21							_	lated Sample		
			22								elated Sample		
			23								nateu <u>s</u> ampi]
			24										
			25										
			26										
			27										
			28										
			29										

Mann-Whitney U test in SPSS software: specification of variables for analysis

ta Tv	vo-Independe	nt-Samples Te	sts			x
			Test Var	iable List:	E <u>x</u> act Options	=
			Group(g Variable: 1 2) Groups		
	est Type Mann-Whitne Mo <u>s</u> es extrer		E <u>K</u> olmogoro			
		DK <u>P</u> aste	Reset	Cancel He	lp	

Note: Do not forget to define the group values!

Mann-Whitney test in SPSS software: asking for exact p-values when samples are small (i.e. both n1 and n2 are less than 20)

	Exact Tests
	O Asymptotic only
	© Monte Carlo
	Confidence level: 99 %
	Number of samples: 10000
	Time limit per test: 1 minutes
-TI	Exact method will be used instead of Monte Carlo when computational limits allow.
	For nonasymptotic methods, cell counts are always rounded or truncated in computing the test statistics.
	Continue Cancel Help

Note: the Asymptotic option is the default in SPSS, the Asymptotic option uses a simplified formula for calculation of p-value, and this formula works well if large enough data (>20).

Mann-Whitney U test in SPSS software: results

	Ranks									
	Group	N	Mean Rank	Sum of Ranks						
	Normal	6	10.00	60.00						
CS	DM	7	4.43	31.00						
	Total	13								

Test Statistics^a

	CS
Mann-Whitney U	3.000
Wilcoxon W	31.000
Z	-2.589
Asymp. Sig. (2-tailed)	.010
Exact Sig. [2*(1-tailed Sig.)]	.008 ^b
Exact Sig. (2-tailed)	.008
Exact Sig. (1-tailed)	.004
Point Probability	.002

a. Grouping Variable: Group

b. Not corrected for ties.

Conclusion? Do we reject the null hypothesis of equality of CS distributions?

Mann-Whitney U test in SPSS software: results

Ranks					
	Group	N	Mean Rank	Sum of Ranks	
	Normal	6	10.00	60.00	
CS	DM	7	4.43	31.00	
	Total	13			

Test Statistics^a

	CS
Mann-Whitney U	3.000
Wilcoxon W	31.000
Z	-2.589
Asymp. Sig. (2-tailed)	.010
Exact Sig. [2*(1-tailed Sig.)]	.008 ^b
Exact Sig. (2-tailed)	.008
Exact Sig. (1-tailed)	.004
Point Probability	.002

a. Grouping Variable: Group

b. Not corrected for ties.

Conclusion?

Do we reject the null hypothesis of equality of CS distributions? Answer is Yes, b/c pvalue=0.008<0.05..

Summary

- When to use <u>non-parametric tests</u> for group comparisons?
 - When data are not Normal
 - Or when data too small checked normality
- If we want to compare more than 3 using a continuous independent data then we use Kruskal-Wallis test
 - If the test finds significant difference than we do post-hoc analyses using Wilcoxon test
 - Need to adjust for multiple comparisons.

Resources



Books

- Practical statistics for medical research by Douglas G. Altman
- Medical Statistics from Scratch by David Bowers

Journals' with series on how to do statistics in clinical research

- American Journal of Ophthalmology has Series on Statistics
- British Medical Journal has series Statistics Notes

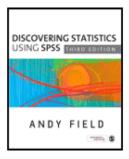
Manual for SPSS statistical software - with lots of worked-out examples

• Andy Field, Discovering statistics using SPSS

Workshops organized by Biostatistics Department, U of Liverpool

http://www.liv.ac.uk/translationalmedicine/research/departmentsandgroups/biostatistics/coursesandworkshops/

- 3 June 2013 Statistical Process Control
- 4 June 2013 Validity and reliability of diagnostic tests and other methods of measurement
- (Fall) Unbiased design, error prediction and statistical analysis when quantifying biological structures



Thank you for your attention

These <u>slides</u> and <u>worksheet</u> can be found on: <u>http://pcwww.liv.ac.uk/~czanner/</u>

Planned future workshops:

- How to diagnose if a patient is having a disease or how to determine if he is at high risk? Classification methods. (Spt/Oct)
- How to make sense of many measured characteristics? Multivariate stats methods.
- Odd-ratios: What are the odds of developing diseases in smokers as opposed to non-smokers?
- Ideas are welcome!



Statistical Clinics for ophthalmic clinicians and researchers ! Run by appointment. Email: czanner@liv.ac.uk Phone: +44-151-706-4019 Further information: http://pcwww.liv.ac.uk/~czanner/