

Non-parametric tests

Part 1

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Non-parametric tests

Learning objectives

- Criteria for choosing a non-parametric test
- Non-parametric tests

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Non-parametric tests

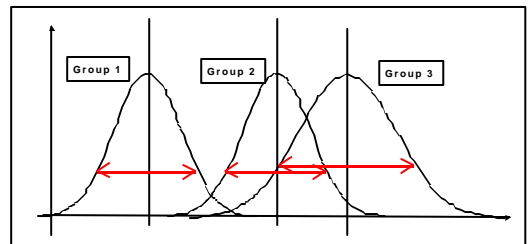
Why non-parametric test?

- Violation of the assumption of normally distributed data
- Inhomogeneity of variance
- However: Parametric tests tend to be robust

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Non-parametric tests

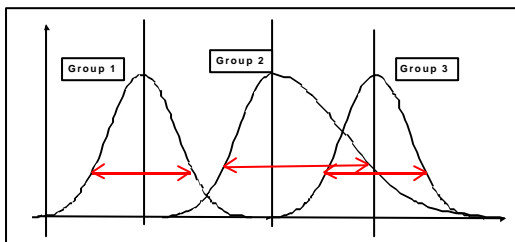
Inhomogeneity of variance



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Non-parametric tests

NOT normally distributed



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Non-parametric tests

Non-parametric tests

Parametric test	Non-parametric test
t-test	Wilcoxon's Rank-Sum Test (Mann Whitney U test)
Related t-test	Wilcoxon's Matched-Pairs Signed-Ranks Test
One-way ANOVA	Kruskal-Wallis ANOVA
Repeated measure ANOVA	Friedman's Rank test

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Non-parametric tests

Wilcoxon's Rank-Sum Test

- = Mann-Whitney U test
- Two independent samples
- Analogue of the t-test for two independent samples
- Basic idea: Comparison of ranking of data

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Non-parametric tests

1. Example

- Sample 1: 4, 9, 12, 13, 17, 15
- Sample 2: 4, 8, 11, 13, 16, 18

Score	4	4	8	9	11	12	13	13	15	16	17	18
Rank	1.5	1.5	3	4	5	6	7.5	7.5	9	10	11	12

- Sum of Ranks:
 - Sample 1: 39
 - Sample 2: 39

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Non-parametric tests

2. Example

- Sample 1: 4, 9, 10, 11, 15, 16
- Sample 2: 13, 14, 15, 16, 17, 18

Score	4	9	10	11	13	14	15	15	16	16	17	18
Rank	1	2	3	4	5	6	7.5	7.5	9.5	9.5	11	12

- Sum of Ranks:
 - Sample 1: 27
 - Sample 2: 51

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Non-parametric tests

Inferences from test

- If sums of ranks are similar, H_0 is accepted
- If sums of ranks are very different, H_0 is rejected
- p-value is given by the Wilcoxon W statistics for the given sums of ranks

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Non-parametric tests

SPSS output: 1. Example

Ranks				
SCORE	SAMPLE	N	Mean Rank	Sum of Ranks
1.00		6	6.50	39.00
2.00		6	6.50	39.00
	Total	12		

Test Statistics ^a	
	SCORE
Mann-Whitney U	18.000
Wilcoxon W	39.000
Z	.000
Asymp. Sig. (2-tailed)	1.000
Exact Sig. [2*(1-tailed Sig.)]	1.000 ^b

- a. Not corrected for ties.
b. Grouping Variable: SAMPLE

Relevant p-value

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Non-parametric tests

SPSS output: 2. Example

Ranks				
SCORE	SAMPLE	N	Mean Rank	Sum of Ranks
1.00		6	4.50	27.00
2.00		6	6.50	51.00
	Total	12		

Test Statistics ^a	
	SCORE
Mann-Whitney U	6.000
Wilcoxon W	27.000
Z	-1.928
Asymp. Sig. (2-tailed)	.054
Exact Sig. [2*(1-tailed Sig.)]	.065

- a. Not corrected for ties.
b. Grouping Variable: SAMPLE

Relevant p-value

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Non-parametric tests

Properties of non-parametric tests

- No estimation of parameters, therefore works with very small sample sizes
- characterization of data by median instead of mean
- little effected by outliers
- Unclear which difference between data exactly causes the rejection of null hypothesis
- Lower power than parametric test, if conditions for parametric test are fulfilled

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Non-parametric tests

Checklist for non-parametric test

- ✓ Inhomogeneity of variance between conditions
- ✓ Not normally distributed data
- ✓ Very small sample size
- ✓ Unequal sample size between conditions
- ✓ Many outliers
- ✓ Data better characterized by median than by mean

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Non-parametric tests

Experiment

- Influence of mood on attractiveness of women
- 12 participants in a between-participants design
- Rate women in bad or good mood (maximal rating: 20)
- Good mood: 7, 15, 14, 3, 17
- Bad mood: 4, 6, 11, 7, 9, 4, 7

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Non-parametric tests

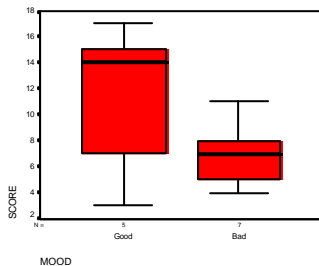
Descriptive statistics

- | Good mood | Bad mood |
|---------------------------|---------------------------|
| • Mean: 11.2 | • Mean: 6.9 |
| • Standard deviation: 5.9 | • Standard deviation: 2.5 |
| • Median: 14.0 | • Median: 7.0 |

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Non-parametric tests

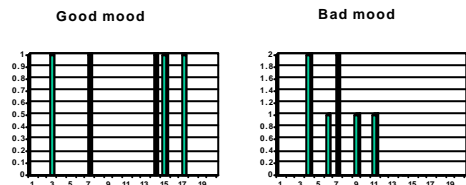
Box plot



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Non-parametric tests

Histogram



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Non-parametric tests

Why parametric test?

- Unequal sample size
- Small sample size for "good mood"
- Different variability
- Not normally distributed data

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SPSS output

Test Statistics ^a	
	SCORE
Mann-Whitney U	10.000
Wilcoxon W	38.000
Z	-1.229
Asymp. Sig. (2-tailed)	.219
Exact Sig. [2*(1-tailed Sig.)]	.268 ^b

Relevant
p-value

^a. Not corrected for ties.

^b. Grouping Variable: CONDITIO

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Report

- Histograms for the two conditions were inspected separately. As data were not normally distributed and the participant numbers were small, the most appropriate statistical test was Wilcoxon's rank-sum test.
- Descriptive statistics showed that participants who rated the attractiveness of an actress in a good mood gave higher ratings (median = 14) than participants who rated her in a bad mood (median = 7).
- However, the Wilcoxon W was found to be 38.00 with an associated probability of 0.22 which shows no significant difference between the two conditions.

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Wilcoxon's Matched-Pairs Signed-Ranks Test

- Two related samples
- Analogue of the t-test for related samples
- Basic idea:
Comparison of ranking of difference between related scores

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Experiment

- Program of long range running reduce blood pressure
- 8 participants were engaged in a 6-week running program
- Measure of blood pressure before and after

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Non-parametric tests

Data

Before	130	170	125	170	130	130	145	160
After	120	163	120	135	143	136	144	120

Before

- Sample size: 8
- Mean: 145
- Standard deviation: 19.1
- Median: 137.5

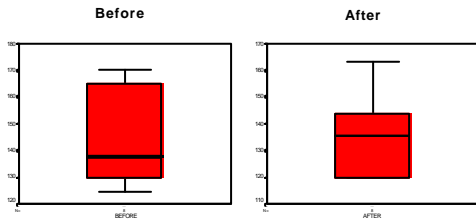
After

- Sample size: 8
- Mean: 135.1
- Standard deviation: 15.1
- Median: 135.5

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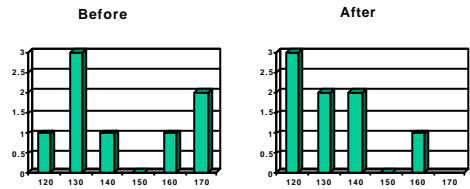
Box plot



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Non-parametric tests

Histogram



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Non-parametric tests

Why parametric test?

- sample size ok
- Variability ok (just)
- Not normally distributed data, especially After

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Non-parametric tests

Wilcoxon's Matched-Pairs Signed-Ranks Test

Before	130	170	125	170	130	130	145	160
After	120	163	120	135	143	136	144	120
Difference	10	7	5	35	-13	-6	1	40
Rank	5	4	2	7	6	3	1	8
Signed rank	5	4	2	7	-6	-3	1	8

- Sum of Ranks:
 - Positive Ranks: 27
 - Negative Ranks: -9

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Non-parametric tests

Inference

- If similar amount of pos. and neg. ranks, H_0 is accepted
- If there is a large difference between pos. and neg. ranks, H_0 is rejected
- The p-value is given by the t-score (the smaller of the two ranks)

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Non-parametric tests

SPSS output

Ranks				
	N	Mean Rank	Sum of Ranks	
AFTER - BEFORE	6 ^a	4.50	27.00	
Negative Ranks				
Positive Ranks	2 ^b	4.50	9.00	
Ties	0 ^c			
Total	8			

- a. AFTER < BEFORE
b. AFTER > BEFORE
c. BEFORE = AFTER

Test Statistics ^a	
	AFTER - BEFORE
Z	-1.260 ^a
Asymp. Sig. (2-tailed)	.208

- a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test

Relevant p-value

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Non-parametric tests

Report

- An inspection of the descriptive statistics revealed a skewed distribution of the data and a slightly intolerable difference in standard deviations (15 vs. 19).
- Therefore it was concluded that the appropriate test was Wilcoxon's Matched-Pairs Signed-Ranks test. The test indicated no significant difference between the two conditions ($t = 9$, $p = 0.208$).

One-tailed Hypothesis

- Directional (one-sided) hypothesis
- Divide p-value by 2
- Same as in t-test