Dr Silia Vitoratou

Department: Biostatistics and Health Informatics

Topic materials:
Silia Vitoratou

Contributions:
Zahra Abdula

Improvements:
Nick Beckley-Hoelscher
Kim Goldsmith
Sabine Landau

Institute of Psychiatry, Psychology and Neuroscience

KING'S College LONDON

Module Title: Introduction to Statistics

Session Title: Equality of medians (non-parametric tests)

Topic title: Comparing groups II (non-parametric methods)

Learning Outcomes

- Learn when and how to use the **non-parametric** tests for equality of medians.
- Understand the assumptions of the various test of equality of medians.
- Be able to conduct these test in a statistical software.

Previously on 'Introduction to Statistics'.....

Based on the **type** of data and on the hypotheses, we use different statistical tests.

Hypotheses testing	Means	Proportions
one group *versus* a pre-defined value	one sample t-test	one sample χ^2-test
one group *versus* another group	two independent samples t-test	(two independent samples) Pearson's χ^2-test
one group (twice or) *versus* another matched group	two paired samples t-test	(two paired samples) McNemar test

Previously on 'Introduction to Statistics'.....

Based on the **type** of data and on the hypotheses, we use different statistical tests.

Hypotheses testing	Means	Proportions
one group *versus* a pre-defined value	is the mean weight equal to μ_0=66kg?	is the proportion of women in the sample π_0=50%?
one group *versus* another group	is the mean 'weight before' equal across genders?	proportion of women who exercised before =proportion of men who exercised before ?
one group (twice or) *versus* another matched group	is the mean 'weight before' equal to the mean 'weight after'?	proportion of those who exercised before =proportion of those who exercised after ?

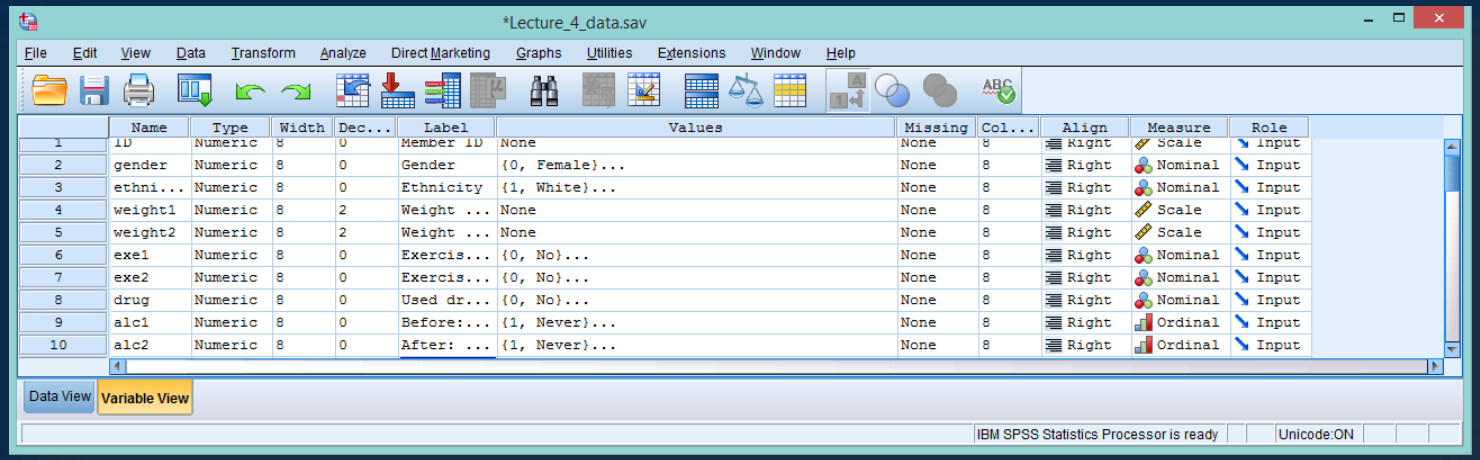
What if the assumptions do not hold?

Parametric and Non-Parametric Tests

Numerical data	Normality assumed	Normality not assumed
Hypotheses testing	parametric	Non-parametric
one group *versus* a pre-defined value	one sample t-test	Wilcoxon signed rank
one group *versus* another group	two independent samples t-test	Mann-Whitney (Wilcoxon sum rank)
one group (twice or) *versus* another matched group	two paired samples t-test	Wilcoxon signed rank for paired samples

SPSS Slide

Download the data that we are going to use during the lecture. The dataset is the **lecture_5_data.sav**. We have data for 300 individuals.



Same scenarios as in lecture 4, but this time the assumptions are violated)

- **gender**: 1-male, 0-female and **ethnicity** : 1-white, 2-black, 3-Asian, 4-other
- **weight1**: their weight when they entered the programme (in kg)
- **weight2**: their weight by the end of the programme (in kg)
- **exe1**: info if they regularly exercised (1-yes, 0-no) when they entered the programme
- **exe2**: info if they regularly exercised (1-yes, 0-no) by the end of the programme
- **drug**: if they have ever used drugs to lose weight (1-yes, 0-no)
- **alc1**: more than 2 units of alcohol, before (1:never, 2: sometimes, 3:always)
- **alc2**: more than 2 units of alcohol, after (1:never, 2: sometimes, 3:always)

Wilcoxon Signed Rank Test

The Wilcoxon signed rank test is the non-parametric analogue of the one sample t-test.

When to use

- Skewed continuous data
- Ordinal (interval) or discrete data

Null hypothesis

- H_0: Median equals a certain pre-defined value
- H_a: Median is different than a certain pre-defined value

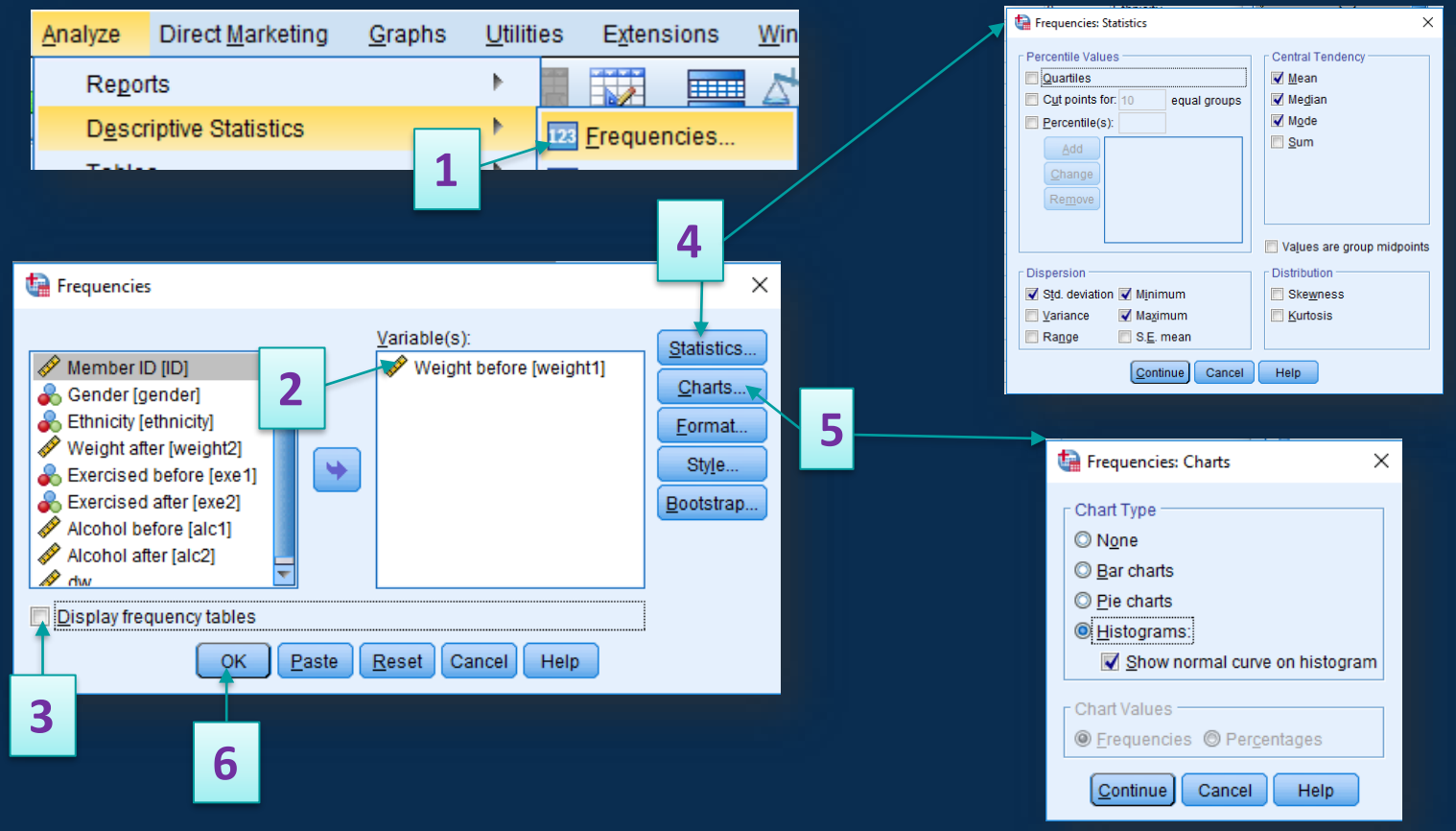
Assumptions

- The observations are randomly and independently drawn
- At least interval data

SPSS Slide: ‘how to’

According to the researchers, in the population from which our data were sampled from the median weight of the people is **66kg**. Do our data support this?

Step 1: Check the suitability of the data, here what type of distribution has ‘weight1’ ?



In ‘Statistics’ ask for descriptive statistics

In ‘Charts’ ask for a Histogram

Output & Interpretation Slide

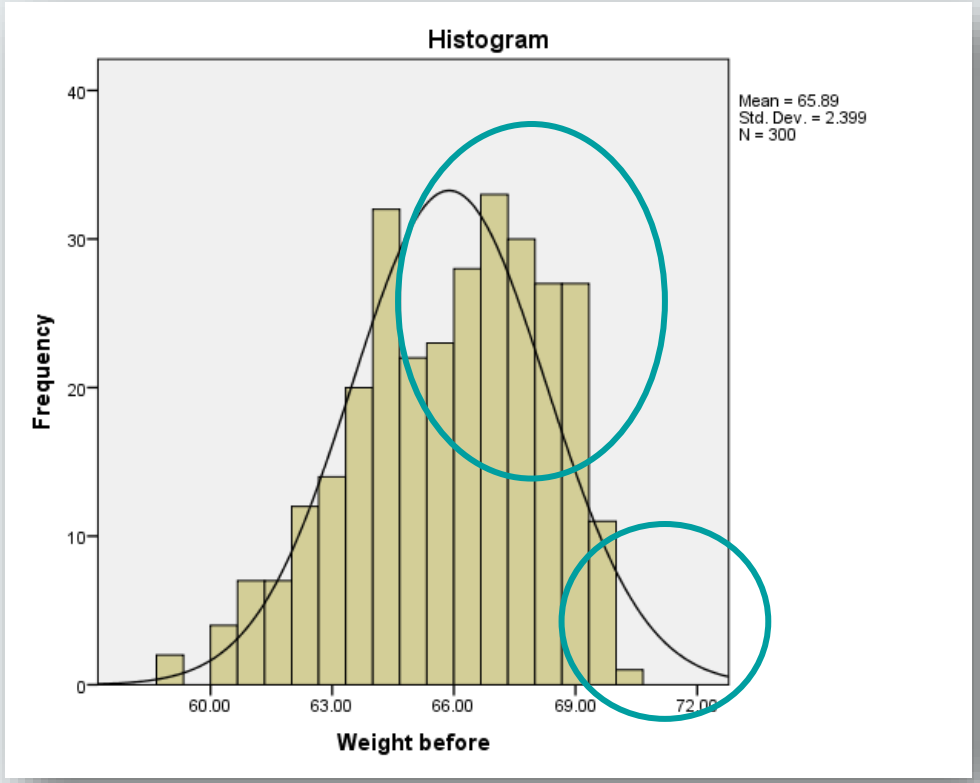
Step 1: Check the suitability of the data, here: what type of distribution has 'weight1' ?

Statistics

Weight before

N	Valid	300
	Missing	0
Mean		65.8856
Median		66.2450
Mode		62.55[a]
Std. Deviation		2.39880
Minimum		58.70
Maximum		70.04

a. Multiple modes exist. The smallest value is shown



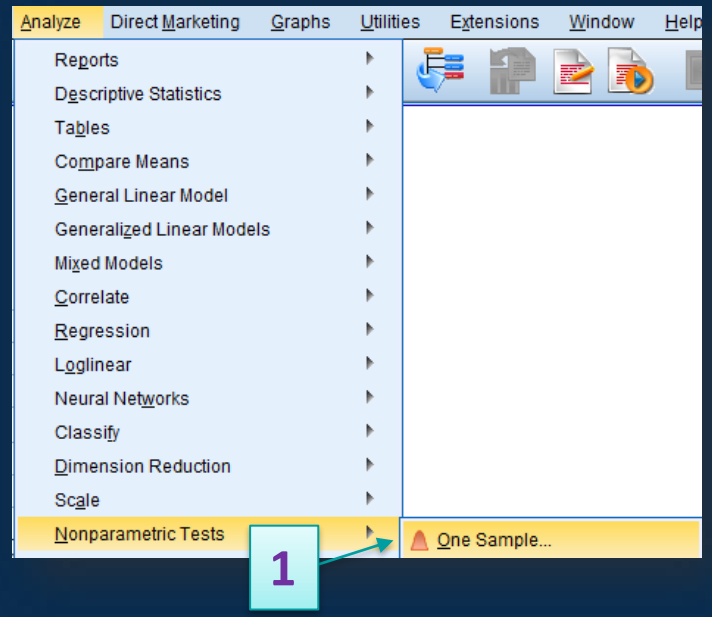
'weight1' is a negatively skewed variable, we can conclude it is not normally distributed. Therefore it is best not to rely on its mean and standard deviation, and use a non-parametric test.

H_0: Median = 66kg H_a: Median ≠ 66kg

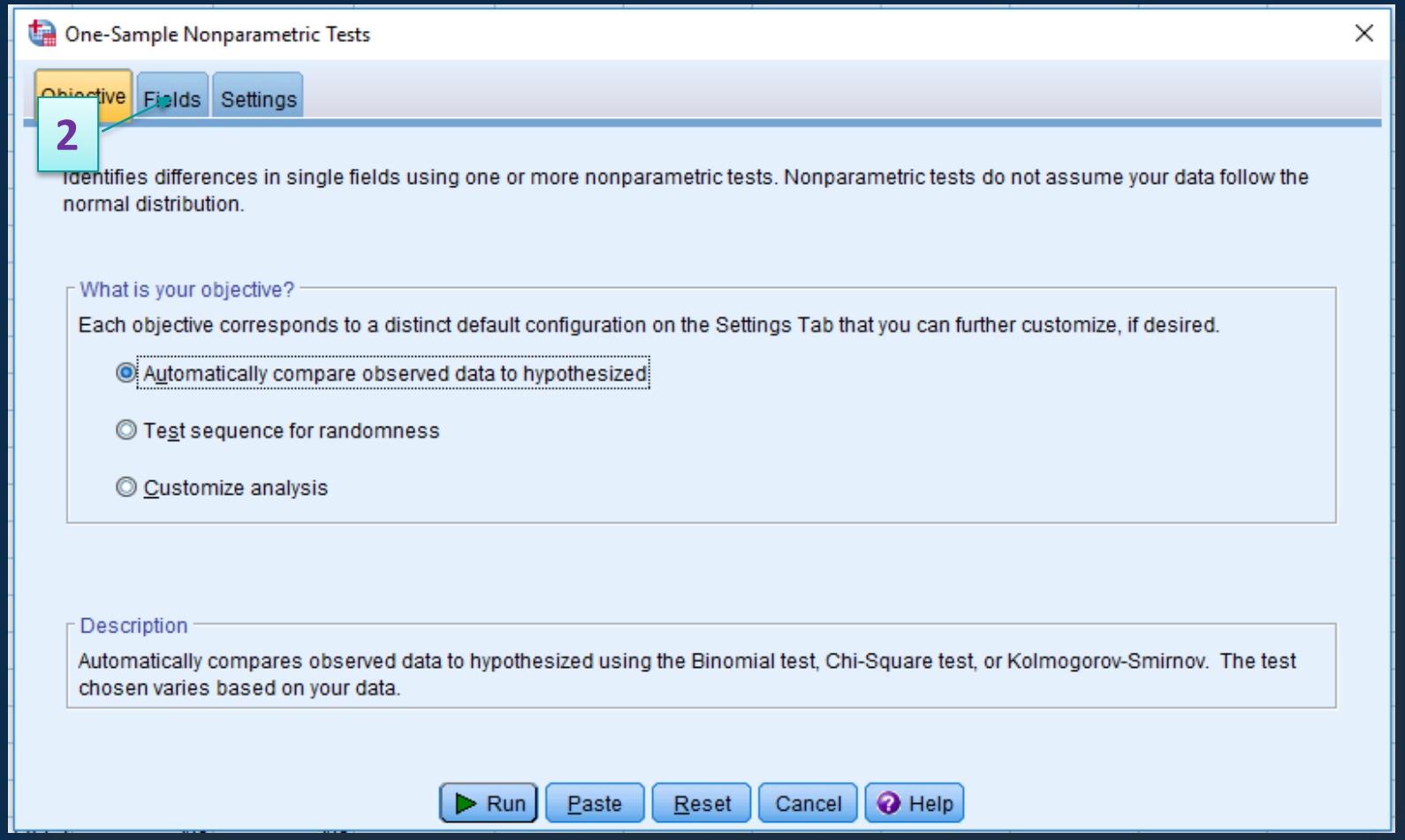
SPSS Slide: ‘how to’

Step 2: Use the appropriate test, here: ‘Wilcoxon Signed Rank test’.

Analyse -> Nonparametric tests-> ‘One sample’



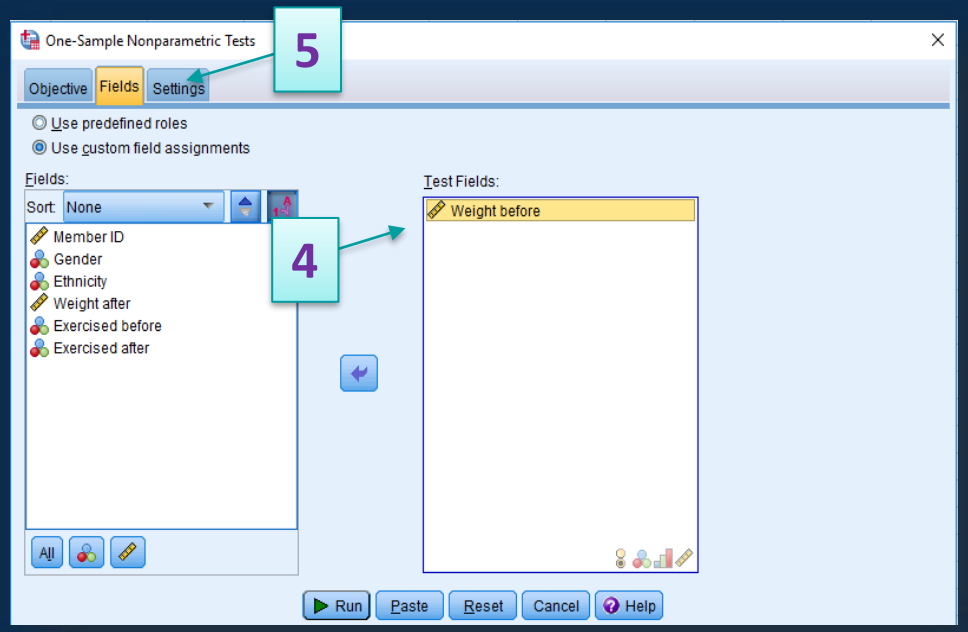
Click on the ‘Fields’ tab ’



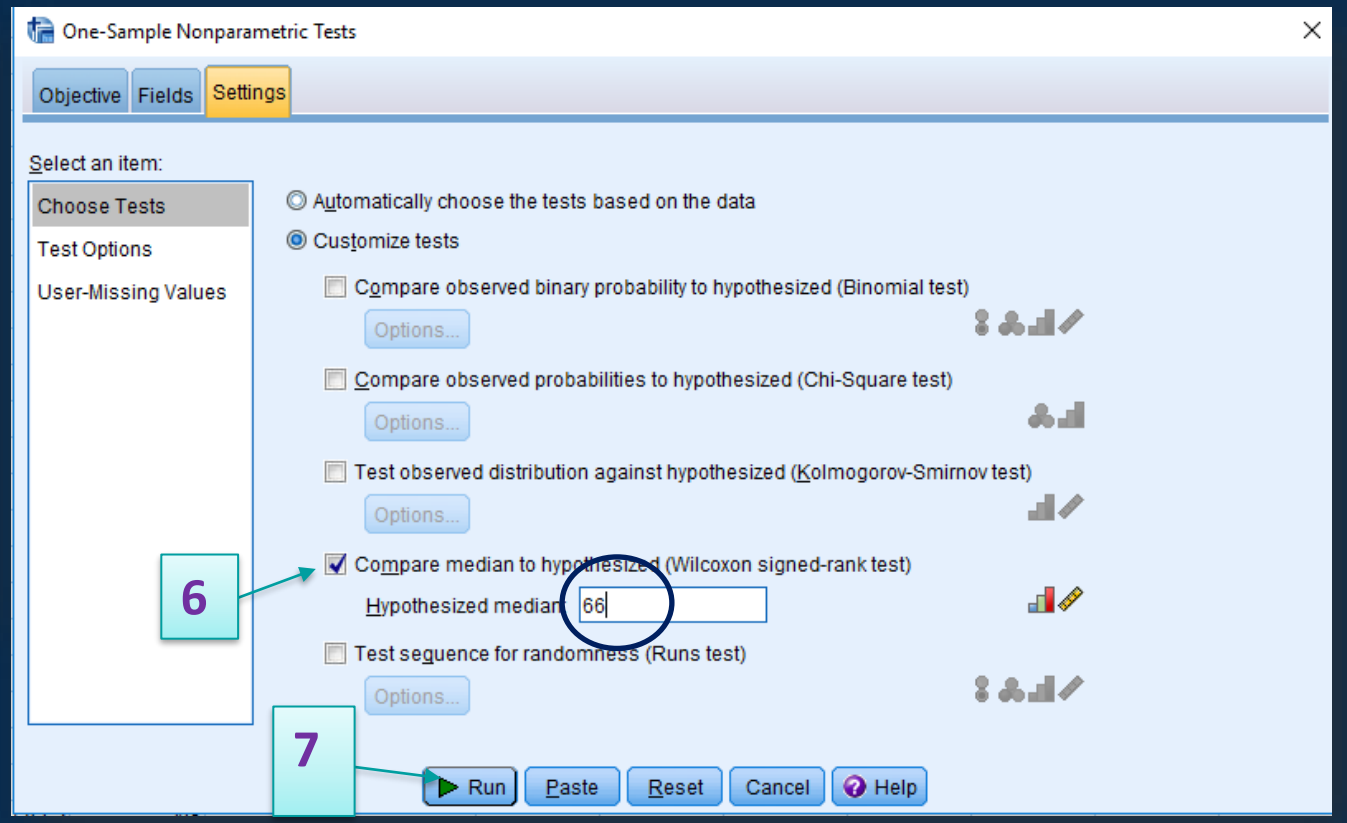
SPSS Slide: ‘how to’

Step 2: Use the appropriate test, here: ‘Wilcoxon Signed Rank test’.

Analyse -> Nonparametric tests-> ‘One sample’



Add the variable of interest (weight before) in the ‘Test Fields’ box



Add in the hypothesized median: 66kg

Output and Interpretation Slide

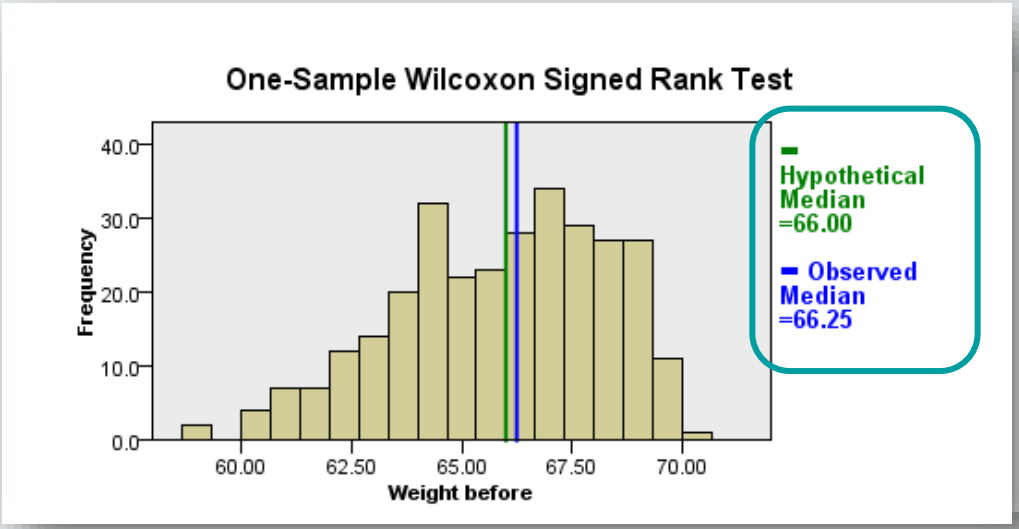
SPSS prints a table with all the information we need

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of Weight before equals 66.00.	One-Sample Wilcoxon Signed Rank Test	.874	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

But if you double click this table, you are able to see more useful details:



Total N	300
Test Statistic	22,187.000
Standard Error	1,496.243
Standardized Test Statistic	-.159
Asymptotic Sig. (2-sided test)	.874

The one-sample Wilcoxon signed-rank test indicated that the median was not significantly different than 66kg (Z =-0.159, p =0.874).

Mann – Whitney U Test

The Mann-Whitney U test is the non-parametric analogue of the two independent samples t-test.

When to use

- Skewed continuous data
- Ordinal (interval) or discrete data

Null hypothesis

- H_0: the two distributions are equal
- H_a: the two distributions are not equal

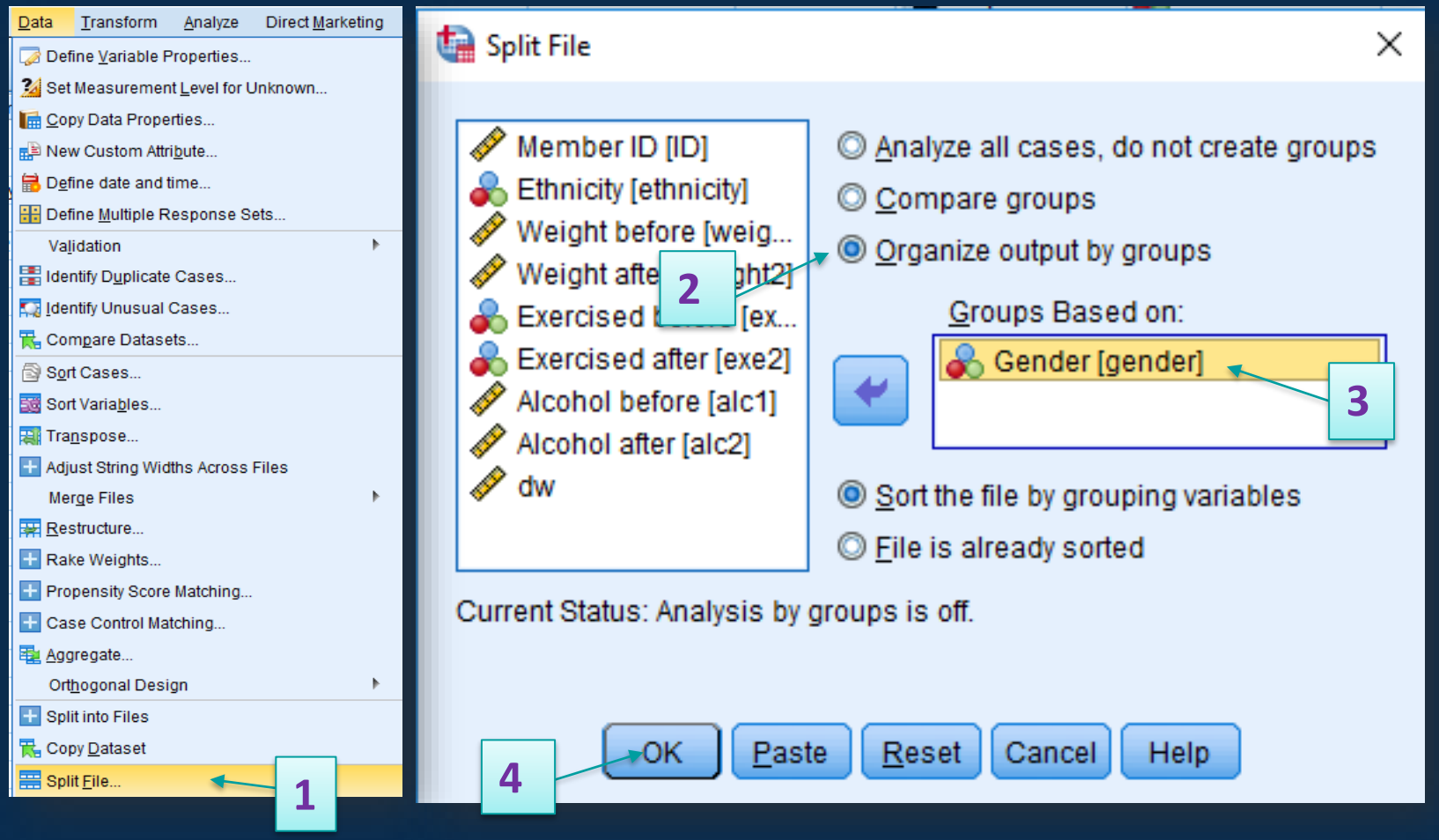
Assumptions

- The observations are randomly and independently drawn
- At least interval data

SPSS Slide: ‘how to’

The next question is whether the ‘weight before’ was different across genders.

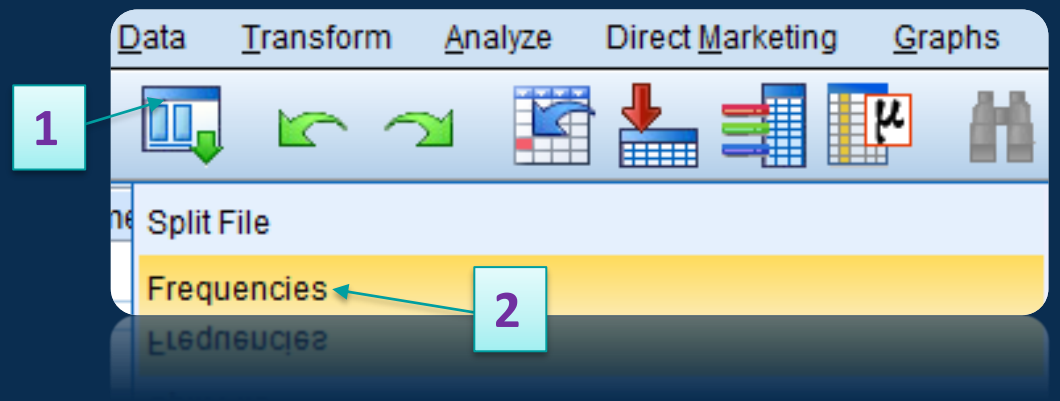
Step 1: Check the suitability of the data, here: what type of distribution has ‘weight1’, for each gender ?



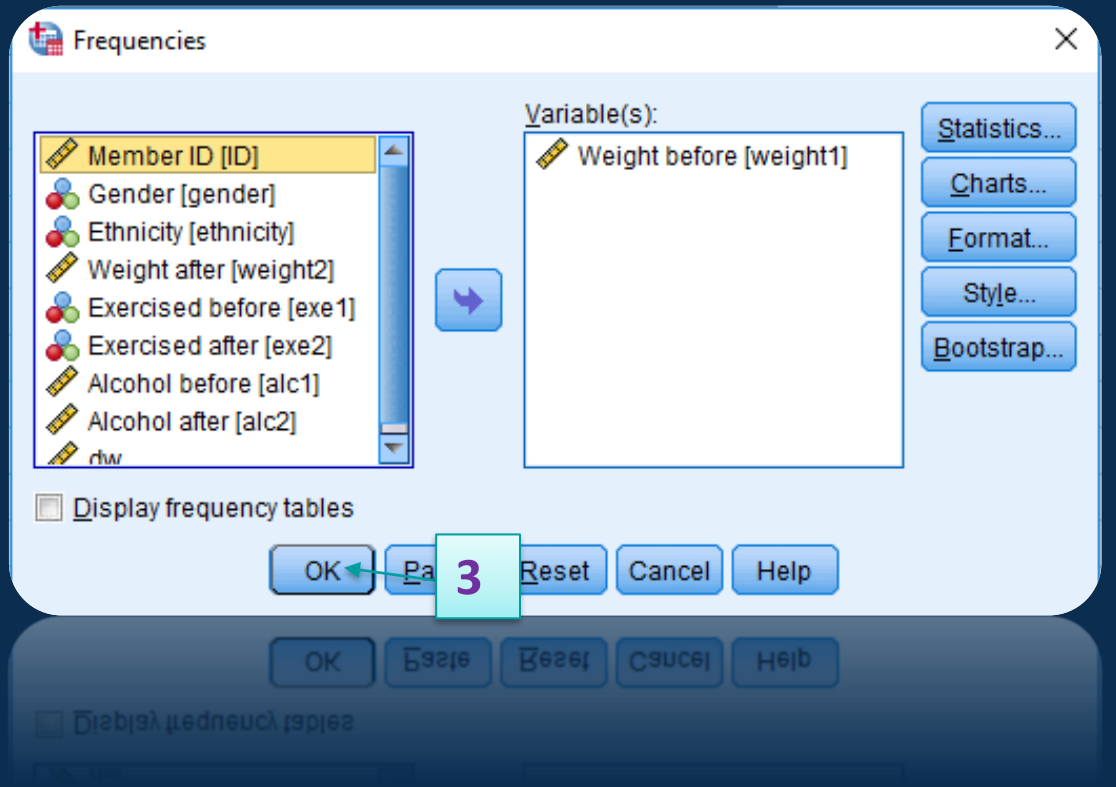
Go to ‘Data’ to use the ‘Split File’ function
Split the file by groups (gender)
Click on ‘OK’

SPSS Slide: ‘how to’

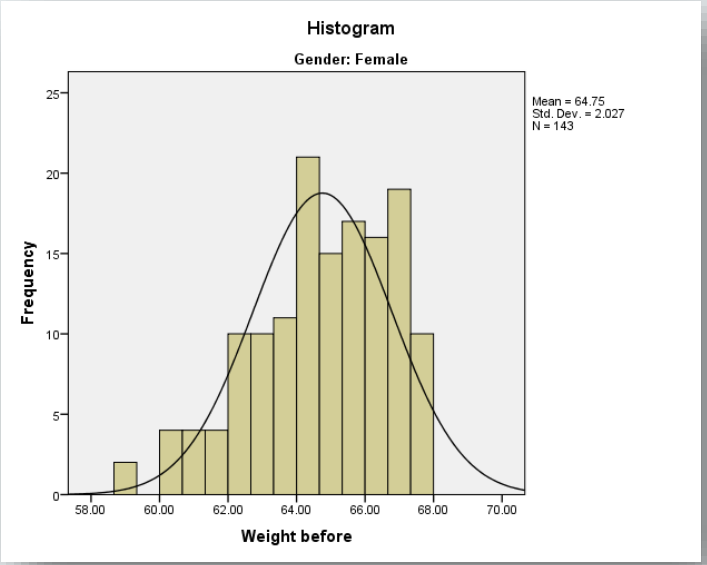
Step 1: Check the suitability of the data, here what type of distribution has ‘weight1’, for each gender ? SPSS is now ready to show us the frequencies for each gender separately. Use the recall button.

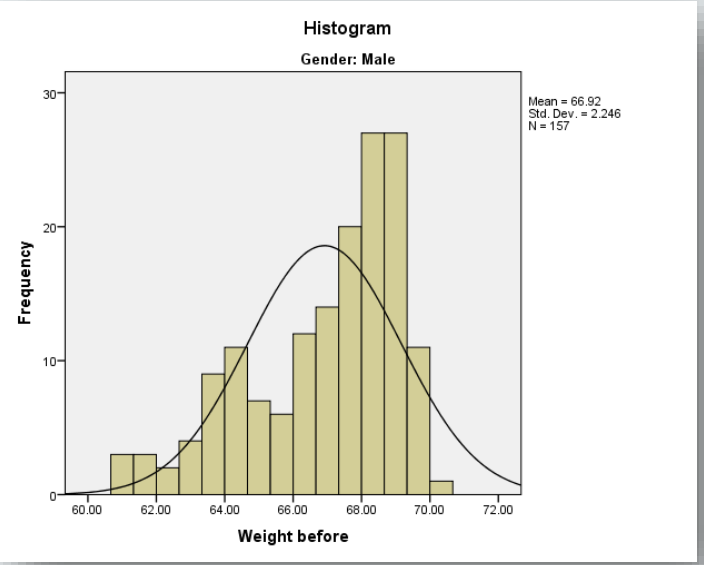


Or click on the ‘Analyse Tab’→ ‘Descriptive Statistics’ → ‘Frequencies’
Add the variable of interest (weight1) into the ‘Variable(s)’ box
In ‘Charts’ choose to display histograms
Click on ‘OK.



Output & Interpretation Slide





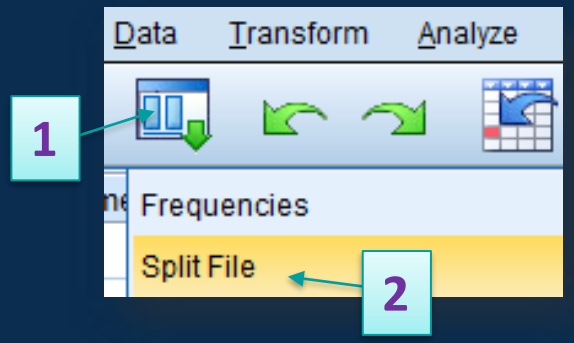
Both distributions are severely skewed (left, negative). Therefore we should use the 'Mann – Whitney test' for the hypotheses:

H_0: the two distributions are equal

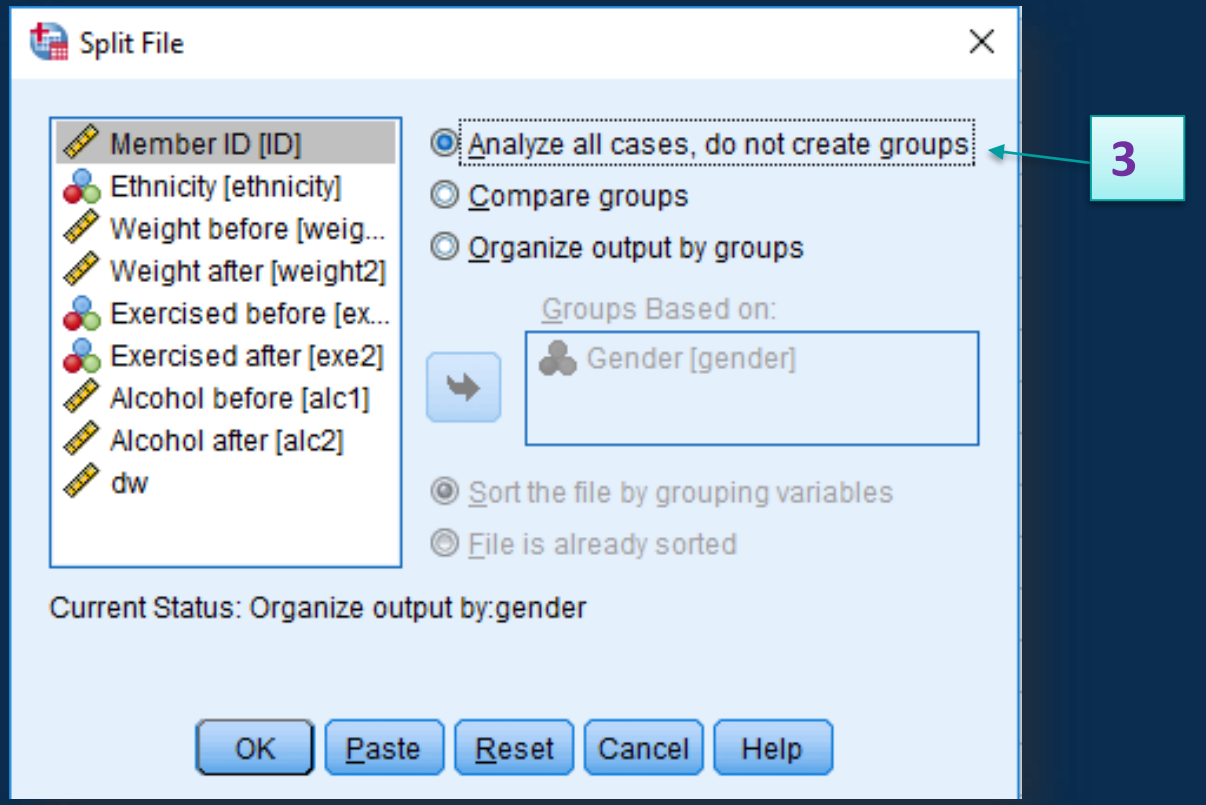
H_a: the two distributions are different

SPSS Slide: ‘how to’

Before proceeding with the test, use the ‘recall button’ to go back to the ‘split file’ and re-unite the data.

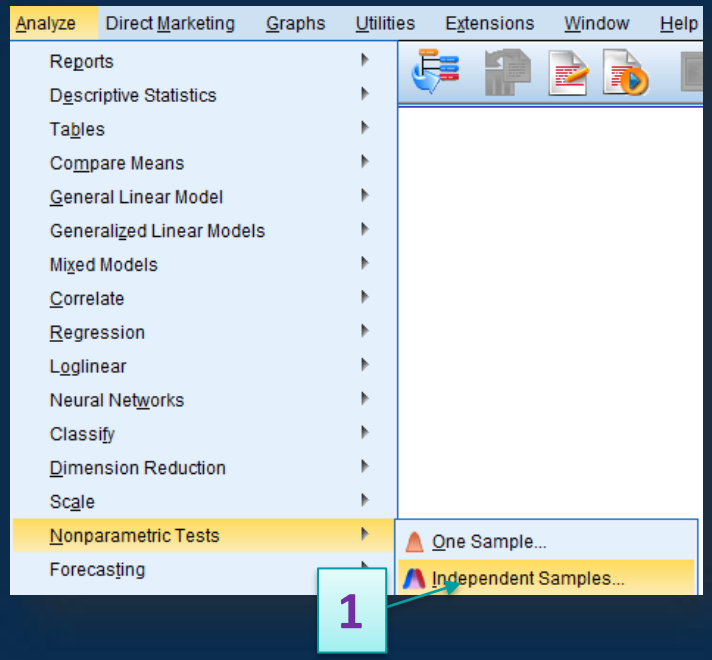


Go to ‘Data’ to use the ‘Split File’ function
‘Click on Analyse all cases’
Click on ‘OK’

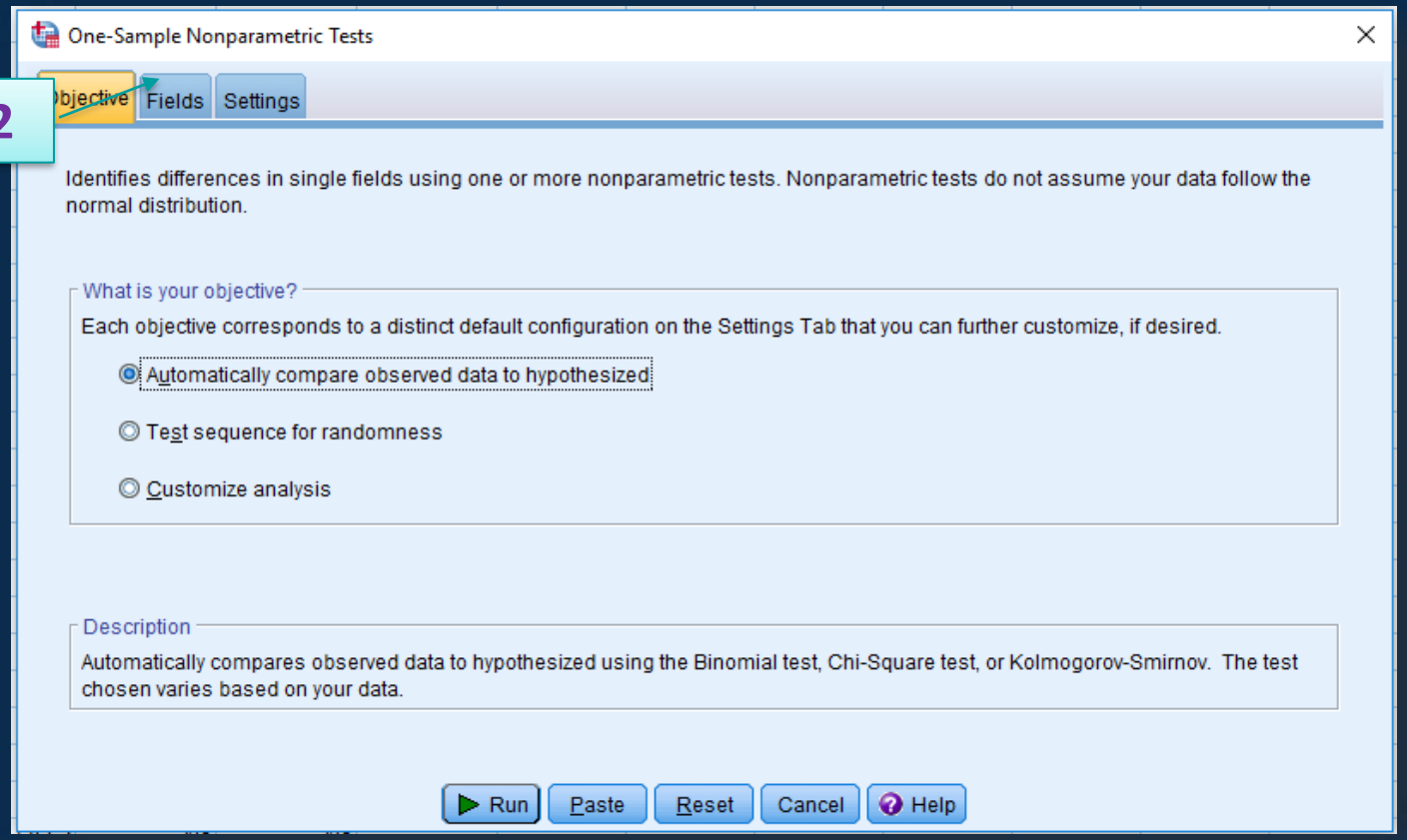


SPSS Slide: ‘how to’

Step 2: Use the appropriate test, here: ‘Mann – Whitney test’.
Analyse -> Nonparametric tests-> ‘independent samples’

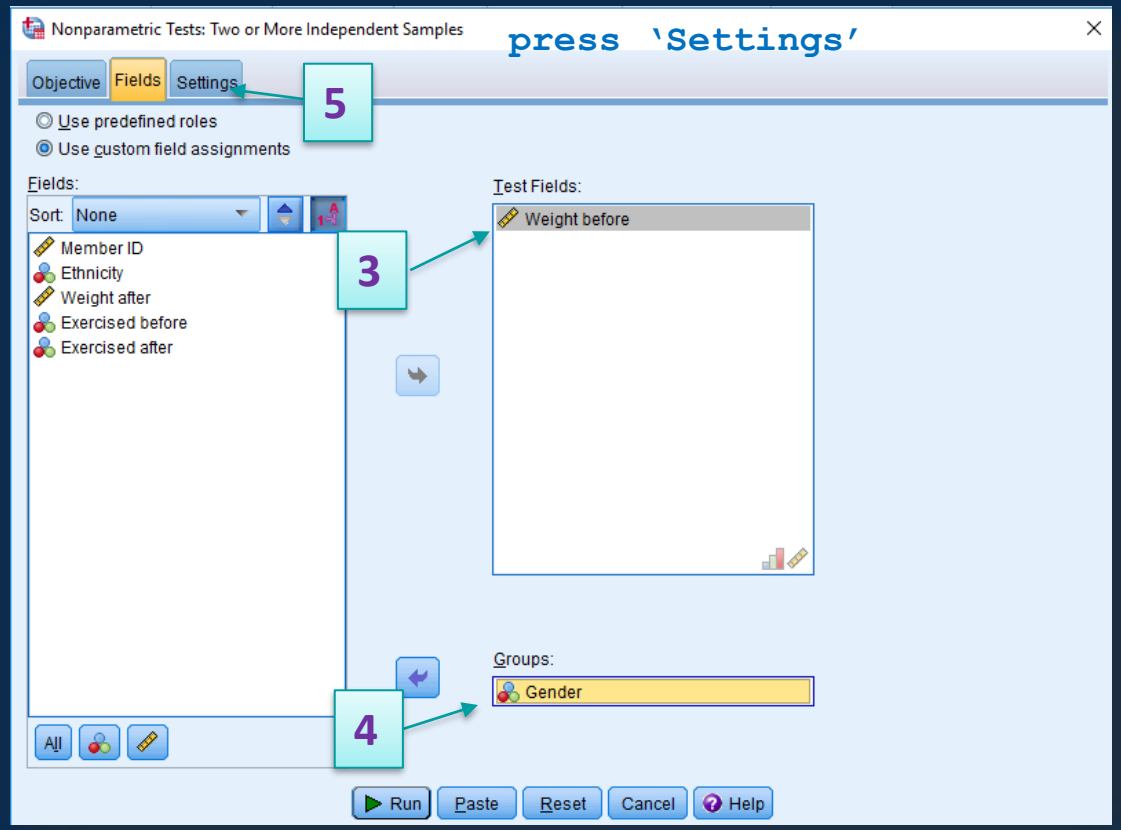


Click on the ‘Fields’ tab ’



SPSS Slide: ‘how to’

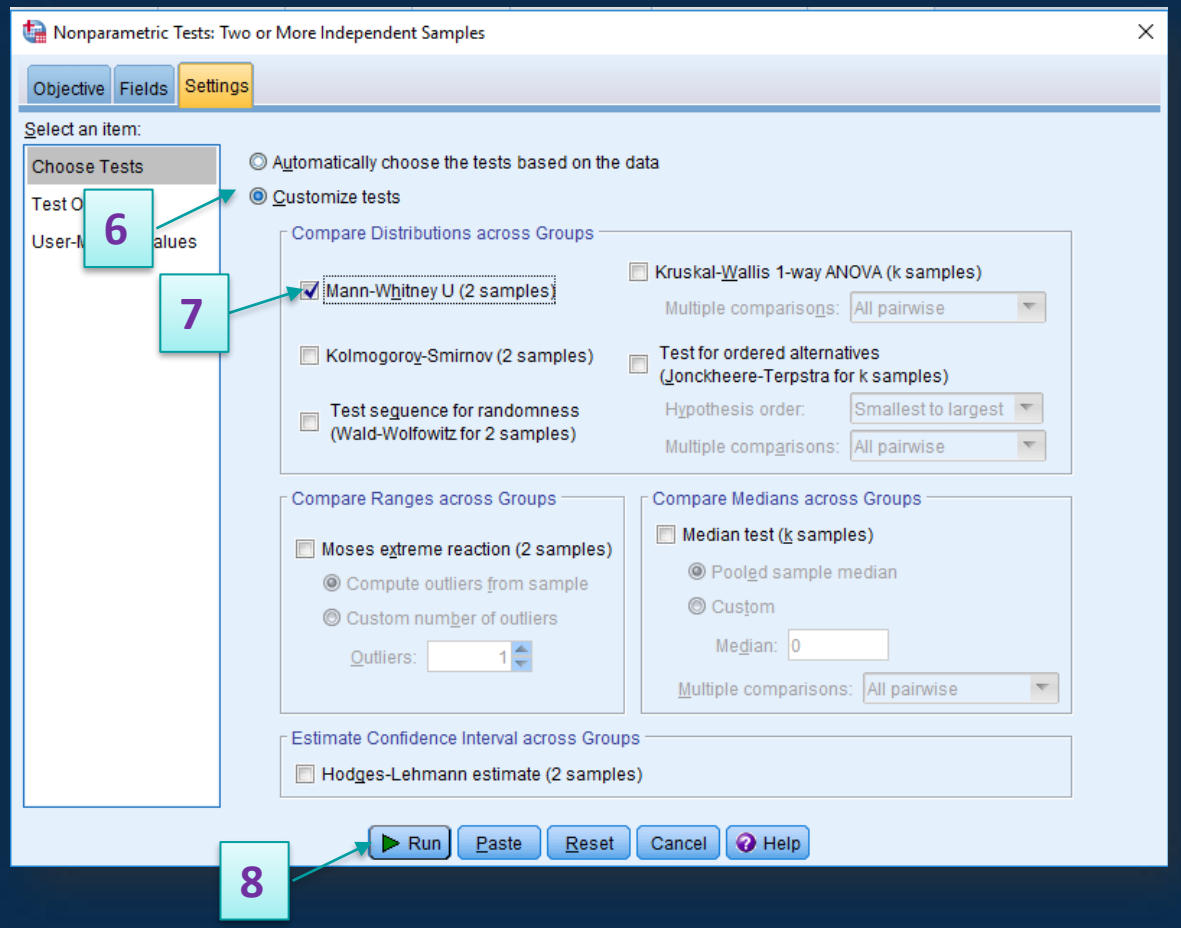
Analyse -> Nonparametric tests-> ‘independent samples’



Add the variable of interest (weight before) in the ‘Test Fields’ box
Add the grouping variable (gender) in the ‘Groups’ box
Click on the ‘Settings’ tab

SPSS Slide: ‘how to’

Analyse -> Nonparametric tests-> ‘independent samples’



Choose the ‘Customised tests’ option
Choose the ‘Mann Whitney U’ test
Click on ‘Run’

Output & Interpretation Slide

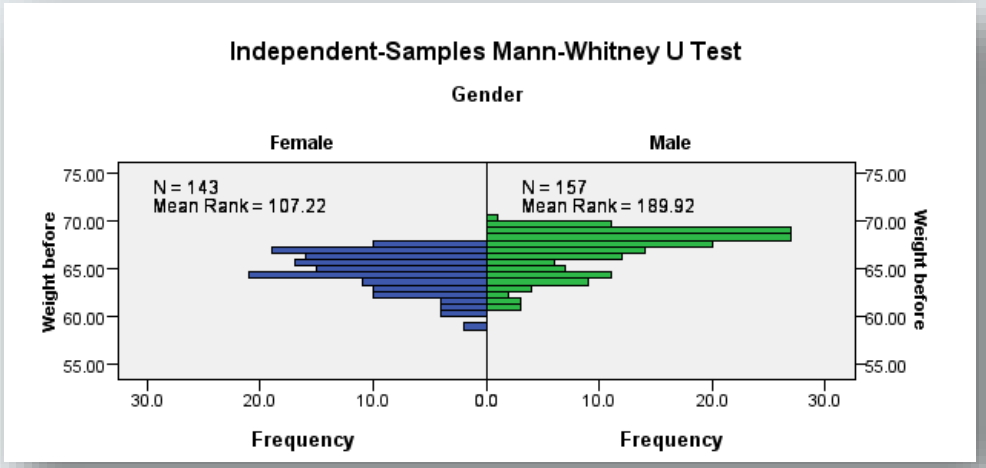
SPSS prints a table with all the information we need

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Weight before is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

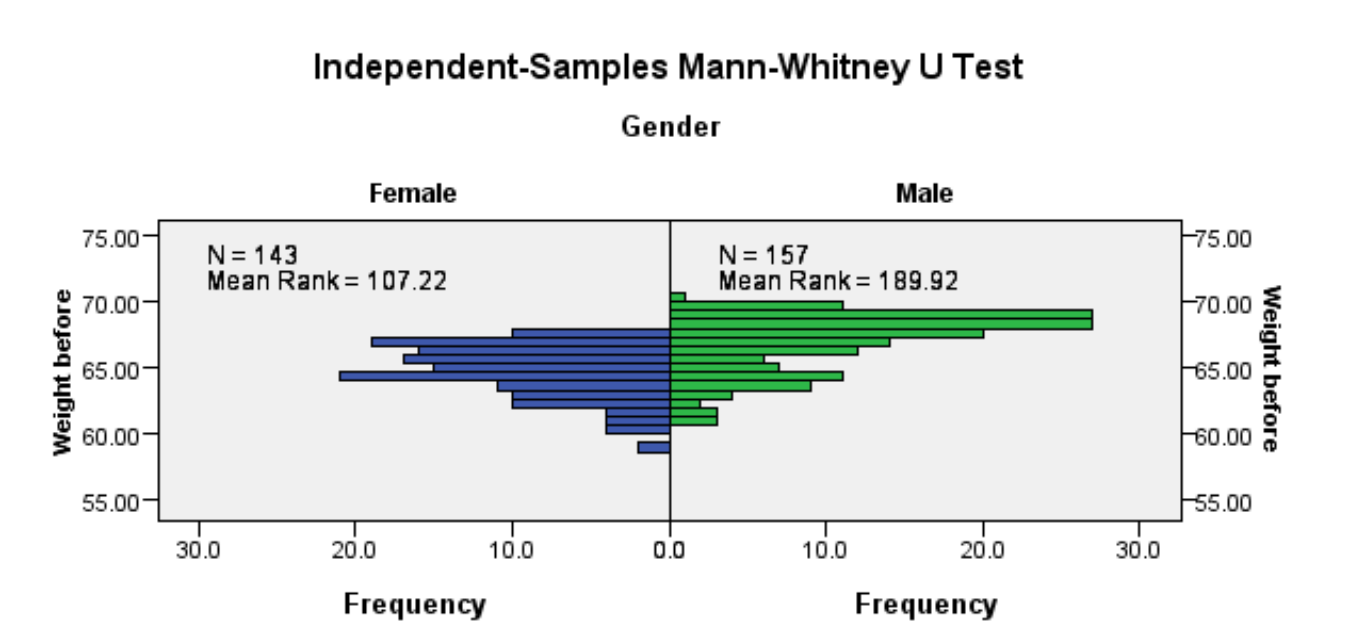
Asymptotic significances are displayed. The significance level is .05.

But if you double click this table, you are able to see more useful details:



Total N	300
Mann-Whitney U	17,414.500
Wilcoxon W	29,817.500
Test Statistic	17,414.500
Standard Error	750.425
Standardized Test Statistic	8.247
Asymptotic Sig. (2-sided test)	.000

Output & Interpretation Slide



Total N	300
Mann-Whitney U	17,414.500
Wilcoxon W	29,817.500
Test Statistic	17,414.500
Standard Error	750.425
Standardized Test Statistic	8.247
Asymptotic Sig. (2-sided test)	.000

The distribution of 'weight before' was statistically different across genders (Mann-Whitney U= 17,414.5, p <0.001), with men's weight tending to be higher than women's, before the program.

To see which gender had higher values, the best strategy is to check the descriptive indices (slide 16).

Wilcoxon Matched-Pair Signed Rank Test

The Wilcoxon Matched – Pair Signed Rank test is the non-parametric analogue of the paired sample t-test

When to use

- Skewed continuous data
- Ordinal (interval) or discrete data

Null hypothesis

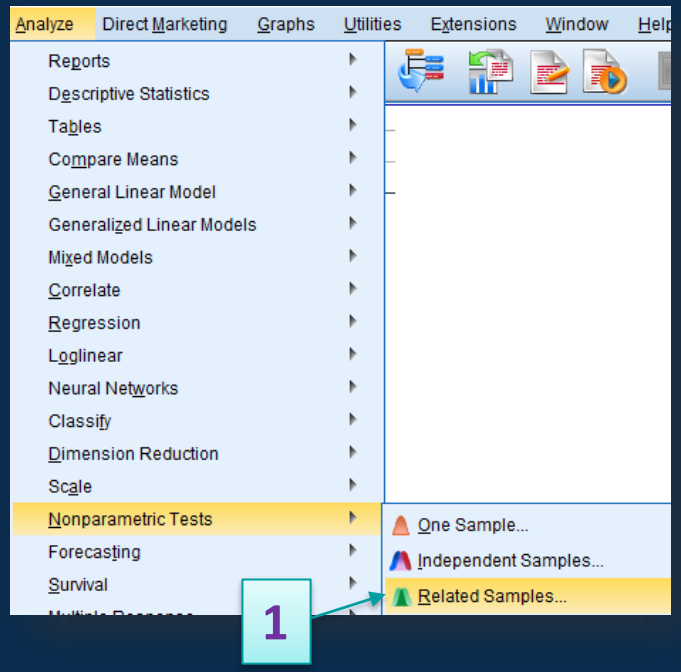
- H_0: Median of the paired differences equals zero
- H_a: Median of the paired differences is different than zero

Assumptions

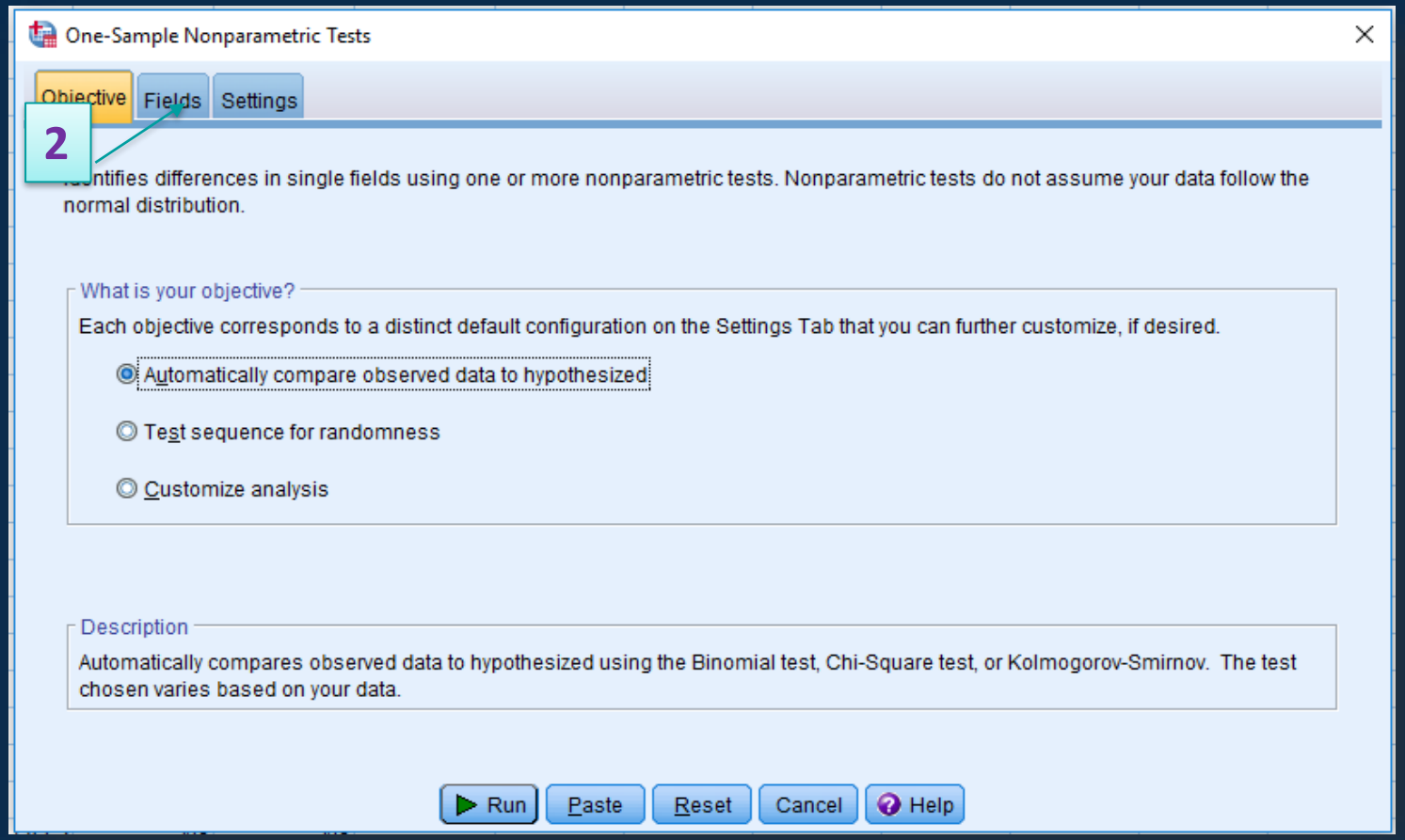
- The pairs of observations are randomly and independently drawn
- At least interval data
- The two samples need to be dependent observations of the cases, i.e. they are paired or matched

SPSS Slide: ‘how to’

Step 1: Use the appropriate test, here ‘related samples Wilcoxon signed rank test’.
Analyse -> nonparametric tests -> ‘related samples’

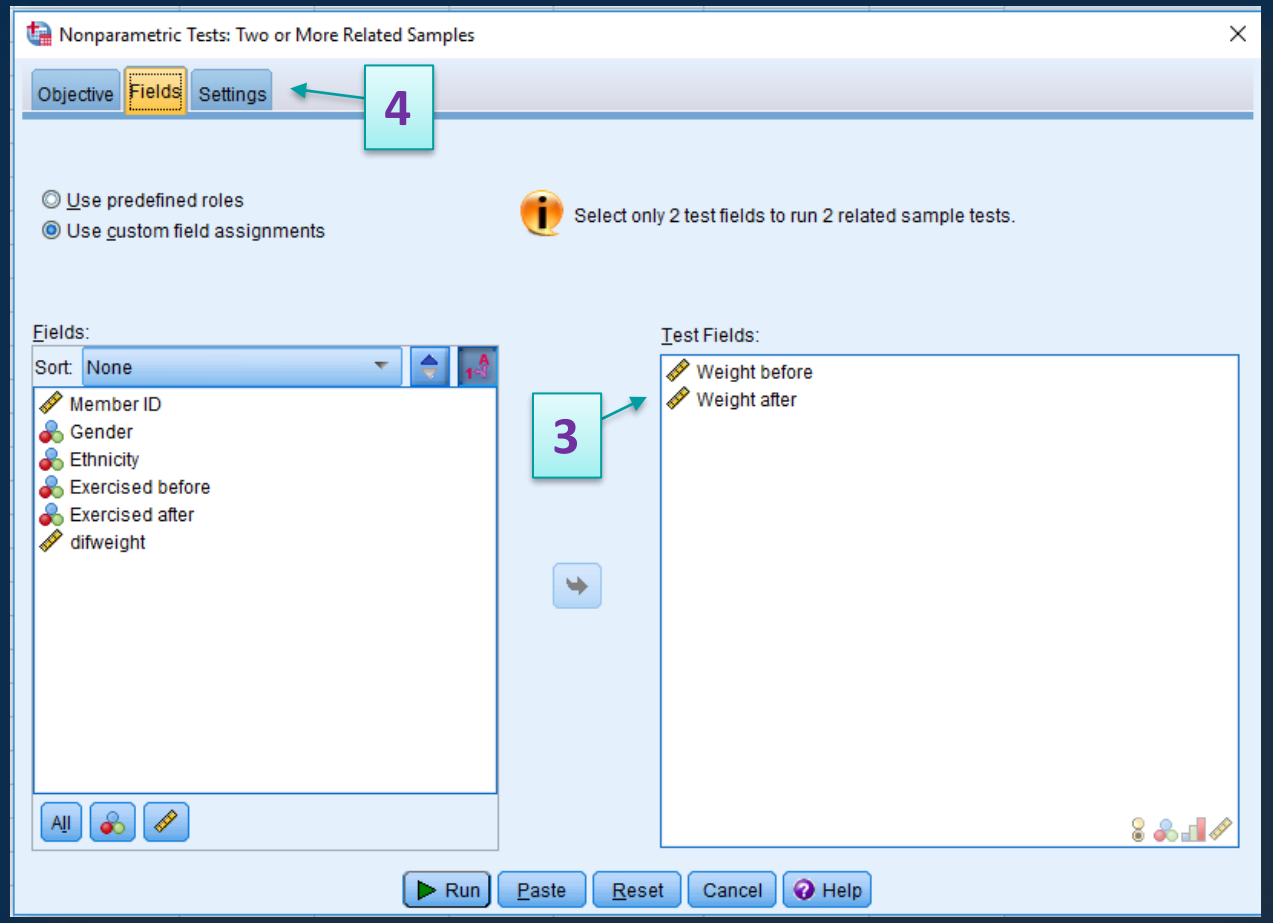


Click on the ‘Fields’ tab ’



SPSS Slide: ‘how to’

Analyse -> nonparametric tests -> ‘related samples’

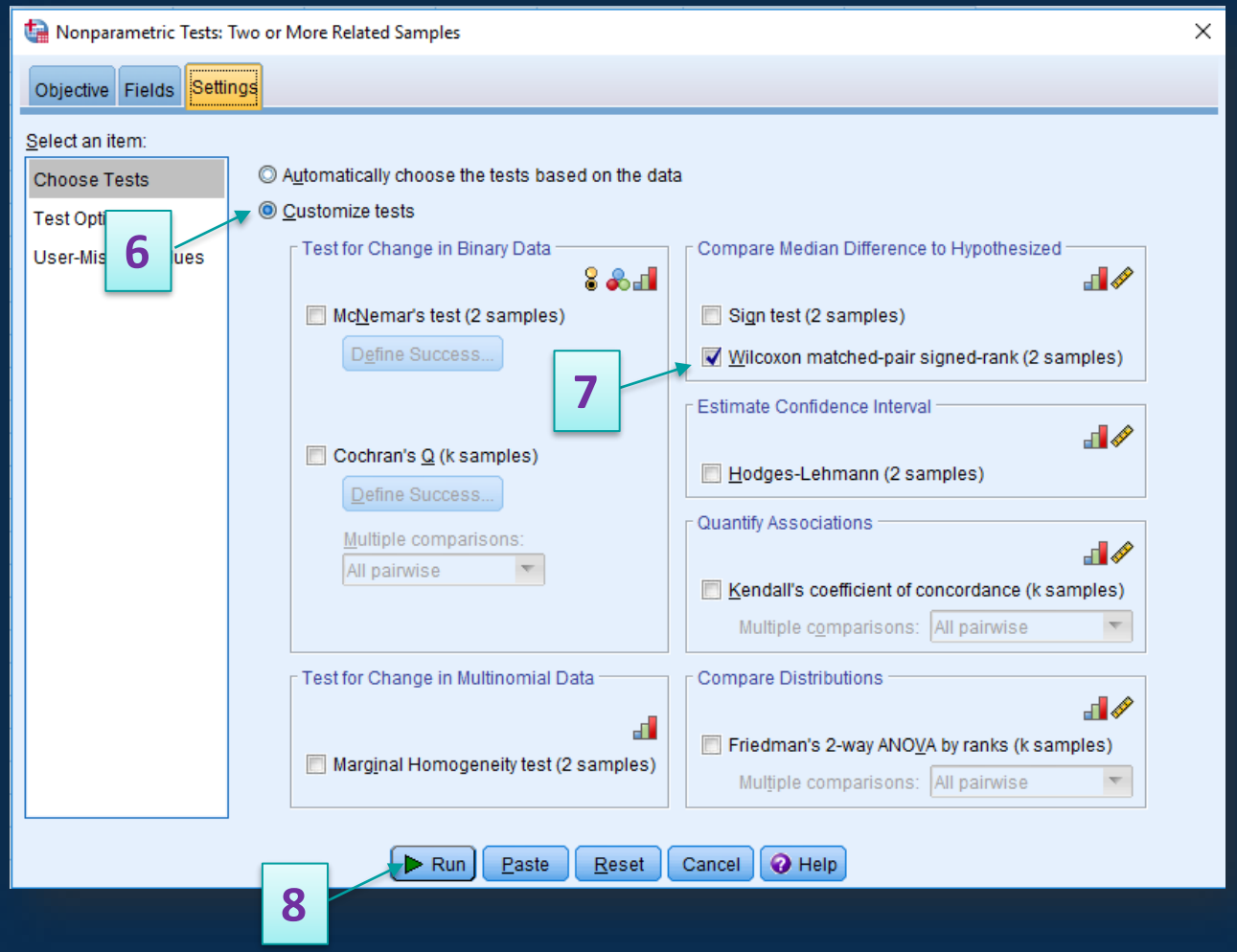


Add the variables of interest (weight before and weight after) into the ‘Test fields’ box

Click on ‘Settings’

SPSS Slide: ‘how to’

Analyse -> nonparametric tests -> ‘related samples’



Click on ‘Customise tests’
Choose ‘Wilcoxon matched-pair signed-rank’
Click on ‘Run’

Output & Interpretation Slide

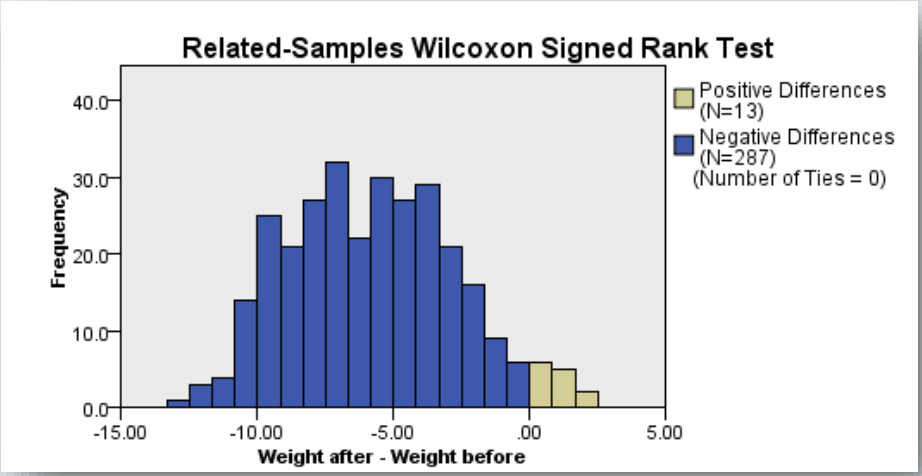
SPSS prints a table with all the information we need

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Weight before and Weight after equals 0.	Related-Samples Wilcoxon Signed Rank Test	.000	Reject the null hypothesis.

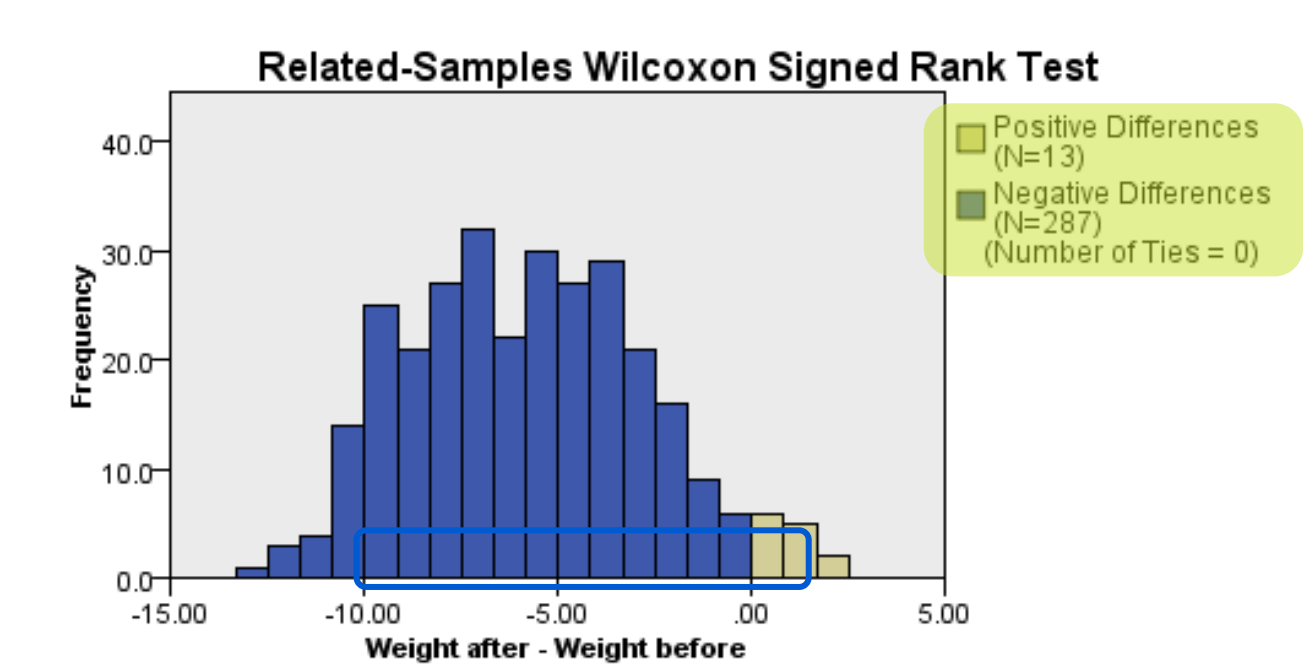
Asymptotic significances are displayed. The significance level is .05.

But if you double click this table, you are able to see more useful details:



Total N	300
Test Statistic	197.000
Standard Error	1,503.748
Standardized Test Statistic	-14.881
Asymptotic Sig. (2-sided test)	.000

Output & Interpretation Slide



Total N	300
Test Statistic	197.000
Standard Error	1,503.748
Standardized Test Statistic	-14.881
Asymptotic Sig. (2-sided test)	.000

The median difference between the 'weight after' and the 'weight before' was significantly different than zero (Wilcoxon rank sum Z = -14.88, p <0.001). The weight decreases significantly after the programme.

Parametric and Non-Parametric Tests

Numerical data	Normality assumed	Normality not assumed
Hypotheses testing	Means	Medians
one group *versus* a pre-defined value	one sample t-test	Wilcoxon signed rank
one group *versus* another group	two independent samples t-test	Mann-Whitney (Wilcoxon sum rank)
one group (twice or) *versus* another matched group	two paired samples t-test	Wilcoxon signed rank for paired samples

Parametric and Non-Parametric Tests for Numerical Data: Comparison

Parametric tests

They assume approximately normally distributed data

Not suitable for small sample sizes (less than N=30)

Powerful

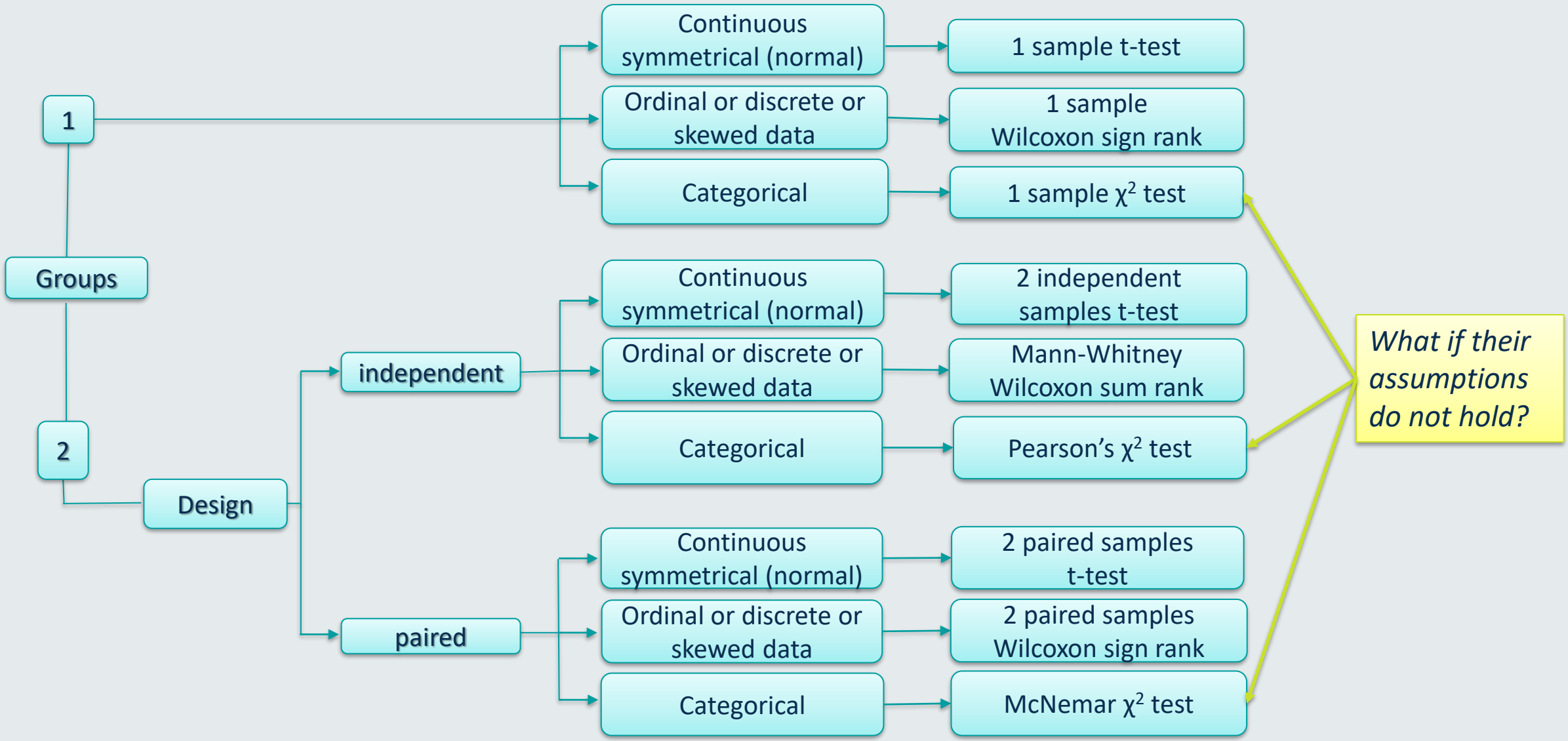
Non-parametric tests

They do not assume approximately normally distributed data

Suitable for small sample sizes (less than N=30)

Less powerful

The Tests in a Flow Chart…



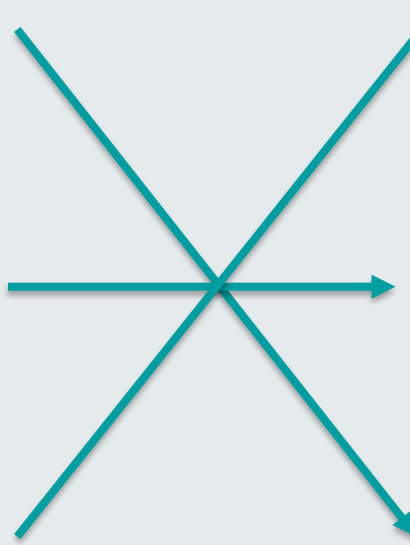
Knowledge Test

Match the scenario with the correct test.

Tom wants to test if mothers' reported ADHD scores for children are higher than those reported by fathers.

Tom wants to test if boys' ADHD scores are higher than those of girls.

Tom wants to test if children's ADHD scores are higher than 30.



1 sample
Wilcoxon signed rank

Mann-Whitney
(Wilcoxon sum rank)

2 paired samples
Wilcoxon signed rank

Reflection

Reflecting on your field of study

Write down three examples from your research that would require the use of each of the three non-parametric tests.

Reference List

- **Agresti and Finlay (2009) Statistical Methods for the Social Sciences, 4th Edn, Pearson Hall, Upper Saddle River, NJ.**
  - Comparison of Two Groups, Ch 7, pages 183-209
  - Analyzing Association between Categorical Variables, Ch 8, pages 221-239

- **Field (2005) Discovering Statistics using SPSS, 2nd Edn, Sage, London.**
  - Comparing Two Means, Ch 7
  - Categorical Data, Ch 16

Thank you

Please contact your module leader or the course lecturer of your programme, or visit the module's forum for any questions you may have.

If you have comments on the materials (spotted typos or missing points) please contact Dr Vitoratou:

Silia Vitoratou, PhD
Psychometrics & Measurement Lab,
Department of Biostatistics and Health Informatics
IoPPN, King's College London, SE5 8AF, London, UK
silia.vitoratou@kcl.ac.uk

For any other comments or remarks on the module structure, please contact one of the three module leaders of the Biostatistics and Health Informatics department:

Zahra Abdula: **zahra.abdulla@kcl.ac.uk**

Raquel Iniesta: **raquel.iniesta@kcl.ac.uk**

Silia Vitoratou: **silia.vitoratou@kcl.ac.uk**