Cheat Sheet

	Numerical data		Categorical data	
Hypotheses testing	parametric	non-parametric	chi-squared tests	exact tests
one group *versus* a pre-defined value	one sample t-test	Wilcoxon sign rank	one sample χ^2-test	One sample Binomial exact test
one group *versus* another group	two independent samples t-test	Mann-Whitney (Wilcoxon sum rank)	Pearson's χ^2-test	Fisher's Exact test
one group (twice or) *versus* another matched group	two paired samples t-test	Wilcoxon sign rank	McNemar test	Binomial exact test

Numerical Data: compare means

Categorical data: proportions (%)

Parametric W4 Lecture 1

Chi-squared tests W4 Lecture 2

Non-parametric W5 Lecture 1

Exact tests W5 Lecture 2

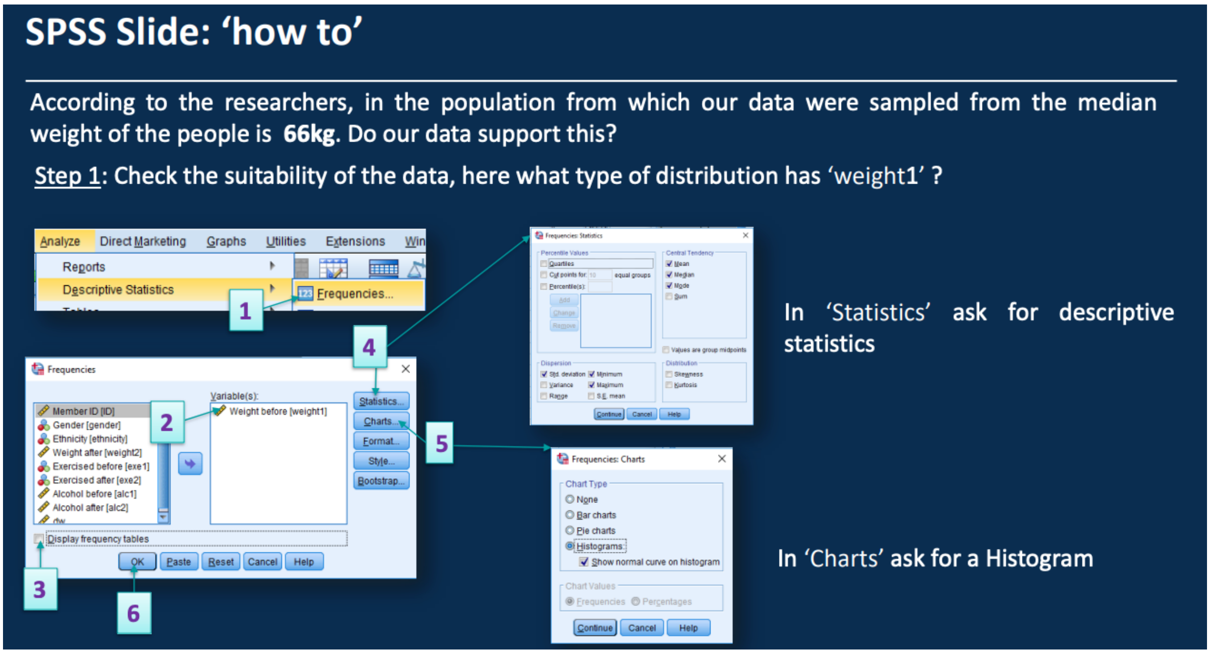
📘 Week 5 Revision Notes — *Non-Parametric Tests in SPSS*

🧠 When Do We Use Non-Parametric Tests?

Use these tests when:

- Your data is **not normally distributed**
- You have **ordinal**, **skewed**, or **small sample size** data
- Parametric tests like t-tests aren't appropriate

1)To check if the data normally distributed <u>(one sample/ two paired samples)</u>:



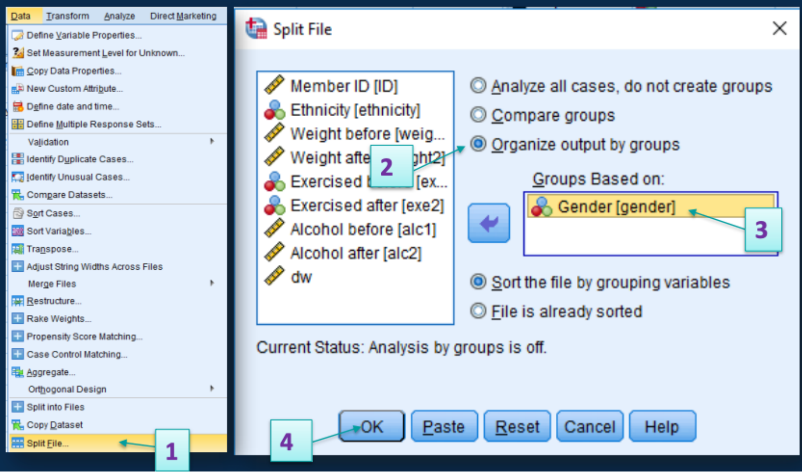
When check "Frequencies", click the 'charts' ask for histogram!

2)To check if the data normally distributed <u>(two sample):</u>

"Data"-"split file first" (this should be use 'recall 'button to recover after generating the histogram)

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

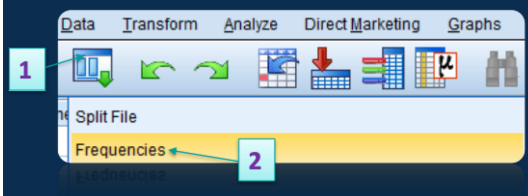
Split the file by groups (gender)

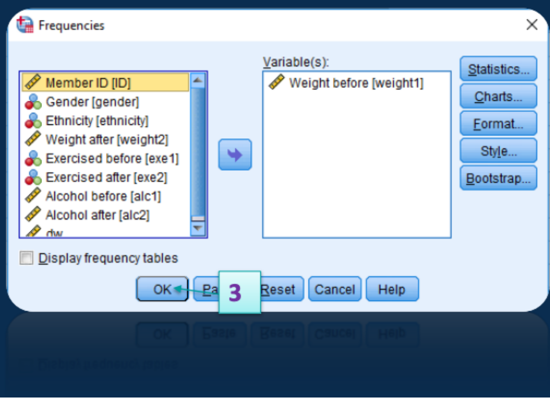
Click on 'OK'

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.





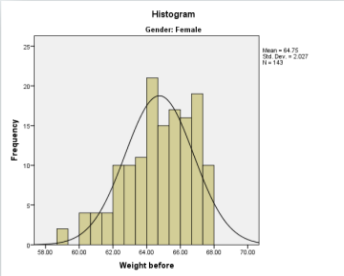
Or click on the 'Analyse Tab'→ 'Descriptive Statistics' → 'Frequencies'

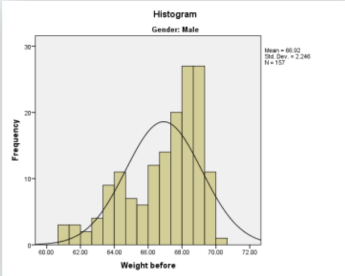
Add the variable of interest (weight1) into the 'Variable(s)' box

In 'Charts' choose to display histograms

Click on 'OK.

Output & Interpretation Slide





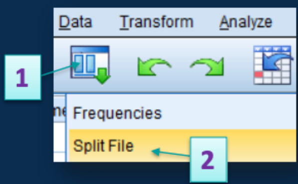
Both distributions are severely skewed (left, negative). Therefore we should use the 'Mann – Whitney test' for the hypotheses:

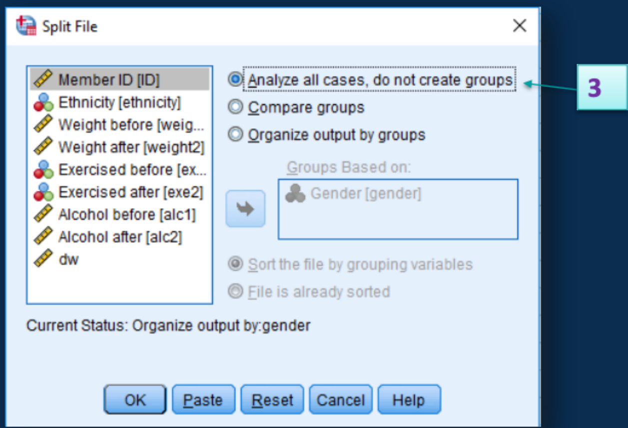
H_0: the two distributions are equal

H_a: the two distributions are different

Recall:

Before proceeding with the test, use the 'recall button' to go back to the 'split file' and re-unite the dat





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

🔷 Key Non-Parametric Tests

1. Wilcoxon Signed Rank Test (One Sample)

- 💬 *Use when comparing a group's median to a known value (e.g. "is median weight = 66kg?")*
- ✔️ Works with: skewed continuous, ordinal, or discrete data
- **SPSS Path**:
  `Analyze > Nonparametric Tests > One Sample`
  ➤ Click `Fields`, add variable (e.g. `weight1`)
  ➤ Set test value (e.g. `66`)

2. Mann–Whitney U Test (Two Independent Groups)

- 💬 *Use to compare medians between two **unrelated** groups (e.g. men vs. women)*
- ✔️ Works with: skewed, ordinal, discrete data
- **SPSS Path**:
  `Analyze > Nonparametric Tests > Independent Samples`
  ➤ Add outcome variable (e.g. `weight1`)
  ➤ Add grouping variable (e.g. `gender`)
  ➤ Under `Settings` tab: choose `Customized tests` → `Mann–Whitney`

3. Wilcoxon Matched-Pair Signed Rank Test (Two Paired Groups)

- 💬 *Use to compare two **related** variables (e.g. weight before vs. after)*
- ✔️ Works with: paired ordinal or skewed numeric data
- **SPSS Path**:
  `Analyze > Nonparametric Tests > Related Samples`
  ➤ Add both variables (e.g. `weight1`, `weight2`)
  ➤ Click `Settings`, choose `Wilcoxon matched–pair signed–rank`

✅ When Do You Use Exact Tests for Proportions?

You use **exact tests** (like **binomial**, **Fisher's exact**, or **McNemar's exact**) when the assumptions for **chi-square tests** are **not met**.

🧠 The 3 Chi-Square Assumptions You MUST Check:

1. Expected Frequency in Each Cell Must Be ≥ 1

- No cell in your contingency table should have an expected value less than 1.

2. No More Than 20% of Cells Should Have Expected Frequencies < 5

- This rule means: if your table has 10 cells, then at most 2 of them can have expected counts below 5.

3. Observations Must Be Independent

- The individuals in your table should not appear in more than one cell (not repeated measures, unless using McNemar).

1) To check if the if the chi-square assumptions are violated:

🔍 How to Check These Assumptions in SPSS:

➤ After running a Chi-Square test (Crosstabs):

1. Go to:
   `Analyze > Descriptive Statistics > Crosstabs`
2. Add your **row** and **column** variables.
3. Click:
   - `Statistics` → Tick **Chi-Square**
   - `Cells` → Tick **Expected** and **Observed**
4. Click **OK**

<u>Example 1:</u>

SPSS Slide: ‘how to’

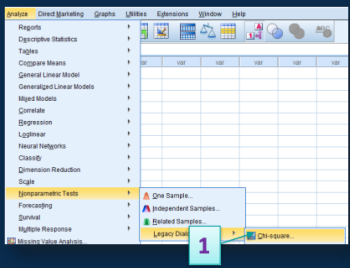
The programme developers had hoped that no more than 1% of the population has used drugs. Is that what our data tell us?

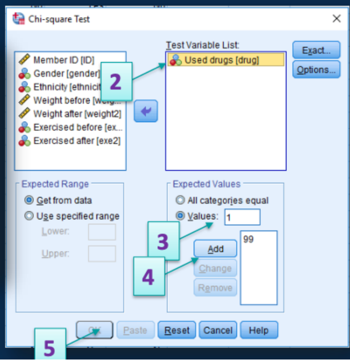
H_0: π=1%

H_a: π≠1%

Step 1: Use the appropriate test, here ‘one-sample chi-square t-test’.

Analyse -> nonparametric tests -> legacy dialogs -> ‘Chi-square’





Add the variable of interest (used drugs) in to the ‘Variables box’. Choose to Test ‘values’

Check the coding in the dataset as ‘0’ coding is ‘not used drugs’ ‘add’ in 99 (100%- 1%) first.
Then as ‘1’ coding is ‘used drugs’ ‘add’ in 1 (to represent the 1% in the question).
Click ‘OK’

Output and Interpretation Slide

Step 2: Check the suitability of the data, do the assumptions of the chi-square test hold?

Used drugs

	Observed N	Expected N	Residual
No	290	297.0	-7.0
Yes	10	3.0	7.0
Total	300		

Test Statistics

	Used drugs
Chi-Square	16.498[a]
df	1
Asymp. Sig.	.000

a. 1 cells (50.0%) have expected frequencies less than 5. The minimum expected cell frequency is 3.0.

Only up to 20% of the cells are allowed to have expected frequencies less than 5.

Thus, one assumption is violated!

Example2:

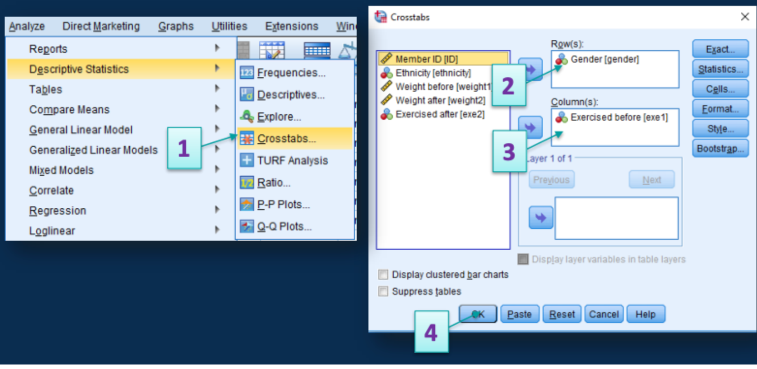
SPSS Slide: 'how to'

The next question is: do men exercise more than women prior to entering the programme?
Are the proportions of those exercised before the programme, different for men and women?

Step 1: Use the appropriate test, here: 'Pearson's chi-square test'.

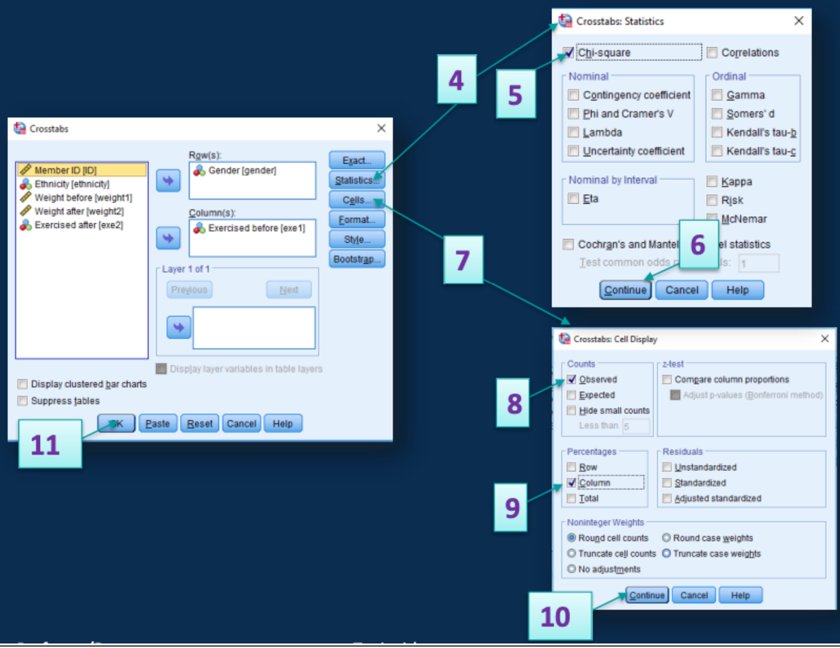
Analyse -> Descriptive Statistics-> Crosstabs

H_0: $\pi_m = \pi_f$
H_a: $\pi_m \neq \pi_f$



Add the variable of interest (gender) in to the 'Rows box'. Add the second variable interest (Exe before) in the 'columns box'

Step 1: Use the appropriate test, here: 'Pearson's chi-square test'.



Output and Interpretation Slide

Unfortunately, due to a technical problem, most of the data we had in 'exercise before' were accidentally deleted. We only have info for 29 people.

Gender * Exercised before Crosstabulation

			Exercised before		
			No	Yes	Total
Gender	Female	Count	17	3	20
		% within Exercised before	100.0%	25.0%	69.0%
	Male	Count	0	9	9
		% within Exercised before	0.0%	75.0%	31.0%
Total		Count	17	12	29
		% within Exercised before	100.0%	100.0%	100.0%

Step 2: Check the suitability of the data, do the assumptions of the chi-square test hold?

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	18.488[a]	1	.000		
Continuity Correction[b]	15.149	1	.000		
Likelihood Ratio	22.428	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	17.850	1	.000		
N of Valid Cases	29				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.72.
b. Computed only for a 2x2 table

- Only up to 20% of the cells are allowed to have expected frequencies less than 5.
- **Thus, one assumption is violated!**

To conclude:

If SPSS says...	What You Should Do
✅ 0% or <20% cells < 5 and min ≥ 1	✔ You can use chi-square
❌ >20% cells < 5 or min < 1	⚠️ Use an exact test

🔶 Exact Tests for Proportions (Categorical Data)

4. Binomial Exact Test (One Sample)

- 💬 *Use when testing if a proportion equals a specific value (e.g. "Is drug use = 1%?")*
- **SPSS Path:**
  `Analyze > Nonparametric Tests > Legacy Dialogs > Binomial`

5. Fisher’s Exact Test (Two Independent Groups, 2x2 Table)

- 💬 *Use instead of Pearson’s chi-square if expected frequencies are low*
- **SPSS Path**:

  `Analyze > Descriptive Stats > Crosstabs`

  ➤ Add variables

  ➤ Click `Statistics`, tick `Chi-square`

  ➤ Click `Exact`, tick `Exact test`

6. McNemar Test (Two Paired Categorical Groups)

- 💬 *Use for paired binary variables, like “exercise before vs after”*
- **SPSS Path**:

  `Analyze > Descriptive Stats > Crosstabs`

  ➤ Row = before variable

  ➤ Column = after variable

  ➤ Click `Statistics`, tick `McNemar`

Quiz:

To study the association between 'ethnicity' and 'exercise after', the appropriate test is

Ethnicity * Exercised after Crosstabulation

		Exercised after				Total	
		No		Yes			
		Count	% within Exercised after	Count	% within Exercised after	Count	% within Exercised after
Ethnicity	White	73	43.7%	51	38.3%	124	41.3%
	Black	48	28.7%	41	30.8%	89	29.7%
	Asian	43	25.7%	36	27.1%	79	26.3%
	Other	3	1.8%	5	3.8%	8	2.7%
Total		167	100.0%	133	100.0%	300	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	1.743[a]	3	.627	.628		
Likelihood Ratio	1.740	3	.628	.633		
Fisher's Exact Test	1.763			.621		
Linear-by-Linear Association	1.074[c]	1	.300	.323	.166	.031
McNemar-Bowker Test	.	.	.[b]			
N of Valid Cases	300					

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 3.55.

b. Computed only for a PxP table, where P must be greater than 1.

📌 Check Chi-Square Assumptions:

Look at the footnote:

> **"2 cells (25.0%) have expected count less than 5. The minimum expected count is 3.55."**

That **violates** the chi-square assumption:

- ✅ Expected count must be ≥ **1**
- ❌ **No more than 20%** of cells should have expected count **< 5**

Since **25% of the cells** have expected count < 5 → **assumption violated** → chi-square results might be **inaccurate**.

🎓 Summary: When to Use Fisher's Exact Test

Condition	Use Fisher's Exact?
You have a 2x2 table	✅ Yes (always OK)
Expected count in **any** cell < 1	✅ Yes
>20% of cells have expected count < 5	✅ Yes
All chi-square assumptions are met	❌ No, use Chi-square

Practical:

The data set consists of a sample of 1500 people in the UK attending a CBT programme to improve their ability to talk in a public setting. In this dataset you may find the following variables:

sex Sex at birth (0 = Female; 1 = Male)

age

ethnicity (1 = White, 2 = Black, 3 = Asian, 4 = Other)

likA Before CBT: How willing are you to volunteer to give a talk? (0: not at all to 7: very much)

likB After CBT: How willing are you to volunteer to give a talk? (0: not at all to 7: very much)

anxA Anxiety Scale before CBT

anxB Anxiety Scale after CBT

fearA Fear of public speaking before CBT (1 = Intense, 2 = Moderate, 3 = Mild)

fearB Fear of public speaking after CBT (1 = Intense, 2 = Moderate, 3 = Mild)

Familiarize with the data and infer on the type of variables:

- First comment on whether the variable is NUMERICAL or CATEGORICAL
- Then be more specific by denoting within the parenthesis if the variable is CONTINUOUS, DISCRETE, ORDINAL, BINARY or NOMINAL.

sex is a categorical ✓ variable (nominal ✗ *[binary]* in particular)

age is a numerical ✓ variable (continuous ✓ in particular)

ethnicity is a categorical ✓ variable (nominal ✓ in particular)

likA is a numerical ✗ *[categorical]* variable (discrete ✗ *[ordinal]* in particular)

likB is a numerical ✗ *[categorical]* variable (discrete ✗ *[ordinal]* in particular)

anxA is a numerical ✓ variable (continuous ✓ in particular)

anxB is a numerical ✓ variable (continuous ✓ in particular)

fearA is a categorical ✓ variable (ordinal ✓ in particular)

fearB is a categorical ✓ variable (ordinal ✓ in particular)

*sex-only males and females-categorical binary

The scales have certain items-categorical ordinal

The programme facilitator want to test if males experienced more anxiety than females before their CBT treatment. Use the appropriate test and infer on the results.

To decide on which test to use, we consider the following:

- the design is a [two independent samples design], and
- anxA is a numerical ✓ variable.

Hence we can either use a test from the family of the parametric tests ✓ or, if the assumptions do not hold, a test from the family of the non-parametric tests ✓ .

- The appropriate test to use here is the two independent samples t-test ✓ because anxA is a numerical ✗ *[symmetrical]* variable within each group.

According to our data, males experienced ✓ significantly more anxiety than females (t=-24.275 ✓ , df=1172.128 ✓ , p<0.001 ✓).

The programme facilitator wants to test if CBT improved the levels of anxiety significantly. Use the appropriate test to see if the anxiety scores were the same before and after CBT. Infer on the results.

To decide on which test to use, we consider the following:

- the design is a two paired samples design ✓ , and
- anxA and anxB are numerical ✓ variables.

Hence we can either use a test from the family of the parametric tests ✓ or, if the assumptions do not hold, a test from the family of the non-parametric tests ✓ .

- The appropriate test to use here is the two paired samples t-test ✓ because the change between anxA and anxB are numerical ✗ *[fairly symmetrical]* variables.

In statistics:

- A distribution is **symmetrical** if it looks the same on the left and right of the mean.
- A **normal distribution** (bell curve) is the ideal form of symmetry.

So:

Term	Meaning
Symmetrical	Bell-shaped, normally distributed (ideal for t-test).
Fairly symmetrical	Some small skew, but not extreme — still OK for t-test.
Not symmetrical	Heavily skewed — consider non-parametric tests like Mann-Whitney or Wilcoxon.

Institute of Psychiatry, Psychology and Neuroscience

Module Title: Introduction to Statistics

Session Title: Lecture Knowledge Quiz 5 - Solutions

Topic title: Comparing groups II (non parametric methods)

Lecture Progress Quiz 5

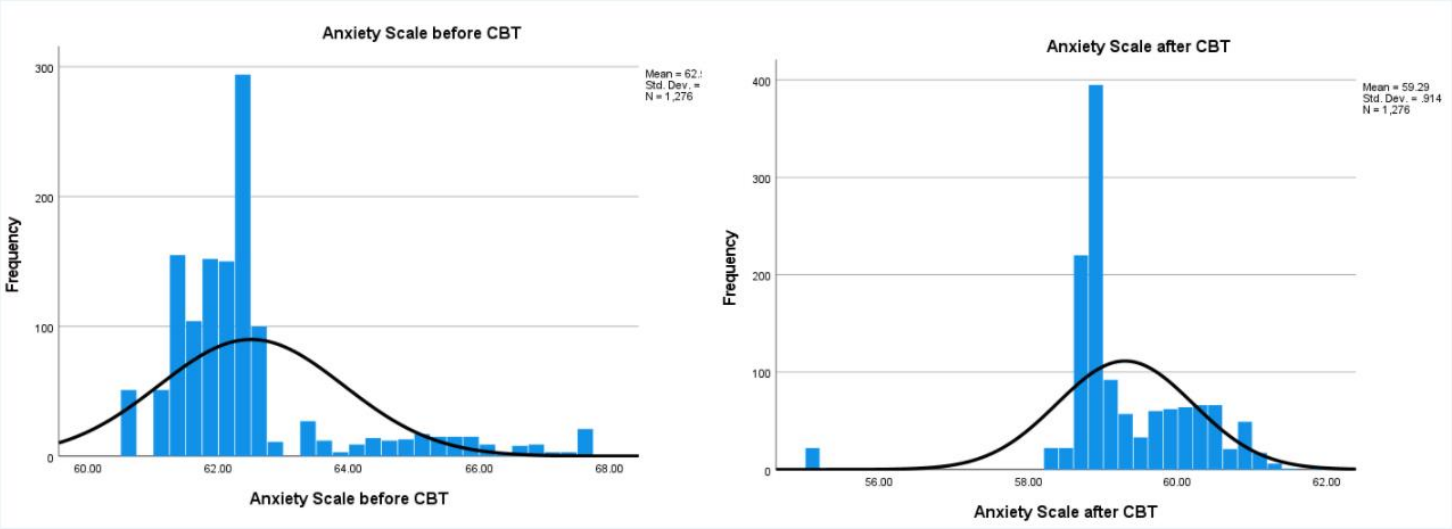
Welcome to the **Topic 5 Knowledge Quiz**

This quiz is made up of 5 multiple choice questions. You have are given 10 mins to complete the quiz. The quiz is timed and you will not be able to answer a question after the time has ended.

The quiz has free navigation and you can move between the questions using the navigation pane to your left.

Question 1

To study the differences in the anxiety score 'before' and 'after' a CBT programme, the appropriate test is



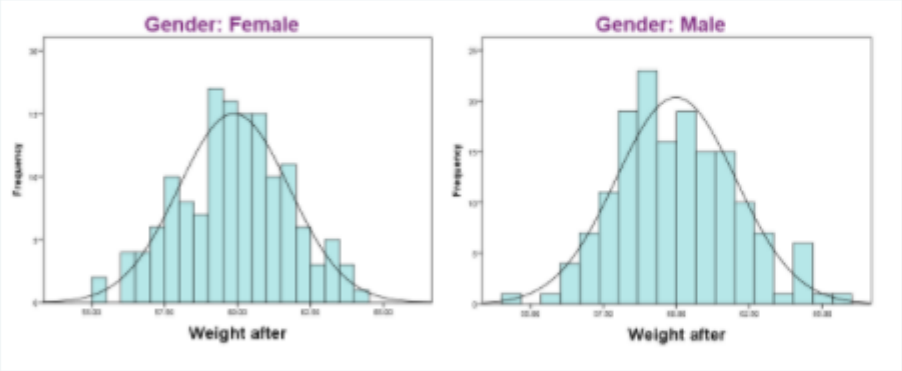
Select one:

- a. 2-paired samples t-test
- b. McNemar Test
- c. 2-paired samples Wilcoxon sign rank test
- d. 2-independent samples Mann-Whitney test

As the variables are not normally distributed the 2-paired samples Wilcoxon sign rank test is the appropriate test here.

Question 2

To study the differences between 'males' and 'females' in 'weight after', the appropriate test is



Select one:

- a. Independent samples t-test
- b. Independent samples Mann-Whitney test
- c. Paired samples Wilcoxon sign rank test
- d. Paired samples t-test

As both variables are symmetrically distributed and there are independent samples, the independent samples t-test is the appropriate test.

Question 3

To study the differences in the' alcohol consumption', 'before' and 'after' the programme, the appropriate test is

More than 2 units of alcohol on a weekend

		After						Total	
		Never		Sometimes		Always			
		Count	% within Before	Count	% within Before	Count	% within Before	Count	% within Before
Before	Never	65	95.6%	3	4.4%	0	0.0%	68	100.0%
	Sometimes	9	5.7%	148	94.3%	0	0.0%	157	100.0%
	Always	0	0.0%	13	17.3%	62	82.7%	75	100.0%
Total		74	24.7%	164	54.7%	62	20.7%	300	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	461.6[a]	4	.000	.000		
Likelihood Ratio	438.05	4	.000	.000		
Fisher's Exact Test	421.74			.000		
Linear-by-Linear Association	250.2[b]	1	.000	.000	.000	.000
McNemar-Bowker Test	16.000	2	.000			
N of Valid Cases	300					

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 14.05.

b. The standardized statistic is 15.819.

Select one:

- a. Pearson's chi-square test
- b. Linear - by - Linear Association
- c. Fisher's exact test
- d. McNemar-Bowker test

As we have 3 levels for each variable (3x3 table) and it is paired data (before and after) the McNemar-Bowker test is the most appropriate.

Question 4

Based on the table below, the correct comparison of percentages is:

Ethnicity * Exercised after Crosstabulation

		Exercised after				Total	
		No		Yes			
		Count	% within Exercised after	Count	% within Exercised after	Count	% within Exercised after
Ethnicity	**White**	73	43.7%	51	38.3%	124	41.3%
	Black	48	28.7%	41	30.8%	89	29.7%
	Asian	43	25.7%	36	27.1%	79	26.3%
	Other	3	1.8%	5	3.8%	8	2.7%
Total		167	100.0%	133	100.0%	300	100.0%

Select one:

- a. 43.7 vs 1.8%
- b. 43.7% vs 38.3%
- c. 3.8% vs 2.7%
- d. 41.3% vs 100%

As column percentages are presented, we can compare across a row. Thus 43.7% vs 38.3% is the correct percentage to report.

Question 5

To study the association between 'ethnicity' and 'exercise after', the appropriate test is

Ethnicity * Exercised after Crosstabulation

		Exercised after				Total	
		No		Yes			
		Count	% within Exercised after	Count	% within Exercised after	Count	% within Exercised after
Ethnicity	White	73	43.7%	51	38.3%	124	41.3%
	Black	48	28.7%	41	30.8%	89	29.7%
	Asian	43	25.7%	36	27.1%	79	26.3%
	Other	3	1.8%	5	3.8%	8	2.7%
Total		167	100.0%	133	100.0%	300	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	1.743[a]	3	.627	.628		
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Linear-by-Linear Association	1.074[c]	1	.300	.323	.166	.031
McNemar-Bowker Test	.	.	.[b]			
N of Valid Cases	300					

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 3.55.

b. Computed only for a PxP table, where P must be greater than 1.

Select one:

- a. Linear by Linear Association
- b. McNemar-Bowker test
- c. Pearson's chi-square
- d. Fisher's exact test

We have independent samples. More than 20% of the cells have less than 5 expected count, thus the corresponding assumption is violated and we cannot use Pearson's. Thus Fisher's exact test is for the data.