🧠 Week 4 Key Notes — *Comparing Groups*

🔷 The Three Types of t-Tests

1. **One-Sample t-Test**
    - Compares a sample mean to a known/reference value (e.g. μ = 66kg)
    - Example: Is the average weight of this group different from 66kg?
2. **Independent Samples t-Test**
    - Compares means between **two unrelated groups** (e.g. men vs women)
    - Example: Do men and women weigh the same?
3. **Paired Samples t-Test**
    - Compares means between **two measurements of the same group** (e.g. before vs after)
    - Example: Did people lose weight after the program?

🔶 When to Use Each t-Test

Test Type	Use when...
One-Sample	Comparing sample mean to a known value
Independent Samples	Comparing two separate/unrelated groups
Paired Samples	Comparing before/after or matched pair values

✅ Assumptions for t-Tests

- Your data should be **symmetrical or bell-shaped (normal distribution)**
- Observations are **independent**
- **No extreme outliers** (especially in small samples)

🧪 The Three Types of Chi-Square (χ^2) Tests

1. **One-Sample χ^2-Test**
    - Compares observed proportions with expected ones
    - Example: Is the gender split in the sample equal (50%-50%)?
2. **Pearson's χ^2-Test (Independent Groups)**
    - Compares proportions between two separate groups
    - Example: Do men and women differ in their exercise habits?
3. **McNemar's χ^2-Test (Paired Groups)**
    - Compares proportions between **before and after** or **paired** categories
    - Example: Did more people exercise after the programme?

🧩 Assumptions for Chi-Square Tests

- No more than **20% of cells** with expected frequencies < 5
- **Minimum expected frequency** = 1
- Data must be **categorical** and **independent** (except McNemar's)

🧠 What the rule means:

✅ Rule 1: No more than 20% of the cells should have expected counts < 5

- Expected count = what SPSS would expect if the null hypothesis were true.
- If too many cells have very low expected counts (e.g. 2 or 3), the chi-square test becomes **unreliable**.
- This rule ensures that the test has **enough data to detect real differences**.

✅ Rule 2: The smallest expected frequency must be at least 1

- No cell should have **expected count less than 1**.
- If any expected value is below 1, the math behind the test breaks — it becomes statistically invalid.

🎯 How to Interpret It:

Message SPSS Gives	What It Means
✅ *Only 10% of cells < 5*	Assumption is met – you're good to go!
⚠️ *25% of cells < 5*	Assumption is **violated** – be cautious
❌ *Minimum expected count < 1*	Assumption **not met** – results are invalid

💻 SPSS: Essential Commands

Test Type	SPSS Menu Path
One-Sample t-Test	`Analyze > Compare Means > One-Sample T-Test`
Independent t-Test	`Analyze > Compare Means > Independent-Samples T-Test`
Paired t-Test	`Analyze > Compare Means > Paired-Samples T-Test`
One-Sample χ^2	`Analyze > Nonparametric Tests > Legacy Dialogs > Chi-Square`
Pearson's χ^2	`Analyze > Descriptive Stats > Crosstabs > Statistics: Chi-Square`
McNemar's χ^2	`Analyze > Nonparametric Tests > 2 Related Samples`

🧠 Decision Rule (for all tests)

p-value	What to do	What it means
≤ 0.05	Reject H_0	There is a statistically significant difference
> 0.05	Do not reject H_0	Not enough evidence to say there's a difference

Quiz:

Based on the output, the correct interpretation for the difference in 'weight after' across males and females, is:

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Weight after	Equal variances assumed	1.04	.310	.417	298	.677	.09537	.22886	-.3550	.54575
	Equal variances not assumed			.418	297.9	.676	.09537	.22805	-.3534	.54416

Select one:

a. Non significant (F=1.04, df=297.9, p=0.676)

b. Non significant (t=0.418, df=297.9, p=0.676)

c. Non significant (t=0.417, df=298, p=0.677)

d. Non significant (F=1.04, df=298, p=0.677) ×

Your answer is incorrect.

Check Levenes test under the null hypothesis H0: Variances are equal

As the p-value is >0.05 we fail to reject the null hypothesis and conclude that we are assuming equal variance.

From the top line of the output we get a non significant result as the p-value is > 0.05 (t=0.417, df=298, p=0.677) and we can conclude that there is no statistically significance difference in weight (kg) after in the two gender groups.

The correct answer is: Non significant (t=0.417, df=298, p=0.677)

✅ **t-test for Equality of Means (Top row)**

- t = **0.417**
- df = **298**
- p = **.677**
- CI = [−0.3550, 0.54575] → Includes **0** → **Not significant**

❌ Why Option D is Wrong

Option D says:

> "Non significant (F=1.04, df=298, p=0.677)"

🚫 This mixes two different tests:

- F = 1.04 is from **Levene's test** (for variance)
- df = 298 and p = .677 are from **the t-test**

🧠 So it's **mismatching stats from two different tests**.

🚫 The F value from Levene's test is not used for interpretation.

The **F-statistic** is used to **calculate the p-value**, but it's **not important** for your decision in SPSS output.

Week 4 Revision Sheet: Comparing Groups & Chi-Square Tests

Types of t-tests

1. One-sample t-test: compares mean to known value

2. Independent samples t-test: compares means between 2 groups

3. Paired samples t-test: compares means in matched pairs

Types of chi-square tests

1. One-sample chi-square: test observed % vs expected %

2. Pearson's chi-square: compare proportions across independent groups

3. McNemar chi-square: compare proportions across matched groups

Assumptions for t-tests

- Approximately normal distribution (bell-shaped)

- Independent observations

- No extreme outliers

Assumptions for chi-square tests

- Expected frequency in each cell > 1

- No more than 20% of cells < 5

- Random and independent observations

SPSS: One-Sample t-test

Analyze > Compare Means > One-Sample T-Test

-> Add variable to Test Variable

-> Enter test value

-> Click OK

SPSS: Independent Samples t-test

Analyze > Compare Means > Independent-Samples T-Test

-> Test Variable: your measurement

-> Grouping Variable: your two groups

-> Define groups -> OK

SPSS: Paired Samples t-test

Analyze > Compare Means > Paired-Samples T-Test

-> Pair: before and after (e.g. weight1, weight2)

-> Click OK

SPSS: One-Sample Chi-Square

Analyze > Nonparametric Tests > Legacy Dialogs > Chi-Square

-> Add variable -> Choose 'All categories equal' or enter expected values

SPSS: Pearson's Chi-Square

Analyze > Descriptive Statistics > Crosstabs

-> Add row + column variable

-> Click Statistics > Chi-Square

-> Cells > column % -> OK

SPSS: McNemar's Chi-Square

Analyze > Nonparametric Tests > Legacy Dialogs > 2 Related Samples

-> Use McNemar for paired categorical variables (e.g. before vs after)

Institute of Psychiatry, Psychology and Neuroscience

Module Title: Introduction to Statistics

Session Title: Lecture Knowledge Quiz 4 - Solutions

Topic title: Comparing groups I (parametric methods)

Lecture Progress Quiz 4

Welcome to the **Topic 4 Knowledge Quiz**

This quiz is made up of 5 multiple choice questions and a bonus question.

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

A researcher wants to study the difference in 'weight' (in kg), across genders. Which is the appropriate test to use?

Select one:

- a. One sample t-test
- b. Independent samples t-test
- c. McNemar test
- d. Paired samples t-test

As the weight (kg) is a numerical continuous variable, and we are comparing two independent groups (male and female) the only suitable test among the listed ones is the independent samples t-test, provided that the assumptions of the test are satisfied.

Question 2

Based on the output, the correct interpretation for the difference in 'weight after' across genders, is:

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Weight after	Equal variances assumed	1.04	.310	.417	298	.677	.09537	.22886	-.3550	.54575
	Equal variances not assumed			.418	297.9	.676	.09537	.22805	-.3534	.54416

Select one:

- a. Non significant (F=1.04, df=297.9, p=0.676)
- b. Non significant (t=0.418, df=297.9, p=0.676)
- c. Non significant (F=1.04, df=298, p=0.677)
- d. Non significant (t=0.417, df=298, p=0.677)

We first check the Levene's test under the null hypothesis of the group variances being equal. As the p-value is >0.05 we do not reject the null hypothesis and allow to assume equal variances.

From the top line of the output we get a non significant result (t=0.417, df=298, p=0.677) and we can conclude that there is no statistically significant difference in the mean weight (kg) between these two gender groups.

Question 3

		Gender				Total	
		Female		Male			
		Count	% within Gender	Count	% within Gender	Count	% within Gender
Exercised before	No	119	83.2%	103	65.6%	222	74.0%
	Yes	24	16.8%	54	34.4%	78	26.0%
Total		143	100.0%	157	100.0%	300	100.0%

Select one or more:

- [ ] a. 65.6% versus 34.4%
- [ ] b. 83.2% versus 16.8%
- [ ] c. 26% versus 100%
- [ ] d. 83.2% versus 65.6%

The % have been computed by column (they add up to 100% by column) and we need to compare by row (as we never compare % that add to 100%). The only correct response is 83.2% versus 65.6%.

Question 4

Based on the output for the association between exercise 'before' and 'after', the correct interpretation is:

		Exercised after				Total	
		No		Yes			
		Count	% of Total	Count	% of Total	Count	% of Total
Exercised before	No	119	39.7%	103	34.3%	222	74.0%
	Yes	48	16.0%	30	10.0%	78	26.0%
Total		167	55.7%	133	44.3%	300	100.0%

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.473[a]	1	.225		
Continuity Correction[b]	1.169	1	.280		
Likelihood Ratio	1.484	1	.223		
Fisher's Exact Test				.236	.140
Linear-by-Linear Association	1.468	1	.226		
McNemar Test				.000[c]	
N of Valid Cases	300				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 34.58.

b. Computed only for a 2x2 table

c. Binomial distribution used.

Select one:

- a. The percentage of those exercising 'before' is different than that of those exercising 'after' (26% vs 44.3% , Pearson Chi Squared=1.473, df=1, p=0.226)
- b. The percentage of those exercising 'before' is different than that of those exercising 'after' (26% vs 44.3% , McNemar p<0.001)
- c. The percentage of those exercising 'before' is not different than that of those exercising 'after' (39.7% vs 16% , Pearson Chi Squared=1.473, df=1, p=0.226)
- d. The percentage of those exercising 'before' is not different than that of those exercising 'after' (16.0% vs 34.3% , Fisher's exact p=0.236)

We are comparing paired categorical data (before and after), with the assumption of discordant cells <25 not violated.

The percentage of those exercising 'before' is different than that of those exercising 'after' (26% vs 44.3% , McNemar p<0.001)

Question 5

Based on the output for the association between 'ethnicity' and 'gender', the correct interpretation is:

Ethnicity * Gender Crosstabulation

		Gender				Total	
		Female		Male			
		Count	% within Ethnicity	Count	% within Ethnicity	Count	% within Ethnicity
Ethnicity	White	53	42.7%	71	57.3%	124	100.0%
	Black	44	49.4%	45	50.6%	89	100.0%
	Asian	46	58.2%	33	41.8%	79	100.0%
	Other	0	0.0%	8	100.0%	8	100.0%
Total		143	47.7%	157	52.3%	300	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.136[a]	3	.007
Likelihood Ratio	15.219	3	.002
Linear-by-Linear Association	.801	1	.371
N of Valid Cases	300		

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 3.81.

Select one:

- a. All of the above
- b. Among women, those who classified themselves as Asian had significantly highest percentage (58.2%; Pearson chi-squared=12.136, df=3, p=0.007)
- c. Among Asian people, the percentage of women was significantly higher than men (58.2% vs 41.8%, Pearson chi-squared=12.136, df=3, p=0.007)
- d. None of the above

Option c would have been a correct interpretation but we see under the table that the Pearson chi-squared assumptions are violated and therefore none of the options is correct (we will learn in the next topic that a different test is suitable for such cases).