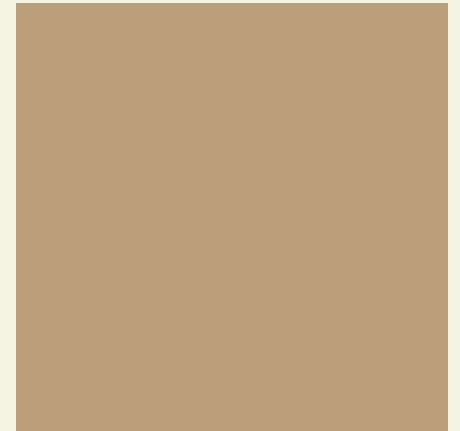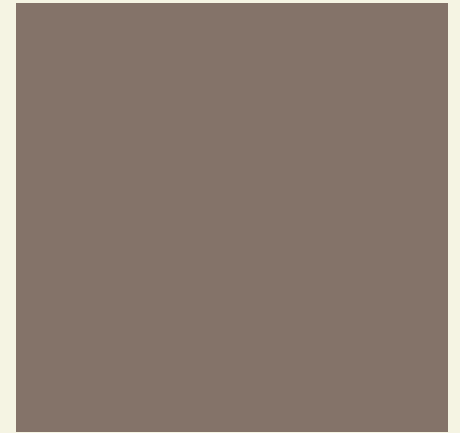# ICCPP-STATISTICS
- Cochran's Q Test

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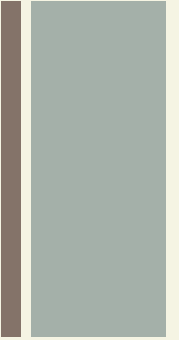*Director ICCPP International*

William Gemmell Cochran (1909-1980)

Cochran's Q Test

+ Definition

- Cochran's Q Test is a non parametric way to find differences in matched sets of three or more frequencies or proportions.

+ Formula

$$T = k\,(k-1)\,\dfrac{\displaystyle\sum_{j=1}^{k}\left(X_{\bullet j} - \frac{N}{k}\right)^{2}}{\displaystyle\sum_{i=1}^{b} X_{i\bullet}\,(k - X_{i\bullet})}$$

+ Formula

- Where

k is the number of treatments

$X\bullet_j$ is the column total for the jth treatment
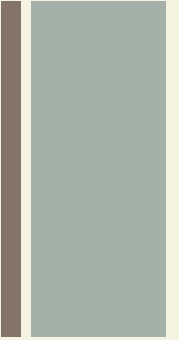
b is the number of blocks

$X_i\bullet$ is the row total for the ith block
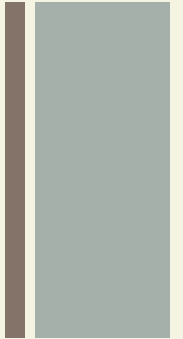
N is the grand total

+ Cochran's Q Test

- It is an extension of the McNemar test; the two tests are equal if Cochran's Q is calculated for two groups.

+ Hypothesis

- Null hypothesis (H_0): the treatments are equally effective.

- Alternative hypothesis (H_a): there is a difference in effectiveness between treatments.
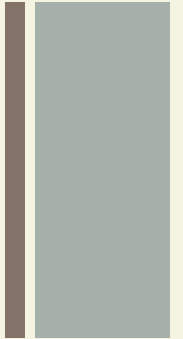
+ Use

- The test is usually used when you have a group of people performing a series of tasks or getting a set of treatments where the outcome is a "Success" or "Failure."

- Like the binomial distribution, success/failure could mean yes/no, black/white or any one of a number of success/failure options.
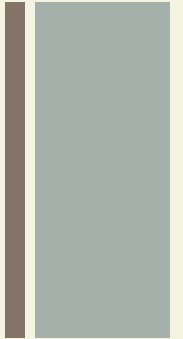
+ Assumptions

- You must have one dependent, dichotomous variable. Dichotomous variables are categorical variables with two categories or levels.

- The groups/levels must be mutually exclusive. For example, you could have "Pass" and "Fail".

+ Assumptions

- You must have one independent variable with three groups or levels. For example, you might use three different tests or administer three different treatments.

- Ideally, use a random sampling method (e.g. simple random sampling).
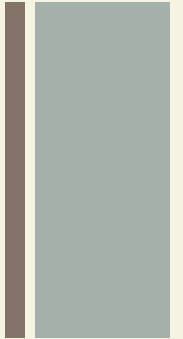
+ Assumptions
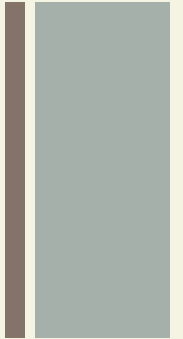
- You must have a large enough sample size. A rule of thumb is that the number of subjects, n, multiplied by the number of levels in the independent variable, k, are greater than or equal to 24.

Example

- A school teacher wanted to examine whether pass rates increased as students had more time to study. In this hypothetical study, 60 students were recruited to take part.

- All students were first given a "surprise exam" to test their current knowledge. They were then given a "mock exam" two weeks later before they took a "final exam" a further two weeks later. Students' performance in the exams were assessed in terms of a "pass" or "fail".

+ Example

- Due to the same students being measured on three occasions (i.e., during the "surprise", "mock" and "final" exam), we have repeated measures.

- We also have a dependent variable that is dichotomous with two mutually exclusive categories (i.e. "Failed" and "Passed").

- As a result, Cochran's Q test is the appropriate choice to analyse the data.
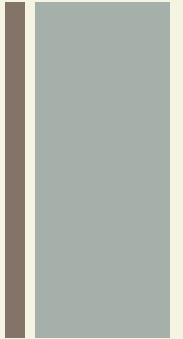
+ Calculation
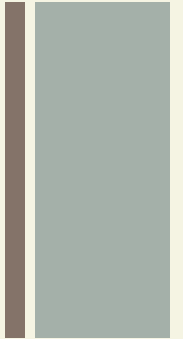
Setup in SPSS Statistics:

- For Cochran's Q test, you will have at least three variables (i.e. as many variables as you have related groups).

- In our example, we have three related groups – the "surprise exam", "mock exam" and "final exam" – so we have three variables:

Calculation

- (1) The dichotomous responses for the first of your related groups (e.g. surprise exam, which reflects whether students "Passed" or "Failed" their surprise exam);

- (2) the dichotomous responses for the second of your related groups (e.g. mock exam, which reflects whether students "Passed" or "Failed" their mock exam); and
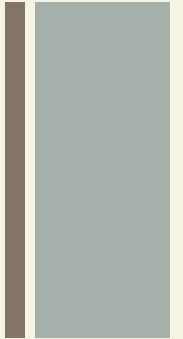
+ Calculation
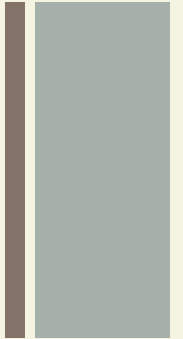
- (3) the dichotomous responses for the third of your related groups (e.g. final exam, which reflects whether students "Passed" or "Failed" their final exam).

+ Calculation

■ In addition, if you have entered your data into SPSS Statistics using frequencies (i.e. total counts) rather than entering the individual scores for each participant, you will have one more variable, frequencies.

+ Calculation

- In the diagram below, we show you how you would have set up your data in the Data View of SPSS Statistics if you had entered your data using:

- (a) the individual scores for each participant (shown in the diagram on the left below), where you only have three variables; or

- (b) total count data, also known as frequencies (shown in the diagram on the right below), where you have four variables.

Calculation

Individual scores for each participant

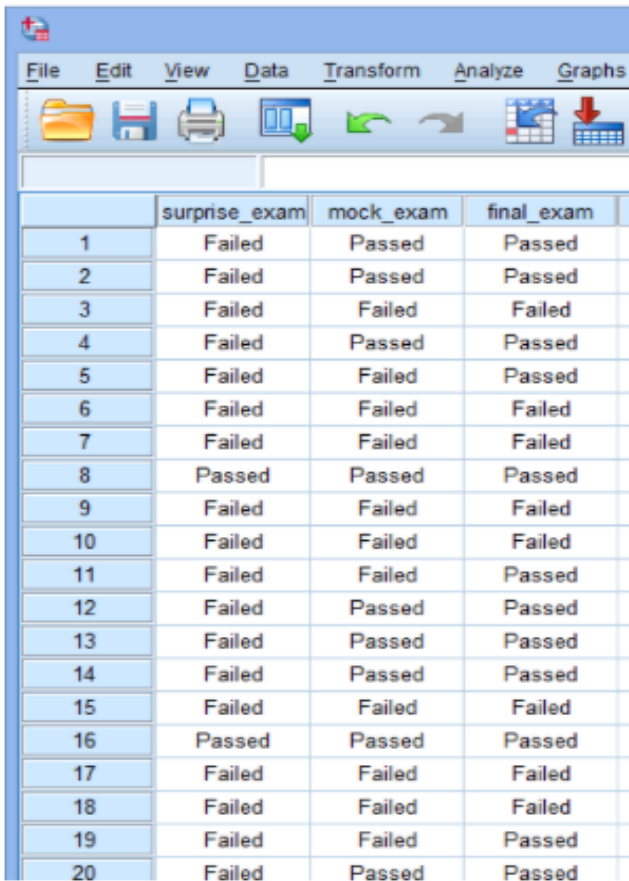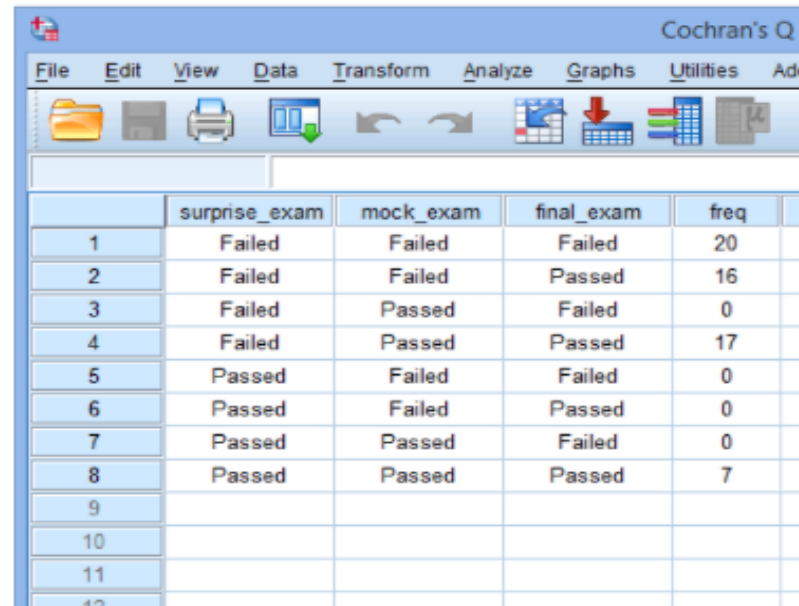|	surprise_exam	mock_exam	final_exam
1	Failed	Passed	Passed
2	Failed	Passed	Passed
3	Failed	Failed	Failed
4	Failed	Passed	Passed
5	Failed	Failed	Passed
6	Failed	Failed	Failed
7	Failed	Failed	Failed
8	Passed	Passed	Passed
9	Failed	Failed	Failed
10	Failed	Failed	Failed
11	Failed	Failed	Passed
12	Failed	Passed	Passed
13	Failed	Passed	Passed
14	Failed	Passed	Passed
15	Failed	Failed	Failed
16	Passed	Passed	Passed
17	Failed	Failed	Failed
18	Failed	Failed	Failed
19	Failed	Failed	Passed
20	Failed	Passed	Passed

Total count data (frequencies) — Cochran's Q

	surprise_exam	mock_exam	final_exam	freq
1	Failed	Failed	Failed	20
2	Failed	Failed	Passed	16
3	Failed	Passed	Failed	0
4	Failed	Passed	Passed	17
5	Passed	Failed	Failed	0
6	Passed	Failed	Passed	0
7	Passed	Passed	Failed	0
8	Passed	Passed	Passed	7
9				
10				
11				
12				

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+

Calculation

- Just remember that if you have entered your data using total count data (i.e. frequencies), shown in the diagram on the right above, you will also have to weight your cases before you can analyse your data (i.e. this is an additional procedure in SPSS Statistics).

- If you do not use the Weight cases … procedure in SPSS Statistics before running Cochran's Q test procedure in the next section, your analysis will fail.

+ Interpreting the results

- SPSS Statistics generates two main tables of output for the "standard" Cochran's Q test when using the Legacy Dialogs > K Related Samples procedure: the Frequencies table and Test Statistics table. These are discussed in turn below:
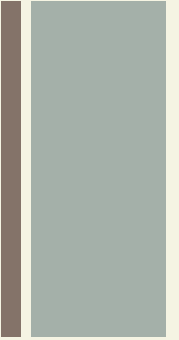
Interpreting the results
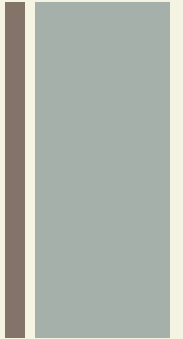
Frequencies Table:

- It is important when reporting Cochran's Q test result that you also interpret and report descriptive statistics in order to get a 'feel' for your data, as well as to provide an appropriate description of your data.

- One important measure that we can report is the number of participants that passed and failed each of the three exams:

+ Interpreting the results

Frequencies Table:

Frequencies

	Value	
	1	2
Surprise exam	53	7
Mock exam	36	24
Final exam	20	40

+ Interpreting the results

- You can see from the Frequencies table that 53 students failed and 7 students passed the surprise exam, whereas 36 students failed and 24 passed the mock exam.

- Finally, 20 students failed the final exam, whereas 40 passed. In the sense that the study was designed to evaluate the change in the proportion of pass and failure rates as student had more time to revise, it appears that failure rates decreased across the three exams.

+ Interpreting the results

■ However, although it can appear that these proportions are different, the differences could simply be due to sampling variation.

■ Therefore, to establish whether these proportions of passes are different in the population and are not simply due to sampling variation, you need to consult the Cochran's Q test result, as set out in the next section.

+ Interpreting the results
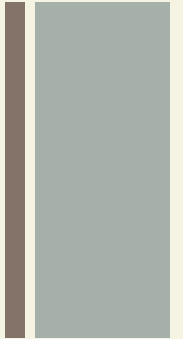
Test Statistics Table:

- Now that we know the proportion of students who passed and failed the three exams – the surprise, mock and final exams – we would like to know whether these proportions are statistically significantly different.

- To know this, we can use the result of Cochran's Q test, which can be found in the Test Statistics table below:

+ Interpreting the results

Test Statistics Table:

Test Statistics

| N	60
Cochran's Q	49.515[a]
df	2
Asymp. Sig.	.000

a. 1 is treated as a success.

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Interpreting the results

- If the statistical significance value (i.e. p-value) is less than .05 (i.e. $p < .05$), you have a statistically significant result and the proportion of students who passed and failed their exams across the three exams is statistically significantly different.

- Alternatively, if $p > .05$, you do not have a statistically significant result and the proportion of students who passed and failed their exams across the three exams is not statistically significantly different.

+ Interpreting the results

- In our example, p = .000 (i.e. p < .0005), which means that the proportion of students who passed their exams is statistically significantly different across the three exams.
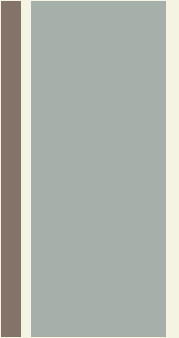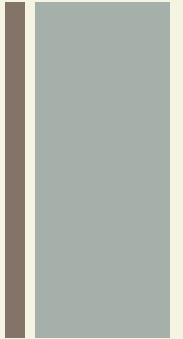
+ Reporting the results

Based on the SPSS Statistics output above, we could report the results of the study as follows:

- Sixty participants were recruited to take part in study to examine whether pass rates changed over three exams – a surprise, mock and final exam – as students had more time to study.

- Cochran's Q test determined that there was a statistically significant difference in the proportion of students who passed their exams over time, $\chi^2(2) = 49.515$, p < .0005.

References

Conover, William Jay (1999). Practical Nonparametric Statistics (Third ed.). Wiley, New York, NY USA. pp. 388–395. ISBN 9780471160687.

Stephanie Glen. "Cochran's Q Test" From StatisticsHowTo.com: Elementary Statistics for the rest of us! https://www.statisticshowto.com/cochrans-q-test/, date 06.11.21, 20:00 h MET

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