Steps for Running Statistical Tests

Chi-square — Two Way Chi-square Test

When to use it:
To compare two categorical variables where the observations are UNRELATED

Assumptions:

1. Observations must be independent
2. 80% of the cell values in the contingency table must be at least 5
3. No cell values can be less than 1

Steps:

1. Identify the two categorical variables A and B.
2. Figure the type of hypothesis you want to test. Is it the test of homogeneity or test of independence?
3. Construct your contingency table.
4. To calculate the chi-square test statistic, you will need to find the expected value of each cell in the table. The expected value of each cell can be found by the formula: (corresponding marginal row total) (corresponding column marginal total)/ total count

   Example:

Cell 1: 10	Cell 2: 30	Marginal row Total= 40
Cell 3: 20	Cell 4: 40	Marginal row Total= 60
Marginal Column Total= 30	Marginal Column Total= 70	Grand Total= 100

Expected Cell 1= (40) (30)/ 100 = 12
Expected Cell 2= (70) (40)/ 100= 28
Expected Cell 3= (60) (30) /100 = 18
Expected Cell 4 = (70) (60)/ 100 = 42

5. For each of the cell i= 1...4, calculate the term (Cell i - Expected Cell i)^2/ Expected Cell i
6. Sum up of all those terms to obtain the Chi-square test statistic
7. Calculate the degrees of freedom, which is the (number of rows - 1) (number of columns - 1)
8. Go onto https://www.socscistatistics.com/pvalues/chidistribution.aspx and enter the chi-square test statistic, the degrees of freedom, and your significance level. It will then spit out the p-value.

Cohen's Effect Size d

When to use it:
To quantify the strength of a phenomenon or event that occurred between two groups

Steps:

1. We need the following pieces to calculate effect size:
   X1= mean of first sample, X2= mean of second sample, s1= standard deviation of first sample, s2= standard deviation of second sample, n1= sample size of first group, n2= sample size of second group
2. The formula is: X1 - X2/ (Pooled Standard Deviation) First calculate the numerator: X1 - X2. Then to calculate denominator (pooled standard deviation), take the squareroot of ((n1- 1)* s1^2 + (n2- 1) * s2^2) / (n1 + n2)
3. Divide the numerator by the denominator to obtain effect size

Cohen's Kappa Value

When to use it:
To assess the interrater reliability between TWO raters

Assumptions:

1. There can only be two raters
2. Each rater must rate the same number of categories. For example, rater 1 and rater 2 must produce responses like "Yes" or "No". It is not appropriate to use this test if either rater 1 or 2 produced an additional category like "Maybe"

Steps:
It's best to use an example:

	Rater 1 chooses Yes	Rater 1 chooses No
Rater 2 chooses Yes	10	20
Rater 2 chooses No	30	40

1. Construct a frequency table like above.
2. Calculate p0, which is the proportion of agreements out of all cases.
   In this case, p0= (10 + 40) / 100 = 0.5
3. Let pE= total probability of both raters selecting each category by chance
   In this case, the probability of both Rater 1 and 2 choose Yes plus the probability of both Rater 1 and 2 choose No

   pE= (10 + 30)/ 100 * (10 + 20)/ 100 + (20+ 40)/100 * (30+ 40)/ 100
4. Calculate k= (p0 - pE) / (1- pE)

McNemar Test

When to use it:

To compare two categorical variables with dichotomous responses where the observations are RELATED

Assumptions:

1. Random sample
2. Two categorical variables, with dichotomous responses like Yes/No, Pass/Fail…etc
3. The observations must be mutually exclusive, meaning observations cannot coexist in more than one group

Steps:

1. Construct a 2 x 2 contingency table.
   Example:

	This year (Pass)	This year (Fail)
Last year (Pass)	a= 10	b= 20
Last year (Fail)	c= 30	d= 40

2. Calculate the McNemar test statistic: (b- c)^2/ (b + c)
3. The degree of freedom for the McNemar test is always 1.
4. Go onto https://www.socscistatistics.com/pvalues/chidistribution.aspx and enter the chi-square test statistic, the degrees of freedom, and your significance level. It will then spit out the p-value.

Proportion Test — Two Sample Proportion Test

When to use it:
To compare TWO proportions or percentages of a population

Assumptions:
1. Random Sample
2. Independent observations
3. Data is normally distributed
4. N * P and N* (1- P) must be at least 10, where P is the proportion of cases where the characteristic is identified

Steps:
1. Identify the two large samples A and B
2. Write down your null and research hypotheses. Ex. Null: there is no difference between proportions of sample A and sample B; Research: There is a difference between proportions of sample A and sample B.
3. Figure out whether the research hypothesis is a one-tailed or two-tailed test. E.g., one-tailed: proportion A is greater than proportion B; two-tailed: proportions A and B are different
4. You will need these pieces to calculating the proportion test statistic:
P1= proportion associated with first sample, P2= proportion associated with second sample, HP1= hypothesized proportion associated with first sample, HP2= hypothesized proportion associated with second sample, n1= sample size of first sample, n2= sample size of second sample
5. Then, you will need to calculate PC, which is the combined weighted value of both sample proportions. First, calculate the numerator: n1 * P1 + n2 * P2, and then denominator: n1 + n2. Then, divide the numerator by the denominator to obtain PC.
6. To calculate the proportion test statistic, first the numerator: (P1- P2) - (HP1-HP2), then denominator: square root of ((PC(1- PC))/ n1) + ((PC(1- PC))/n2). Then divide the numerator by the denominator.
7. Once you obtain your test statistic, go to https://www.socscistatistics.com/pvalues/normaldistribution.aspx and enter the test statistic, your significance level, and indicate whether it's one- or two-tailed. Then, it will spit out the p-value

*For your reference, the proportion test statistic formula is: ((P1- P2) - (HP1-HP2))/ square root(PC(1- PC)/ n1 + PC(1- PC)/n2) and PC = (n1 * P1 + n2 * P2)/ (n1 + n2)*

Note: no degrees of freedom associated with this test

T-test — Two Sample Unpaired T-test

When to use it:
To compare TWO SEPARATE groups and you only know the sample variance

Assumptions:
1. Random Sample
2. Independent observations
3. Data is normally distributed

Steps:
1. Identify the two sample groups A and B
2. Write down your null and research hypotheses. E.g., Null: there is no difference between groups A and B. Research: There is a difference between groups A and B.
3. Figure out whether the research hypothesis is a one-tailed or two-tailed test. E.g., one-tailed: group A is greater than group B; two-tailed: groups A and B are different
4. You will need these pieces to calculating the t-test statistic:
   X1= mean of first sample, X2= mean of second sample, s1 = standard deviation of first sample, H1= hypothesized mean of sample 1, H2= hypothesized mean of sample 2, s2= standard deviation of second sample, n1= sample size of first sample, n2= sample size of second sample.
   In Excel, you can find the mean of a list of values by using the function average(), and you can find the standard deviation of a list of values by the function stdev()
5. First, calculate the numerator: ((X1- X2) - (H1 -H2)). Then calculate the denominator: square root of ((s1^2 / n1) + (s2^2/ n2)). Then divide the numerator by the denominator.
6. For an unpaired t-test, you will need to calculate the degrees of freedom. Calculate V1 = s1^2/n1 and V2= s2^2/n2. Once you have V1 and V2, calculate numerator which is (V1 + V2)^2 and denominator which is ((V1^2/n1 -1) + (V2^2/ n2- 1)). Then, divide the numerator by the denominator and you'll get the degree of freedom.
7. Once you have your t-test statistic, go to https://www.socscistatistics.com/pvalues/tdistribution.aspx and enter the t-value, your significance level, degrees of freedom, and indicate whether it's one-tailed or two-tailed. Then, it will spit out the p-value.

For your reference, the t-test statistic formula is: ((X1 - X2) - (H1- H2))/ squareroot(s1^2/n1 + s2^2/n2) and degrees of freedom for this test is: (V1 + V2)^2 / ((V1^2/ n1-1) + (V2^2/ n2-1))

Z-test — Two Sample Z-test

When to use it:

For comparing TWO groups, when the sample sizes are very large and you know the population variance

Assumptions:

1. Random Sample
2. Independent observations
3. Data is normally distributed

Steps:

1. Identify the two population groups A and B
2. Write down your null and research hypotheses. E.g., Null: there is no difference between groups A and B. Research: There is a difference between groups A and B.
3. Figure out whether the research hypothesis is a one-tailed or two-tailed test. E.g., one-tailed: groups A is greater than group B; two-tailed: groups A and B are different
4. You will need these pieces to calculate the z-test statistic:
   X1= mean of first population, X2= mean of second population, sigma1 = standard deviation of first population, H1= hypothesized mean of population 1, H2= hypothesized mean of population 2, sigma2= standard deviation of second population, n1= sample size of first population, n2= sample size of second population.
   In Excel, you can find the mean of a list of values by using the function average(), and you can find the standard deviation of a list of values by the function stdev()
5. First, calculate the numerator: ((X1- X2) - (H1 -H2)). Then calculate the denominator: square root of ((sigma1^2 / n1) + (sigma2^2/ n2)). Then divide the numerator by the denominator.
6. Once you have your z-test statistic, go to https://www.socscistatistics.com/pvalues/normaldistribution.aspx and enter the z-value, your significance level, and indicate whether it's one-tailed or two-tailed. Then, it will spit out the p-value.

For your reference, the formula is: ((X1 - X2) - (H1- H2)) / square root (sigma1^2/n1 + sigma2^2/n2)

Note: no degrees of freedom associated with the Z-test

References

https://en.wikipedia.org/wiki/Cohen%27s_kappa

https://en.wikipedia.org/wiki/McNemar%27s_test

https://en.wikipedia.org/wiki/Effect_size

https://www.socscistatistics.com/pvalues/chidistribution.aspx

https://www.socscistatistics.com/pvalues/tdistribution.aspx

https://www.socscistatistics.com/pvalues/normaldistribution.aspx

Peck, R., Devore, J.L., (2012) *Statistics: The Exploration and Analysis of Data*. Boston, MA: Brooks/Cole