T-LEVELS | Institute for Apprenticeships & Technical Education

T Level Technical Qualification in Science

Employer set project (ESP)

Laboratory Sciences

Statistical techniques handout

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Contents

Use of this document

Information for tutors

This document should be printed, and a copy made available to all students for use during Task 3 of the Laboratory Sciences employer-set project for November 2023. Students can use the information in this document, along with access to a computer with Excel, and access to the internet for the purposes of using online statistics tools, to support their analysis of the data.

Statistical techniques

Formulae

Standard Deviation

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

s = Standard deviation

Σ = Sum of

x = Individual value within sample

$\bar{x}$ = Mean

n = Number of values in sample

T-test

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

t = t value

$\bar{x}_1$ = Mean of sample 1

s_1 = Standard deviation of sample 1

n_1 = Number of values in sample 1

$\bar{x}_2$ = Mean of sample 2

s_2 = Standard deviation of sample 2

n_2 = Number of values in sample 2

Chi-Square test

$$X^2 = \sum \frac{(\text{Observed value} - \text{Expected value})^2}{\text{Expected value}}$$

Spearman's Rank

$$\rho = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

ρ = Spearman's rank correlation coefficient

Σ = Sum of

d = Difference in each pair of ranked measurements

n = Number of pairs of items in sample

T-test table

t Distribution: Critical Values of t

		Significance level					
Degrees of freedom	*Two-tailed test:* / *One-tailed test:*	10% / 5%	5% / 2.5%	2% / 1%	1% / 0.5%	0.2% / 0.1%	0.1% / 0.05%
1		6.314	12.706	31.821	63.657	318.309	636.619
2		2.920	4.303	6.965	9.925	22.327	31.599
3		2.353	3.182	4.541	5.841	10.215	12.924
4		2.132	2.776	3.747	4.604	7.173	8.610
5		2.015	2.571	3.365	4.032	5.893	6.869
6		1.943	2.447	3.143	3.707	5.208	5.959
7		1.894	2.365	2.998	3.499	4.785	5.408
8		1.860	2.306	2.896	3.355	4.501	5.041
9		1.833	2.262	2.821	3.250	4.297	4.781
10		1.812	2.228	2.764	3.169	4.144	4.587
11		1.796	2.201	2.718	3.106	4.025	4.437
12		1.782	2.179	2.681	3.055	3.930	4.318
13		1.771	2.160	2.650	3.012	3.852	4.221
14		1.761	2.145	2.624	2.977	3.787	4.140
15		1.753	2.131	2.602	2.947	3.733	4.073
16		1.746	2.120	2.583	2.921	3.686	4.015
17		1.740	2.110	2.567	2.898	3.646	3.965
18		1.734	2.101	2.552	2.878	3.610	3.922
19		1.729	2.093	2.539	2.861	3.579	3.883
20		1.725	2.086	2.528	2.845	3.552	3.850
21		1.721	2.080	2.518	2.831	3.527	3.819
22		1.717	2.074	2.508	2.819	3.505	3.792
23		1.714	2.069	2.500	2.807	3.485	3.768
24		1.711	2.064	2.492	2.797	3.467	3.745
25		1.708	2.060	2.485	2.787	3.450	3.725
26		1.706	2.056	2.479	2.779	3.435	3.707
27		1.703	2.052	2.473	2.771	3.421	3.690
28		1.701	2.048	2.467	2.763	3.408	3.674
29		1.699	2.045	2.462	2.756	3.396	3.659
30		1.697	2.042	2.457	2.750	3.385	3.646
32		1.694	2.037	2.449	2.738	3.365	3.622
34		1.691	2.032	2.441	2.728	3.348	3.601
36		1.688	2.028	2.434	2.719	3.333	3.582
38		1.686	2.024	2.429	2.712	3.319	3.566
40		1.684	2.021	2.423	2.704	3.307	3.551
42		1.682	2.018	2.418	2.698	3.296	3.538
44		1.680	2.015	2.414	2.692	3.286	3.526
46		1.679	2.013	2.410	2.687	3.277	3.515
48		1.677	2.011	2.407	2.682	3.269	3.505
50		1.676	2.009	2.403	2.678	3.261	3.496
60		1.671	2.000	2.390	2.660	3.232	3.460
70		1.667	1.994	2.381	2.648	3.211	3.435
80		1.664	1.990	2.374	2.639	3.195	3.416
90		1.662	1.987	2.368	2.632	3.183	3.402
100		1.660	1.984	2.364	2.626	3.174	3.390
120		1.658	1.980	2.358	2.617	3.160	3.373
150		1.655	1.976	2.351	2.609	3.145	3.357
200		1.653	1.972	2.345	2.601	3.131	3.340
300		1.650	1.968	2.339	2.592	3.118	3.323
400		1.649	1.966	2.336	2.588	3.111	3.315
500		1.648	1.965	2.334	2.586	3.107	3.310
600		1.647	1.964	2.333	2.584	3.104	3.307
∞		1.645	1.960	2.326	2.576	3.090	3.291

Chi-Square table

Percentage Points of Chi-Square Distribution

Probability of a larger value of x^2

Degrees of freedom	0.99	0.95	0.90	0.75	0.50	0.25	0.10	0.05	0.01
1	0.000	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63
2	0.020	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21
3	0.115	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34
4	0.297	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28
5	0.554	1.145	1.610	2.675	4.351	6.63	9.24	11.07	15.09
6	0.872	1.635	2.204	3.455	5.348	7.84	10.64	12.59	16.81
7	1.239	2.167	2.833	4.255	6.346	9.04	12.02	14.07	18.48
8	1.647	2.733	3.490	5.071	7.344	10.22	13.36	15.51	20.09
9	2.088	3.325	4.168	5.899	8.343	11.39	14.68	16.92	21.67
10	2.558	3.940	4.865	6.737	9.342	12.55	15.99	18.31	23.21
11	3.053	4.575	5.578	7.584	10.341	13.70	17.28	19.68	24.72
12	3.571	5.226	6.304	8.438	11.340	14.85	18.55	21.03	26.22
13	4.107	5.892	7.042	9.299	12.340	15.98	19.81	22.36	27.69
14	4.660	6.571	7.790	10.165	13.339	17.12	21.06	23.68	29.14
15	5.229	7.261	8.547	11.037	14.339	18.25	22.31	25.00	30.58
16	5.812	7.962	9.312	11.912	15.338	19.37	23.54	26.30	32.00
17	6.408	8.672	10.085	12.792	16.338	20.49	24.77	27.59	33.41
18	7.015	9.390	10.865	13.675	17.338	21.60	25.99	28.87	34.80
19	7.633	10.117	11.651	14.562	18.338	22.72	27.20	30.14	36.19
20	8.260	10.851	12.443	15.452	19.337	23.83	28.41	31.41	37.57
22	9.542	12.338	14.041	17.240	21.337	26.04	30.81	33.92	40.29
24	10.856	13.848	15.659	19.037	23.337	28.24	33.20	36.42	42.98
26	12.198	15.379	17.292	20.843	25.336	30.43	35.56	38.89	45.64
28	13.565	16.928	18.939	22.657	27.336	32.62	37.92	41.34	48.28
30	14.953	18.493	20.599	24.478	29.336	34.80	40.26	43.77	50.89
40	22.164	26.509	29.051	33.660	39.335	45.62	51.80	55.76	63.69
50	27.707	34.764	37.689	42.942	49.335	56.33	63.17	67.50	76.15
60	37.485	43.188	46.459	52.294	59.335	66.98	74.40	79.08	88.38

Statistical functions in Excel

Mean

Type “=average” into a cell, then select all of the cells you want to know the mean value for. Press enter and the mean value will be displayed in the cell.

Median

Type “=median” into a cell then select all of the cells you want to know the median value for. Press enter and the median value will be displayed in the cell.

Standard deviation

Type “=STDEV.S” into a cell then select all of the cells you want to know the standard deviation for. Press enter and the standard deviation will be displayed in the cell

Range

Type "=MAX(xxx)-MIN(xxx)" (where xxx is all the cells you want to know the range for) to find the range in a single step. This tells Excel to find the maximum of the data and then subtract the minimum of the data from it.

T-test

To perform a T-test in Excel use the function “=T.Test”. This formula has the following associated arguments; (array1, array2, tails, type)

Where **array1** is the first data set, **array2** is the second data set, **tails** is the number of distribution tails (this will almost always be set at “2” to detect differences in both directions away from the mean), **type** is the kind of T-test to perform – set this to “1” to perform a Student’s paired T-test.

Enter your values in the appropriate place and press enter to return the result of the test.

Chi-Square test

In order to perform the Chi-square test the expected values of the dataset must be calculated (i.e. what would the values be if there were no differences between the two groups in line with the null hypothesis).

See below for an example dataset:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Group 1	Group 2	Response							Combine the two tables to get a new table with observed values and expected values									
2	58	35	A																
3	11	25	B							**Observed values**			**Expected values**						
4	10	23	C							Group 1	Group 2	Response	Group 1	Group 2	Response				
5										58	35	A	45.3519	47.6481	A				
6	Sum total of group 1									11	25	B	17.5556	18.4444	B				
7	79									10	23	C	16.0926	16.9074	C				
8	Sum total of group 2																		
9	83									Chi Square test									
10	Sum total of both groups																		
11	162									Use the Chi Square formula									
12										= CHISQ.TEST(									
13	formula to calculate expected value for Group 1 response A																		
14	= (A2+B2)/A11*A7									in the first part of the test select your observed values, and in the second your expected values									
15	= (58+35)/162*79									= CHISQ.TEST(J5:K7,M5:N7)									
16	Result =	45.3519																	
17										For a value of									
18	Repeat this for all the values in Group 1 to obtain expected values of:									0.00031									
19		45.3519																	
20		17.5556																	
21		16.0926																	
22																			
23	Repeat this for Group 2 using the sum total of group 2																		
24	= (A2+B2)/A11*A9																		
25	= (58+35)/162*83																		
26	Result =	47.6481																	
27																			
28	Repeat this for all the values in Group 2 to obtain expected values of:																		
29		47.6481																	
30		18.4444																	
31		16.9074																	
32																			
33	For an expected value table off:																		
34	Group 1	Group 2	Response																
35	45.3519	47.6481	A																
36	17.5556	18.4444	B																
37	16.0926	16.9074	C																
38																			
39																			

Spearman's rank

To calculate the Spearman's rank correlation coefficient in Excel we must first rank the data for each response using the "=Rank.AVG" function. Once these have been calculated we can then use the "CORREL" function to calculate the Spearman's rank correlation coefficient. See below for an example dataset:

	A	B	C	D	E	F	G
1				Use function =RANK.AVG(B3,$B$3:$B$8,0) for Subject A then drag the formula down to Subject F	Use function =RANK.AVG(C3,$C$3:$C$8,0) for Subject A then drag the formula down to Subject F		
2	**Subject**	**Measurement 1**	**Measurment 2**	**Measurement 1 (rank)**	**Measurment 2 (rank)**		
3	A	66	118	1	5		
4	B	55	117	2	6		
5	C	25	120	5	3		
6	D	50	121	3	2		
7	E	40	119	4	4		
8	F	10	124	6	1		
9							
10							
11							
12	**Spearman correlation coefficient**			=	CORREL(D3:D8,E3:E8)		
13				=	-0.771428571		
14							
15							

Document information

Owner: Head of Assessment Design