

Two-Group Hypothesis Tests Using Excel T.TEST Function

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*Slides and audio at: [www.StatLit.org/
pdf/TTEST-Function-Excel-2008-6up.pdf](http://www.StatLit.org/pdf/TTEST-Function-Excel-2008-6up.pdf)
[Audio/TTEST-Function-Excel-2008.mp3](http://www.StatLit.org/Audio/TTEST-Function-Excel-2008.mp3)*

Excel T.TEST Function

Purpose: Calculate likelihood (p-value) of getting the observed difference in two sample means (or more extreme) by chance in random samples – assuming there is no difference in the two population means (the Null Hypothesis).

Note: TTEST function was available in Excel 2003.

Four Inputs:

- 1) Array or range of 1st sample. 2) Array or range of 2nd sample.
- 3) Tails: 1 (Excel matches Alternate with sample means) or 2.
- 4) Type of T.TEST. 1 dependent, matched subjects.
2: population variances unknown but equal. [Often true]
3: population variances unknown & unequal. [Conservative]

Run Hypothesis Tests from this data: B1:I241

Data for Q1-Q4 (B-E) is Binary: 0=No, 1=Yes.
 Data for Q5-Q6 (F-G) is Ordinal (discrete): 1-5.
 Data for Q7-Q8 (H-I) is Quantitative (ratio).

	A	B	C	D	E	F	G	H	I
1	ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
2	1	0	1	0	0	3	5	67	5
3	2	0	1	0	1	4	1	62	4
4	3	0	1	0	1	3	4	60	5
5	4	0	1	1	0	4	5	60	4
6	5	0	0	1	0	3	1	71	3

Excel instructions and data at:

www.StatLit.org/xls/2012Isaacson240Data.xls

Approach

Excel's two-population T-Test function requires that the data be “stacked” (separated into two groups) by the value of the predictor. Predictor must be binary.

If the binary predictor is the answer to Q1, then *the entire data set* must be sorted by Q1.

The Excel “Sort” requires that the entire data set be selected **before** invoking the sort command. A common mistake is to sort just a single column rather than the entire dataset.

Unfortunately Excel does not have a “stacked” or conditional T-Test function. T-Test function will automatically update p-values if data is re-sorted.

A: Select data!! From the Home or Data tab, select Sort

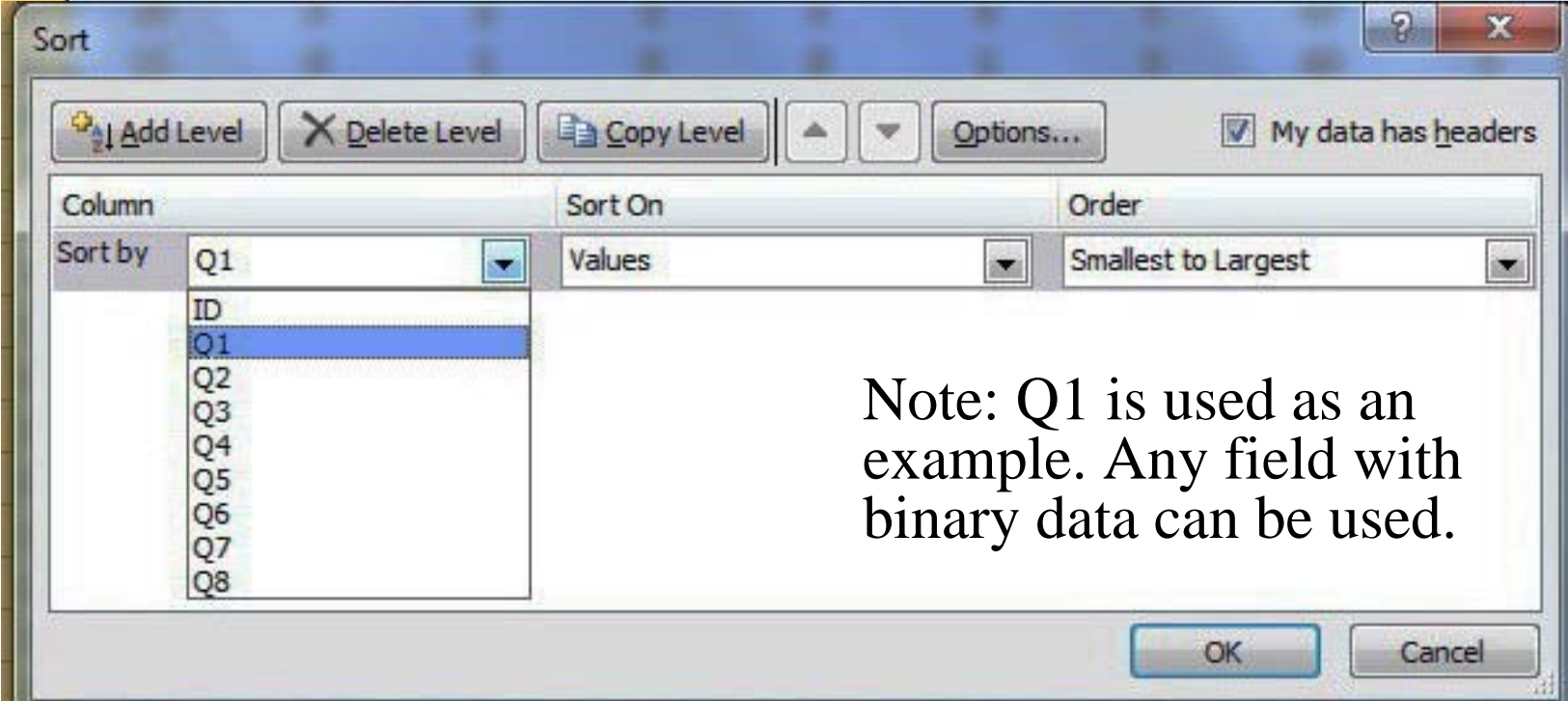
The screenshot shows the Microsoft Excel interface with the 'Data' tab selected on the ribbon. The 'Sort & Filter' group contains the 'Sort' button, which is highlighted in yellow. A tooltip is displayed over the 'Sort' button, providing instructions on how to use it.

Sort
Show the Sort dialog box to sort data based on several criteria at once.
? Press F1 for more help.

3	2	0	1	0	1	4	1		
4	3	0	1	0	1	3	4		
5	4	0	1	1	0	4	5		
6	5	0	0	1	0	3	1		
7	6	0	0	0	0	5	2		
8	7	0	0	1	0	1	1	63	5
9	10	0	1	1	1	2	1	67	6
10	11	0	1	0	0	1	5	60	5
11	13	0	1	1	1	1	3	61	3
12	14	0	0	1	0	4	2	67	6
13	19	0	1	1	1	3	1	73	4
14	21	0	0	1	0	3	2	69	5
15	22	0	0	1	0	2	3	76	4

B: In Sort dialogue box, select Sort Column by “Q1”

	A	B	C	D	E	F	G	H	I
1	ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
2	1	0	1	0	0	3	5	67	5
3	2	0	1	0	1	4	1	62	4
4	3	0	1	0	1	3	4	60	5
5	4	0	1	1	0	4	5	60	4



Note: Q1 is used as an example. Any field with binary data can be used.

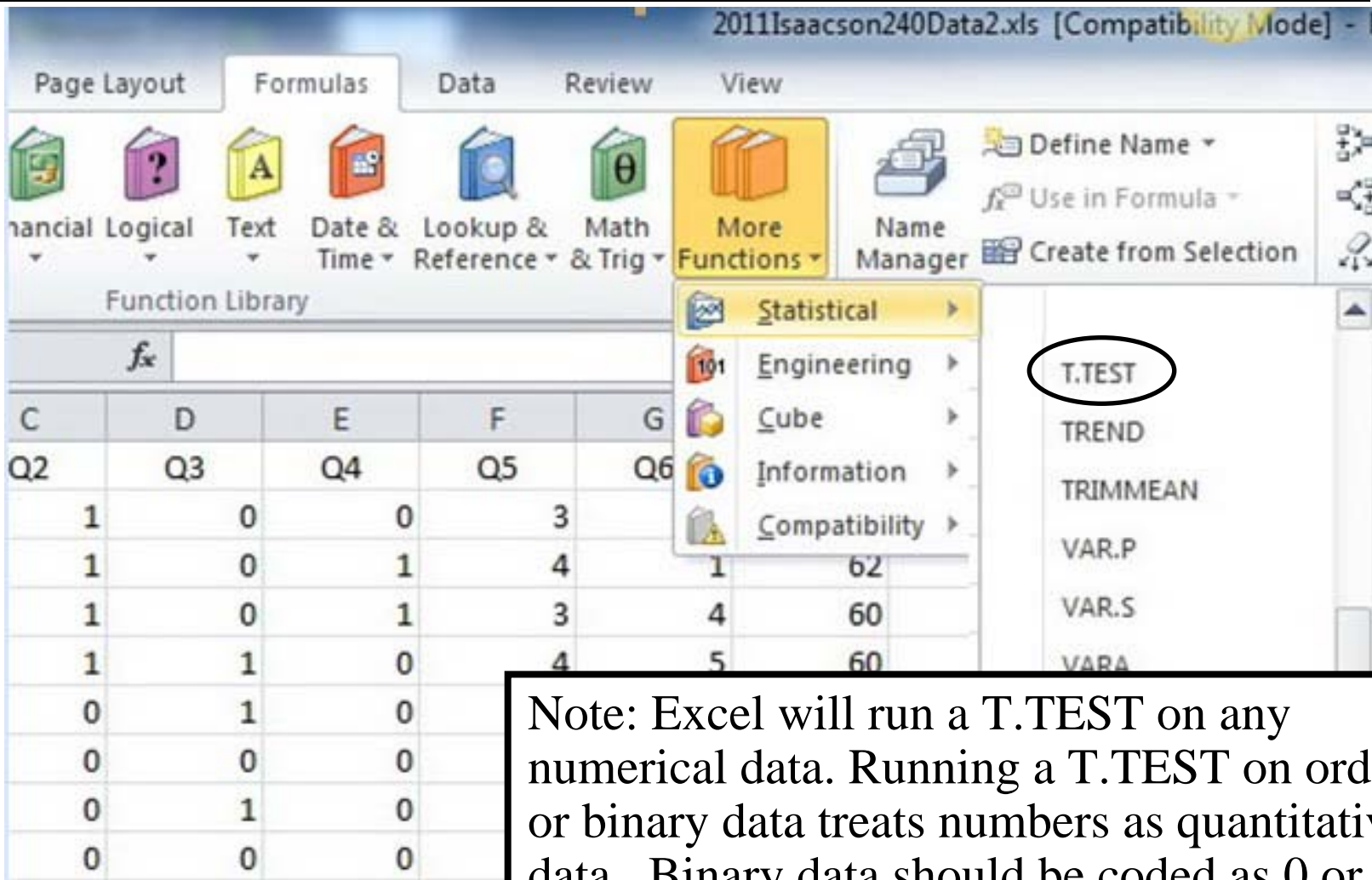
**C: Q2 for Q1=0 from C2 to C131.
Q2 for Q1=1 from C132 to C241.**

	A	B	C	D	E	F	G	H	I
1	ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
2	1	0	1	0	0	3	5	67	5
3	2	0	1	0	1	4	1	62	4
4									
125									
126	228	0	0	1	1	5	1	76	6
127	229	0	0	1	0	1	1	68	6
128	232	0							4
129	233	0							7
130	237	0							5
131	239	0							5
132	8	1							5
133	9	1							7
134	12	1							5
135	15	1	0	0	0	4	2	70	6
136	16	1	0	0	1	5	1	54	5
137	17	1	0	1	1	3	2	48	6

All Excel hypothesis tests require the data to be **stacked: one group on top of the other**. After sort on binary data in column B (Q1), data in columns C through I (Q2-Q8) is **stacked**. **Group 1** in rows 2-131 have Q1=0; **Group 2** in rows 132-241 have Q1=1.

D: Place cursor for results.

From *Statistical*, select T.TEST



The screenshot shows the Excel ribbon with the 'Formulas' tab selected. The 'More Functions' button is highlighted, and the 'Statistical' menu is open. The 'T.TEST' option is circled in the list of functions. Below the ribbon, a data table is visible with columns C through G and rows Q2 through Q6. The data in the table is as follows:

C	D	E	F	G
Q2	Q3	Q4	Q5	Q6
1	0	0	3	
1	0	1	4	1
1	0	1	3	4
1	1	0	4	5
0	1	0		
0	0	0		
0	1	0		
0	0	0		

Note: Excel will run a T.TEST on any numerical data. Running a T.TEST on ordinal or binary data treats numbers as quantitative data. Binary data should be coded as 0 or 1.

T.TEST Procedure

Given Stacked Data

- 1: Place cursor where T.TEST p-value will be recorded.
Locate this cell in a different place for each new test.
Label the cell to reflect the T.TEST inputs. E.g., Q2 by Q1.
- 2: Insert T.TEST in Excel 2008 or newer (TTEST in 2003):
Test for a two-group difference in Means (Measures) or
in Proportions (Counts)
- 3: Enter appropriate data or cell references for the T.TEST
function arguments. See examples on following slides.
- 4: T.TEST will change if data is resorted. Three solutions:
A) Put data from each sort in a separate tab.
B) Copy sorted data to a separate place on one worksheet.
C) Copy & Paste/Special/Values with appropriate labeling.

1-3) Insert T-Test Function

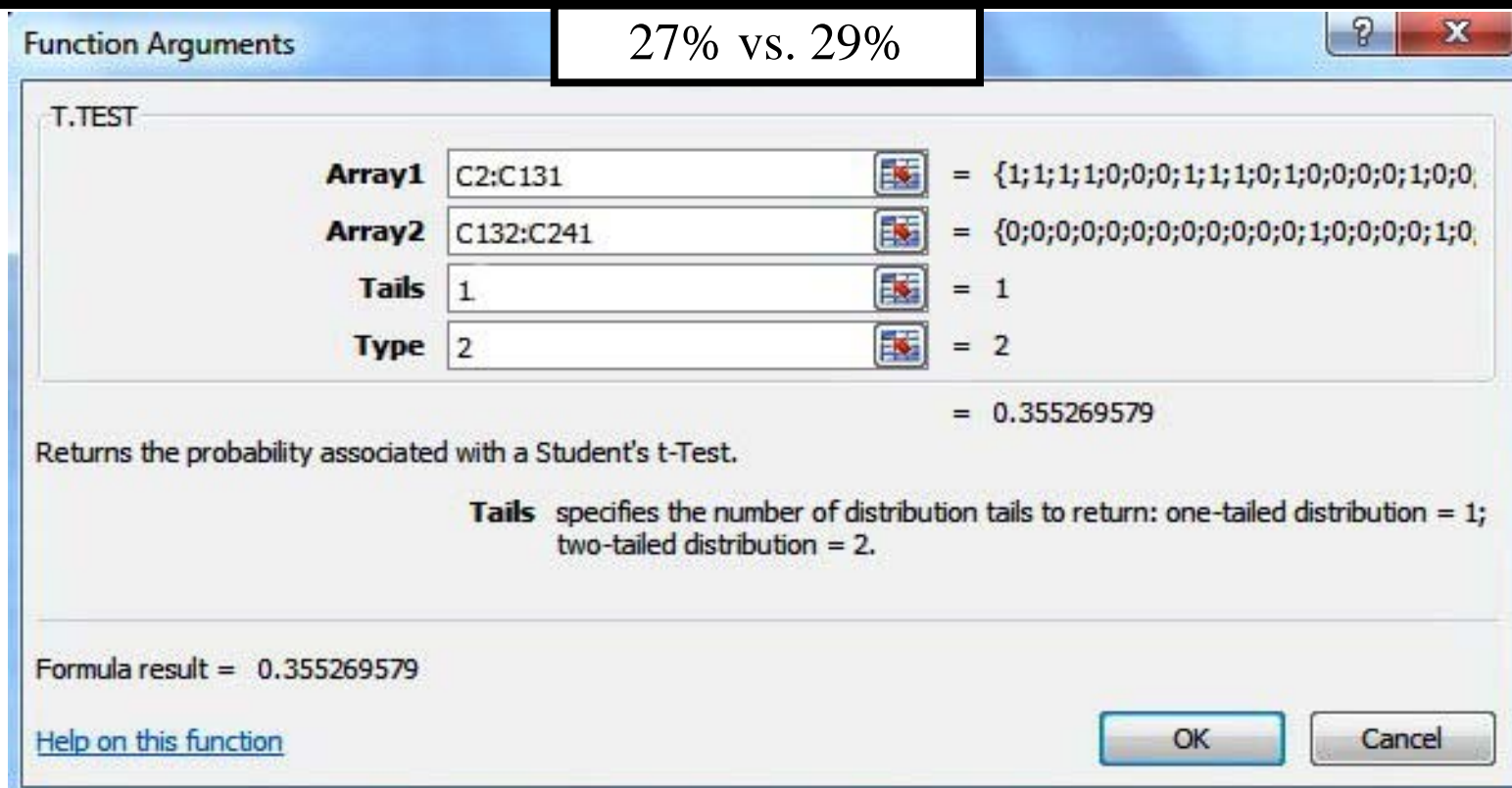
TTEST											
A	B	C	D	E	F	G	H	I	J	K	L
ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8			
1	1	0	0	0	5	1	75	7			
3	1	0	0	0	3	4	76	5			
6	1	0	1	0	3	4	73	6			
7	1	0	0	0	4	1	72	6			
8	1	0	0	0	4	1	88	6			
9	1	0	0	0	4	3	90	6			
10	1	0	0	0	3	4	39	5			

T-TEST FUNCTION	
Tails	1
Type	3
ID	P-value
Q2 by Q1	=T.TEST

Insert T.TEST function in cell L7.

Enter four arguments: Array1, Array2, Tails and Type.

3a) T-Test for Proportions: Results for Q2 by Q1



The image shows the Excel T.TEST function dialog box. The title bar reads "Function Arguments" and the subtitle is "27% vs. 29%". The dialog box contains the following arguments:

Argument	Value	Array
Array1	C2:C131	{1; 1; 1; 1; 0; 0; 0; 1; 1; 1; 0; 1; 0; 0; 0; 0; 1; 0; 0}
Array2	C132:C241	{0; 0; 0; 0; 0; 0; 0; 0; 0; 0; 0; 0; 0; 0; 0; 1; 0; 0; 0; 0; 1; 0}
Tails	1	= 1
Type	2	= 2

The result of the formula is 0.355269579. Below the arguments, there is a description of the T.TEST function: "Returns the probability associated with a Student's t-Test." and a note about the Tails argument: "Tails specifies the number of distribution tails to return: one-tailed distribution = 1; two-tailed distribution = 2." The dialog box also includes a "Help on this function" link and "OK" and "Cancel" buttons.

One-tailed P-value is 0.36; Fail to reject the Null.
Difference in Q2 by Q1 is “not statistically significant”

3b) T-Test for Proportions: Results for Q3 by Q1

The image shows the 'Function Arguments' dialog box for the T.TEST function in Excel. The title bar indicates the test is for '78% vs. 36%'. The dialog is configured for a one-tailed test (Tails = 1) comparing two arrays (Array1: D2:D131, Array2: D132:D241) with a Type of 2. The formula result is displayed as 2.42479E-12, which is circled in red. A text box explains that this value in decimal notation is 0.000 000 000 002 424 79 E-12, where the decimal point is moved 12 places to the left. The dialog also includes 'OK' and 'Cancel' buttons and a 'Help on this function' link.

Function Arguments: 78% vs. 36%

T.TEST

Array1: D2:D131 = {0;0;0;1;1;0;1;1;0;1;1;1;1;1;0;1;1;1;0}

Array2: D132:D241 = {0;1;1;0;0;1;1;0;1;1;0;0;0;1;1;1;0;1;1}

Tails: 1 = 1

Type: 2 = 2

In decimal notation, this is 0.000 000 000 002 424 79 E-12: the decimal point is moved 12 places to the left!

Formula result = 2.42479E-12

Help on this function

OK Cancel

One-tailed P-value is 2.4 E-12; **Reject the Null!**
Difference in Q3 by Q1 is 'statistically significant'.

3c) T-Test for Proportions: Results for Q4 by Q1

Function Arguments 35% vs. 39%

T.TEST

Array1	E2:E131	= {0;1;1;0;0;0;0;1;0;1;0;1;0;0;0;1;0;0;
Array2	E132:E241	= {0;0;0;0;1;1;1;0;0;1;0;0;1;0;0;1;0;1;0;
Tails	1	= 1
Type	2	= 2

= 0.237758082

Returns the probability associated with a Student's t-Test.

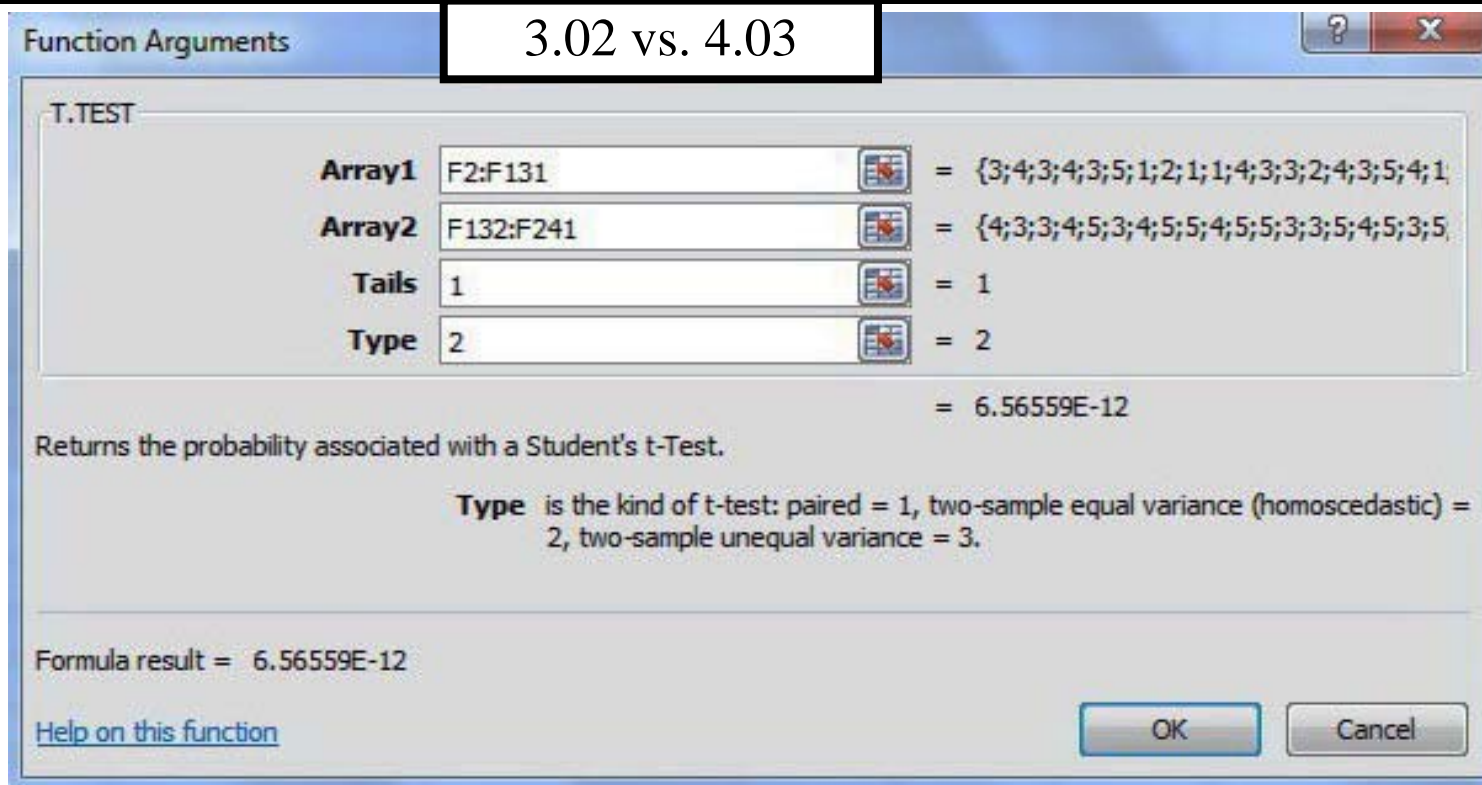
Type is the kind of t-test: paired = 1, two-sample equal variance (homoscedastic) = 2, two-sample unequal variance = 3.

Formula result = 0.237758082

[Help on this function](#) OK Cancel

One-tailed P-value is 0.24; Fail to reject the Null.
Difference in Q4 by Q1 is “not statistically significant”

3d) T-Test for Measures: Results for Q5 by Q1



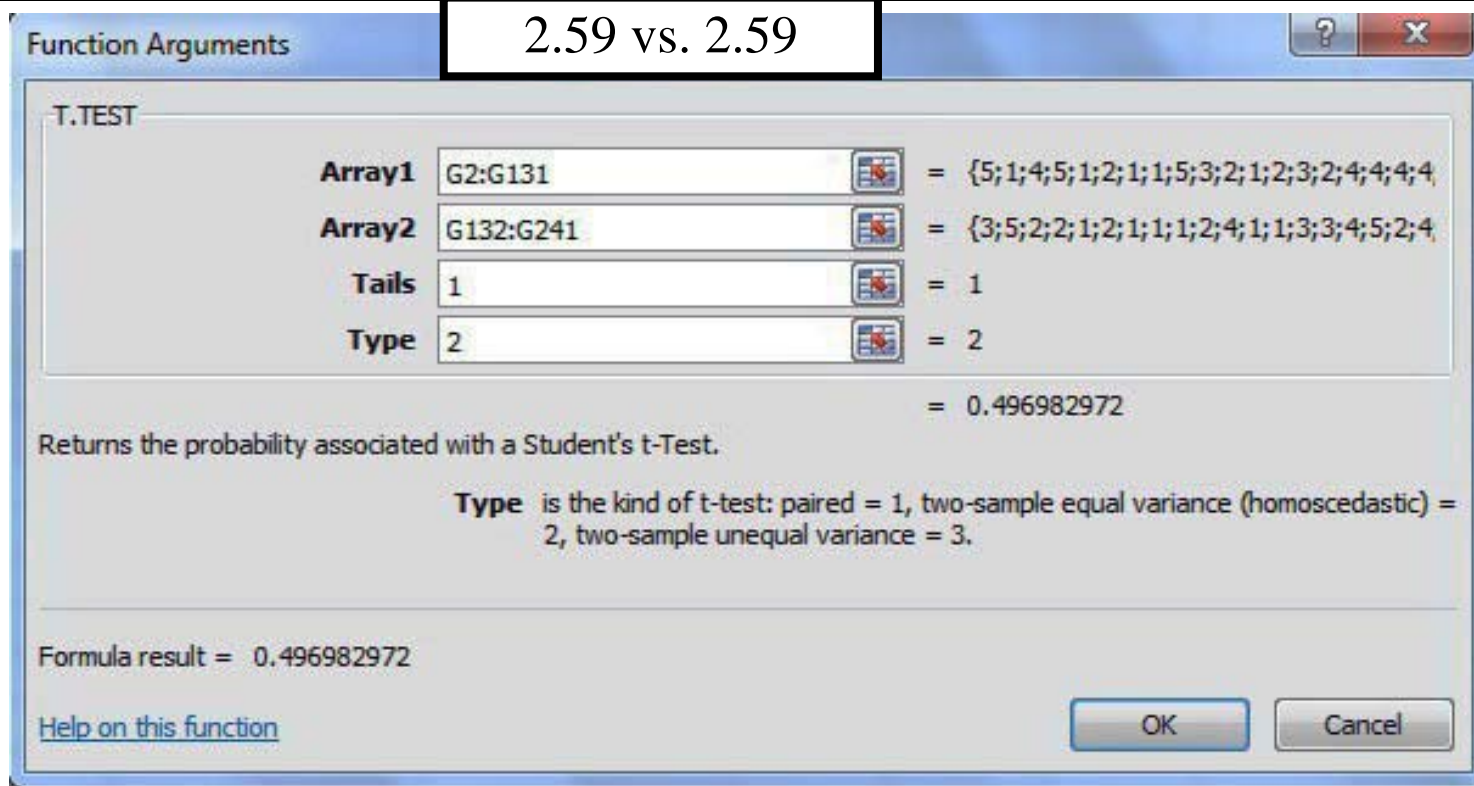
The image shows the Excel T.TEST function dialog box. The title bar reads "Function Arguments" and the subtitle is "3.02 vs. 4.03". The dialog is titled "T.TEST" and contains the following arguments:

Argument	Value	Result
Array1	F2:F131	{3;4;3;4;3;5;1;2;1;1;4;3;3;2;4;3;5;4;1}
Array2	F132:F241	{4;3;3;4;5;3;4;5;5;4;5;5;3;3;5;4;5;3;5}
Tails	1	1
Type	2	2

The result of the function is displayed as $= 6.56559E-12$. Below the arguments, the text reads: "Returns the probability associated with a Student's t-Test." and "Type is the kind of t-test: paired = 1, two-sample equal variance (homoscedastic) = 2, two-sample unequal variance = 3." The formula result is shown as "Formula result = 6.56559E-12". There are "OK" and "Cancel" buttons at the bottom right, and a "Help on this function" link at the bottom left.

One tailed P-value is $6.5E-12$; **Reject the Null.**
Difference in Q5 by Q1 is “statistically significant”.

3e) T-Test for Measures: Results for Q6 by Q1



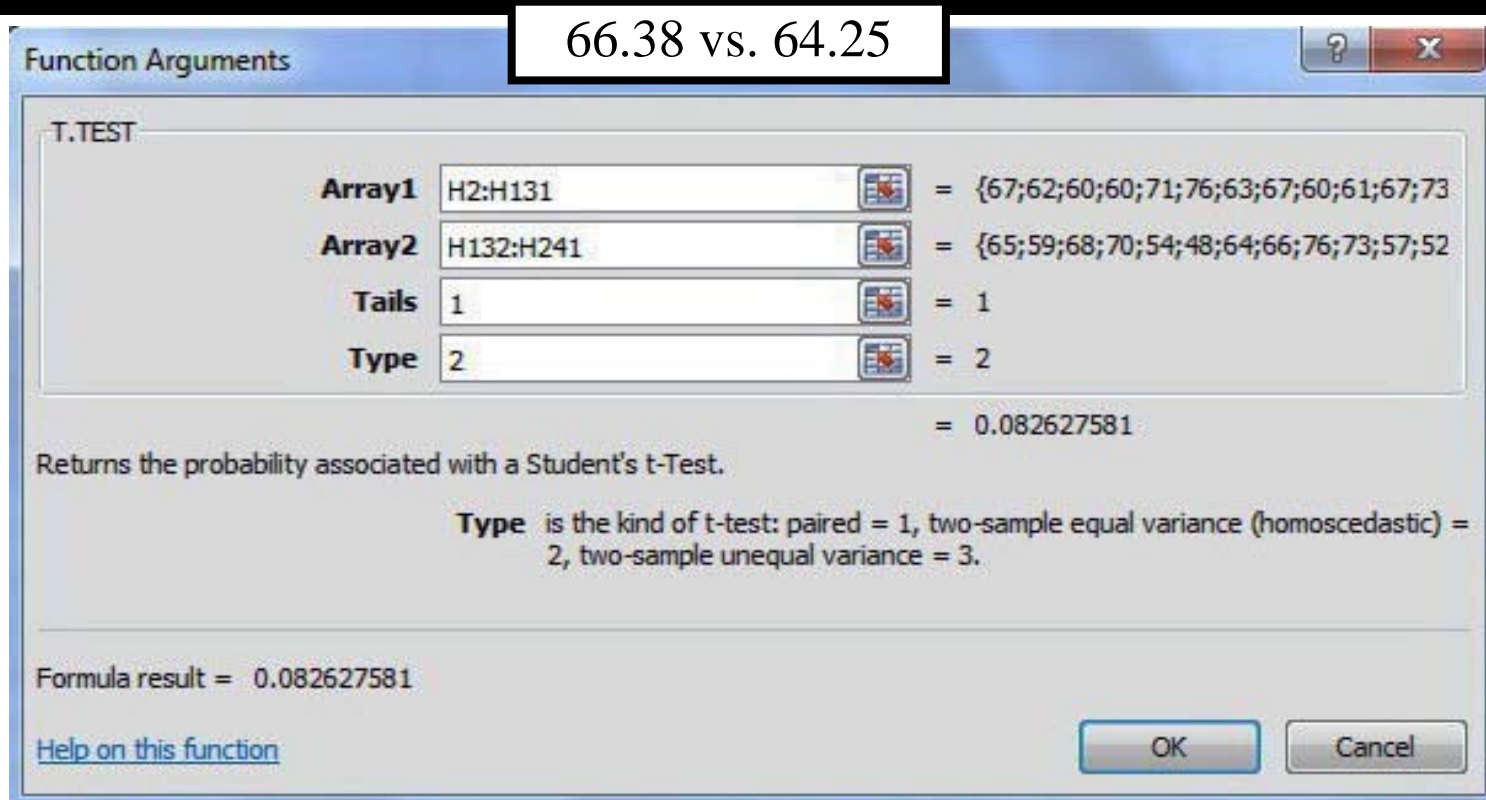
The image shows the 'Function Arguments' dialog box for the T.TEST function in Excel. The title bar reads '2.59 vs. 2.59'. The dialog is titled 'T.TEST' and contains the following arguments:

Argument	Value	Preview
Array1	G2:G131	{5;1;4;5;1;2;1;1;5;3;2;1;2;3;2;4;4;4;4}
Array2	G132:G241	{3;5;2;2;1;2;1;1;1;2;4;1;1;3;3;4;5;2;4}
Tails	1	= 1
Type	2	= 2

Below the arguments, the result is shown as '= 0.496982972'. A description states: 'Returns the probability associated with a Student's t-Test.' A note explains the 'Type' argument: 'Type is the kind of t-test: paired = 1, two-sample equal variance (homoscedastic) = 2, two-sample unequal variance = 3.' The 'Formula result' is also displayed as '= 0.496982972'. There are 'OK' and 'Cancel' buttons at the bottom right, and a 'Help on this function' link at the bottom left.

One tailed P-value is 0.50; Fail to reject the Null.
Difference in Q6 by Q1 is “not statistically significant”

3f) T-Test for Measures: Results for Q7 by Q1



The image shows the 'Function Arguments' dialog box for the T.TEST function in Excel. The title bar of the dialog box contains the text '66.38 vs. 64.25'. The dialog box is titled 'Function Arguments' and contains the following fields and values:

Argument	Value	Result
Array1	H2:H131	{67;62;60;60;71;76;63;67;60;61;67;73}
Array2	H132:H241	{65;59;68;70;54;48;64;66;76;73;57;52}
Tails	1	1
Type	2	2

The result of the function is displayed as = 0.082627581. Below the fields, there is a description: 'Returns the probability associated with a Student's t-Test.' and a note: 'Type is the kind of t-test: paired = 1, two-sample equal variance (homoscedastic) = 2, two-sample unequal variance = 3.' The formula result is shown as 'Formula result = 0.082627581'. There are 'OK' and 'Cancel' buttons at the bottom right, and a 'Help on this function' link at the bottom left.

One tailed P-value is 0.08; Fail to reject the Null.
Difference in Q7 by Q1 is “not statistically significant”

3g) T-Test for Measures: Results for Q8 by Q1

Function Arguments: 5.50 vs. 5.53

T.TEST

Array1	I2:I131	=	{5;4;5;4;3;6;5;6;5;3;6;4;5;4;6;4;6;6;
Array2	I132:I241	=	{5;7;5;6;5;6;6;7;3;6;6;4;5;6;5;5;4;6;4;
Tails	1	=	1
Type	2	=	2

= 0.428475633

Returns the probability associated with a Student's t-Test.

Type is the kind of t-test: paired = 1, two-sample equal variance (homoscedastic) = 2, two-sample unequal variance = 3.

Formula result = 0.428475633

[Help on this function](#) OK Cancel

One tailed P-value is 0.43; Fail to reject the Null.
Difference in Q8 by Q1 is 'not statistically significant'

3h) T.TEST Results: All fields by Q1

Data	Q2 by Q1	Q3 by Q1	Q4 by Q1	Q5 by Q1	Q6 by Q1	Q7 by Q1	Q8 by Q1
P-Value	0.36	2.4E-12	0.24	6.57E-12	0.50	0.08	0.43
Stat. Sig	No	Yes	No	Yes	No	No	No
Average							
Q1=0	0.27	0.78	0.35	3.02	2.59	66.38	5.50
Q1=1	0.29	0.36	0.39	4.03	2.59	64.25	5.53
Differ	0.02	0.42	0.04	1.01	0.00	2.12	0.03
StdDev	0.45	0.49	0.48	1.21	1.42	11.79	1.16
Effect Size	5%	85%	9%	84%	0%	18%	2%

Pooled Std. Dev. = $\text{Sqrt}(((n1-1)S1^2 + (n2-1)S2^2)/(n1+n2 - 2))$

Effect size = Difference in Means / Pooled Std. Deviation

T.TEST Procedure: Step 4

T.TEST function will change if the data is resorted.

There are three solutions:

- 4A) Put data from each sort in a separate tab.
- 4B) Copy sorted data to separate places on one sheet.
- 4C) Copy & Paste/Special/Values with good labels.

4C is not recommended since there is no clear audit trail.

In a one-tailed test, the T.TEST always tests whether the larger statistic is bigger than the smaller.

4A) Separate tabs for each sort

L7										=TTEST(C\$1:C\$26,C\$27:C\$41,1,3)									
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q		
1	ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8								1		
2	1	1	0	0	0	5	1	75	7		T-TEST FUNCTION						2		
3	3	1	0	0	0	3	4	76	5		Tails	1					3		
4	6	1	0	1	0	3	4	73	6		Types	3	2 sample; unequal variances				4		
5	7	1	0	0	0	4	1	72	6								5		
6	8	1	0	0	0	4	1	88	6		ID	P-value	Conclusion: Increase in means				6		
7	9	1	0	0	0	4	3	90	6		Q2 by Q1	0.10	is NOT statistically-significant				7		
8	10	1	0	0	0	3	4	39	5								8		
9	11	1	0	0	0	5	2	40	4		Q3 by Q1	0.01	IS statistically significant				9		
10	12	1	1	1	0	5	5	68	9								10		
11	13	1	1	1	1	5	1	71	8		Q4 by Q1	0.10	is NOT statistically-significant				11		
12	14	1	0	1	0	3	1	98	4								12		
13	15	1	1	0	1	3	1	80	7		Q7 by Q1	0.047	IS statistically significant				13		
14	18	1	0	1	1	4	2	42	8								14		
15	19	1	0	0	0	3	3	39	6		Q8 by Q1	0.30	is NOT statistically-significant				15		
16	22	1	0	1	0	5	4	55	6								16		
17	23	1	1	0	0	4	2	74	6								17		
18	24	1	0	1	0	5	2	36	4		ID	p-value	Technical details (formula)				18		
19	26	1	1	1	1	5	2	49	7	Col C	Q2 by Q1	0.10	=TTEST(C\$1:C\$26,C\$27:C\$41,1,3)				19		
20	31	1	1	0	0	5	1	76	6								20		
21	32	1	0	0	0	3	1	92	4	Col D	Q3 by Q1	0.01	=TTEST(D\$1:D\$26,D\$27:D\$41,1,3)				21		
22	34	1	0	0	0	5	5	62	4								22		
23	35	1	0	0	0	5	4	54	7	Col E	Q4 by Q1	0.10	=TTEST(E\$1:E\$26,E\$27:E\$41,1,3)				23		
24	36	1	0	0	0	5	5	68	5								24		
25	38	1	1	0	1	5	5	60	6	Col H	Q7 by Q1	0.047	=TTEST(F\$1:F\$26,F\$27:F\$41,1,3)				25		
26	40	1	1	0	0	4	2	61	8								26		
27	2	0	0	1	0	1	1	58	6	Col I	Q8 by Q1	0.30	=TTEST(G\$1:G\$26,G\$27:G\$41,1,3)				27		
41	39	0	0	0	0	4	2	83	6										
										Q1Sort / Q2Sort / Q3Sort / Q4Sort									

4B) Separate Sorts on 1 sheet

U6		fx =TTEST(L1:L26,M1:M16,1,3)					RS	T	U	V	W	X
1	Q2 Q1=1	Q2 Q1=0	Q7 Q1=1	Q7 Q1=0	Q8 Q1=1	Q8 Q1=0	T-TEST FUNCTION					
2	0	0	75	58	7	6	Tails	1				
3	0	1	76	89	5	6	Types	3	2 sample; unequal variances			
4	0	1	73	77	6	7						
5	0	0	72	93	6	6	ID	P-value	Conclusion: Increase in means			
6	0	0	88	41	6	6	Q2 by Q1	0.10	is NOT statistically-significant			
7	0	1	90	65	6	7						
8	0	0	39	70	5	6	Q7 by Q1	0.047	IS statistically-significant			
9	0	0	40	65	4	5						
10	1	1	68	89	9	7	Q8 by Q1	0.30	is NOT statistically-significant			
11	1	1	71	64	8	4						
12	0	0	98	82	4	5						
13	1	1	80	82	7	4						
14	0	1	42	75	8	7						
15	0	1	39	80	6	5						
16	0	0	55	83	6	6						
17	1		74		6							
18	0		36		4							
19	1		49		7							
20	1		76		6							
21	0		92		4							
22	0		62		4							
23	0		54		7							
24	0		68		5							
25	1		60		6							
26	1		61		8							

Q2|Q1=1: This is statistical algebra. The vertical bar stands for “given”. Q2|Q1=1 stands for the values of Q2 when (given that) Q1 is 1.

4C) Copy; Paste-Special-Values

L7 → 0.10180642703194

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8								
1	1	0	0	0	5	1	75	7								1
3	1	0	0	0	3	4	76	5								2
6	1	0	1	0	3	4	73	6								3
7	1	0	0	0	4	1	72	6								4
8	1	0	0	0	4	1	88	6								5
9	1	0	0	0	4	3	90	6								6
10	1	0	0	0	3	4	39	5								7
11	1	0	0	0	5	2	40	4								8
12	1	1	1	0	5	5	68	9								9
13	1	1	1	1	5	1	71	8								10
14	1	0	1	0	3	1	98	4								11
15	1	1	0	1	3	1	80	7								12
18	1	0	1	1	4	2	42	8								13
19	1	0	0	0	3	3	39	6								14
22	1	0	1	0	5	4	55	6								15
23	1	1	0	0	4	2	74	6								16
24	1	0	1	0	5	2	36	4								17
26	1	1	1	1	5	2	49	7	ColC							18
31	1	1	0	0	5	1	76	6								19
32	1	0	0	0	3	1	92	4	ColD							20
34	1	0	0	0	5	5	62	4								21
35	1	0	0	0	5	4	54	7	ColE							22
36	1	0	0	0	5	5	68	5								23
38																24
40																25
2																26
																27

T-TEST FUNCTION

Tails: 1

Types: 3 2 sample, unequal variances

ID	P-value	Conclusion: Increase in means
Q2 by Q1	0.10	is NOT statistically-significant
Q3 by Q1	0.01	IS statistically significant
Q4 by Q1	0.10	is NOT statistically-significant
Q7 by Q1	0.047	IS statistically-significant
Q8 by Q1	0.30	is NOT statistically-significant

TEMP DATA: OVERWRITTEN AFTER NEXT SORT

ID	P-value	Technical details (formula)
Q2 by Q1	0.10	=TTEST(C\$1:C\$26,C\$27:C\$41,1,3)
Q3 by Q1	0.01	=TTEST(D\$1:D\$26,D\$27:D\$41,1,3)
Q4 by Q1	0.10	=TTEST(E\$1:E\$26,E\$27:E\$41,1,3)

No audit trail; not recommended.

Summary

In a one-tailed test, T.TEST always tests whether the positive difference between the larger sample statistic and the smaller is statistically-significant.

“Reject the null hypothesis” and “Failure to reject the null hypothesis” are technical conclusions.

“A difference or change IS [or IS NOT] statistically significant” is a non-technical conclusion.

Use the non-technical expressions for everyday communication.

Other Options

In testing sample statistics from two groups for statistical significance, Excel provides two other methods:

- the **t-test command** in the Data Analysis Toolpak, and
- combinations of basic Excel Functions.

The **t-test command** has the clearest documentation (audit trail). All Excel methods require the two-group data be in contiguous blocks.

See statistics textbooks for more on differences between paired or matched subjects. Examples include before-after differences on the same subjects, husband-wife differences, and differences in two appraisals of the same houses.