

## Using T-Test to Determine the Difference of Two Means

### Hypothesis

A Hypothesis is a specific statement of prediction. It describes what you expect will happen in your lab. The two hypothesis that should be considered simultaneously are null hypothesis ( $H_0$ ) and alternative hypothesis ( $H_A$ ). Null hypothesis is a statement that there is no difference. Alternative hypothesis states that there is a difference.

An important thing in determining the hypothesis of the experiment is to determine if the experiment is one-tailed (directional) or two-tailed test (non-directional). One tailed test would be used when the direction of difference is predetermined. For example, apples stored in low oxygen storage has higher shelf life than apples stored in air storage

$$H_0: \mu (\text{low oxygen}) = \mu (\text{air})$$

$$H_a: \mu (\text{low oxygen}) > \mu (\text{air})$$

Where  $\mu$  = shelf life

Two-tailed test would be used when the researcher wants to determine if there is a difference between samples without caring if it will be less or more. For example, the firmness of “Jonagold” apples is different from the firmness of “Red delicious” apples.

$$H_0: \mu \text{ “Jonagold”} = \mu \text{ “Red delicious”}$$

$$H_a: \mu \text{ “Jonagold”} \neq \mu \text{ “Red delicious”}$$

Where  $\mu$  = firmness

### T-test

Once the two hypotheses are determined, t-test can be employed to test the mean difference according the hypotheses. There are two models of t-test. The first assumes that two-population variance are equal ( $\sigma_A = \sigma_B$ ) and the second one assumes that they are unequal ( $\sigma_A \neq \sigma_B$ ). Choosing which model to use, please refer to F-test.

You may perform the t-test by

- Manual calculation: refer to formula in any statistics books or at [p1-4 of this link](#) (require Acrobat Reader)
- Statistical software (e.g. SAS, SPSS, and Minitab): refer to software manual
- Excel: refer to procedure at the end of this handout.

### F-test

F-test is used to tell if the variances of two populations are different. In this case, we use it to evaluate the validity of the equal variance condition for a two-sample t-test. (You may use one-tailed or two-tailed test depending on your purpose)

$$H_0: \sigma_A = \sigma_B$$

$$H_a: \sigma_A < \sigma_B \text{ or } \sigma_A > \sigma_B \text{ (one-tailed test)} \quad \sigma_A \neq \sigma_B \text{ (two-tailed test)}$$

You may perform the F-test by

- Manual calculation: refer to any statistics books or at [p. 5 of this link](#)
- Statistical software (e.g. SAS, SPSS, and Minitab): refer to software manual
- Excel: refer to procedure at the end of this handout.

Procedure to use Excel for t-test (Modified from [this link](#))

1. Check to see if you need to load the “Data Analysis” Add-in
  - Pull down the “Tools” menu to see if “Data Analysis...” is there (at bottom)
  - If it is proceed to step # 2
  - If not: pull down “Tools” menu and choose “Add-Ins...”; put a check by the “Analysis ToolPak”; hit OK

2. To do a 2-sample t-Test:

- a. Enter Data into Excel datasheet

For example,

MOE(A)	MOE(B)
1213454	1343376
1304585	1363748
1254848	1292428

- b. Pull down “Tools” to “Data Analysis”
- c. Scroll down window to “t-Test: two samples assuming unequal variances” or “t-Test: two samples assuming equal variances” depending on the result from F-test.
- d. In open window, look to see “Variable 1 Range” window; choose the little red arrow in right of window; after open window “collapses”, in the main data sheet, use the cursor to drag down the first column of data (e.g., “MOE (A)”) this will enter the cell values into the window; click the red arrow in the small window to open again.

For example,

MOE(A)	MOE(B)
1213454	1343376
1304585	1363748
1254848	1292428

- e. Repeat c. for “Variable 2 Range”

For example,

MOE(A)	MOE(B)
1213454	1343376
1304585	1363748
1254848	1292428

- f. back in the t-Test window, in the “hypothesized mean difference” window, type in “0” (stating your null hypothesis to be no difference between means)
- g. Click in front of “Label”
- h. Leave alpha set at default 0.05 (stating you want a 95% confidence of detecting differences between means)
- i. In the “output range” section, choose the “New worksheet ply” and click “OK”

You will have output looking like in Figure 1 or similar if you use equal variance. Excel will perform both one-tailed and two-tailed t-test

Figure 1. Result from unequal variance t-test performed by Excel

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	Variable 2
Mean	20.67	21
Variance	3.523	3.218
Observations	7	8
Hypothesized Mean Difference	0	
df	13	
t Stat	-0.349	
P(T<=t) one-tail	0.3664	
t Critical one-tail	1.7709	
P(T<=t) two-tail	0.7328	
t Critical two-tail	2.16	

- df =degrees of freedom;
- t Stat is your Calculated t value (T);
- t-Critical refers to the table value against which your t-Critical is tested;
- P(T<=t) reads “the probability that your Calculated T is less than or equal to the critical t”;
- in order to reject the null hypothesis at 95% confidence, you need P(T<=t) less than or equal to .05. This is valid for both one-tailed and two-tailed test performed using Excel.

#### Procedure to use Excel for F-test

Follow the same procedure as t-test except choose “F-test two sample of variances” instead of “t-test: Two samples.....” The result from F-test looks like Figure 2.

Unlike t-test, Excel always performs one-tailed F-test. You have to pay extra attention when you run two-tailed F-test

Figure 2. Result from F-test performed by Excel

F-Test Two-Sample for Variances		
	Variable 1	Variable 2
Mean	1.660938	1.813125
Variance	0.006138	0.005551
Observations	32	32
df	31	31
F	1.105669	
P(F<=f) one-tail	0.39076	
F Critical one-tail	1.822134	

- In order to reject the null hypothesis at 95% confidence, you need P(F<=f) less than or equal to .05 for one-tailed F-test or 0.05/2 for two-tailed T-test.

#### Suggested Reading:

Ott, R. L.; Longnecker, M. *An introduction to statistical methods and data analysis*, 1st ed.; Duxbury: California, 2001,