```
1 #sample average
2 def Meu(num of 1, num of 0):
   meu=num of 1/(num of 1+num of 0)
3
4
   return meu
1 #standard deviation1
2 def SD1(num of 1, num of 0):
   sum1=num of 1*((1-Meu(num of 1, num of 0))**2)
3
   sum0=num_of_0*((0-Meu(num_of_1,num_of_0))**2)
4
   sum of all=sum1+sum0
5
   sd=sum of all/(num of 1+num of 0)
6
   return sd
7
```

standard deviation1

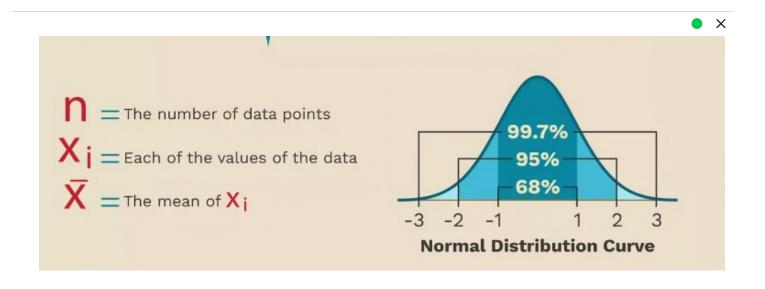
$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (x_i - \mu)^2}.$$

```
1 #standard deviation2
2 def SD2(num_of_1,num_of_0):
3   sum1=num_of_1*((1-Meu(num_of_1,num_of_0))**2)
4   sum0=num_of_0*((0-Meu(num_of_1,num_of_0))**2)
5   sum_of_all=sum1+sum0
6   sd=sum_of_all/(num_of_1+num_of_0-1)
7   return sd
```

standard deviation2

Calculating Standard Deviation

$$S_{X} = \sqrt{\frac{\sum_{i=1}^{n} (\mathbf{x}_{i} - \bar{\mathbf{x}})^{2}}{n}}$$



```
1 #======Example 1=======
2 #total sms=40
3 #group A=20 :
4 print("mean of group A:",Meu(10,10))
5 print("standard deviation of group A:",SD1(10,10))
6 #group B=20 :
7 print("mean of group B:",Meu(18,2))
8 print("standard deviation of group B:",SD1(18,2))

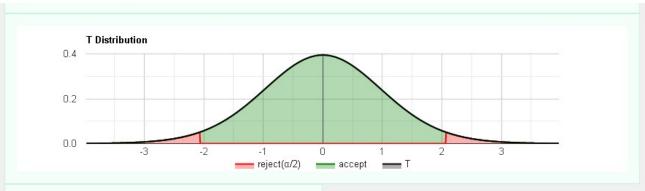
mean of group A: 0.5
    standard deviation of group A: 0.25
    mean of group B: 0.9
    standard deviation of group B: 0.09
```

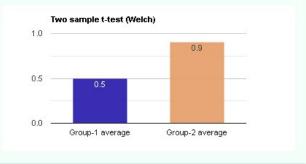
Statistics Kingdom Home > Mean > Two-Sample T (Welch's) Two Sample T-Test Calculator (Welch's T-test) Unknown unequal standard deviation Expected difference between two populations' mean Video Information T-Equal standard deviation Paired-T One sample T Tails: Two (H₁: μ1 ≠ μ2+d) Significance level (α): Effect: Medium ✓ Effect type: Standardized effect size ✓

tandard	deviation	1&0.ipv	vnb -	Colaboratory
---------	-----------	---------	-------	--------------

Difference (d): 0				
Enter raw data or Pas	ste excel data or enter summarized	data (x̄ , n, σ, S) below	
	•			
Group name:	Group-1	G	roup-2	
Sample average (x̄):	0.5	0.	9	
Sample size (n):	20	20)	
Sample SD (S):	0.25	0.	09	
When entering raw data, tl	he t test calculator will run the Shapir	ro-Wilk normal	lity test and calculate ou	utliers, as part of the
and the second control of the second control	enerate the R code for your data.			•
Calculate test Clear				(1)
Calculate test Clear				Load last run
Calculate test Clear	effect			Load last run
(SOLO)				Load last run
p-value Rower 0.329	effect 2.129	RA) (tuvo tallo	d) (validation)	Load last run
Two sample t-test (Welc		<u>34) (two-taile</u>	rd) (validation)	Load last run
p-value Rower 0.329	h), using T distribution (df=23.84)	<u>34) (two-taile</u>	<u>d)</u> (<u>validation)</u>	Load last run
Two sample t-test (Welconstance) 1. H ₀ hypothesis Since p-value < α, H ₀ is regarded and the surface of Group-1's	h), using T distribution (df=23.84) jected. population is considered to be not e	equal to the av	verage of Group-2's pop	oulation.
Two sample t-test (Welconstance) 1. H ₀ hypothesis Since p-value < α, H ₀ is regarded and the surface of Group-1's	h), using T distribution (df=23.84)	equal to the av	verage of Group-2's pop	oulation.
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Two sample t-test (Welcons) 1. H ₀ hypothesis Since p-value < α, H ₀ is region of the average of Group-1's In other words, the differest significant. 2. P-value The p-value equals 5.994e	h), using T distribution (df=23.84) jected. population is considered to be not ence between the sample average of Central population is considered.	equal to the av Group-1 and G	verage of Group-2's pop i roup-2 is big enough t	o <mark>ulation.</mark> o be statistically
Two sample t-test (Welcons) 1. H ₀ hypothesis Since p-value < α, H ₀ is represented the average of Group-1's In other words, the differented significant. 2. P-value	h), using T distribution (df=23.84) jected. population is considered to be not ence between the sample average of Central Property (p(x \le T) = 2.997e-7). It means the figure of the central property (p(x \le T) = 2.997e-7).	equal to the av Group-1 and G	verage of Group-2's pop i roup-2 is big enough t	o <mark>ulation.</mark> o be statistically
Two sample t-test (Welconsum 1. H ₀ hypothesis Since p-value < α, H ₀ is regarded from the regarded from the significant. 2. P-value The p-value equals 5.994e small: 5.994e-7 (0.00006%)	h), using T distribution (df=23.84) jected. population is considered to be not ence between the sample average of Central Property (p(x \le T) = 2.997e-7). It means the figure of the central property (p(x \le T) = 2.997e-7).	equal to the av Group-1 and G	verage of Group-2's pop i roup-2 is big enough t	o <mark>ulation.</mark> o be statistically
Two sample t-test (Welconsum of the statistics The test statistic T equals 5.329 Two sample t-test (Welconsum of the statistic of the statis	h), using T distribution (df=23.84) jected. population is considered to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the sample average of Control (processed to be not ence between the processed to be not	equal to the average of the chance of acceptance	verage of Group-2's pol i roup-2 is big enough to of type I error (rejecting	o <mark>ulation.</mark> o be statistically
Two sample t-test (Welcons) 1. H ₀ hypothesis Since p-value < α, H ₀ is region of the average of Group-1's In other words, the difference significant. 2. P-value The p-value equals 5.994e small: 5.994e-7 (0.000069) The smaller the p-value the p-valu	h), using T distribution (df=23.84); jected. population is considered to be not ence between the sample average of considered. 1-7, (p(x≤T) = 2.997e-7). It means the considered is supports H ₁ .	equal to the average of the chance of acceptance (1227].	verage of Group-2's pop iroup-2 is big enough to of type I error (rejecting de: [-2.0646 : 2.0646].	o <mark>ulation.</mark> o be statistically
Two sample t-test (Welcons) 1. H ₀ hypothesis Since p-value < α, H ₀ is region of the average of Group-1's In other words, the difference significant. 2. P-value The p-value equals 5.994e small: 5.994e-7 (0.000069) The smaller the p-value the p-valu	h), using T distribution (df=23.84) jected. population is considered to be not ence between the sample average of Control (a). 1-7, (p(x≤T) = 2.997e-7). It means the control (a). 1-7, (p(x≤T) = 2.997e-7). It means the control (a). 1-7, (p(x≤T) = 2.997e-7). It means the control (a).	equal to the average of the chance of acceptance (1227].	verage of Group-2's pop iroup-2 is big enough to of type I error (rejecting de: [-2.0646 : 2.0646].	o <mark>ulation.</mark> o be statistically
Two sample t-test (Welcons) 1. H ₀ hypothesis Since p-value < α, H ₀ is regarded from the average of Group-1's In other words, the difference significant. 2. P-value The p-value equals 5.994e small: 5.994e-7 (0.00006%) The smaller the p-value the smaller the p-value the smaller the p-value the smaller statistic T equals from the standard deviation of the standard deviation dev	h), using T distribution (df=23.84) jected. population is considered to be not ence between the sample average of Control (a). 1-7, (p(x≤T) = 2.997e-7). It means the control (a). 1-7, (p(x≤T) = 2.997e-7). It means the control (a). 1-7, (p(x≤T) = 2.997e-7). It means the control (a).	equal to the average of acceptance of acceptance (1227].	verage of Group-2's poli roup-2 is big enough to of type I error (rejecting ce: [-2.0646].	oulation. o be statistically a correct H ₀) is

3 of 26





Test validation

The requested test was calculated, assumes **unequal** standard deviation (σ), it is likely you chose the right test.

Test power

Although the priori power is low (0.3294), the Ho is rejected.

Equality of variances assumption

Based on a two-tailed F test, σ_1 is considered as **unequal** to σ_2 (p-value is 0.0000437)

F test assumes equal standard deviations, which is not your test assumption.

Information

Target: To check if the difference between the average (mean) of two groups (populations) is significant, using sample data

Example1: A man of average is expected to be 10cm taller than a woman of average (d=10)

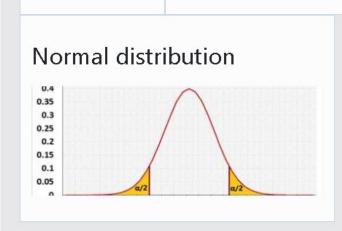
Example2: The average weight of an apple grown in field 1 is expected to be equal in weight to the average apple grown in field 2 (d=0)

Hypotheses | Test statistic

$$H_0$$
: $\mu_1 = \mu_2 + d$
 H_1 : $\mu_1 \neq \mu_2 + d$

$$t=rac{ar{x}_1-ar{x}_2-d}{\sqrt{rac{S_1^2}{n_1}+rac{S_2^2}{n_2}}}$$

$$egin{aligned} t &= rac{ar{x}_1 - ar{x}_2 - d}{\sqrt{rac{S_1^2}{n_1} + rac{S_2^2}{n_2}}} \ df &= rac{(rac{S_1^2}{n_1} + rac{S_2^2}{n_2})^2}{rac{S_1^4}{n_1^2(n_1 - 1)} + rac{S_2^4}{n_2^2(n_2 - 1)}} \end{aligned}$$



Assumptions

- Normal distribution
- **6** The standard deviations of both populations not necessarily equal, so either $\sigma_1 = \sigma_2$ or $\delta_1 \neq \delta_2$)
- **d** Expected difference **d** between the populations's average is known

Required Sample Data

- $\bar{\mathbf{x}} = \bar{\mathbf{x}}_1, \bar{\mathbf{x}}_2$ Sample average of group1 and group2
- n n₁,n₂ Sample size of group1 and group2
- S S₁,S₂ Sample standard deviation of group1 and group2

<u>Examples</u>

1. Two tailed test example:

A factory uses two identical machines to produce plastic plates. You would expect both machines to produce the same number of plates per minute.

Let $\mu 1$ = average number of plates produced by machine1 per minute.

Let μ 2 = average number of plates produced by machine2 per minute.

We would expect $\mu 1$ to be equal to $\mu 2$. If one of the machines is slower than the other one, it should be serviced. In this case, we would like to know both if $\mu 1 < \mu 2$ or $\mu 1 > \mu 2$, since either machine could be slower.

2. Left tail example.

A farmer uses fertilizer-1 with good results.

A friend told him fertilizer-2 is better than fertilizer #1.

Let $\mu 1$ = average number of potatoes per square meter in gardens using fertilizer-1.

Let μ 2 = average number of potatoes per square meter in gardens using fertilizer-2.

The farmer assumes that the fertilizer currently in use (fertilizer-1) is better than the suggested one.(or equal)

He is willing to change fertilizer only if the new one is better.

A one-tailed test is controversial. It increase the type I error. In this example, it may be important to know if fertilizer-2 is less effectione than fertilizer-1, and use the two-tailes test.

Statistics Kingdom

Home > Mean > Two-Sample T (Welch's)

Two Sample T-Test Calculator (Welch's T-test) Unknown unequal standard deviation Expected difference between two populations' mean Video Information T-Equal standard deviation Paired-T One sample T 0.05 Tails: Two $(H_1: \mu 1 \neq \mu 2 + d)$ Significance level (α): Effect Medium Effect type: Standardized effect size Effect Size: 0.5 Outliers: Included Difference (d): Paste excel data or enter summarized data (x̄, n, σ, S) below Group name: Group-1 Group-2 Sample average (x): 0.3333333333333333 8.0 Sample size (n): 10 Sample SD (S): 0.222222222222227 0.16

When entering raw data, the t test calculator will run the Shapiro-Wilk normality test and calculate outliers, as part of the test calculation, and will generate the R code for your data.





Load last run







Two sample t-test (Welch), using T distribution (df=21.5323) (two-tailed) (validation)

1. H₀ hypothesis

Since p-value < α, H₀ is rejected.

The average of Group-1's population is considered to be not equal to the average of Group-2's population.

In other words, the difference between the sample average of Group-1 and Group-2 is big enough to be statistically significant.

2. P-value

The p-value equals 3.717e-7, (p($x \le T$) = 1.858e-7). It means that the chance of type I error (rejecting a correct H_0) is small: 3.717e-7 (0.000037%).

The smaller the p-value the more it supports H₁.

3. The statistics

The test statistic T equals -7.1956, which is not in the 95% region of acceptance: [-2.0765].

x1-x2=-0.47, is not in the 95% region of acceptance: [-0.1347 : 0.1347].

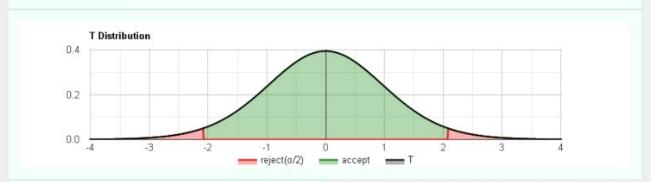
The standard deviation of the difference, S' equals 0.0649, is used to calculate the statistic.

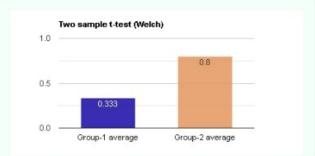
4. Effect size

The observed effect size d is large, 2.23. This indicates that the magnitude of the difference between the average and average is large.

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Like 313 Share





Test validation

The requested test was calculated, assumes unequal standard deviation (a). it is likely you chose the right test.

Test power

Although the priori power is low (0.2972), the Ho is rejected.

Equality of variances assumption

Based on a two-tailed F test, σ₁ is considered as **equal** to σ₂ (p-value is 0.302) F test assumes equal standard deviations, which is not your test assumption.

Recommendations

The F-test can't reject the unequal variance assumption, since it is based on the equal variance assumption, which is not your preliminary assumption. You should continue with the Welch's t-test, which is also robust to variances equality.

Information

Target: To check if the difference between the average (mean) of two groups (populations) is significant, using sample

Example1: A man of average is expected to be 10cm taller than a woman of average (d=10)

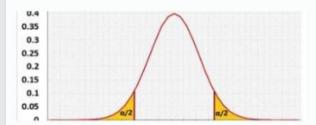
Example 2: The average weight of an apple grown in field 1 is expected to be equal in weight to the average apple grown in field 2 (d=0)

$$H_0$$
: $\mu_1 = \mu_2 + d$
 H_1 : $\mu_1 \neq \mu_2 + d$

Hypotheses | Test statistic

$$egin{aligned} t &= rac{ar{x}_1 - ar{x}_2 - d}{\sqrt{rac{S_1^2}{n_1} + rac{S_2^2}{n_2}}} \ df &= rac{(rac{S_1^2}{n_1} + rac{S_2^2}{n_2})^2}{rac{S_1^4}{n_1^2(n_1 - 1)} + rac{S_2^4}{n_2^2(n_2 - 1)}} \end{aligned}$$

Normal distribution



Assumptions

- Normal distribution
- The standard deviations of both populations not necessarily equal, so either $\sigma_1 = \sigma_2$ or $\delta_1 \neq \delta_2$)
- d Expected difference d between the populations's average is known

Required Sample Data

- x
 , x
 , x
 , z
 Sample average of group1 and group2
- n₁,n₂ Sample size of group1 and group2
- S S1,S2 Sample standard deviation of group1 and group2

Examples

1. Two tailed test example:

A factory uses two identical machines to produce plastic plates. You would expect both machines to produce the same number of plates per minute.

Let µ1 = average number of plates produced by machine1 per minute.

Let μ2 = average number of plates produced by machine2 per minute.

We would expect μ 1 to be equal to μ 2. If one of the machines is slower than the other one, it should be serviced. In this case, we would like to know both if μ 1 < μ 2 or μ 1 > μ 2, since either machine could be slower.

2. Left tail example.

A farmer uses fertilizer-1 with good results.

A friend told him fertilizer-2 is better than fertilizer #1.

Let μ 1 = average number of potatoes per square meter in gardens using fertilizer-1.

Let μ 2 = average number of potatoes per square meter in gardens using fertilizer-2.

The farmer assumes that the fertilizer currently in use (fertilizer-1) is better than the suggested one.(or equal)

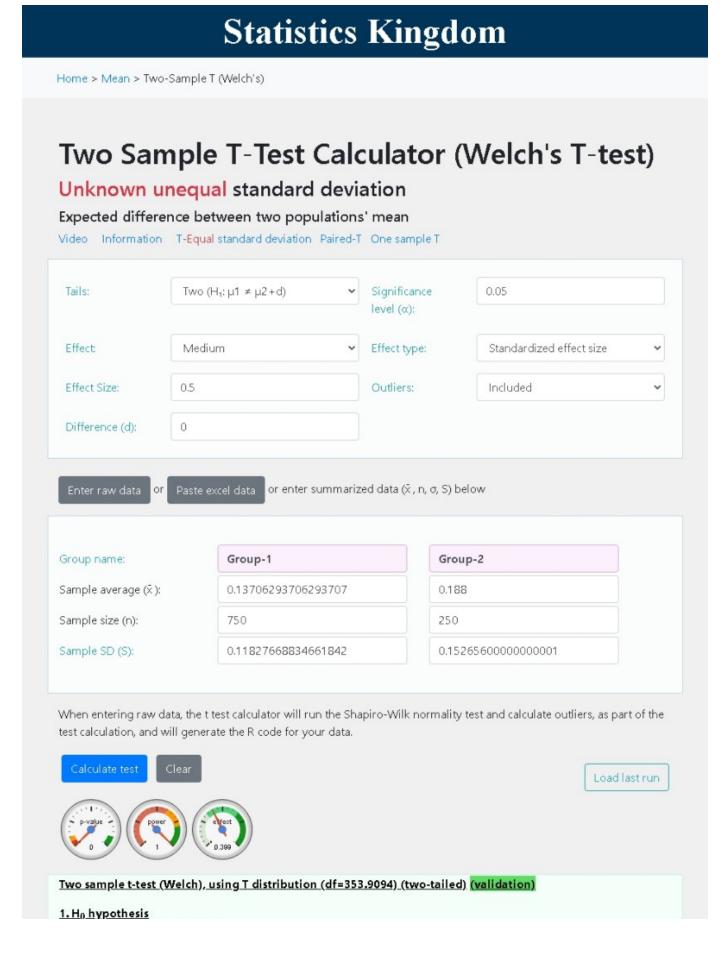
He is willing to change fertilizer only if the new one is better.

A one-tailed test is controversial. It increase the type I error. In this example, it may be important to know if fertilizer-2 is less effectinve than fertilizer-1, and use the two-tailes test.

```
1 #======Example 3=======
2 #total sms=1000
3 #group A=750 :
4 print("mean of group A:",Meu(98,617))
5 print("standard deviation of group A:",SD1(98,617))
6 #group B=250 :
7 print("mean of group B:",Meu(47,203))
8 print("standard deviation of group B:",SD1(47,203))

mean of group A: 0.13706293706293707
    standard deviation of group A: 0.11827668834661842
    mean of group B: 0.188
```

standard deviation of group B: 0.15265600000000001



Since p-value $< \alpha$, H_0 is rejected.

The average of Group-1's population is considered to be not equal to the average of Group-2's population.

In other words, the difference between the sample average of Group-1 and Group-2 is big enough to be statistically significant.

2. P-value

The p-value equals 0.000002176, (p(x \leq T) = 0.000001088). It means that the chance of type I error (rejecting a correct H₀) is small: 0.000002176 (0.00022%).

The smaller the p-value the more it supports H₁.

3. The statistics

The test statistic T equals -4.8159, which is not in the 95% region of acceptance: [-1.9667 : 1.9667].

 $x_1-x_2=-0.051$, is not in the 95% region of acceptance: [-0.0208: 0.0208].

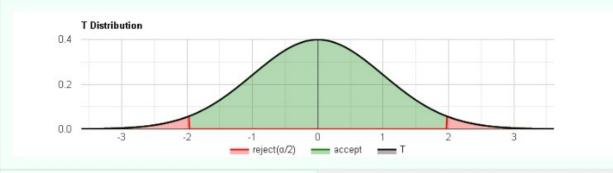
The standard deviation of the difference, S' equals 0.0106, is used to calculate the statistic.

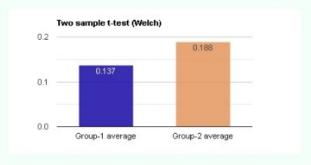
4. Effect size

The observed effect size d is medium, 0.4. This indicates that the magnitude of the difference between the average and average is medium.

If you like the page, please share or like. Questions, comments and suggestions are appreciated. (statskingdom@gmail.com)







Test validation

The requested test was calculated, assumes unequal standard deviation (σ). it is likely you chose the right test.

Test power

The test priori power is strong: 1

Equality of variances assumption

Record on a two-tailed E tact or is considered as unequal to or (n-value is 2.7e-7)

pased of a avortaned it test, of is considered as **unrequal** to by (privated is 2.7 e-7)

F test assumes equal standard deviations, which is not your test assumption.

Information

Target: To check if the difference between the average (mean) of two groups (populations) is significant, using sample data

Example1: A man of average is expected to be 10cm taller than a woman of average (d=10)

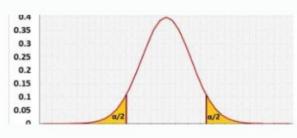
Example2: The average weight of an apple grown in field 1 is expected to be equal in weight to the average apple grown in field 2 (d=0)

$$H_0$$
: $\mu_1 = \mu_2 + d$
 H_1 : $\mu_1 \neq \mu_2 + d$

Hypotheses | Test statistic

$$egin{align} t &= rac{ar{x}_1 - ar{x}_2 - d}{\sqrt{rac{S_1^2}{n_1} + rac{S_2^2}{n_2}}} \ df &= rac{(rac{S_1^2}{n_1} + rac{S_2^2}{n_2})^2}{rac{S_1^4}{n_1^2(n_1 - 1)} + rac{S_2^4}{n_2^2(n_2 - 1)}} \end{aligned}$$

Normal distribution



Assumptions

- ∧ Normal distribution
- The standard deviations of both populations not necessarily equal, so either σ₁=σ₂ or 6₁≠6₂)
- d Expected difference d between the populations's average is known

Required Sample Data

- \bar{x} \bar{x}_1, \bar{x}_2 Sample average of group1 and group2
- n n₁,n₂ Sample size of group1 and group2
- S₁,S₂ Sample standard deviation of group1 and group2

Examples

1. Two tailed test example:

A factory uses two identical machines to produce plastic plates. You would expect both machines to produce the same

```
number of plates per minute.

Let \mu 1 = average number of plates produced by machine1 per minute.

Let \mu 2 = average number of plates produced by machine2 per minute.

We would expect \mu 1 to be equal to \mu 2. If one of the machines is slower than the other one, it should be serviced. In this case, we would like to know both if \mu 1 < \mu 2 or \mu 1 > \mu 2, since either machine could be slower.

2. Left tail example.

A farmer uses fertilizer-1 with good results.

A friend told him fertilizer-2 is better than fertilizer #1.

Let \mu 1 = average number of potatoes per square meter in gardens using fertilizer-1.

Let \mu 2 = average number of potatoes per square meter in gardens using fertilizer-2.

The farmer assumes that the fertilizer currently in use (fertilizer-1) is better than the suggested one.(or equal) He is willing to change fertilizer only if the new one is better.

A one-tailed test is controversial. It increase the type I error. In this example, it may be important to know if fertilizer-2 is less effectinve than fertilizer-1, and use the two-tailes test.
```

```
1 #======Example 4=======
2 #total sms=1000
3 #group A=750 :
4 print("mean of group A:",Meu(39,711))
5 print("standard deviation of group A:",SD1(39,711))
6 #group B=250 :
7 print("mean of group B:",Meu(9,241))
8 print("standard deviation of group B:",SD1(9,241))

mean of group A: 0.052
    standard deviation of group A: 0.049296
    mean of group B: 0.036
    standard deviation of group B: 0.034704
```

Statistics Kingdom Home > Mean > Two-Sample T (Welch's) Two Sample T-Test Calculator (Welch's T-test) Unknown unequal standard deviation Expected difference between two populations' mean Video Information T-Equal standard deviation Paired-T One sample T Tails: Two (H₁: \mu 1 \neq \mu 2+d) \quad Significance 0.05

tandard	deviation	1&0.ipv	vnb -	Colaboratory
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Effect	Medium ~	Effect type:	Standardized effect size	`
Effect Size:	0.5	Outliers:	Included	`
Difference (d):	0			
Enter raw data Or	Paste excel data or enter summari:	zed data (x̄ , n, σ, S)	below	
Group name:	Group-1	Gro	oup-2	
Sample average (x̄):	0.052	0.03		
Sample size (n):	750	250		
Sample SD (S):	0.049296	0.03	34704	
Calculate test	data, the t test calculator will run the Sh will generate the R code for your data.		Load las	
Calculate test Power Two sample t-test (1. Ho hypothesis Since p-value < \alpha, Ho	will generate the R code for your data. Clear Output Distribution (df=60)	5 <u>.5212) (two-taile</u>	Load la:	
Two sample t-test (1. H ₀ hypothesis Since p-value < \alpha, H The average of Grou	will generate the R code for your data. Clear Welch), using T distribution (df=60) is rejected.	5.5212) (two-taile	Load lat d) (validation) rage of Group-2's population.	st run
Two sample t-test (1. H ₀ hypothesis Since p-value < α, H ₀ The average of Grou In other words, the disignificant. 2. P-value The p-value equals 2 2.661 e-8 (0.0000027)	will generate the R code for your data. Clear Welch), using T distribution (df=60) is rejected. p-1's population is considered to be not ifference between the sample average .661e-8, (p(x≤T) = 1). It means that the	5.5212) (two-taile ot equal to the ave of Group-1 and Gro	d) (validation) rage of Group-2's population. pup-2 is big enough to be statistica	st run
Two sample t-test (1. H ₀ hypothesis Since p-value < α, H ₁ The average of Grou In other words, the disignificant. 2. P-value The p-value equals 2 2.661 e-8 (0.0000027) The smaller the p-value smaller the p-value the p-value smaller the p-value the test statistic T equals 2 x ₁ -x ₂ =0.016, is not in	will generate the R code for your data. Clear Welch), using T distribution (df=60 is rejected. p-1's population is considered to be no ifference between the sample average ifference between the sample average .661e-8, (p(x≤T) = 1). It means that the	5.5212) (two-taile of equal to the ave of Group-1 and Gro ne chance of type I e gion of acceptance: 575:0.005575].	d) (validation) rage of Group-2's population. pup-2 is big enough to be statistical rror (rejecting a correct H ₀) is small [-1.9639:1.9639].	st run

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Test validation

The requested test was calculated, assumes unequal standard deviation (a). it is likely you chose the right test.

Test power

The test priori power is strong: 1

Equality of variances assumption

Based on a two-tailed F test, σ_1 is considered as **unequal** to σ_2 (p-value is 2.18e-10)

F test assumes equal standard deviations, which is not your test assumption.

Information

Target: To check if the difference between the average (mean) of two groups (populations) is significant, using sample data

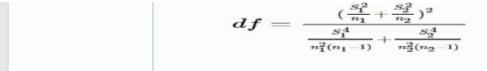
Example1: A man of average is expected to be 10cm taller than a woman of average (d=10)

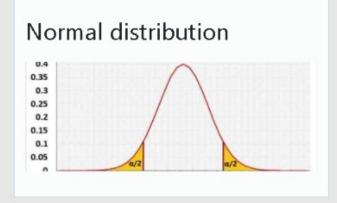
Example 2: The average weight of an apple grown in field 1 is expected to be equal in weight to the average apple grown in field 2 (d=0)

Hypotheses | Test statistic

 H_0 : $\mu_1 = \mu_2 + d$ H_1 : $\mu_1 \neq \mu_2 + d$

$$t=rac{ar{x}_1-ar{x}_2-d}{\sqrt{rac{S_1^2}{n_1}+rac{S_2^2}{n_2}}}$$





Assumptions

- Normal distribution
- The standard deviations of both populations not necessarily equal, so either σ₁=σ₂ or 6₁≠6₂)
- d Expected difference d between the populations's average is known

Required Sample Data

- x x₁, x₂ Sample average of group1 and group2
- n n₁,n₂ Sample size of group1 and group2
- S S₁,S₂ Sample standard deviation of group1 and group2

Examples

1. Two tailed test example:

A factory uses two identical machines to produce plastic plates. You would expect both machines to produce the same number of plates per minute.

Let $\mu 1$ = average number of plates produced by machine1 per minute.

Let μ2 = average number of plates produced by machine2 per minute.

We would expect μ 1 to be equal to μ 2. If one of the machines is slower than the other one, it should be serviced. In this case, we would like to know both if μ 1 < μ 2 or μ 1 > μ 2, since either machine could be slower.

2. Left tail example.

A farmer uses fertilizer-1 with good results.

A friend told him fertilizer-2 is better than fertilizer #1.

Let μ 1 = average number of potatoes per square meter in gardens using fertilizer-1.

Let $\mu 2$ = average number of potatoes per square meter in gardens using fertilizer-2.

The farmer assumes that the fertilizer currently in use (fertilizer-1) is better than the suggested one.(or equal)

He is willing to change fertilizer only if the new one is better.

A one-tailed test is controversial. It increase the type I error. In this example, it may be important to know if fertilizer-2 is less effectinve than fertilizer-1, and use the two-tailes test.

```
1 #======Example 5=======
2 #total sms=10000
3 #group A=9000 :
4 print("mean of group A:",Meu(2927,6073))
5 print("standard deviation of group A:",SD1(2927,6073))
6 #group B=1000 :
7 print("mean of group B:",Meu(742,258))
8 print("standard deviation of group B:",SD1(742,258))

mean of group A: 0.325222222222222222225
standard deviation of group A: 0.21945272839506172
mean of group B: 0.742
standard deviation of group B: 0.1914359999999997
```

Statistics Kingdom

Home > Mean > Two-Sample T (Welch's)

Group name:

Sample average (\bar{x}) :

Sample size (n):

Two Sample T-Test Calculator (Welch's T-test) Unknown unequal standard deviation Expected difference between two populations' mean Video Information T-Equal standard deviation Paired-T One sample T 0.05 Tails: Two $(H_1: \mu 1 \neq \mu 2 + d)$ Significance level (α): Effect Medium Effect type: Standardized effect size Effect Size: 0.5 Outliers: Included Difference (d): or enter summarized data (x̄ , n, σ, S) below

17 of 26 6/16/2022, 2:00 PM

Group-2

0.742

1000

Group-1

9000

0.325222222222225

Sample SD (S): 0.21945272839506172 0.1914359999999999

When entering raw data, the t test calculator will run the Shapiro-Wilk normality test and calculate outliers, as part of the test calculation, and will generate the R code for your data.



Load last run





Two sample t-test (Welch), using T distribution (df=1308.9351) (two-tailed) (validation)

1. H₀ hypothesis

Since p-value < α, H₀ is rejected.

The average of Group-1's population is considered to be not equal to the average of Group-2's population.

In other words, the difference between the sample average of **Group-1** and **Group-2** is big enough to be statistically significant.

2. P-value

The p-value equals 0, (p(x \leq T) = 0). It means that the chance of type I error (rejecting a correct H_0) is small: 0 (0%). The smaller the p-value the more it supports H_1 .

3. The statistics

The test statistic T equals -64.3111, which is not in the 95% region of acceptance: [-1.9618: 1.9618].

 $x_1-x_2=-0.42$, is not in the 95% region of acceptance: [-0.01271 : 0.01271].

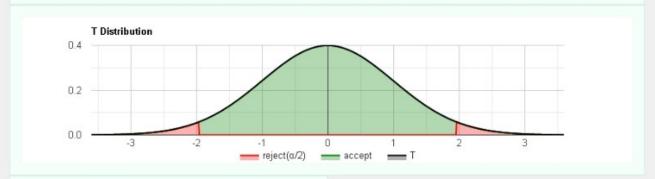
The standard deviation of the difference, S' equals 0.00648, is used to calculate the statistic.

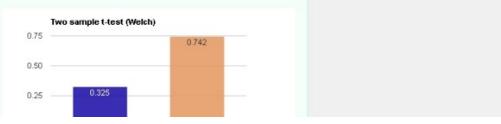
4. Effect size

The observed effect size d is **large**, **1.92**. This indicates that the magnitude of the difference between the average and average is large.

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Test validation

The requested test was calculated, assumes unequal standard deviation (σ). it is likely you chose the right test.

Test power

The test priori power is strong: 1

Equality of variances assumption

Based on a two-tailed F test, σ_1 is considered as **unequal** to σ_2 (p-value is NaN)

F test assumes equal standard deviations, which is not your test assumption.

Information

Target: To check if the difference between the average (mean) of two groups (populations) is significant, using sample

Example1: A man of average is expected to be 10cm taller than a woman of average (d=10)

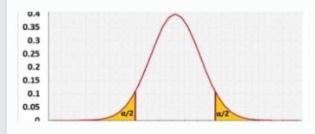
Example 2: The average weight of an apple grown in field 1 is expected to be equal in weight to the average apple grown in field 2 (d=0)

$$H_0$$
: $\mu_1 = \mu_2 + d$
 H_1 : $\mu_1 \neq \mu_2 + d$

Hypotheses | Test statistic

$$egin{aligned} t &= rac{ar{x}_1 - ar{x}_2 - d}{\sqrt{rac{S_1^2}{n_1} + rac{S_2^2}{n_2}}} \ df &= rac{(rac{S_1^2}{n_1} + rac{S_2^2}{n_2})^2}{rac{S_1^4}{n_1^2(n_1 - 1)} + rac{S_2^4}{n_2^2(n_2 - 1)}} \end{aligned}$$

Normal distribution



Assumptions

Normal distribution

- The standard deviations of both populations not necessarily equal, so either $\sigma_1 = \sigma_2$ or $\delta_1 \neq \delta_2$)
- d Expected difference d between the populations's average is known

Required Sample Data

- $\bar{\mathbf{x}}$ $\bar{\mathbf{x}}_1, \bar{\mathbf{x}}_2$ Sample average of group1 and group2
- n₁,n₂ Sample size of group1 and group2
- S S1,S2 Sample standard deviation of group1 and group2

<u>Examples</u>

1. Two tailed test example:

A factory uses two identical machines to produce plastic plates. You would expect both machines to produce the same number of plates per minute.

Let $\mu 1$ = average number of plates produced by machine1 per minute.

Let μ2 = average number of plates produced by machine2 per minute.

We would expect $\mu 1$ to be equal to $\mu 2$. If one of the machines is slower than the other one, it should be serviced. In this case, we would like to know both if $\mu 1 < \mu 2$ or $\mu 1 > \mu 2$, since either machine could be slower.

2. Left tail example.

A farmer uses fertilizer-1 with good results.

A friend told him fertilizer-2 is better than fertilizer #1.

Let μ 1 = average number of potatoes per square meter in gardens using fertilizer-1.

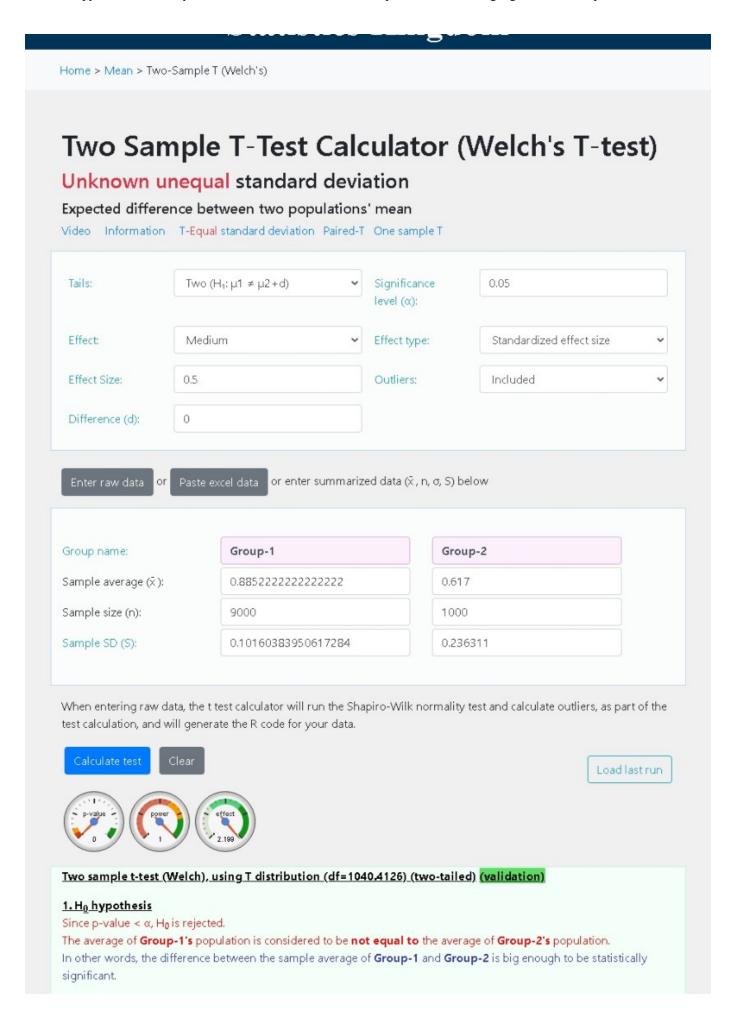
Let μ 2 = average number of potatoes per square meter in gardens using fertilizer-2.

The farmer assumes that the fertilizer currently in use (fertilizer-1) is better than the suggested one.(or equal)

He is willing to change fertilizer only if the new one is better.

A one-tailed test is controversial. It increase the type I error. In this example, it may be important to know if fertilizer-2 is less effectinve than fertilizer-1, and use the two-tailes test.

Statistics Kingdom



2. P-value

The p-value equals 0, $(p(x \le T) = 1)$. It means that the chance of type I error (rejecting a correct H_0) is small: 0 (0%). The smaller the p-value the more it supports H₁.

3. The statistics

The test statistic T equals 35.53, which is not in the 95% region of acceptance: [-1.9622 : 1.9622].

x1-x2=0.27, is not in the 95% region of acceptance: [-0.01481:0.01481].

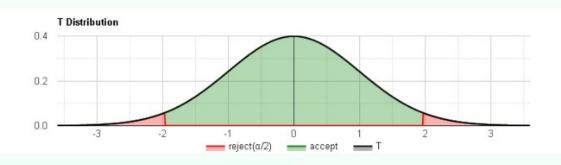
The standard deviation of the difference, S' equals 0.00755, is used to calculate the statistic.

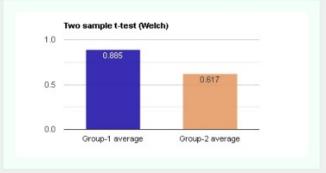
4. Effect size

The observed effect size d is large, 2.2. This indicates that the magnitude of the difference between the average and average is large.

If you like the page, please share or like. Questions, comments and suggestions are appreciated. (statskingdom@gmail.com)

Like 313 Share





Test validation

The requested test was calculated, assumes unequal standard deviation (σ). it is likely you chose the right test.

Test power

The test priori power is strong: 1

Equality of variances assumption

Based on a two-tailed F test, σ_1 is considered as **unequal** to σ_2 (p-value is 2.67e-13)

F test assumes equal standard deviations, which is not your test assumption.

Information

Target: To check if the difference between the average (mean) of two groups (populations) is significant, using sample

Example1: A man of average is expected to be 10cm taller than a woman of average (d=10)

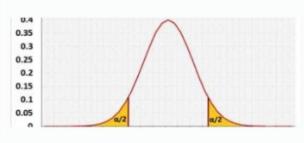
Example 2: The average weight of an apple grown in field 1 is expected to be equal in weight to the average apple grown in field 2 (d=0)

Hypotheses | Test statistic

$$H_0$$
: $\mu_1 = \mu_2 + d$
 H_1 : $\mu_1 \neq \mu_2 + d$

$$egin{aligned} t &= rac{ar{x}_1 - ar{x}_2 - d}{\sqrt{rac{S_1^2}{n_1} + rac{S_2^2}{n_2}}} \ df &= rac{(rac{S_1^2}{n_1} + rac{S_2^2}{n_2})^2}{rac{S_1^4}{n_1^2(n_1 - 1)} + rac{S_2^4}{n_2^2(n_2 - 1)}} \end{aligned}$$

Normal distribution



Assumptions

- Normal distribution
- The standard deviations of both populations not necessarily equal, so either σ₁=σ₂ or 6₁≠6₂)
- d Expected difference d between the populations's average is known.

Required Sample Data

- x x1, x2 Sample average of group1 and group2
- n n₁,n₂ Sample size of group1 and group2
- S₁,S₂ Sample standard deviation of group1 and group2

Examples

1. Two tailed test example:

A factory uses two identical machines to produce plastic plates. You would expect both machines to produce the same number of plates per minute.

Let μ1 = average number of plates produced by machine1 per minute.

Let μ 2 = average number of plates produced by machine2 per minute.

We would expect $\mu 1$ to be equal to $\mu 2$. If one of the machines is slower than the other one, it should be serviced. In this case, we would like to know both if μ 1 < μ 2 or μ 1 > μ 2, since either machine could be slower.

2. Left tail example.

A farmer uses fertilizer-1 with good results.

A friend told him fertilizer-2 is better than fertilizer #1.

Let $\mu 1$ = average number of potatoes per square meter in gardens using fertilizer-1.

```
Let \mu2 = average number of potatoes per square meter in gardens using fertilizer-2.
   The farmer assumes that the fertilizer currently in use (fertilizer-1) is better than the suggested one.(or equal)
   He is willing to change fertilizer only if the new one is better.
   A one-tailed test is controversial. It increase the type I error. In this example, it may be important to know if fertilizer-2 is
   less effectinve than fertilizer-1, and use the two-tailes test.
1
1
   #======Example 1======
2
   #total sms=40
   #group A=20:
3
   print("mean of group A:",Meu(10,10))
4
   print("standard deviation of group A:",SD1(10,10))
5
6
   #group B=20:
  print("mean of group B:",Meu(18,2))
7
   print("standard deviation of group B:",SD1(18,2))
   mean of group A: 0.5
   standard deviation of group A: 0.25
   mean of group B: 0.9
   standard deviation of group B: 0.09
1
  #======Example 2======
2
   #total sms=40
   #group A=30 :
3
  print("mean of group A:",Meu(10,20))
4
  print("standard deviation of group A:",SD1(10,20))
5
6
   #group B=10 :
   print("mean of group B:",Meu(8,2))
7
   print("standard deviation of group B:",SD1(8,2))
8
   standard deviation of group A: 0.22222222222227
   mean of group B: 0.8
   standard deviation of group B: 0.16
   #======Example 3======
1
```

```
2
  #total sms=1000
  #group A=750 :
3
  print("mean of group A:",Meu(98,617))
4
  print("standard deviation of group A:",SD1(98,617))
  #group B=250 :
6
  print("mean of group B:",Meu(47,203))
7
  print("standard deviation of group B:",SD1(47,203))
8
  mean of group A: 0.13706293706293707
  standard deviation of group A: 0.11827668834661842
  mean of group B: 0.188
  standard deviation of group B: 0.15265600000000001
1 #======Example 4======
2 #total sms=1000
3 #group A=750 :
4 print("mean of group A:", Meu(39,711))
5 print("standard deviation of group A:",SD1(39,711))
6 #group B=250 :
7 print("mean of group B:",Meu(9,241))
8 print("standard deviation of group B:",SD1(9,241))
  mean of group A: 0.052
  standard deviation of group A: 0.049296
  mean of group B: 0.036
  standard deviation of group B: 0.034704
1 #======Example 5======
2 #total sms=10000
3 #group A=9000 :
4 print("mean of group A:", Meu(2927, 6073))
5 print("standard deviation of group A:",SD1(2927,6073))
6 #group B=1000 :
7 print("mean of group B:",Meu(742,258))
8 print("standard deviation of group B:",SD1(742,258))
  mean of group A: 0.325222222222225
  standard deviation of group A: 0.21945272839506172
  mean of group B: 0.742
  standard deviation of group B: 0.1914359999999997
1 #======Example 6======
2 #total sms=10000
```