Summary of Inferential Statistics

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One-sample *t*-test

Objectives

To compare one sample mean with specific mean parameter

Null hypothesis	$H_0: \mu = \mu_0$	
Alternative hypothesis	$H_1: \mu \neq \mu_0$	(Two-tailed)
	$H_1: \mu > \mu_0$	(One-tailed)
	$H_1: \mu < \mu_0$	(One-tailed)

Hypothesis Testing, Confidence Interval and Effect Size

Example 1

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
family	120	16.8000	2.86268	.26133

One-Sample Test

	Test Value = 15					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
family	6.888	119	.000	1.80000	1.2825	2.3175

Example 2

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
moralbeh	79	3.1272	.32636	.03672

Author Note

This article was written in July 2008 for teaching in Introduction to Statistics Class, Faculty of Psychology, Chulalongkorn University

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One-Sample Test

	Test Value = 3.1					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
moralbeh	.741	78	.461	.02722	-.0459	.1003

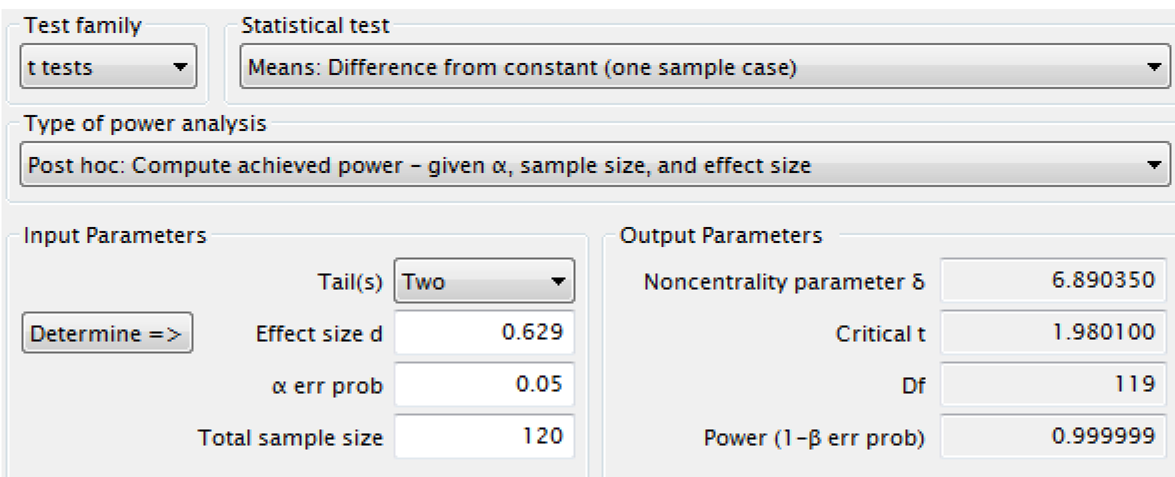
Effect size

$$d = \frac{\bar{X} - \mu_0}{SD} = \frac{16.80 - 15}{2.863} = 0.629$$

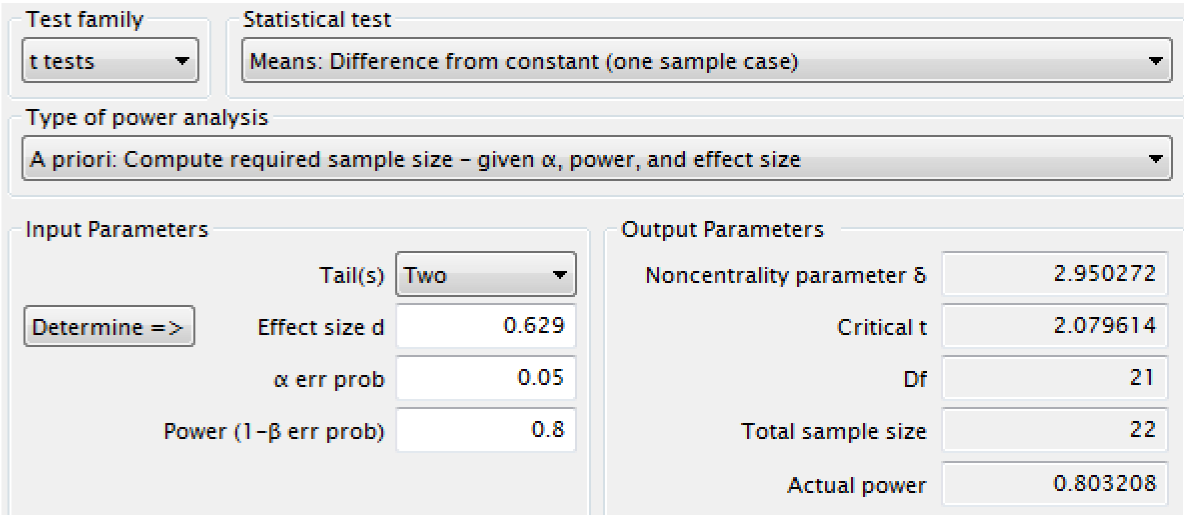
Cohen's *d*: .20 = small; .50 = medium; .80 = large

Power Analysis and Number of Sample

Power Analysis



Determining Number of Samples



Paired-sample *t*-test (Dependent *t*-test)

Objectives

The dependent t test is used when the observations in both groups are not statistical independent.

Samples are dependent if the selection of elements in one sample is affected by the selection of elements in the other.

1) Repeated measures in the same unit.
2) Matching design or randomized block design
3) Twin matching
4) Matching by mutual selection

Null hypothesis $H_0: \mu_1 - \mu_2 = 0; \mu_1 = \mu_2$

Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0; \mu_1 \neq \mu_2$ (Two-tailed)

$H_1: \mu_1 - \mu_2 > 0; \mu_1 > \mu_2$ (One-tailed)

$H_1: \mu_1 - \mu_2 < 0; \mu_1 < \mu_2$ (One-tailed)

Hypothesis Testing, Confidence Interval and Effect Size

Example 1

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	family	16.8000	120	2.86268	.26133
	couple	14.7430	120	3.32347	.30339

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	family & couple	120	.086	.352

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	family - couple	2.05704	4.19622	.38306	1.29854	2.81554	5.370	119	.000

Example 2

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	bpcle	3.4059	79	.34394	.03870
	bmcle	3.3349	79	.45322	.05099

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	bpcle & bmcle	79	.471	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	bpcle - bmcle	.07094	.42055	.04732	-.02326	.16514	1.499	78	.138

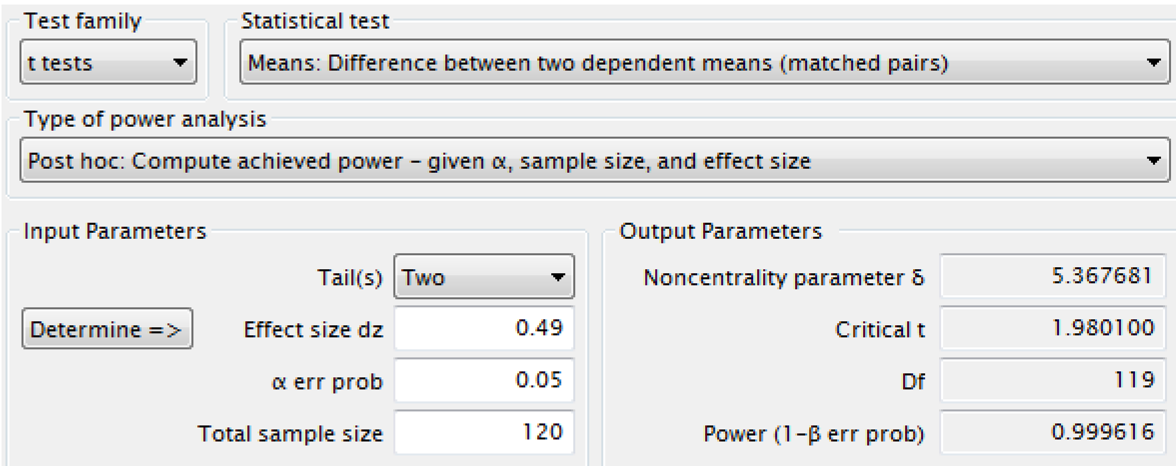
Effect Size

$$d = \frac{\bar{X}_1 - \bar{X}_2}{SD_d} = \frac{d}{SD_d} = \frac{2.057}{4.20} = 0.49$$

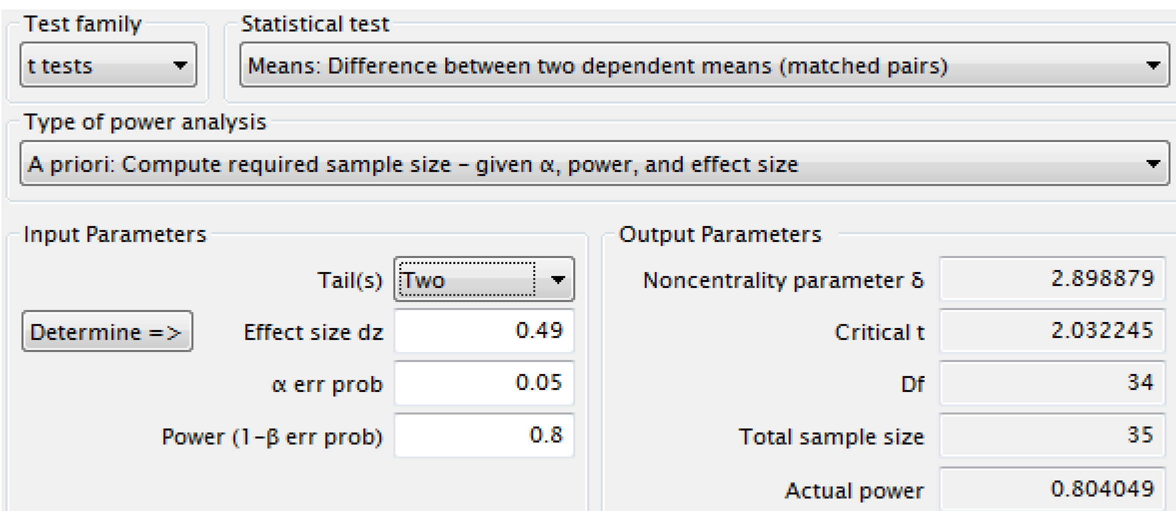
Cohen's *d*: .20 = small; .50 = medium; .80 = large

Power Analysis and Number of Sample

Power Analysis



Determining Number of Samples



Independent-samples T-test

Objectives

Although the population difference is equal to zero, the differences between two sample means are not equal to zero by chance.

Therefore, the difference between two independent sample means must be proved that this difference did not occur by sampling error.

Null hypothesis	$H_0: \mu_1 - \mu_2 = 0; \mu_1 = \mu_2$	
Alternative hypothesis	$H_1: \mu_1 - \mu_2 \neq 0; \mu_1 \neq \mu_2$	(Two-tailed)
	$H_1: \mu_1 - \mu_2 > 0; \mu_1 > \mu_2$	(One-tailed)
	$H_1: \mu_1 - \mu_2 < 0; \mu_1 < \mu_2$	(One-tailed)

Hypothesis Testing, Confidence Interval and Effect Size

Example 1

Group Statistics

	sex	N	Mean	Std. Deviation	Std. Error Mean
family	male	58	16.8621	2.43835	.32017
	female	62	16.7419	3.22864	.41004

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
family	Equal variances assumed	3.558	.062	.229	118	.819	.12013	.52504	-.91958	1.15985
	Equal variances not assumed			.231	113.075	.818	.12013	.52023	-.91053	1.15080

Example 2

Group Statistics

	SchoolID	N	Mean	Std. Deviation	Std. Error Mean
moralbeh	102	79	3.1272	.32636	.03672
	110	50	3.3237	.25749	.03642

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
moralbeh	Equal variances assumed	2.421	.122	-3.604	127	.000	-.19648	.05451	-.30435	-.08860
	Equal variances not assumed			-3.799	120.828	.000	-.19648	.05171	-.29886	-.09409

Effect Size

$$s^2_{\text{pooled}} = \frac{df_1 s_1^2 + df_2 s_2^2}{df_1 + df_2} = \frac{(58-1)(2.438)^2 + (62-1)(3.229)^2}{(58-1)+(62-1)} = 8.261$$

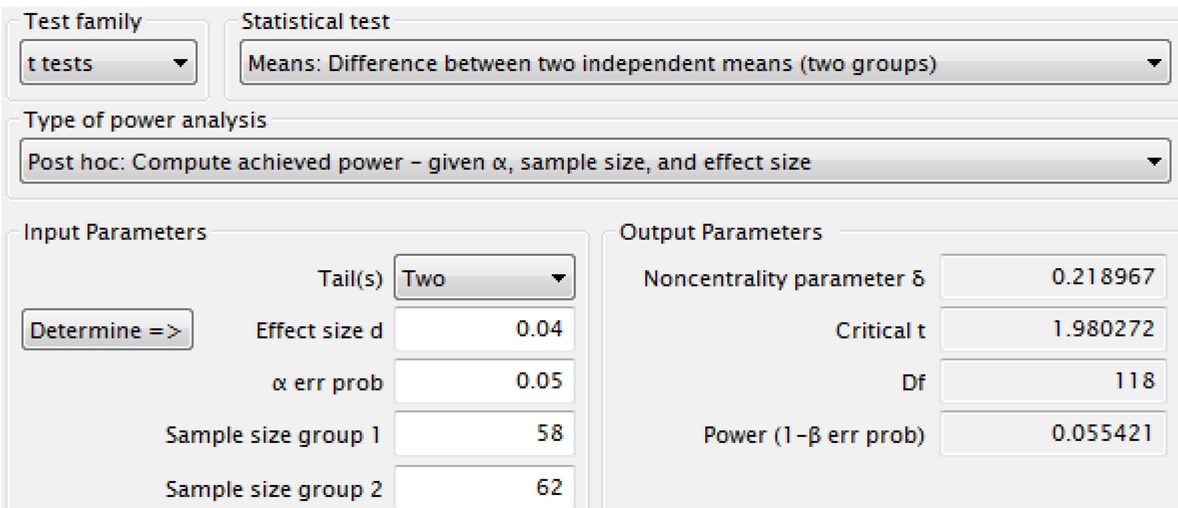
$$d = \frac{\bar{X}_1 - \bar{X}_2}{SD_{\text{pooled}}} = \frac{16.862 - 16.742}{\sqrt{8.261}} = \frac{0.120}{2.874} = 0.04$$

Cohen's *d*: .20 = small; .50 = medium; .80 = large

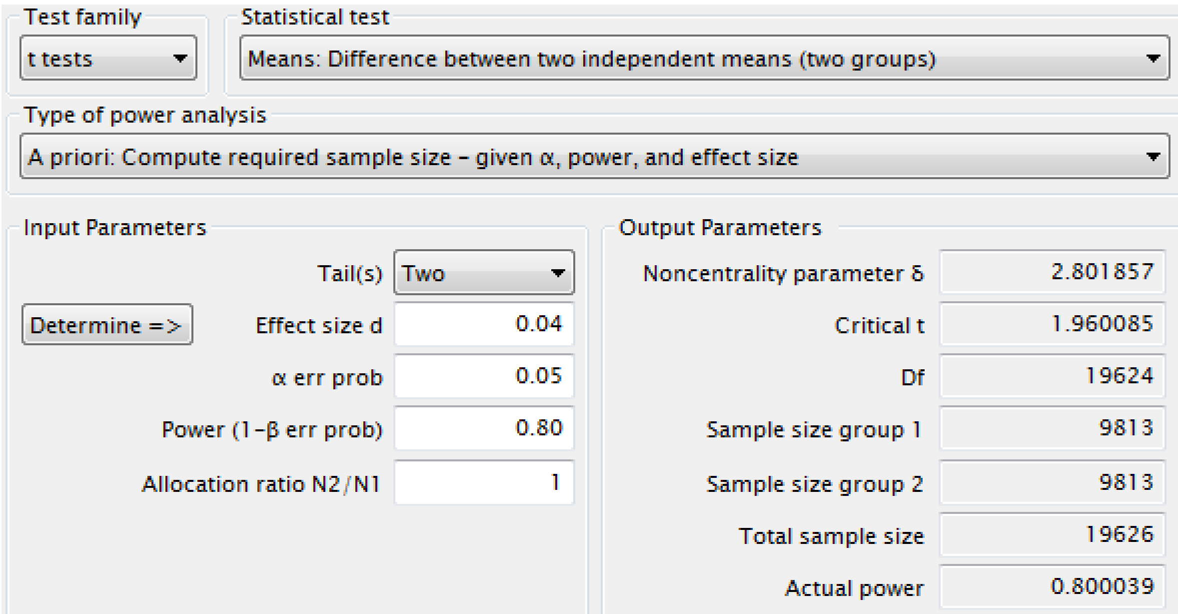
If the assumption that the population variances are equal is not tenable, the variances should not be pooled in computing *d*. Sample standard deviation of control group or the standard deviation of group that is used as baseline is used in place of pooled standard deviation.

Power Analysis and Number of Sample

Power Analysis



Determining Number of Samples



Correlation

Objectives

The correlation coefficient determines the relationship of two variables.

Correlation coefficient (r or ρ)

- Direction (Negative, Positive)
- Strength of relationship
  Correlation: .10 = small; .30 = medium; .50 = large
- Coefficient of determination (Variance explained) → (r^2 or ρ^2)
- Coefficient of nondetermination → ($1 - r^2$ or $1 - \rho^2$)

Therefore, the correlation statistics must be tested for confirming that this correlation is not stemmed from sampling error.

Null hypothesis $H_0: \rho = 0$

Alternative hypothesis $H_1: \rho \neq 0$ (Two-tailed)

$H_1: \rho > 0$ or $H_1: \rho < 0$ (One-tailed)

Types of Correlation

Pearson's correlation	(Interval/Interval)
Point-biserial correlation	(Interval/Dichotomous)
Phi correlation	(Dichotomous/Dichotomous)
Spearman's rank correlation	(Ordinal/Ordinal)

Hypothesis Testing and Effect Size

<u>Pearson's correlation</u>

Correlations

		family	friend	couple
family	Pearson Correlation	1	.285(**)	.086
	Sig. (2-tailed)		.002	.352
	N	120	120	120
friend	Pearson Correlation	.285(**)	1	.396(**)
	Sig. (2-tailed)	.002		.000
	N	120	120	120
couple	Pearson Correlation	.086	.396(**)	1
	Sig. (2-tailed)	.352	.000	
	N	120	120	120

** Correlation is significant at the 0.01 level (2-tailed).

<u>Spearman's rank correlation</u>

Correlations

			family	friend	couple
Spearman's rho	family	Correlation Coefficient	1.000	.282(**)	.116
		Sig. (2-tailed)	.	.002	.207
		N	120	120	120
	friend	Correlation Coefficient	.282(**)	1.000	.294(**)
		Sig. (2-tailed)	.002	.	.001
		N	120	120	120
	couple	Correlation Coefficient	.116	.294(**)	1.000
		Sig. (2-tailed)	.207	.001	.
		N	120	120	120

** Correlation is significant at the 0.01 level (2-tailed).

Pearson's Correlation, Point-biserial correlation, Phi coefficient

Correlations

		evertake	evergive	gpax	unhappywithgrade
evertake	Pearson Correlation	1	.630(**)	-.103(**)	.032
	Sig. (2-tailed)		.000	.001	.298
	N	1093	1093	1085	1087
evergive	Pearson Correlation	.630(**)	1	-.009	-.039
	Sig. (2-tailed)	.000		.779	.201
	N	1093	1093	1085	1087
gpax	Pearson Correlation	-.103(**)	-.009	1	-.472(**)
	Sig. (2-tailed)	.001	.779		.000
	N	1085	1085	1085	1081
unhappywithgrade	Pearson Correlation	.032	-.039	-.472(**)	1
	Sig. (2-tailed)	.298	.201	.000	
	N	1087	1087	1081	1087

** Correlation is significant at the 0.01 level (2-tailed).

Effect Size

Correlation: .10 = small; .30 = medium; .50 = large

Confidence Interval

Pearson's correlation or Point-biserial correlation

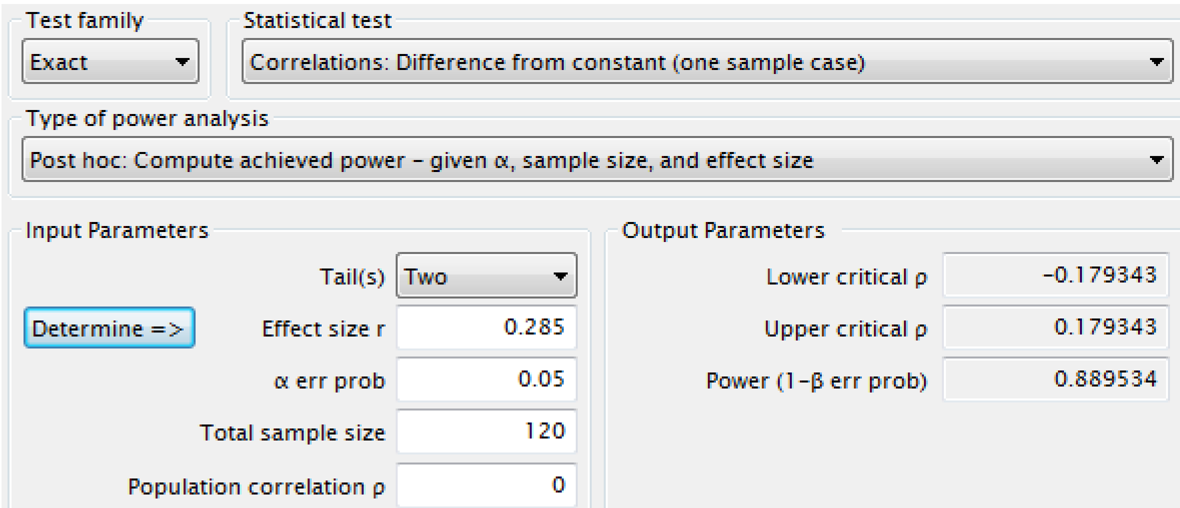
File: CI of r.xls

Confidence Interval of Pearson's Correlation		
r	0.6	
n	50	
CI	0.95	
CI of *r*	0.386	0.753

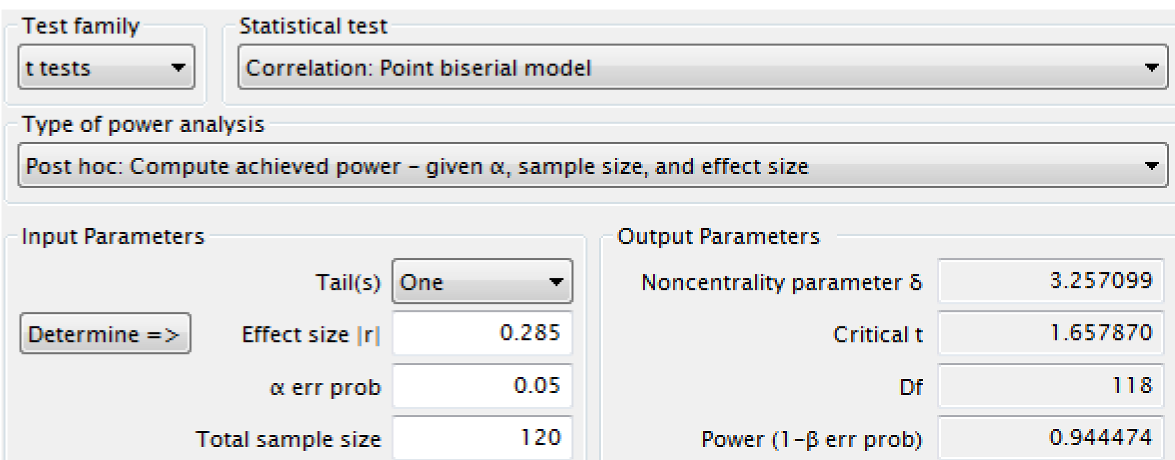
Power Analysis and Number of Sample

Power Analysis

<u>Pearson's correlation</u>

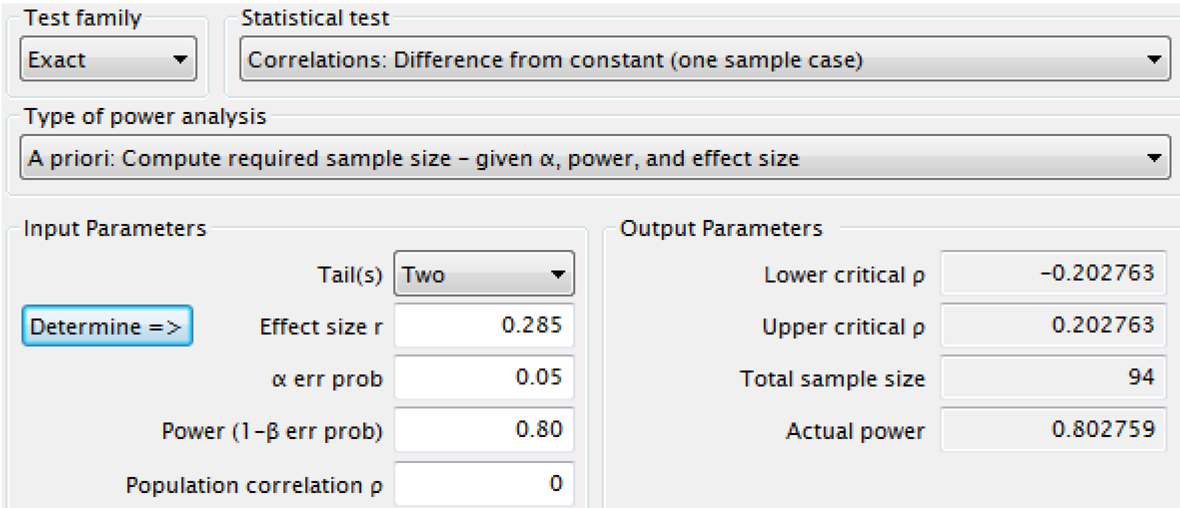


<u>Point-biserial correlation</u>

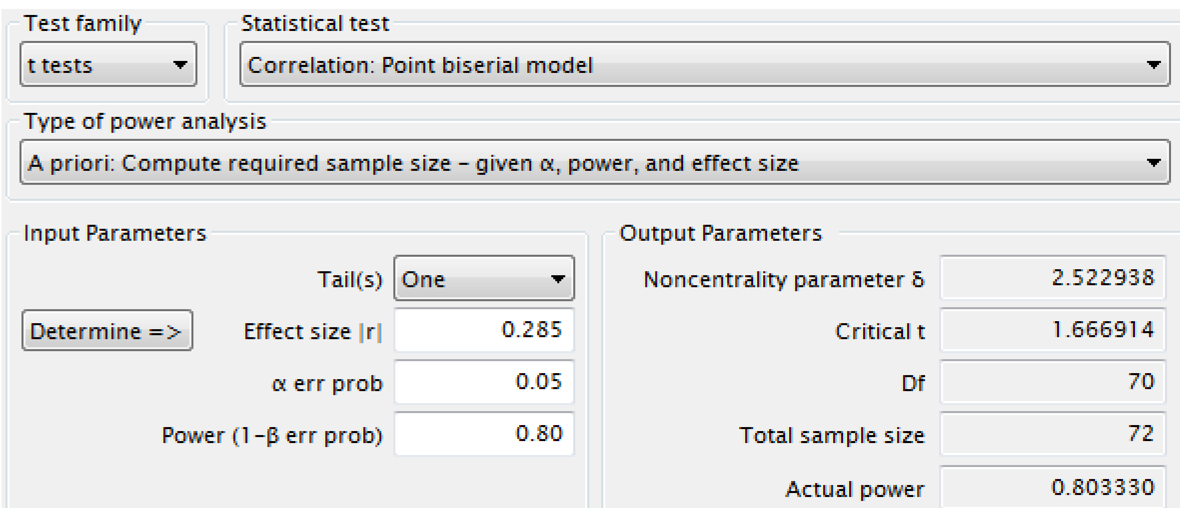


Determining Number of Samples

Pearson's correlation



Point-biserial correlation



One-way Analysis of Variance (One-way ANOVA)

Objectives

Sometimes, researchers want to compare mean differences between three or more independent groups. (If comparing dependent groups, use repeated-measure ANOVA)

Null hypothesis $H_0: \mu_1 = \mu_2 = \mu_3 = \cdots = \mu_k$

If one pair of groups has significant mean differences, the null hypothesis is not tenable.

Alternative hypothesis $H_1: \mu_i \neq \mu_j$

The Analysis of Variance (ANOVA) proves whether the null hypothesis is tenable.

The multiple *t* tests should not be used, because of inflated type I error. The ANOVA method can control the probability of making a type I error equal to α.

If reject null hypothesis, which means are different?

Method of Post Hoc (Multiple Comparisons) Test

Tukey HSD — Homogeneity of Variance / Equal n

Gabriel — Homogeneity of Variance / Unequal n

Games-Howell — Heterogeneity of Variance

Hypothesis Testing and Effect Size

Example 1

Descriptives

SocialSupport

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
high school science	29	62.8797	7.45808	1.38493	60.0428	65.7166	49.00	76.00
high school arts	32	61.5669	9.52880	1.68447	58.1314	65.0024	32.00	77.00
undergraduate	59	65.3553	6.42781	.83683	63.6802	67.0304	47.74	75.00
Total	120	63.7468	7.72156	.70488	62.3510	65.1425	32.00	77.00

Test of Homogeneity of Variances

SocialSupport

Levene Statistic	df1	df2	Sig.
1.711	2	117	.185

ANOVA

SocialSupport

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	326.516	2	163.258	2.822	.064
Within Groups	6768.553	117	57.851		
Total	7095.070	119			

Robust Tests of Equality of Means

SocialSupport

	Statistic(a)	df1	df2	Sig.
Welch	2.598	2	56.752	.083

a Asymptotically F distributed.

Multiple Comparisons

Dependent Variable: SocialSupport

	(I) edu2	(J) edu2	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	high school science	high school arts	1.31285	1.95005	.779	-3.3164	5.9421
		undergraduate	-2.47557	1.72493	.326	-6.5704	1.6193
	high school arts	high school science	-1.31285	1.95005	.779	-5.9421	3.3164
		undergraduate	-3.78842	1.66984	.064	-7.7525	.1756
	undergraduate	high school science	2.47557	1.72493	.326	-1.6193	6.5704
		high school arts	3.78842	1.66984	.064	-.1756	7.7525
Gabriel	high school science	high school arts	1.31285	1.95005	.875	-3.4071	6.0328
		undergraduate	-2.47557	1.72493	.379	-6.5889	1.6377
	high school arts	high school science	-1.31285	1.95005	.875	-6.0328	3.4071
		undergraduate	-3.78842	1.66984	.069	-7.7856	.2088
	undergraduate	high school science	2.47557	1.72493	.379	-1.6377	6.5889
		high school arts	3.78842	1.66984	.069	-.2088	7.7856
Games-Howell	high school science	high school arts	1.31285	2.18071	.820	-3.9329	6.5585
		undergraduate	-2.47557	1.61812	.286	-6.3864	1.4352
	high school arts	high school science	-1.31285	2.18071	.820	-6.5585	3.9329
		undergraduate	-3.78842	1.88088	.120	-8.3414	.7646
	undergraduate	high school science	2.47557	1.61812	.286	-1.4352	6.3864
		high school arts	3.78842	1.88088	.120	-.7646	8.3414

Example 2

Descriptives

moralbeh

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
102	79	3.1272	.32636	.03672	3.0541	3.2003	2.13	3.80
106	77	3.1913	.25750	.02934	3.1329	3.2498	2.60	3.62
110	50	3.3237	.25749	.03642	3.2505	3.3969	2.53	3.80
114	80	3.2153	.24835	.02777	3.1600	3.2706	2.71	3.67
Total	286	3.2035	.28206	.01668	3.1706	3.2363	2.13	3.80

Test of Homogeneity of Variances

moralbeh

Levene Statistic	df1	df2	Sig.
1.651	3	282	.178

ANOVA

moralbeh

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.205	3	.402	5.274	.001
Within Groups	21.469	282	.076		
Total	22.673	285			

Robust Tests of Equality of Means

moralbeh

	Statistic(a)	df1	df2	Sig.
Welch	5.037	3	146.592	.002

a Asymptotically F distributed.

Multiple Comparisons

Dependent Variable: moralbeh
Gabriel

(I) SchoolID	(J) SchoolID	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
102	106	-.06413	.04419	.615	-.1812	.0529
	110	-.19648*	.04986	.001	-.3277	-.0652
	114	-.08810	.04376	.241	-.2040	.0278
106	102	.06413	.04419	.615	-.0529	.1812
	110	-.13235*	.05011	.049	-.2643	-.0004
	114	-.02397	.04405	.995	-.1406	.0927
110	102	.19648*	.04986	.001	.0652	.3277
	106	.13235*	.05011	.049	.0004	.2643
	114	.10838	.04974	.162	-.0225	.2392
114	102	.08810	.04376	.241	-.0278	.2040
	106	.02397	.04405	.995	-.0927	.1406
	110	-.10838	.04974	.162	-.2392	.0225

*. The mean difference is significant at the .05 level.

Effect Size

<u>Overall Difference</u>

<u>Eta squared</u>

$$\eta^2 = \frac{SS_{\text{group}}}{SS_{\text{total}}} = \frac{326.52}{7095.07} = 0.046$$

<u>Omega squared</u>

$$\omega^2 = \frac{(k-1)(F-1)}{(k-1)(F-1)+nk} = \frac{(3-1)(2.822-1)}{(3-1)(2.822-1)+(120)(3)} = 0.010$$

Omega squared: .010 = small; .059 = medium; .138 = large

<u>*Cohen's f*</u>

$$f = \frac{\sigma_M}{\sigma} = \frac{\frac{\sum(M-\mu_M)^2}{k}}{\sqrt{MS_{\text{error}}}} = \frac{1.57}{7.606} = 0.206$$

Cohen's *f*: .10 = small; .25 = medium; .40 = large

<u>Each comparison</u>

$$d = \frac{\bar{X}_1 - \bar{X}_2}{SD_{\text{pooled}}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{MS_{\text{error}}}}$$

$$d_{1-2} = \frac{1.313}{\sqrt{57.851}} = 0.17$$

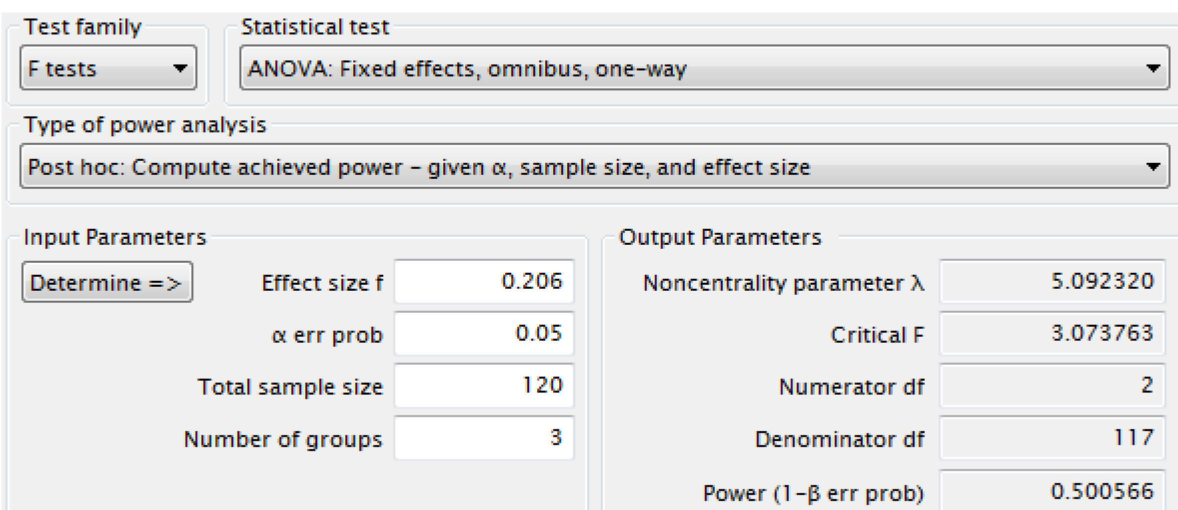
$$d_{1-3} = \frac{-2.476}{\sqrt{57.851}} = -0.33$$

$$d_{2-3} = \frac{-3.788}{\sqrt{57.851}} = -0.50$$

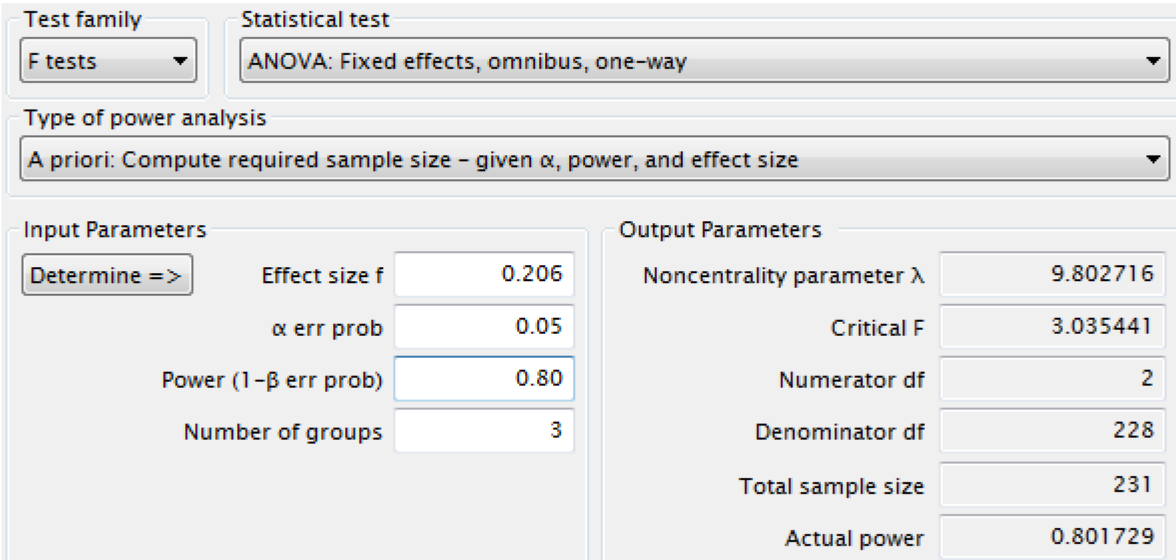
Cohen's *d*: .20 = small; .50 = medium; .80 = large

Power Analysis and Number of Sample

Power Analysis



Determining Number of Samples



Simple Regression

Objectives

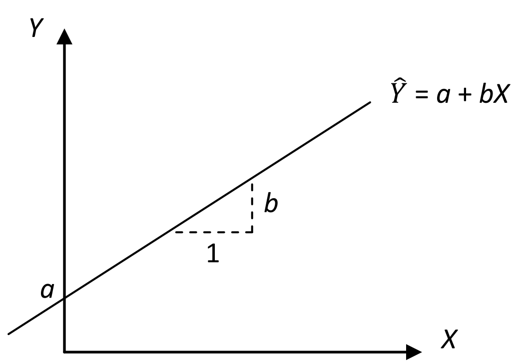
When two variables are correlated, the knowledge of one variable can predict the value of another variable.

Predictor Variable (Independent Variable; *X*) is the variable use for prediction
Predicted variable (Criterion Variable or Dependent Variable; *Y*) is the variable predicted by *X*.
Actual Value (Y), Predicted Value ($\hat{Y}$), Error of Prediction (e)

$$Y - \hat{Y} = e$$

Regression Line

$$\hat{Y} = a + bX$$



Slope (*b*) is change in predicted *Y* if *X* change in one unit.

Y-intercept (*a*) is predicted *Y* value if *X* = 0.

You must test $H_0: \rho = 0$ before run regression analysis. If the correlation is equal to 0, the predictor is not predicted more precise than $\bar{Y}$.

There are two more null hypotheses testing in regression analysis.

$H_0: a = 0$ and $H_0: b = 0$

The alternative hypotheses are

$H_0: a \neq 0$ and $H_0: b \neq 0$ (Two-tailed)

$H_0: a > 0$ and $H_0: b > 0$ (One-tailed)

$H_0: a < 0$ and $H_0: b < 0$ (One-tailed)

Standardized regression coefficient (β) is the change in predicted standard score of *Y* if *X* change in one standard score unit (one *SD*).

Standard regression coefficient (β): .10 = small; .30 = medium; .50 = large

In simple regression, the correlation coefficient is equal to standardized regression coefficient.

If there are more than one predictors in regression analysis, the name is changed to multiple regression.

$$\hat{Y} = a + b_1X_1 + b_2X_2$$

Hypothesis Testing and Effect Size

Example 1

Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
1	couple(a)	.	Enter

a All requested variables entered.
b Dependent Variable: family

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.086(a)	.007	-.001	2.86419

a Predictors: (Constant), couple

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.175	1	7.175	.875	.352(a)
	Residual	968.025	118	8.204		
	Total	975.200	119			

a Predictors: (Constant), couple
b Dependent Variable: family

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	15.711	1.194		13.161	.000
	couple	.074	.079	.086	.935	.352

a Dependent Variable: family

Example 2

Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
1	bdelig(a)	.	Enter

a All requested variables entered.
b Dependent Variable: Grade

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.326(a)	.106	.103	.44796

a Predictors: (Constant), bdelig

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.700	1	6.700	33.386	.000(a)
	Residual	56.387	281	.201		
	Total	63.087	282			

a Predictors: (Constant), bdelig
b Dependent Variable: Grade

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.303	.147		15.694	.000
	bdelig	.286	.049	.326	5.778	.000

a Dependent Variable: Grade

Effect Size

<u>All predictors</u>

$$f^2 = \frac{R^2}{1 - R^2} = \frac{0.007}{1 - 0.007} = 0.007$$

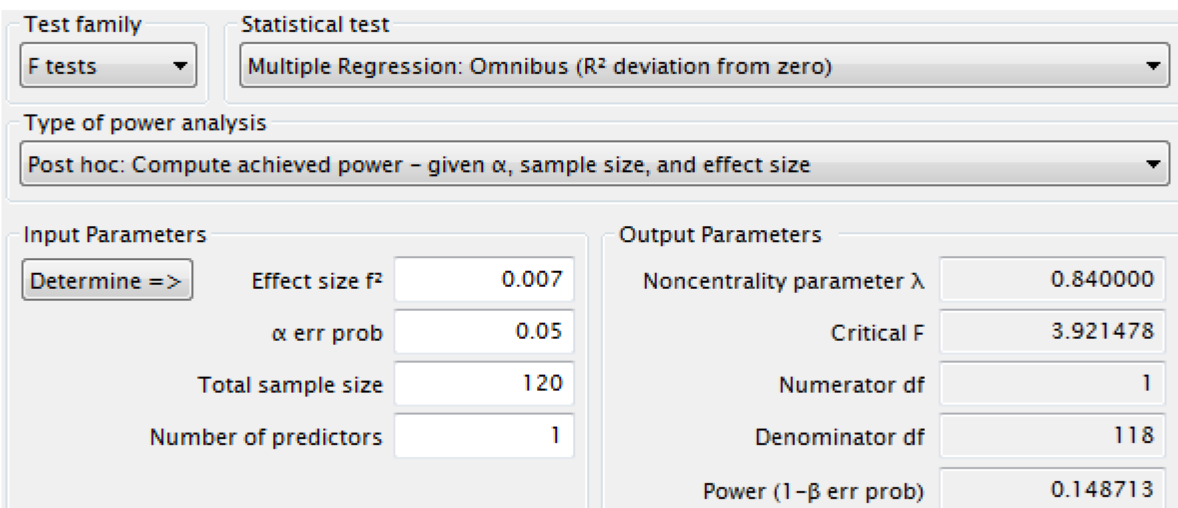
<u>*f* squared</u>: .02 = small; .15 = medium; .35 = large

<u>Each predictors</u>

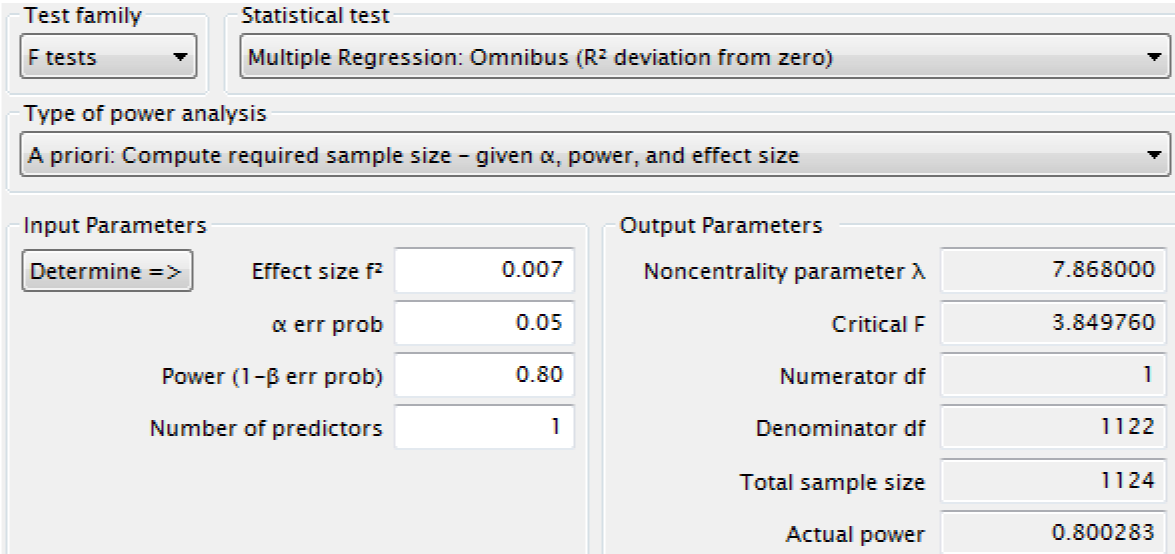
<u>Standard regression coefficient (β)</u>: .10 = small; .30 = medium; .50 = large

Power Analysis and Number of Sample

Power Analysis



Determining Number of Samples



Chi-Square: Goodness-of-fit Test

Objectives

The chi-square goodness-of-fit test is used for testing that the proportion is different from expected proportion.

Null hypothesis $H_0: p_1 = P_1; p_2 = P_2; \ldots; p_i = P_i$

or $H_0: (p_1 : p_2 : \ldots : p_i) = (P_1 : P_2 : \ldots : P_i)$

Alternative hypothesis $H_1: p_i \neq P_i$ for one or more categories

or $H_0: (p_1 : p_2 : \ldots : p_i) \neq (P_1 : P_2 : \ldots : P_i)$

Hypothesis Testing and Effect Size

Example 1

age

	Observed N	Expected N	Residual
15	4	13.3	-9.3
16	18	13.3	4.7
17	26	13.3	12.7
18	23	13.3	9.7
19	14	13.3	.7
20	16	13.3	2.7
21	12	13.3	-1.3
22	6	13.3	-7.3
23	1	13.3	-12.3
Total	120		

Test Statistics

	age
Chi-Square(a)	43.350
df	8
Asymp. Sig.	.000

a 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 13.3.

Example 2

evertake

	Observed N	Expected N	Residual
.00	377	546.5	-169.5
1.00	716	546.5	169.5
Total	1093		

Test Statistics

	evertake
Chi-Square(a)	105.143
df	1
Asymp. Sig.	.000

a 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 546.5.

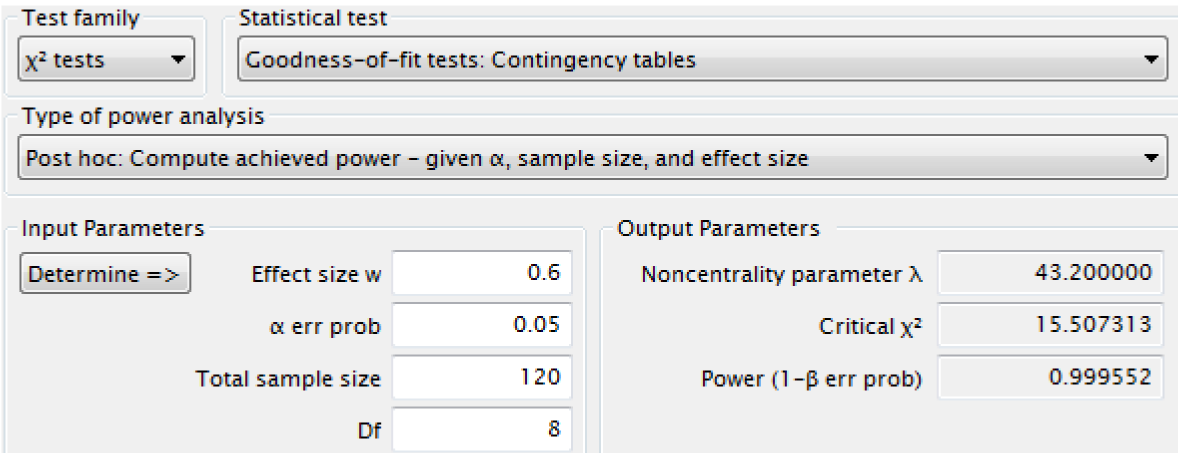
Effect Size

$$w = \sqrt{\frac{\chi^2}{n}} = \sqrt{\frac{43.35}{120}} = 0.60$$

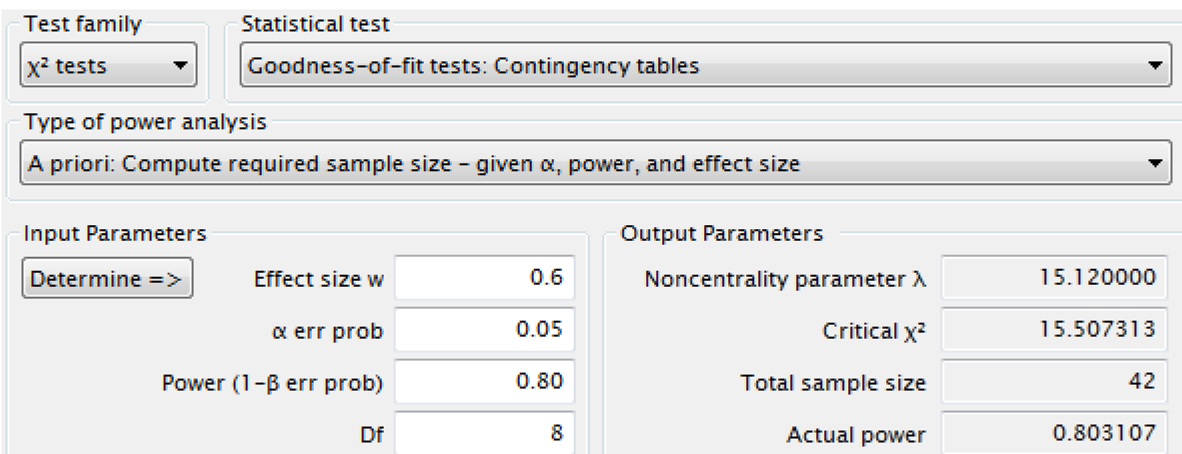
Cohen's *w*: .10 = small; .30 = medium; .50 = large

Power Analysis and Number of Sample

Power Analysis



Determining Number of Samples



Chi-Square: Contingency Table

Objectives

The chi-square contingency table is used for testing whether groups are equal in distribution of proportion of each category.

Null hypothesis $H_0: (p_1: p_2: \ldots : p_i)_1 = (p_1: p_2: \ldots : p_i)_2 = \cdots = (p_1: p_2: \ldots : p_i)_k$

Alternative hypothesis: $H_1: (p_1: p_2: \ldots : p_i)_k = (p_1: p_2: \ldots : p_i)_l$ for one or more categories

Hypothesis Testing, Confidence Interval and Effect Size

Example 1

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
evergive * evertake	1093	100.0%	0	.0%	1093	100.0%

evergive * evertake Crosstabulation

			evertake		Total
			.00	1.00	.00
evergive	.00	Count	325	147	472
		% within evertake	86.2%	20.5%	43.2%
	1.00	Count	52	569	621
		% within evertake	13.8%	79.5%	56.8%
Total		Count	377	716	1093
		% within evertake	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	434.167(b)	1	.000		
Continuity Correction(a)	431.494	1	.000		
Likelihood Ratio	465.360	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	433.770	1	.000		
N of Valid Cases	1093				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 162.80.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.630	.000
	Cramer's V	.630	.000
N of Valid Cases		1093	

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.

Example 2

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
evertake * class	1087	99.5%	6	.5%	1093	100.0%

evertake * class Crosstabulation

			class				Total
			1	2	3	4	1
evertake	.00	Count	115	93	91	77	376
		% within class	37.0%	30.6%	34.2%	37.4%	34.6%
	1.00	Count	196	211	175	129	711
		% within class	63.0%	69.4%	65.8%	62.6%	65.4%
Total		Count	311	304	266	206	1087
		% within class	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.656(a)	3	.301
Likelihood Ratio	3.682	3	.298
Linear-by-Linear Association	.032	1	.858
N of Valid Cases	1087		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 71.26.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.058	.301
	Cramer's V	.058	.301
N of Valid Cases		1087	

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.

Effect Size

<u>Phi</u>: Pearson's *r* in 2 x 2 contingency table

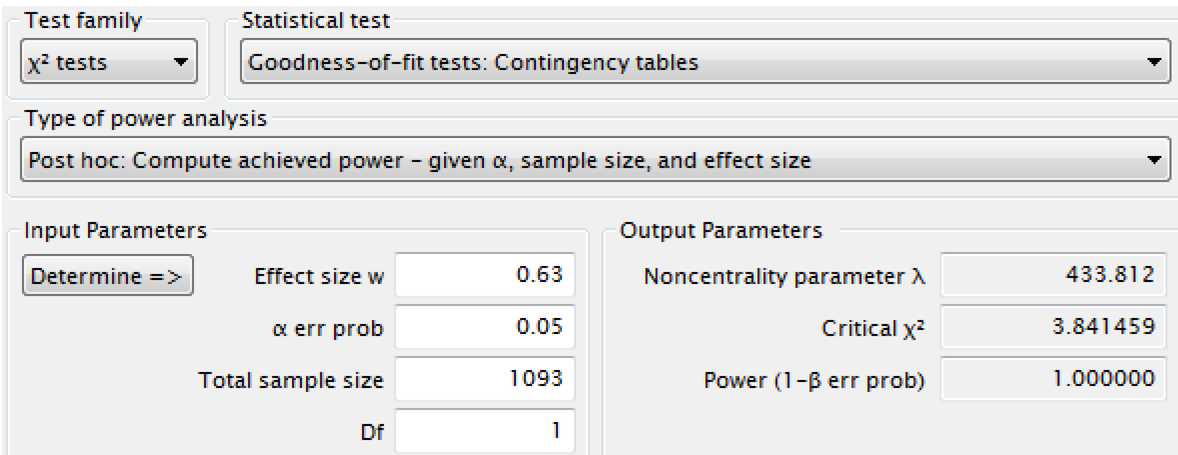
<u>Cohen's *w*</u>

$$w = \sqrt{\frac{\chi^2}{n}} = \sqrt{\frac{434.167}{1093}} = 0.63$$

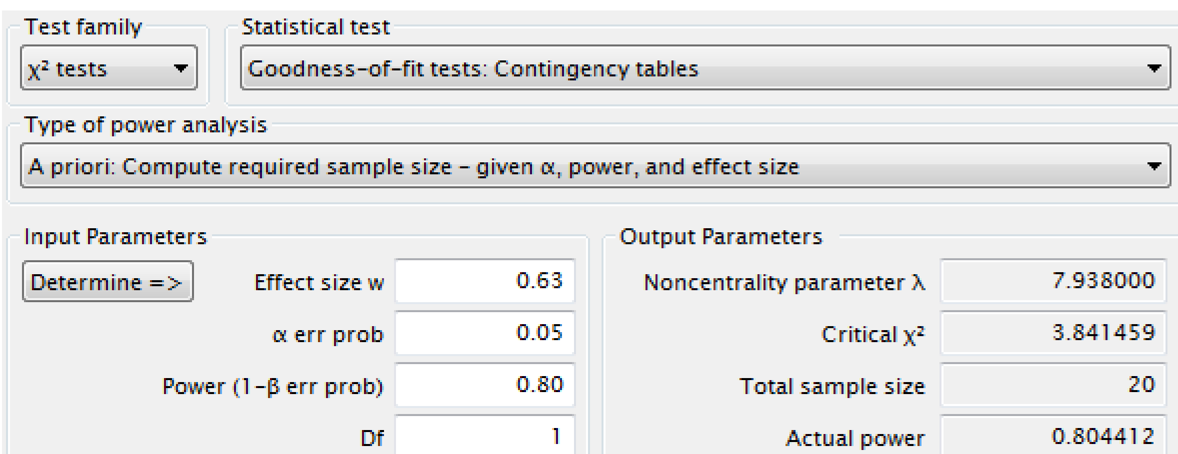
Cohen's *w*: .10 = small; .30 = medium; .50 = large

Power Analysis and Number of Sample

Power Analysis



Determining Number of Samples



Correlation (or Difference) and Causation

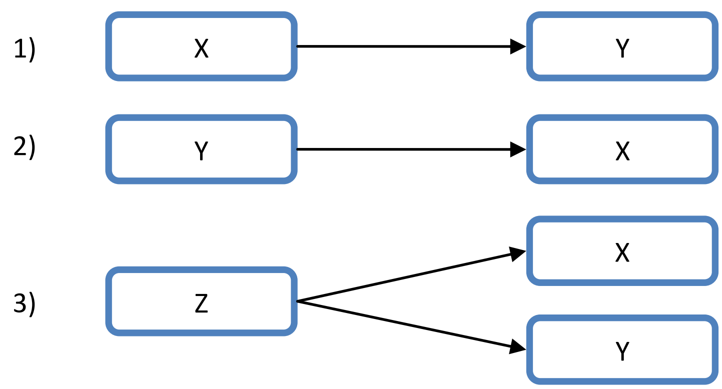
The conditions make causal relation

1) X precedes Y in time
2) Some mechanism explained
3) Change in X is accompanied by change in Y
4) Effect X on Y cannot be explained by other variables

The research design that can prove casual relationship is experimental design.

Interpretation of correlation (or difference)

1) X causes Y.
2) Y causes X.
3) Z causes both X and Y.



Statistical Decision Tree

In this statistical decision tree, the statistics that include in this tree are only in introduction to statistics lecture. For advanced statistic, this decision tree will enhance its sophistication.

1) Fitting Population Parameters
    a. Means → One-sample *z*-test or One-sample *t*-test
    b. Proportions → Chi-square Goodness-of-fit
2) Comparison between Groups
    a. Means
        i. Independent Group
            1. Two Categories → Independent *t*-test
            2. Three or More Categories → One-way ANOVA
        ii. Dependent Group
            1. Two Categories → Dependent *t*-test
            2. Three or More Categories → Repeated-measure ANOVA
    b. Proportions → Chi-square
3) Correlation
    a. Interval & Interval → Pearson's correlation (Prediction: Simple Regression)
    b. Interval & Dichotomous → Point-biserial Correlation
    c. Ordinal & Ordinal → Spearman's rank correlation
    d. Dichotomous & Dichotomous → Phi Coefficient