HANDOUT ON HOW TO RUN POWER USING G*POWER PROGRAM

G*Power is a freeware power program developed by Axel Buchner, Franz Faul, & Edgar Erdfelder at the University of Düsseldorf. The website is:

http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3/

The power program implements a large number of options. In particular for correlation and regression, they have a few routines. G*Power was based on Cohen's 1988 book, thus if you want to fully understand how to use G*Power to its maximum, at some point you may want to read Cohen's book

Based on the description of how the program operates in the tutorial, you have three options for every routine[1]: you can ask for 1) a **Post-hoc power** analysis, 2) an **A priori power** analysis or you can ask for 3) a **Compromise power** analysis.

Post-hoc analysis is used when you want to estimate power. The program works from the assumption that you have collected data already, and are trying to estimate the power for the data that you have.

A priori analysis is used when you want to figure out how many subjects you need to reach a specific level of power.

Compromise power analysis is used when you understand that your power may be low, but you know that you cannot possibly get as many subjects as you may need. In that case, you manipulate how much you are willing to risk in terms of making a type I error or a type II error. You are forced to produce a ratio of beta to alpha (i.e., beta/alpha). For an explanation of how to interpret this beta/alpha ratio, check the "Compromise power analyses" webpage: http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3/user-guide-type_of_power_analysis/compromise

POWER FOR CORRELATION

Starting with G*Power 3.2 (and higher), we can calculate power for different types of correlations:
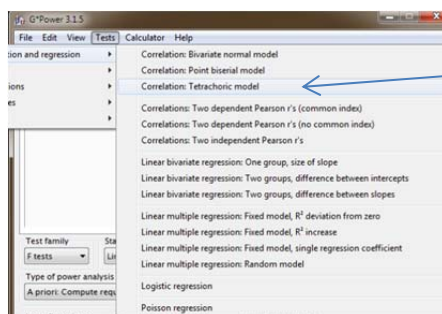
Correlation: Tetrachoric correlation is what we have learned for correlations under dichotomous variables

---

[1] In fact, there are five options. Briefly, a **criterion power analysis** involves computing alpha, based on the sample size, the effect size and the statistical power level. Mostly used as an alternative to post hoc power analysis where the control of alpha is less important than the control of beta. A **sensitivity power analysis** involves determining the effect size based on the sample size, statistical power level and the alpha level. Mostly used when evaluating research published by others. It helps you determine the minimum effect size that the study could capture, given a specific power, and based on the sample size and the alpha specified.

TO ESTIMATE POWER, WE NEED TO:

- Switch to **Post hoc** mode
- Test family: Exact
- Figure out if you want to calculate power based on either one- or two-tails
- Alpha
- Number of cases
- Correlation ρH1 (the correlation coefficient you computed) and ρH0 (the correlation coefficient for the population under the null hypothesis). Most times, we'll set the correlation under the null hypothesis as zero, but G*Power will give you the option to change it if you know the population value.
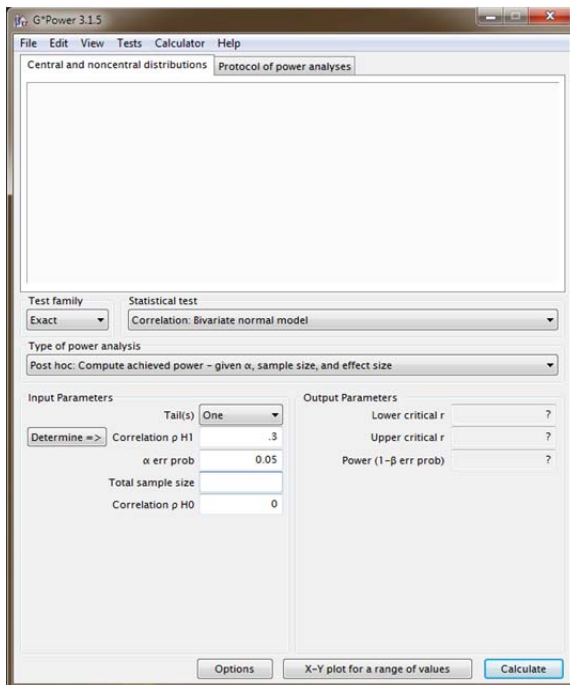

- There is an option where you can provide R^2 (Coefficient of determination ρ^2 in G*Power lingo), and you can ask G*Power to "calculate r" for you (under "*Determine*")

You can Provide R^2, as an estimate
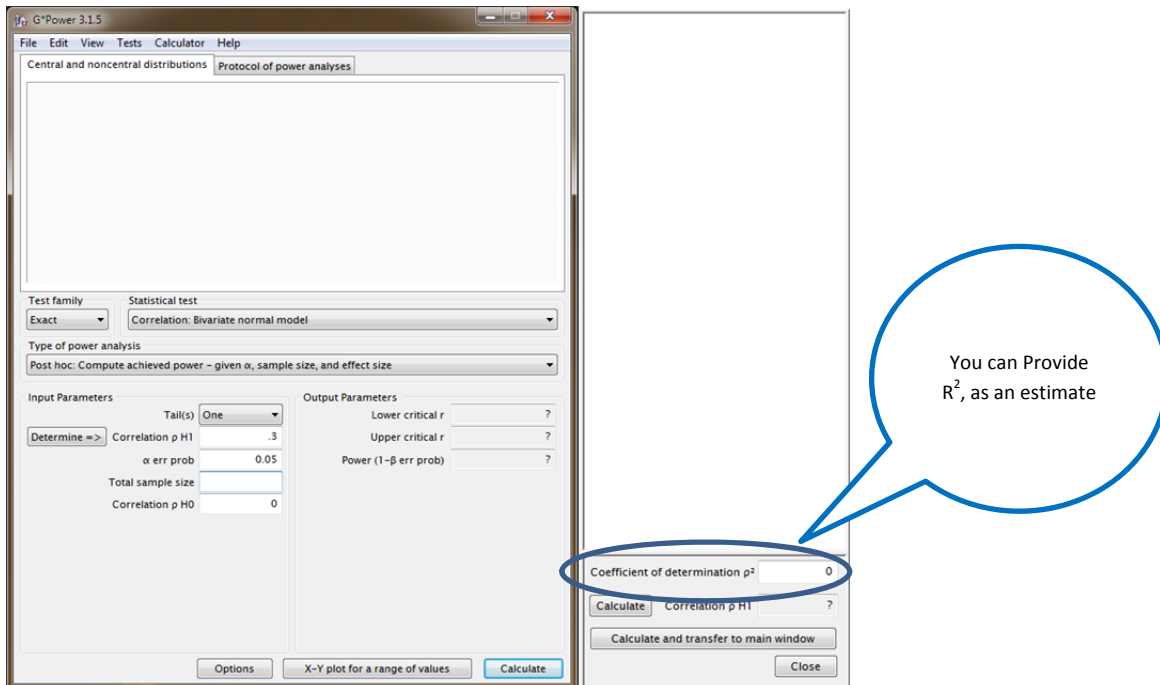
YOU GET:

- Power (1-β err probability)
- Upper and lower critical r (you can reject the null hypothesis if the correlation coefficient is larger than the lower/upper critical value)

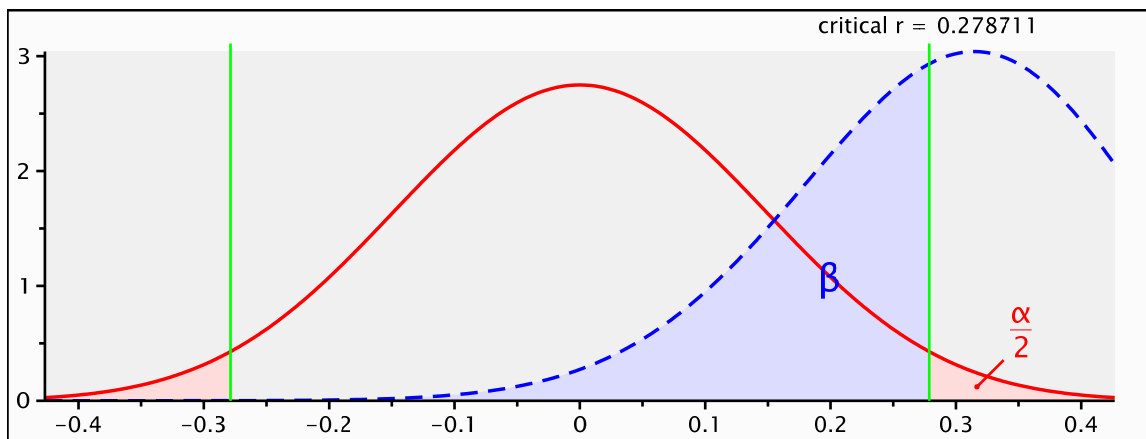Estimated Power based on the input parameters you provided
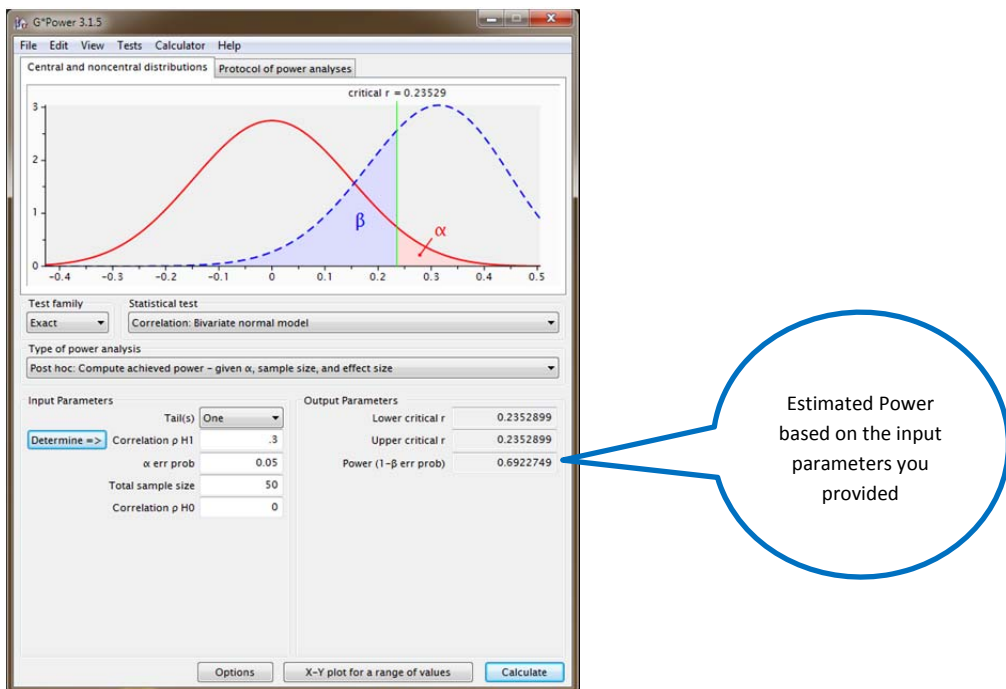
Notice that in the above example, the upper and lower critical r's are the same. That is because I asked for a one-tail test. If you ask for a two-tail test, you get something like this:
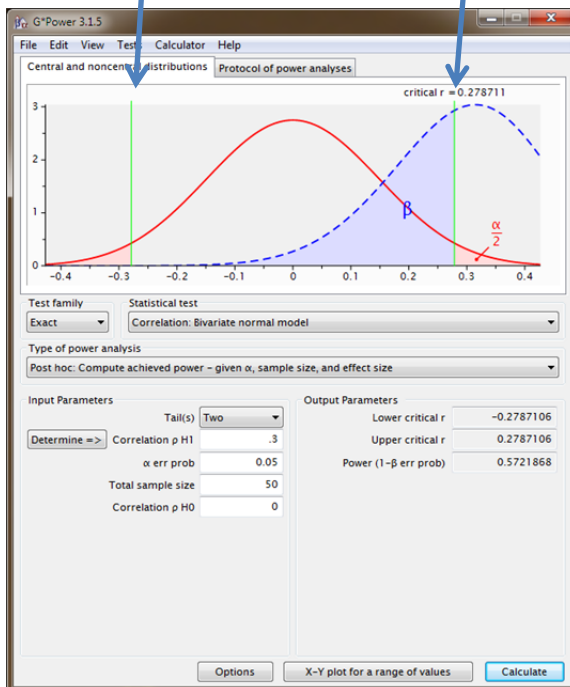
There is an option to copy the graph (Edit ➔ copy distribution plot). Once you copy the graph, you can paste it. The chart looks like this:

TO ESTIMATE SAMPLE SIZE OF A CORRELATION COEFFICIENT ESTIMATE:

- Switch to **A priori** mode
- Select test family: EXACT
- Figure out if you want to calculate power based on either one- or two-tails
- Correlation under the alternative (ρH1) and under the null (ρH0) hypothesis
- Notice that for alternative, we can use Cohen's estimates (i.e., we can use small (r = 0.1), medium (r = 0.3) or large (r = 0.5)). There is an option where you can provide R^2, (Coefficient of determination ρ^2 in G*Power lingo) and you can ask G*Power to "calculate r" for you (under "Determine")
- Alpha
- Power

YOU GET:

- Lower and upper critical r
- Total sample size
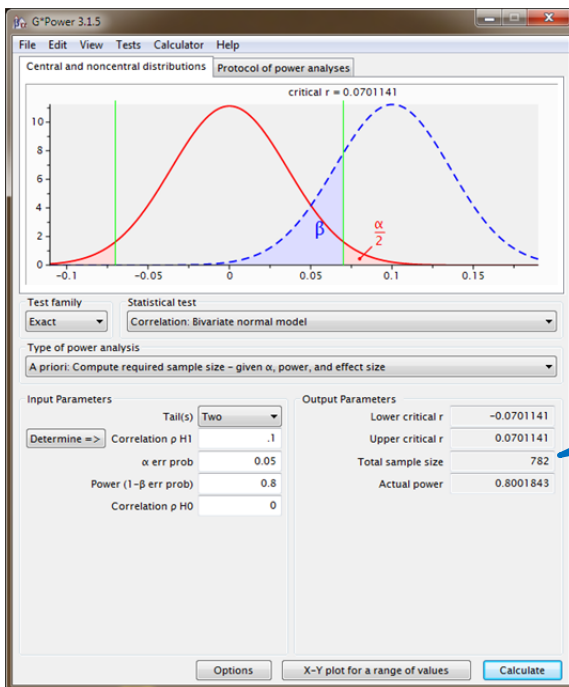
This is the sample size estimate you will need, given the input parameters you provided

POWER FOR TWO INDEPENDENT CORRELATIONS

You can compute both power and sample size for two independent correlations.

TO ESTIMATE POWER, WE NEED TO:

- Tests (main menu) ➔ Correlation ➔ independent Pearson r's
- Switch to **Post hoc** mode
- Figure out if you want to calculate power based on either one- or two-tails
- Effect size q (the correlation coefficient you computed/found)
- Alpha
- Sample size group for groups 1 and 2


YOU GET:

- Critical z
- Power

This is the power estimate you get given the input parameters you provided

TO ESTIMATE SAMPLE SIZE OF TWO INDEPENDENT CORRELATION COEFFICIENTS:

- Tests (main menu) ➔ Correlation ➔ independent Pearson r's
- Switch to **A priori** mode
- Figure out if you want to calculate power based on either one- or two-tails
- Effect size q (correlation coefficient you expect to get)
- Alpha
- Power
- Allocation ratio N2/N1 (the sample sizes for your two groups), submitted as a ratio (i.e., N2/N1)

YOU GET:

- Critical z
- Sample size groups 1 and 2
- Total sample size (N1 + N2)
- Actual Power
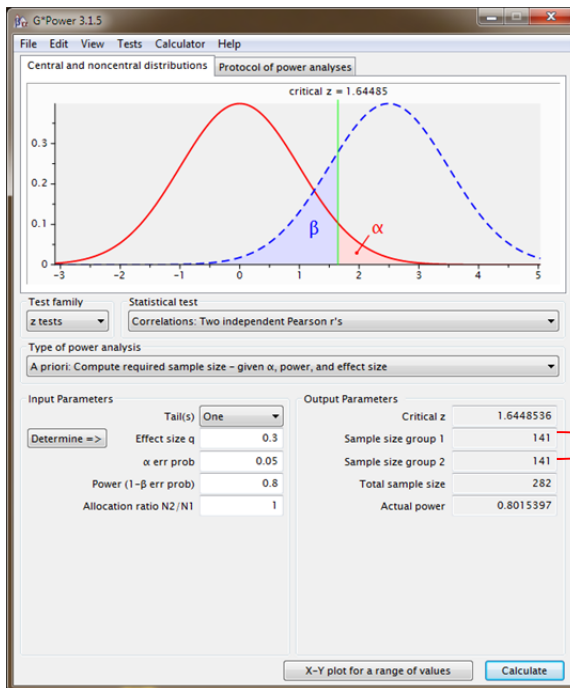
These are the sample sizes **(group 1 and group 2)** you will need, given the input parameters you provided

POWER FOR TWO DEPENDENT CORRELATIONS

You can compute both power and sample size for two dependent correlations. You can compute for correlations where one of the variables is the same or for when the variables are different. Requires that you create a correlation matrix, and organize it according to some specific rules that the authors present in

http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3/user-guide-by-distribution/z/correlations_two_dependent_pearson_rs

POWER FOR REGRESSION

Just like in the case of correlation, there are multiple options. We'll just cover some of them in this handout.

SIMPLE REGRESSION

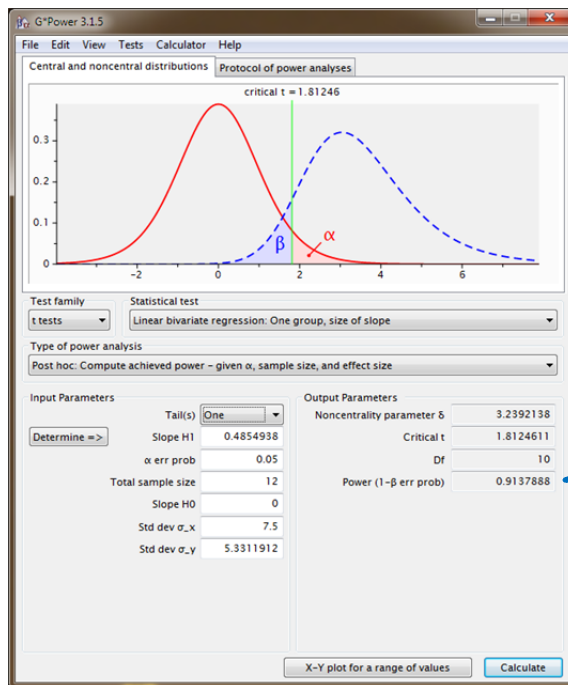### POWER FOR SIMPLE REGRESSION, SIZE OF THE SLOPE

- Tests (main menu) ➔ Correlation ➔ linear bivariate regression one group, size of slope
- Switch to **Post-hoc** mode
- Figure out if you want to calculate power based on either one- or two-tails

- Slope under the alternative hypothesis (the slope you computed from your data or guesstimated)
- Alpha
- Total sample size
- Slope under the null hypothesis
- Standard deviation of x and of y (computed from your data), or guesstimated

YOU GET:

- Non-centrality parameter lambda[2] (λ)
- Critical t
- Degrees of freedom
- Power

---

[2] It is customary to use lambda (λ) to describe the noncentrality parameter. However, the authors use delta (δ). We'll stick with the convention of using lambda

The callout in the figure reads: "This is the power estimate you get given the input parameters you provided"

## SAMPLE SIZE FOR SIMPLE REGRESSION, SIZE OF THE SLOPE

- Tests (main menu) ➜ Correlation ➜ linear bivariate regression one group, size of slope
- Switch to **A priori** mode
- Figure out if you want to calculate power based on either one- or two-tails
- Slope under the alternative hypothesis (the slope you computed from your data or guesstimated). Note: if you only have a correlation, you can compute the slope by using the "Determine" option. More below
- Alpha
- Power
- Slope under the null hypothesis (usually zero, but you could change this if you have information regarding the slope under the null hypothesis).
- Standard deviation of x and of y (computed from your data, or guessed)

- As mentioned above, you can use a correlation coefficient (as a form of effect size) by using the "Determine" option. However, note that if you use this option, you now need to provide estimates for standard deviation of the residuals and standard deviation of x. G*Power will estimate the values for the standard deviation of y and the slope under the alternative hypothesis.

Notice that you need to provide the correlation, standard deviation of the residuals, and standard deviation of x

YOU GET:

- Non-centrality parameter λ
- Critical t
- Degrees of freedom

- Total sample size
- Actual Power
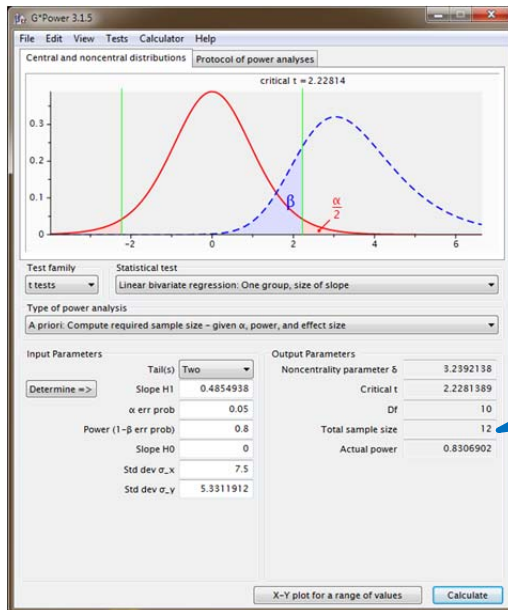
This is the sample size estimate you get given the input parameters you provided

MULTIPLE REGRESSION

IMPORTANT NOTE FOR MULTIPLE REGRESSION ESTIMATES: you'll notice that to compute power, G*Power is asking for something called f^2. f^2 is estimated as follows:

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

If you don't want to calculate this, or if you are using some of the effect size estimates Cohen (77) and Cohen & Cohen (83) provide as customary (i.e., 0.1 for small effect size, 0.3 for medium and 0.5 for high), you can always use the option "*Determine*", but make sure you provide G*Power with R^2 values (i.e., raise the customary effect sizes to the square).

To calculate f^2, you can use the multiple correlation (or your estimate) to the square

For example, if you are assuming a medium effect size (i.e., 0.5), then you need to enter $0.5^2 = 0.25$ as your R^2 in the "squared multiple correlation" under the "*Determine*" option, calculate effect size, and then transfer the value to the program so it will accurately calculate power (see above).
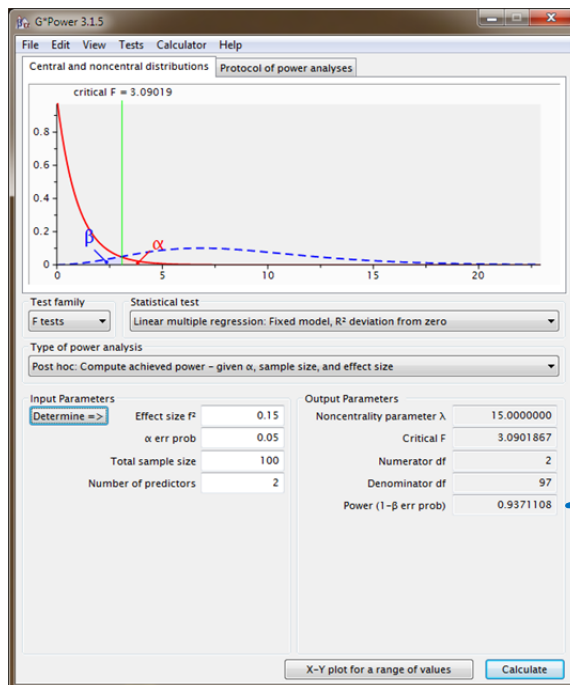
POWER FOR THE MULTIPLE REGRESSION CASE:

- Tests (main menu) ➔ Correlation ➔ linear multiple regression: Fixed model, R^2 deviation from zero
- Switch to **Post hoc** mode
- Effect size (in Cohen's terms; i.e., we can use small (r = 0.1), medium (r = 0.3) or large (r = 0.5) effect size). NOTE, READ: IMPORTANT NOTE FOR REGRESSION ESTIMATES (above).
- Alpha
- Total sample size
- Number of predictors (i.e., number of IV's in your model)

YOU GET:

- Non-centrality parameter λ
- Critical F
- Numerator Degrees of freedom
- Denominator Degrees of freedom
- Power

This is the power estimate you get given the input parameters you provided

TO ESTIMATE SAMPLE SIZE FOR THE MULTIPLE REGRESSION:

- Tests (main menu) ➔ Correlation ➔ linear multiple regression: Fixed model, R^2 deviation from zero
- Switch to **A priori** mode
- Effect size (in Cohen's terms; i.e., we can use small (r = 0.1), medium (r = 0.3) or large (r = 0.5) effect size). NOTE, READ: IMPORTANT NOTE FOR REGRESSION ESTIMATES (above).
- Alpha
- Power
- Number of predictors (i.e., number of IV's in your model)

YOU GET:

- Non-centrality parameter λ
- Critical F
- Numerator Degrees of freedom
- Denominator Degrees of freedom
- Total sample size
- Actual Power

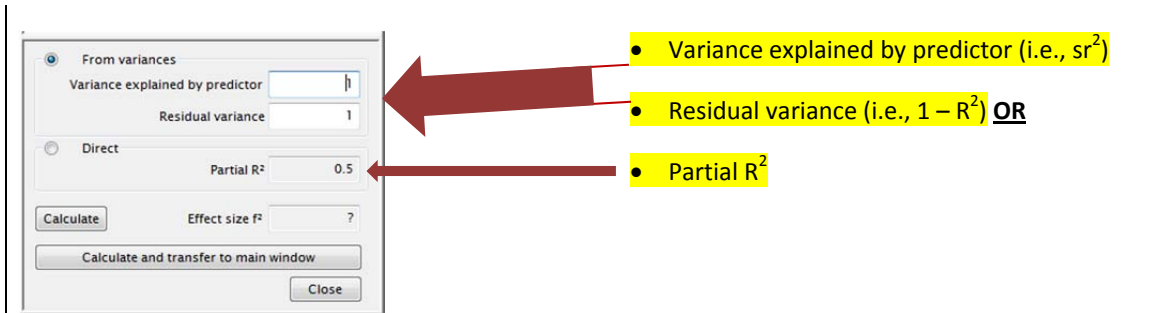This is the sample size estimate you get given the input parameters you provided

POWER FOR MULTIPLE REGRESSION (INDIVIDUAL VARIABLES)

This is for the case when we want to estimate the power of an individual independent variable in the regression model. In this case, we need to find **semi-partial correlations**. We'll review next week what partial and semi-partial correlations mean.
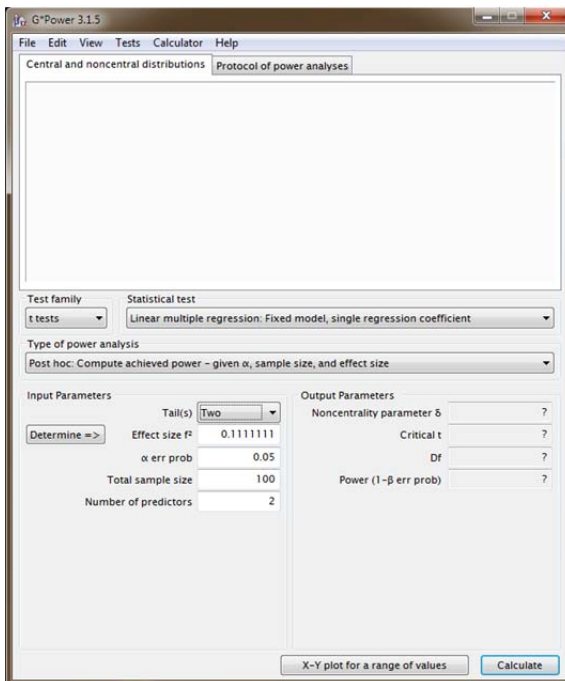
TO ESTIMATE POWER FOR THE MULTIPLE REGRESSION CASE (INDIVIDUAL VARIABLES):

- Tests (main menu) ➔ Correlation ➔ linear multiple regression: Fixed model, single regression coefficient
- Switch to **Post hoc** mode
- Figure out if you want to calculate power based on either one- or two-tails
- Effect size (f^2)

NOTE: to estimate effect size you need to remember that we have to use semi-partial correlations. Using the "Determine" option, you need to provide the following info:
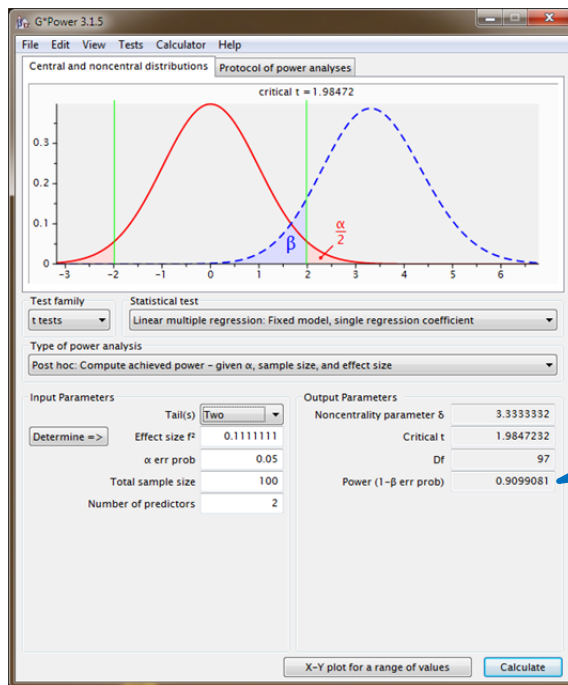
- Variance explained by predictor (i.e., sr^2)
- Residual variance (i.e., $1 - R^2$) **OR**
- Partial R^2

- Alpha
- Total sample size
- Number of predictors (i.e., IV's)

YOU GET:

- Non-centrality parameter λ
- Critical t
- Degrees of freedom
- Power

This is the power estimate you get given the input parameters you provided

TO ESTIMATE SAMPLE SIZE FOR THE MULTIPLE REGRESSION CASE SINGLE REGRESSION COEFFICIENT:

- Tests (main menu) ➔ Correlation ➔ linear multiple regression: Fixed model, single regression coefficient
- Switch to **A priori** mode
- Figure out if you want to calculate power based on either one- or two-tails
- Effect size (f^2) (see note above)
- Alpha
- Power
- Number of predictors

YOU GET:

- Non-centrality parameter λ
- Critical t
- Degrees of freedom
- Total sample size
- Actual Power

This is the sample size estimate you get given the input parameters you provided