

Power Examples

I will illustrate a few basic a priori power analyses for several tests that we have covered in this class using G*Power and the R package pwrss (Bulus & Polat, 2023).¹ There are two general ways to conduct an a priori power analysis—estimate the needed sample size for assuming sufficient power (usually .8) or estimate power given an existing sample size. Effect size estimates can be specific, based on published research (multiple studies or a meta-analysis are better than a single study) literature, or can using generic suggested recommendations for small and medium effect sizes (e.g., Cohen, 1992). I use the latter approach below for general illustration purposes. Note that throughout these examples I assume $\alpha = .05$ two-tailed and power = .8.

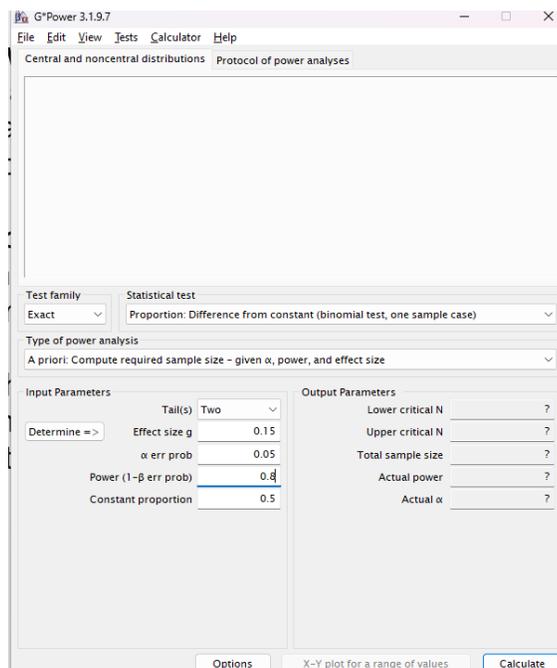
G*Power

There are several specific ways to implement power estimates in G*Power.² I will illustrate the approach I usually use, which is to generate figures for small, medium, and large effect sizes with power plotted on the Y axis and sample size plotted on the X axis.

z proportions test

Cohen's g can be used for effect size estimates with the binomial test (small = .05, medium = .15, large = .25).

First choose the test under the Tests menu, which is *Proportions: Difference from a constant* (binomial, one sample test). Then, be sure to change the default to a two-tailed test and the default power value to .8. I entered a medium effect size of .15 to start. The test family only has the Fisher's exact test for this test, which will be on the conservative side.

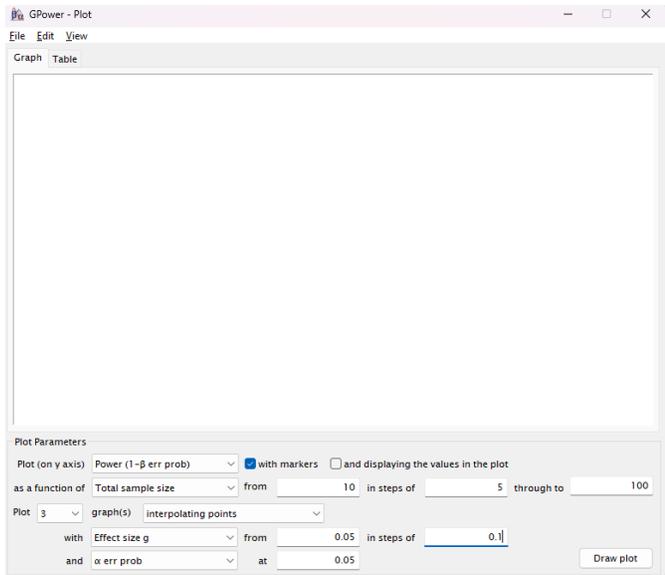


Then choose *Calculate*

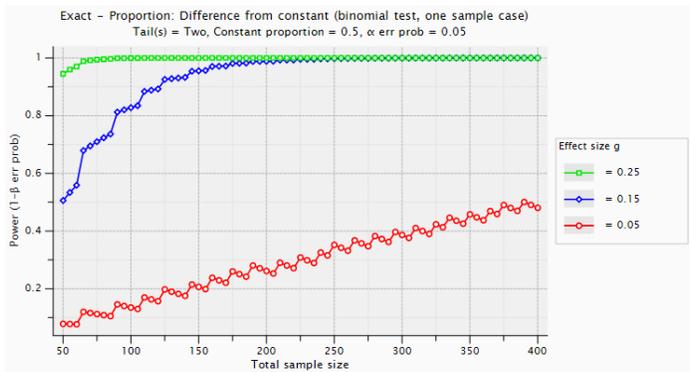
The next dialog gives the estimate for sample size needed for this medium effect size, which was 90. Next, choose *X-Y plot for a range of values* at the bottom of the results dialog box to obtain the plot. I change the Y axis to power and the X axis to sample size with a range of sample sizes (from 50 to 400).

¹ Please see the power examples on regression analysis for next terms class for more.

² I am using version 3.1.9.6 for these examples.



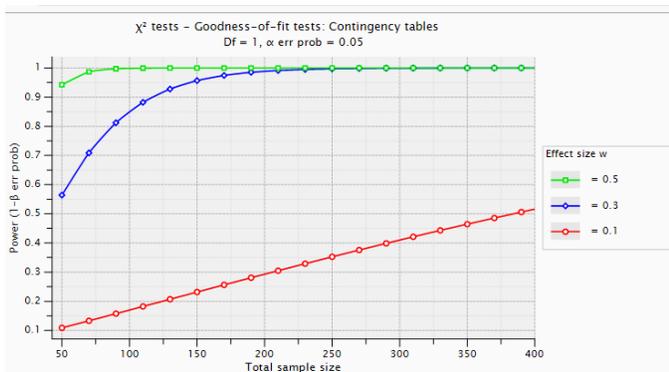
Choose *Draw plot* in the bottom righthand corner. The resulting plot shows that a little less than 90 cases are needed for the medium effect size (blue), fewer than 50 would be needed for a large effect size (green), and far more than 400 would be needed for a small effect size (red)



For the remaining examples with G*Power, I will use the same process but skip the step by step illustrations.

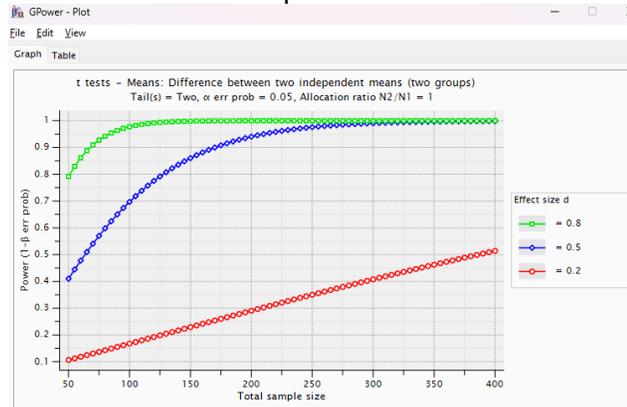
Contingency Chi-Square

Choose Proportions under the Tests menu and then Multigroup: Goodness of Fit. I used a Cohen's w of .3 for medium effect and assumed a 2×2 chi-square, which has a df of 1. The estimate for required sample size was 88.



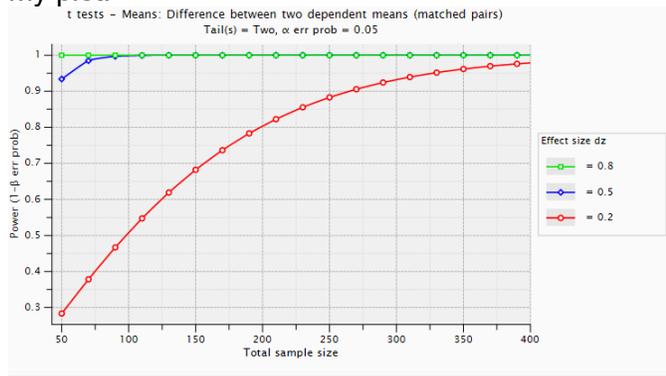
Independent Groups *t* Test

The estimate for sample size with for a Cohen's *d* of .5 (medium) suggests 128 cases are needed.



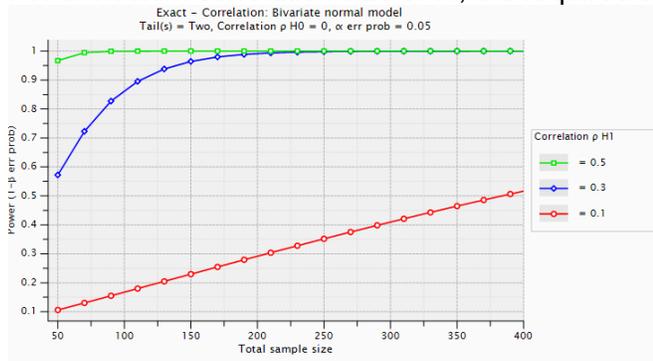
Paired *t* test

For the repeated measures/paired/matched *t* test, use Dependent Groups under the Means option. For a medium effect of $d = .5$, 34 cases would be required. I used .2, .5, and .8 Cohen's *d* values in my plot.



Correlation

For a medium correlation size of .3, the required sample size was 84.



One-way ANOVA

Effect size for ANOVA uses Cohen's f , which is $f = \sqrt{R^2 / (1 - R^2)} = \sqrt{\eta^2 / (1 - \eta^2)}$. Cohen suggests that f of .10 is small, .25 is medium, and .4 is large. (My rough estimates suggest that these values correspond to η^2 values of approximately .01, .06, and .14.) For f value of .25, the required sample size estimate for two groups is 128 (same as the *t* test).


```
-----  
Sample Size      = 2178 <<  
Type 1 Error (alpha) = 0.050  
Type 2 Error (beta)  = 0.200  
Statistical Power   = 0.8
```

```
> probs.to.w(prob.matrix = prob.matrix)  
w      df  
0.1668596 1.0000000  
>  
> #2 x 2 chi-square (Cohen's w = .3 is medium effect size)  
> power.chisq.gof(w = 0.30,  
+               df = 1,  
+               alpha = 0.05,  
+               power = 0.80)
```

```
-----  
|                SAMPLE SIZE CALCULATION                |  
-----
```

Chi-Square Test for Goodness-of-Fit or Independence

Hypotheses

```
-----  
H0 (Null Claim) :  $P[i,j] = P0[i,j]$  for all (i,j)  
H1 (Alt. Claim) :  $P[i,j] \neq P0[i,j]$  for some (i,j)  
-----
```

Results

```
-----  
Total Sample Size      = 88 <<  
Type 1 Error (alpha)   = 0.050  
Type 2 Error (beta)    = 0.196  
Statistical Power      = 0.804
```

```
>  
> #chi-square can also be done by comparing two proportions  
> # (the conditional proportions usually reported n a 2 x 2 chi-square)  
> power.z.twoprops(prob1 = 0.65,  
+                 prob2 = 0.75,  
+                 power = 0.80,  
+                 alpha = 0.05,  
+                 alternative = "two.sided")
```

```
-----  
|                SAMPLE SIZE CALCULATION                |  
-----
```

Independent Proportions

```
Method      : Normal Approximation
```

Hypotheses

```
-----  
H0 (Null Claim) :  $prob1 - prob2 = 0$   
H1 (Alt. Claim) :  $prob1 - prob2 \neq 0$   
-----
```

Results

```
-----  
Sample Size      = 329 and 329 <<  
Type 1 Error (alpha) = 0.050  
Type 2 Error (beta)  = 0.199  
Statistical Power   = 0.801
```

```
>  
> #t test--must calculate Cohen's d for your problem (medium effect size)  
> power.t.student(d = 0.50,  
+               power = 0.80,  
+               alpha = 0.05,  
+               alternative = "two.sided",  
+               design = "independent")
```

```
-----  
|                SAMPLE SIZE CALCULATION                |  
-----
```

Student's T-Test (Independent Samples)

Hypotheses

```
-----  
H0 (Null Claim) :  $d - null.d = 0$   
H1 (Alt. Claim) :  $d - null.d \neq 0$   
-----
```

Results

```
Sample Size      = 64 and 64 <<      (note that the values shown show 64 per group)
Type 1 Error (alpha) = 0.050
Type 2 Error (beta)  = 0.199
Statistical Power   = 0.801
```

```
>
> #the paired t test is available using the design = "paired"
> power.t.student(d = 0.50,
+               power = 0.80,
+               alpha = 0.05,
+               alternative = "two.sided",
+               design = "paired")
```

-----+
| SAMPLE SIZE CALCULATION |
-----+

Student's T-Test (Paired Samples)

Hypotheses

```
H0 (Null Claim) : d - null.d = 0
H1 (Alt. Claim) : d - null.d != 0
```

Results

```
Sample Size      = 34 <<
Type 1 Error (alpha) = 0.050
Type 2 Error (beta)  = 0.192
Statistical Power   = 0.808
```

```
> #correlation (medium effect size)
> power.z.onecor(rho = 0.30,
+               null.rho = 0.00,
+               power = 0.80,
+               alpha = 0.05,
+               alternative = "two.sided")
```

-----+
| SAMPLE SIZE CALCULATION |
-----+

One-Sample Correlation

Hypotheses

```
H0 (Null Claim) : rho - null.rho = 0
H1 (Alt. Claim) : rho - null.rho != 0
```

Results

```
Sample Size      = 85 <<
Type 1 Error (alpha) = 0.050
Type 2 Error (beta)  = 0.200
Statistical Power   = 0.8
```

pwrss requires eta-squared effect size input. My rough estimates for Cohen's f of .10 is small, .25 is medium, and .4 is large correspond to r^2 values of approximately .01, .06, and .14.

```
> #one-way ANOVA (eta-squared = .09 should be close to medium effect size)
> power.f.ancova(eta.squared = 0.059,
+               factor.levels = 2,
+               power = 0.80,
+               alpha = 0.05)
```

-----+
| SAMPLE SIZE CALCULATION |
-----+

One-way Analysis of Variance (F-Test)

Hypotheses

```
H0 (Null Claim) : eta.squared = 0
H1 (Alt. Claim) : eta.squared > 0
```

Results

Total Sample Size = 128 <<
Type 1 Error (alpha) = 0.050
Type 2 Error (beta) = 0.197
Statistical Power = 0.803

```
> #factorial  
> power.f.ancova(eta.squared = 0.059,  
+               factor.levels = c(2, 2),  
+               power = 0.80,  
+               alpha = 0.05)
```

-----+
| SAMPLE SIZE CALCULATION |
+-----

Two-way Analysis of Variance (F-Test)

Hypotheses

H0 (Null Claim) : eta.squared = 0
H1 (Alt. Claim) : eta.squared > 0

Results

Total Sample Size = 128 <<
Type 1 Error (alpha) = 0.050
Type 2 Error (beta) = 0.197
Statistical Power = 0.803

References

Buluş, M., & Polat, C. (2023). Statistical Power Analysis with pwrss R Package. *Journal of Kirsehir Education Faculty*, 24(3).
Cohen, J. (1992) A power primer. *Psychological Bulletin*, 112, 155-159.