

NEW SAS MODULES FOR PRACTICAL POWER ANALYSIS

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Introduction

Nearly every introductory book on statistics has a section or two, usually in the back of a chapter on hypothesis testing, devoted to "sample size". The author may make a statement like "Determining the sample size is very important in the planning of an experiment." This is true, but too often there is no mention of research budgets, grants, the realities of subject recruitment and retention, the expense of giving a treatment or of administering the study, or a myriad of other practical considerations. Besides these practical considerations, there often is no mention of statistical power and its importance in the development of a research project.

The methods traditionally presented for determining the sample size often ignore the fact that a researcher typically comes to the statistician with an "N" in mind. He/she knows how much funding is available or how many subjects can be recruited and these are the first and most important constraints of the sample size dilemma. For these reasons we use a somewhat different approach for assessing sample size. It compares the power of several fixed total sample sizes for detecting conjectured treatment differences for a specific design. The SAS modules we use have the flexibility to handle the testing of independent proportions (π), means (μ), and correlations (ρ) in one to several groups, which may have unequal sample sizes.

This approach involves finding out from the researcher the number of groups of interest and the parameters of interest in the researcher's major hypotheses. We then elicit conjectured values for these parameters and use these values directly in the software. (Templates are given in the appendix.) Also, the researcher must determine whether the study groups will have balanced sample sizes. If this is not expected, then the weights of the groups are entered in the "weight" statement in the template. The weights must sum to one. The significance level(s) at which the tests are to be performed are entered in the "alpha" statement. The possible total sample sizes are specified on the line "Ntotal". Also, when testing means, we need to elicit conjectured values for the common within-group standard deviation (σ). These values are then put on the "sigma" line. And finally, depending upon the hypotheses being investigated, the investigator and the statistician may want to include single or multiple degree of freedom contrasts. Each is done separately by the format illustrated in the templates.

For much greater detail, including more examples, see O'Brien and Muller (1993).

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Example One: Comparison of Two Proportions

Research Design: Dr. Anderson proposes to study two groups: a control group that will receive a placebo and a separate treatment group that will receive DWB. The subjects will be followed over the next two years to see what proportion of the subjects will avoid corrective surgery.

Statistical Design: Comparison of two independent proportions.

Conjectures: $\pi_{\text{placebo}}=0.30$, $\pi_{\text{DWB}}=0.45$

Input:

```
/* -----
   Program for Comparing Two Proportions
   ----- */
options ls=72 nosource2;
%include "OneWyPow.sas";
title1 "Dr. Anderson: Study of DWB";
title2 "30% expected to avoid surgery in control group and";
title3 "45% expected to avoid surgery in the treatment group";
cards;
pi .30 .45 .          /* two conjectured proportions */
alpha 0.01 0.05 .    /* from 1 to 10 alphas */
Ntotal 80 160 320 .  /* from 1 to 10 total sample sizes */
end
%include "PowTab2.sas";          /* or use own PROC */
```

Output:

```
Dr. Anderson: Study of DWB
30% expected to avoid surgery in control group and
45% expected to avoid surgery in the treatment group
```

```
*****
OneWyPow: Power Analysis Software for SAS
Ralph G. O'Brien
Statistics/Biostatistics, University of Florida
*****
```

Specifications processed:

```
PI 0.3 0.45 .
ALPHA 0.01 0.05 .
NTOTAL 80 160 320 .
END
```

Normal ending of specifications.

Dr. Anderson: Study of DWB
 30% expected to avoid surgery in control group and
 45% expected to avoid surgery in the treatment group

		ALPHA					
		0.01			0.05		
		Total N			Total N		
		80	160	320	80	160	320
		Pow-er	Pow-er	Pow-er	Pow-er	Pow-er	Pow-er
Unpooled	2-tailed t	.115	.270	.585	.283	.505	.799
Approx.							
Uncond. Test	1-tailed t	.172	.360	.680	.400	.629	.876
Pooled	2-tailed t	.115	.270	.585	.283	.505	.799
Approx.							
Uncond. Test	1-tailed t	.172	.360	.680	.400	.629	.876
Approx.	2-tailed z	.085	.222	.535	.228	.443	.762
Conditional							
Test	1-tailed z	.132	.304	.633	.334	.570	.849
Log Odds	2-tailed z	.118	.271	.580	.284	.502	.793
Ratio LR							
Test	1-tailed z	.174	.359	.674	.399	.625	.872

Example Two: 3x2 ANOVA Including Contrasts

Research Design: In a randomized study Dr. Barkley proposes to compare how three distinct exercise programs affect weight loss. Also, Dr. Barkley is interested in detected differences between the males and females.

Statistical Design: 3x2 ANOVA with specific questions of interest being answered through the use of contrasts.

Conjectures: Means for males: $\mu_1=10$, $\mu_2=14$, $\mu_3=20$

Means for women: $\mu_1=6$, $\mu_2=10$, $\mu_3=20$

Common standard deviation: $\sigma=8$.

Input:

```

/* -----
   Program for ANOVA Test of Means
   ----- */

options ls=72 nosource2;
%include "OneWyPow.sas";
title1 "Dr. Barkley: Study of exercise programs";
title2 "Studying the difference in weight loss between males and females";
title3 "under three exercise programs";
cards;
mu 10 14 20 6 10 20 .      /* up to J = 20 conjectured means */
sigma 8 10 12 .            /* from 1 to 10 sigmas */
alpha 0.01 0.05 .          /* from 1 to 10 alphas */
Ntotal 60 78 120 .        /* from 1 to 10 total sample sizes */
nooverall                  /* skip overall test; optional */
contrasts
"Treatments Overall" 1 -1 0 1 -1 0 .
> 0 1 -1 0 1 -1 .
"Males vs. Females" 1 1 1 -1 -1 -1 .
"Diet 2 vs. Diet 3" 0 1 -1 0 1 -1 .
end
%include "FPowTabl.sas";      /* where 1 can be 2 */

```

Output:

Dr. Barkley: Study of exercise programs
 Studying the difference in weight loss between males and females
 under three exercise programs

```

Specifications processed:
MU    10    14    20    6    10    20    .
SIGMA  8    10    12    .
ALPHA  0.01  0.05  .
NTOTAL 60    78    120  .
NOOVERALL
CONTRASTS
Treatments Overall
  1    -1    0    1    -1    0    .
> 0    1    -1    0    1    -1    .
Males vs. Females
  1    1    1    -1    -1    -1    .
Diet 2 vs. Diet 3
  0    1    -1    0    1    -1    .
END
Normal ending of specifications.

```

Effect: Treatments Overall,
 DF Hypothesis: 2,
 AND Primary SSHe: 24.888888889

		Std Dev								
		8			10			12		
		Total N			Total N			Total N		
		60	78	120	60	78	120	60	78	120
		Pow- er	Pow- er	Pow- er	Pow- er	Pow- er	Pow- er	Pow- er	Pow- er	Pow- er
Test Type	Alpha									
Regular F	0.01	.958	.992	.999	.793	.915	.993	.586	.750	.941
	0.05	.992	.999	.999	.930	.978	.999	.807	.906	.986

Effect: Males vs. Females,
 DF Hypothesis: 1,
 AND Primary SSHe: 1.777777778

		Std Dev								
		8			10			12		
		Total N			Total N			Total N		
		60	78	120	60	78	120	60	78	120
		Pow- er	Pow- er	Pow- er	Pow- er	Pow- er	Pow- er	Pow- er	Pow- er	Pow- er
Test Type	Alpha									
2-tailed t	0.01	.093	.128	.219	.058	.077	.128	.041	.053	.084
	0.05	.245	.306	.441	.174	.213	.305	.135	.162	.226
1-tailed t	0.01	.143	.189	.301	.094	.121	.189	.069	.086	.131
	0.05	.356	.426	.568	.266	.316	.424	.213	.251	.332

Effect: Diet 2 vs. Diet 3,
DF Hypothesis: 1,
AND Primary SSHe: 10.666666667

		Std Dev								
		8			10			12		
		Total N			Total N			Total N		
		60	78	120	60	78	120	60	78	120
		Pow-er	Pow-er	Pow-er	Pow-er	Pow-er	Pow-er	Pow-er	Pow-er	Pow-er
Test Type	Alpha									
2-tailed t	0.01	.688	.828	.966	.451	.596	.829	.297	.410	.641
	0.05	.874	.945	.993	.700	.812	.944	.544	.660	.840
1-tailed t	0.01	.775	.887	.982	.556	.693	.887	.393	.513	.732
	0.05	.930	.973	.997	.803	.887	.972	.669	.769	.906

Example Three: Comparison of Two Correlations

Research Design: Dr. Cobb wants to compare the relationship between the amount of tissue breakdown products and white blood cell functioning in two groups. This will be looked at in a group of diabetic subjects and a group of non-diabetic subjects.

Statistical Design: Comparison of the correlations of two independent groups.

Conjectures: $\rho_{\text{diabetic}}=0.50$, $\rho_{\text{non-diabetic}}=0.75$

Input:

```

/* -----
   Program for Fisher r-to-Z Tests for Correlations
   ----- */

options ls=72 nosource2;
%include "OneWyPow.sas";
title1 "Dr. Cobb: Study of Diabetes and Periodontal Disease";
title2 "Comparison of tissue breakdown products and white blood cell";
title3 "function in non-diabetic and diabetic groups";
cards;
rho 0.5 0.75 . /* up to J = 20 conjectured correlations */
weight .30 .70 . /* at least J-1 sample-size weight */
alpha 0.01 0.05 . /* from 1 to 10 alphas */
Ntotal 80 120 180 . /* from 1 to 10 total sample sizes */
end
%include "PowTab1.sas"; /* where 1 can be 2 or use FPowTab[1,2] */

```

Output:

Dr. Cobb: Study of Diabetes and Periodontal Disease
Comparison of tissue breakdown products and white blood cell
function in non-diabetic and diabetic groups

Effect: Two-Group Test,
DF Hypothesis: 1,
AND Primary Noncentrality for Hypothesis: 0.0376904674

	Alpha					
	0.01			0.05		
	Total N			Total N		
	80	120	180	80	120	180
	Pow-	Pow-	Pow-	Pow-	Pow-	Pow-
	er	er	er	er	er	er
2-tailed t	.190	.316	.502	.403	.559	.736
1-tailed t	.268	.411	.602	.530	.681	.829

Some Final Notes

All computations in this paper were performed within The SAS[®] System using modules (files containing SAS statements) that are processed via %INCLUDE statements in SAS input. At the time of publication, the developers are making these modules available on a "freeware" basis.

The OneWyPow and several PowTab modules handled all univariate methods (Examples 1-3). Their use and output is displayed in the examples. The modules run within the "base" SAS environment.

Getting the SAS Modules

Univariate Modules: OneWyPow, FPowTab1, etc.

Developer: Ralph G. O'Brien, Statistics/Biostatistics, Box 100212 UF Health Sciences Center
University of Florida, Gainesville, FL 32606
904-392-8446, robrien@stat.ufl.edu

These univariate modules are freeware. The files are free and may be distributed freely. The modules run within the "base" SAS environment. Versions of them have run on various computing platforms, including IBM VM/CMS, DEC Ultrix (UNIX), and PC-DOS. The files distributed contain all source statements and instructions on installation and use.

THESE MODULES HAVE NO WARRANTY WHATSOEVER. The developer would appreciate hearing about problems and suggestions for improvements regarding the software. He would also like to hear when they worked well for you. Please correspond via electronic mail (preferred) or telephone. Time rarely allows him to respond to "consulting" questions.

This freeware and their updates and successors may be obtained from the developer using three methods:

- (A) The best method is file transfer via the Internet network and 'anonymous ftp', as described below. There is no fee whatsoever. As the modules will continue to improve and expand their options, one should re-get them at least once a year.
- (B) For a nominal service fee, the developer will transfer the files to your account over the Internet or BITNET networks. Please use email to initiate this.
- (C) For a nominal fee for service and materials, the developer will send a single 3.5-inch, 720K, DOS-formatted diskette. Please call to initiate this.

anonymous ftp

The best way to obtain this freeware is to use the Internet network to ftp-get the files on your own. 'ftp' (lower case letters may be required) stands for File Transfer Protocol and is now available on almost all networked computers. The details regarding where and how these files are stored will change over time. Accordingly, the instructions given here only tell how to get a short file that gives complete, up-to-date instruction on all this.

- (1) Get to the "front door" of the ftp serving workstation for the University of Florida's Department of Statistics by entering

```
ftp ftp.stat.ufl.edu
```

on your local Internet-connected computer.
- (2) Login using the name

```
anonymous
```

For the password, enter your full system name, something of the form

```
mmouse@wdw.orlando.fl
```
- (3) Get a copy of the short information memo by entering

```
cd pub
```

```
get ReadMe.power myfile.asc
```

This will put a file called ReadMe.power on your local computer using the file specification of your choice ('myfile.asc').
- (4) Enter

```
close
```

```
quit
```

to return gracefully to your local environment, where you can study the instructions in robrien.power.
- (5) This method should work for a number of years, but computing systems have unpredictably short half-lives. If you encounter problems, call the Data Services Manager in the GCRC (904 395-0111 Ext: 5-8565). If that doesn't help, contact Ralph O'Brien.

Reference

O'Brien, R.G. and Muller, K. E. (1993), "Unified Power Analysis for t Tests through Multivariate Hypotheses," in Edwards, L. K., *Applied Analysis of Variance in the Behavioral Sciences*, Marcel Dekker.

Appendix: Templates for use with the SAS Modules

```

/* -----
   Template for Comparing Proportions
   ----- */
options ls=72 nosource2;
%include "POWER.public/OneWypow.sas";
title1 "Single Quotes (') are OK!";
cards;
pi # # .          /* two conjectured proportions */
weight # # .      /* at least one sample-size weight */
alpha # # .       /* from 1 to 10 alphas */
Ntotal # # # .    /* from 1 to 10 total sample sizes */
end
%include "POWER.public/PowTab2.sas";      /* or use own PROC */

/* -----
   Template for t and ANOVA Tests for Means
   ----- */
options ls=72 nosource2;
%include "OneWypow.beta.sas";
title1 "Single Quotes (') are OK!";
cards;
mu # # # # .      /* up to J = 20 conjectured means */
weight # # # .    /* at least J-1 sample-size weight */
sigma # # .       /* from 1 to 10 sigmas */
alpha # # .       /* from 1 to 10 alphas */
Ntotal # # # .    /* from 1 to 10 total sample sizes */
nooverall         /* skip overall test; optional */
contrasts
"30 Chars Max Label" # # # # . (double quotes for title)
"Major Hypoth from Smith's Thry" 1 1 1 -3 . (example)
"Equality of Groups A, B, and C" 1 -1 0 0 . (example)
> 0 1 -1 0 . (example)
"Another Label" # # # # . (etc.)
end
%include "FPowTab1.sas"; /* where 1 can be 2 */

/* -----
   Template for Fisher r-to-Z Tests for Correlations
   ----- */
options ls=72 nosource2;
%include "OneWypow.beta.sas";
title1 "Single Quotes (') are OK!";
cards;
rho # # # # .     /* up to J = 20 conjectured correlations */
weight # # # .    /* at least J-1 sample-size weight */
alpha # # .       /* from 1 to 10 alphas */
Ntotal # # # .    /* from 1 to 10 total sample sizes */
nooverall         /* skip overall test; optional */
contrasts
"30 Chars Max Label" # # # # . (double quotes for title)
"Major Hypoth from Smith's Thry" 1 1 1 -3 . (example)
"Equality of Groups A, B, and C" 1 -1 0 0 . (example)
> 0 1 -1 0 . (example)
"Another Label" # # # # . (etc.)
end
%include "PowTab1.sas"; /* where 1 can be 2 or use FPowTab[1,2] */

```