

Using Monte Carlo Methods to Teach Statistics

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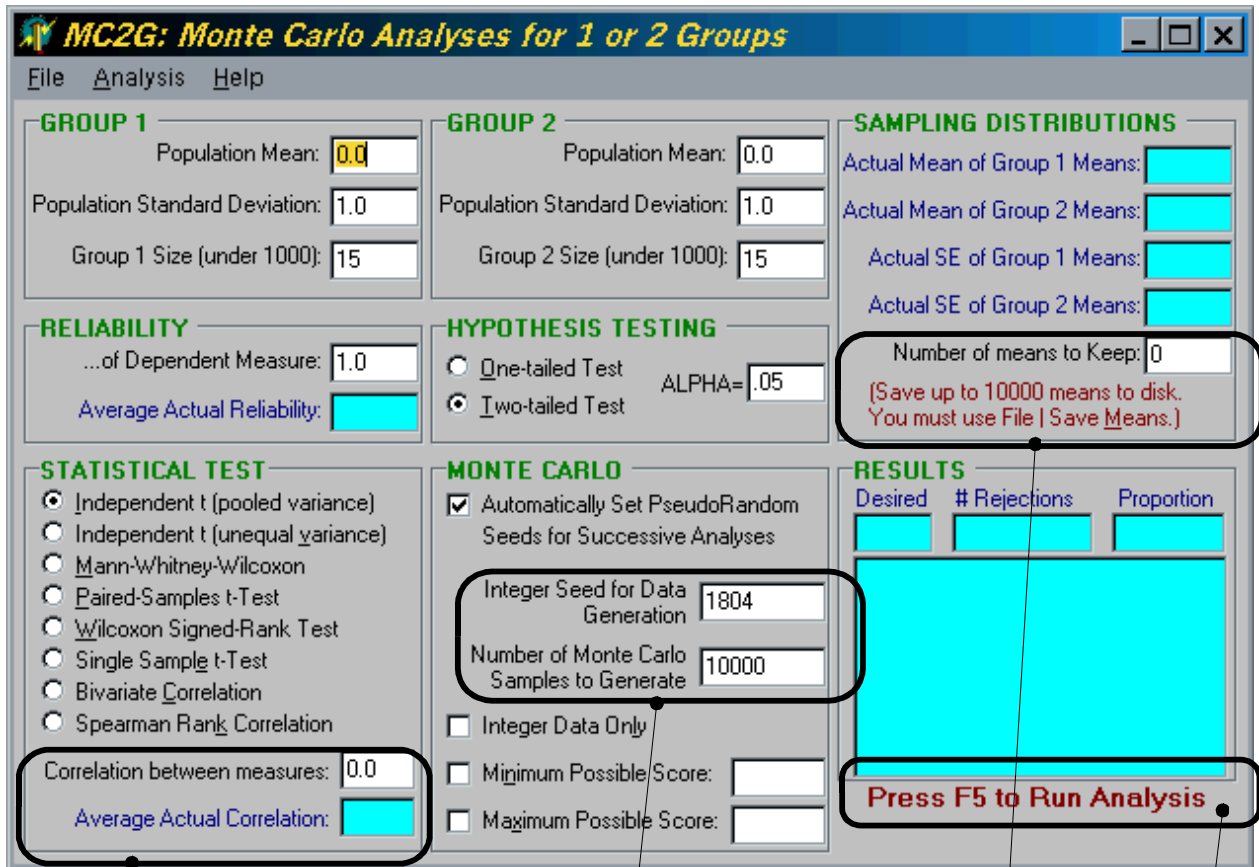
The purpose of this workshop is to present a variety of methods by which instructors of introductory statistics can use Monte Carlo methods in their courses. In particular, a computer program written in Delphi Pascal for Windows 95/98 will be provided on disk to participants. The program performs Monte Carlo simulations for several introductory statistical procedures, including correlations, t-tests, and several nonparametric alternatives. Several examples of lesson plans to use with the software will be provided.

MC2G Program available at:

<http://oak.cats.ohiou.edu/~brooksg/mc2g.htm>

Workshop presented at the annual meeting of the Mid-Western Educational Research Association, October 25, 2001, Chicago, IL.

MC2G Program: Opening Screen



This will be set to 0.5 automatically for Paired-Samples tests (but can be changed)

You should pick your own starting Random number – For the sake of Better results, you’ll want to pick As many Monte Carlo samples as You can stand to wait for

To save the means for exporting Into stats program (e.g., SPSS) so that you can examine the actual sampling distribution of the means

Push F5 or choose Run from The Analysis Menu to start analysis

MC2G Program: After Robustness Analysis

MC2G: Monte Carlo Analyses for 1 or 2 Groups

File Analysis Help

GROUP 1
 Population Mean: 0.0
 Population Standard Deviation: 1.0
 Group 1 Size (under 1000): 15

GROUP 2
 Population Mean: 0.0
 Population Standard Deviation: 1.0
 Group 2 Size (under 1000): 15

SAMPLING DISTRIBUTIONS
 Actual Mean of Group 1 Means: -0.002
 Actual Mean of Group 2 Means: 0.001
 Actual SE of Group 1 Means: 0.2611
 Actual SE of Group 2 Means: 0.2592
 Number of means to Keep: 0
 (Save up to 10000 means to disk. You must use File | Save Means.)

RELIABILITY
 ...of Dependent Measure: 1.0
 Average Actual Reliability: 1.000

HYPOTHESIS TESTING
 One-tailed Test
 Two-tailed Test
 ALPHA = .05

STATISTICAL TEST
 Independent t (pooled variance)
 Independent t (unequal variance)
 Mann-Whitney-Wilcoxon
 Paired-Samples t-Test
 Wilcoxon Signed-Rank Test
 Single Sample t-Test
 Bivariate Correlation
 Spearman Rank Correlation
 Correlation between measures: 0.0
 Average Actual Correlation: 0.004

MONTE CARLO
 Automatically Set PseudoRandom Seeds for Successive Analyses
 Integer Seed for Data Generation: 1804
 Number of Monte Carlo Samples to Generate: 10000
 Integer Data Only
 Minimum Possible Score:
 Maximum Possible Score:

RESULTS: Robustness Analysis

Desired	# Rejections	Proportion
0.05	500	0.0500

 Given these conditions, actual alpha (0.0500) is apparently okay because it is within 10% of nominal alpha (between 0.0450 and 0.0550).
 Press F5 to Run Analysis
 FINISHED 10000 Iterations

You can change the standard deviations to violate homogeneity of variance assumptions – and sample sizes to see their effects

Note that the means are equal for a robustness analysis

The results of the robustness analysis and some sampling Distribution information

In particular note:

- **Desired** takes the given nominal ALPHA value (from “Hypothesis Testing” box)
- **# Rejections** counts how many times the Null Hypothesis of equal means was falsely rejected
- **Proportion** provides the actual ALPHA rate (proportion of false rejections)
- Big Aqua box gives some general guidelines as to acceptability of actual ALPHA rate
- Sampling distribution information can be used for help with that topic
- **Stop Processing** button turns into *how-many-iterations-finished* indicator
- You can save these results using Save Results under the File Menu (or **Ctrl-S**)

MC2G Program: After Power Analysis

MC2G: Monte Carlo Analyses for 1 or 2 Groups

File Analysis Help

GROUP 1
 Population Mean: 0.50
 Population Standard Deviation: 1.00
 Group 1 Size (under 1000): 64

GROUP 2
 Population Mean: 0.00
 Population Standard Deviation: 1.00
 Group 2 Size (under 1000): 64

SAMPLING DISTRIBUTIONS
 Actual Mean of Group 1 Means: 0.501
 Actual Mean of Group 2 Means: -0.003
 Actual SE of Group 1 Means: 0.1261
 Actual SE of Group 2 Means: 0.1244
 Number of means to Keep: 0
 (Save up to 10000 means to disk. You must use File | Save Means.)

RELIABILITY
 ...of Dependent Measure: 1.0
 Average Actual Reliability: 1.000

HYPOTHESIS TESTING
 One-tailed Test
 Two-tailed Test
 ALPHA= .05

STATISTICAL TEST
 Independent t (pooled variance)
 Independent t (unequal variance)
 Mann-Whitney-Wilcoxon
 Paired-Samples t-Test
 Wilcoxon Signed-Rank Test
 Single Sample t-Test
 Bivariate Correlation
 Spearman Rank Correlation
 Correlation between measures: 0.0
 Average Actual Correlation: 0.000

MONTE CARLO
 Automatically Set PseudoRandom Seeds for Successive Analyses
 Integer Seed for Data Generation: 1804
 Number of Monte Carlo Samples to Generate: 10000
 Integer Data Only
 Minimum Possible Score:
 Maximum Possible Score:

RESULTS: Power Analysis

Desired	# Rejections	Proportion
	8132	0.8132

0 (0.0%) of these rejections were Type III errors. Adjusted POWER is 0.8132.

Press F5 to Run Analysis

FINISHED 10000 Iterations

Notice that for a Power Analysis, the means must be different – you can also set standard deviations and sample sizes different to see their effects on Power

Results of the Power Analysis do not include A *Desired* value since none was set – we are trying to find actual Power (*Proportion*), which is the Number of CORRECT rejections (shown as # *Rejections*) of the False Null Hypothesis that means are equal

You can save these results using Save Results under the File Menu (*Ctrl-S*)

MC2G Program: After Single Iteration Analysis

MC2G: Monte Carlo Analyses for 1 or 2 Groups

File Analysis Help

GROUP 1
 Population Mean: 0.50
 Population Standard Deviation: 1.00
 Group 1 Size (under 1000): 64

GROUP 2
 Population Mean: 0.00
 Population Standard Deviation: 1.00
 Group 2 Size (under 1000): 64

SAMPLING DISTRIBUTIONS
 Actual Mean of Group 1: 0.337
 Actual Mean of Group 2: 0.029
 Actual Std Dev of Group 1: 0.8820
 Actual Std Dev of Group 2: 0.9565
 Number of means to Keep: 0
 (Save up to 10000 means to disk. You must use File | Save Means.)

RELIABILITY
 ...of Dependent Measure: 1.0
 Actual Reliability: 1.000

HYPOTHESIS TESTING
 One-tailed Test
 Two-tailed Test
 ALPHA= .05

STATISTICAL TEST
 Independent t (pooled variance)
 Independent t (unequal variance)
 Mann-Whitney-Wilcoxon
 Paired-Samples t-Test
 Wilcoxon Signed-Rank Test
 Single Sample t-Test
 Bivariate Correlation
 Spearman Rank Correlation
 Correlation between measures: 0.0
 Actual Correlation: -0.031

MONTE CARLO
 Automatically Set PseudoRandom Seeds for Successive Analyses
 Integer Seed for Data Generation: 1804
 Number of Monte Carlo Samples to Generate: 1
 Integer Data Only
 Minimum Possible Score:
 Maximum Possible Score:

RESULTS: 2 tails

Desired	# Rejections	Proportion
	0	0.0000

Press F5 to Run Analysis
 FINISHED 1 Iteration

You must set the Number of Monte Carlo samples to 1 in order to run this analysis – you can save the data from this analysis under the File Menu for comparison in a stat package (e.g., SPSS)

Integer data can be particularly useful for nonparametric analyses – thoughtful use of the minimum and maximum scores can change the distribution from true normal

Notice that the output here changed from sampling distribution to single sample information (and the Results file also changes if you Save it (Save Results under the File Menu))

MC2G Program: After Sample Size Analysis

MC2G: Monte Carlo Analyses for 1 or 2 Groups

File Analysis Help

GROUP 1
 Population Mean: 0.50
 Population Standard Deviation: 1.00
 Group 1 Size (under 1000): 65

GROUP 2
 Population Mean: 0.00
 Population Standard Deviation: 1.00
 Group 2 Size (under 1000): 65

SAMPLING DISTRIBUTIONS
 Actual Mean of Group 1 Means: 0.499
 Actual Mean of Group 2 Means: -0.001
 Actual SE of Group 1 Means: 0.1235
 Actual SE of Group 2 Means: 0.1251
 Number of means to Keep: 0
 (Save up to 10000 means to disk. You must use File | Save Means.)

RELIABILITY
 ...of Dependent Measure: 1.0
 Average Actual Reliability: 1.000

HYPOTHESIS TESTING
 One-tailed Test
 Two-tailed Test
 ALPHA= .05

STATISTICAL TEST
 Independent t (pooled variance)
 Independent t (unequal variance)
 Mann-Whitney-Wilcoxon
 Paired-Samples t-Test
 Wilcoxon Signed-Rank Test
 Single Sample t-Test
 Bivariate Correlation
 Spearman Rank Correlation
 Correlation between measures: 0.0
 Average Actual Correlation: -0.002

MONTE CARLO
 Automatically Set PseudoRandom Seeds for Successive Analyses
 Integer Seed for Data Generation: 1804
 Number of Monte Carlo Samples to Generate: 10000
 Integer Data Only
 Minimum Possible Score:
 Maximum Possible Score:

RESULTS: Sample Size Analysis

Desired	# Rejections	Proportion
0.80	8062	0.8062

With the given parameters, the sample sizes: Group1=65 and Group2=65 were found to achieve the desired power. --- Note that the sample sizes found here may not be exact (more Monte Carlo samples will provide better approximations).

Press F5 to Run Analysis

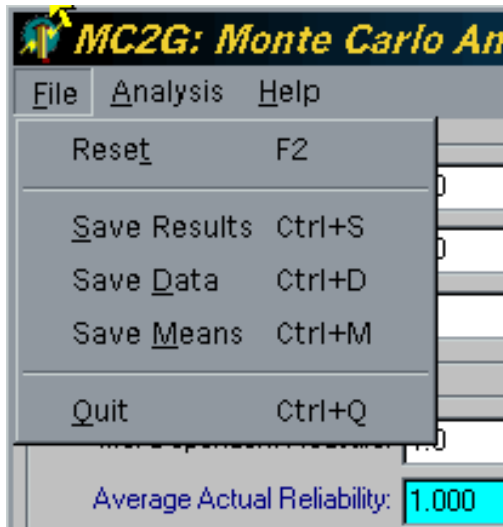
FINISHED 10000 Iterations

After the sample size analysis, the final sample size will be the Monte Carlo approximation for the sample size required to reach the Desired Power. It is not required that sample sizes begin equal.

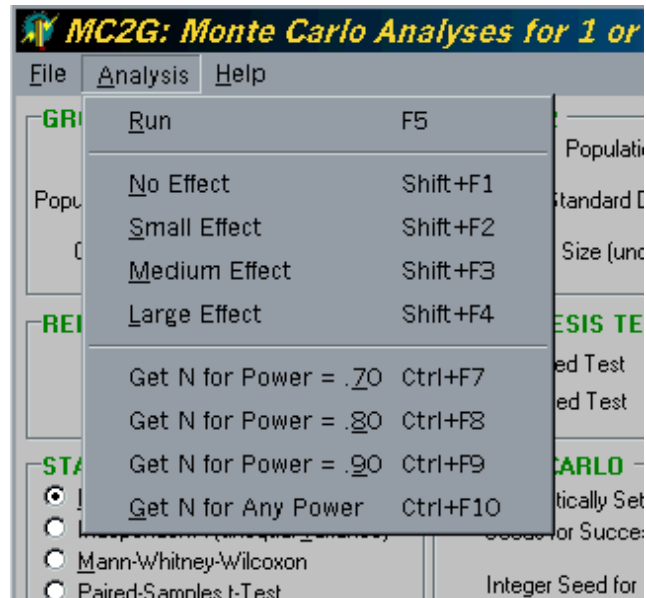
The *Desired* value here represents the power requested. The *# Rejections* and *Proportion* Indicate the actual number of correct rejections and the actual Power (as in a power analysis) for the final sample size.

If sample sizes are not equal at the beginning, they will not be equal at the end and information about the harmonic mean will appear here.

MC2G Program: Menus and Special Buttons



- Reset sets all values to the values on the opening screen.
- You can save the results of each analysis. The results file (see below) will indicate whether you ran power or robustness analysis. You can save the data set from a single sample analysis or the last data set from a many sample Monte Carlo analysis. Finally, you can save up to 10,000 means from your Monte Carlo analysis to import into a stat package for analysis of an actual sampling distribution of the mean.



The Analysis Menu allows you to run a single analysis with Run (**F5**). You can also automatically set the effect size to Cohen's conventional values. Finally, you can get The sample size required for the parameters You provide on the main screen (not exact Sample sizes, but Monte Carlo approximations)



The **STOP processing** button allows you to stop the analysis if you realize you've entered something incorrectly. You will still get results for the Monte Carlo samples analyzed to that point.

MC2G Output: Results File from Robustness Analysis

By default, the Results File name is MC2G_out_#####.TXT, where ##### is the random number seed used to start the analysis, but you can change that name in the Save Dialog box.

MONTE CARLO ANALYSES FOR 1 OR 2 GROUPS

Pooled Variance Independent t-Test

Random Number Generator Seed: 1804

of Simulated Samples Taken: 10000

GIVEN POPULATION VALUES:

Reliability of Dependent Measure: 1.000
Correlation between Dep Measures: 0.000

Group 1 Population Mean: 0.000
Group 1 Population Std Dev: 1.000
Group 1 Sample Size: 15

Group 2 Population Mean: 0.000
Group 2 Population Std Dev: 1.000
Group 2 Sample Size: 15

ACTUAL SAMPLE VALUES:

Avg Reliability of Dep Measure: 1.000
Avg Correlation between Measures: 0.004

Mean of 10000 Group 1 Means: -0.002
Mean of 10000 Group 2 Means: 0.001

Std Dev of 10000 Group 1 Means: 0.261 (Std Error)
Std Dev of 10000 Group 2 Means: 0.259 (Std Error)

MONTE CARLO ROBUSTNESS ANALYSIS

Because the Population Means are EQUAL, the Null Hypothesis is TRUE
Therefore, any rejections of the Null Hypothesis are Type I errors

2-tailed tests were performed at Nominal ALPHA= 0.050

# of Rejections	Actual ALPHA
500	0.0500

Monte Carlo Analyses for 1 or 2 Groups (Release 26)

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Contact: brooksg@ohiou.edu

MC2G Output: Results File from Power Analysis

By default, the Results File name is MC2G_out_#####.TXT, where ##### is the random number seed used to start the analysis, but you can change that name in the Save Dialog box.

MONTE CARLO ANALYSES FOR 1 OR 2 GROUPS

Pooled Variance Independent t-Test

Random Number Generator Seed: 1804

of Simulated Samples Taken: 10000

GIVEN POPULATION VALUES:

Reliability of Dependent Measure: 1.000
Correlation between Dep Measures: 0.000

Group 1 Population Mean: 0.800
Group 1 Population Std Dev: 1.000
Group 1 Sample Size: 26

Group 2 Population Mean: 0.000
Group 2 Population Std Dev: 1.000
Group 2 Sample Size: 26

ACTUAL SAMPLE VALUES:

Avg Reliability of Dep Measure: 1.000
Avg Correlation between Measures: 0.001

Mean of 10000 Group 1 Means: 0.800
Mean of 10000 Group 2 Means: -0.002

Std Dev of 10000 Group 1 Means: 0.196 (Std Error)
Std Dev of 10000 Group 2 Means: 0.196 (Std Error)

MONTE CARLO POWER ANALYSIS

Because the Population Means are NOT equal, the Null Hypothesis is FALSE
Therefore, NON-rejections of the Null Hypothesis are Type II errors

2-tailed tests were performed at Nominal ALPHA= 0.050

# of Rejections	POWER	# of Type III Errors	Adjusted POWER
8076	0.8076	0	0.8076

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MC2G: Output: Results File from Single Iteration Analysis

MONTE CARLO ANALYSES FOR 1 OR 2 GROUPS

Pooled Variance Independent t-Test

Random Number Generator Seed: 1804
of Simulated Samples Taken: 1

GIVEN POPULATION VALUES:

Reliability of Dependent Measure:	1.000
Correlation between Dep Measures:	0.000
Group 1 Population Mean:	0.800
Group 1 Population Std Dev:	1.000
Group 1 Sample Size:	26
Group 2 Population Mean:	0.000
Group 2 Population Std Dev:	1.000
Group 2 Sample Size:	26

ACTUAL SAMPLE VALUES:

Sample Reliability:	1.000
Correlation between Measures:	0.111
Mean of Group 1:	0.975
Mean of Group 2:	-0.623
Std Dev of Group 1:	0.688
Std Dev of Group 2:	0.915

t-Statistic: 7.121
Probability: 0.000

MONTE CARLO POWER ANALYSIS

Because the Population Means are NOT equal, the Null Hypothesis is FALSE
Therefore, NON-rejections of the Null Hypothesis are Type II errors

2-tailed tests were performed at Nominal ALPHA= 0.050

# of Rejections	POWER	# of Type III Errors	Adjusted POWER
1	1.0000	0	1.0000

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MC2G Output: Data File

This file is designed to be imported into a stat package (e.g., SPSS) or a spreadsheet as a COMMA-DELIMITED text file. By default, the file name is MC2G_data_#####.TXT, where ##### is the random number seed used to start the analysis, but you can change that name in the Save Dialog box.

```
case,group,score
1,1,-0.171
2,1,1.673
3,1,0.960
4,1,-1.103
5,1,0.496
6,1,-0.222
7,1,-1.579
8,1,0.272
9,1,0.072
10,1,-0.215
11,1,-1.717
12,1,-0.112
13,1,0.430
14,1,-0.134
15,1,0.388
16,2,0.116
17,2,-1.501
18,2,1.459
19,2,0.621
20,2,0.701
21,2,0.314
22,2,1.545
23,2,-0.123
24,2,0.300
25,2,-0.587
26,2,-0.518
27,2,1.832
28,2,-1.852
29,2,0.707
30,2,2.001
```

MC2G Output: Means File

This file is designed to be imported into a stat package (e.g., SPSS) or a spreadsheet as a COMMA-DELIMITED text file. By default, the file name is MC2G_means_#####.TXT, where ##### is the random number seed used to start the analysis, but you can change that name in the Save Dialog box.

```
sample,mean1,mean2
1,0.97531,-0.62317
2,0.77120,-0.07323
3,0.87702,-0.01259
4,0.76145,-0.10722
5,0.44663,0.22430
6,0.56669,0.09110
7,0.39889,-0.09269
8,0.89839,0.02554
9,0.74919,0.21604
10,0.82889,-0.13091
```