Chapter 27
Monte Carlo Tests for Continuous Data (10 and 20 Patients)

1 General Purpose

Monte Carlo methods allows you to examine complex data more easily than advanced mathematics like integrals and matrix algebra. It uses random numbers from your own study rather than assumed Gaussian curves. For continuous data a special type of Monte Carlo method is used called bootstrap which is based on random sampling from your own data with replacement.

2 Schematic Overview of Type of Data File, Paired Data

Outcome 1	outcome 2
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3 Primary Scientific Question, Paired Data

For paired data the paired t-test and the Wilcoxon test are appropriate (Chap. 3). Does Monte Carlo analysis of the same data provide better sensitivity of testing.

4 Data Example, Paired Data

The underneath study assesses whether some sleeping pill is more efficaceous than a placebo. The hours of sleep is the outcome value. This example was also used in the Chap. 2.

Outcome 1	Outcome 2
6,1	5,2
7,0	7,9
8,2	3,9
7,6	4,7
6,5	5,3
8,4	5,4
6,9	4,2
6,7	6,1
7,4	3,8
5,8	6,3

outcome = hours of sleep after treatment

5 Analysis: Monte Carlo (Bootstraps), Paired Data

The data file is in extras.springer.com and is entitled “chapter2pairedcontinuous”. Open it in SPSS. For analysis the statistical model Two Related Samples in the module Nonparametric Tests is required.

Command:

Analyze....Nonparametric Tests....Legacy Dialogs....Two-Related-Samples....Test Pairs:....Pair 1: Variable 1 enter hoursofsleepone....Variable 2 enter hoursofsleeptwo....mark Wilcoxon....click Exact....mark Monte Carlo....set Confidence Intervals: 99 %....set Numbers of Samples: 10000....click Continue....click OK.

Rank

		N	Mean rank	Sum of rank
Hours of sleep-hours of sleep	Negative ranks	8[a]	6,31	50,50
	Positive ranks	2[b]	2,25	4,50
	Tiles	0[c]		
	Total	10		

[a]Hours of sleep < hours of sleep
[b]Hours of sleep > hours of sleep
[c]Hours of sleep = hours of sleep

Test statistics[a, b]

			Hours of sleep – hours of sleep
Z			−2,346[c]
Asymp. Sig. (2-tailed)			,019
Monte Carlo Sig. (2-tailed)	Sig.		,015
	99 % confidence interval	Lower bound	,012
		Upper bound	,018
Monte Carlo Sig. (1-tailed)	Sig.		,007
	99 % confidence interval	Lower bound	,005
		Upper bound	,009

[a]Wilcoxon Signed ranks test
[b]Based on 10,000 sampled tables with starting seed 2,000,000
[c]Based on positive ranks

The above tables are in the output sheets. The Monte Carlo analysis of the paired continuous data produced a two-sided p-value of 0,015. This is a bit better than that of the two-sided Wilcoxon (p = 0,019).

6 Schematic Overview of Type of Data File, Unpaired Data

Outcome	binary predictor
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7 Primary Scientific Question, Unpaired Data

Unpaired t-tests and Mann-Whitney tests are for comparing two parallel-groups, and use a binary predictor, for the purpose, for example an active treatment and a placebo (Chap. 4). They can only include a single predictor variable. Does Monte Carlo analysis of the same data provide better sensitivity of testing.

8 Data Example, Unpaired Data

We will use the same example as that of the Chap. 4. In a parallel-group study of 20 patients 10 are treated with a sleeping pill, 10 with a placebo. The first 11 patients of the 20 patient data file is given underneath.

Outcome	Group
6,00	,00
7,10	,00
8,10	,00
7,50	,00
6,40	,00
7,90	,00
6,80	,00
6,60	,00
7,30	,00
5,60	,00
5,10	1,00

The group variable has 0 for placebo group, 1 for sleeping pill group
Outcome variable = hours of sleep after treatment

The data file is entitled “chapter4unpairedcontinuous”, and is in extras.springer.com. Start by opening the data file in SPSS.

9 Analysis: Monte Carlo (Bootstraps), Unpaired Data

For analysis the statistical model Two Independent Samples in the module Non-parametric Tests is required.

Command:

Analyze....Nonparametric Tests....Legacy Dialogs....Two-Independent Samples Test....Test Variable List: enter effect treatment....Grouping Variable: enter group....mark Mann-Whitney U....Group 1: 0....Group 2: 1....click Exact....

mark Monte Carlo....set Confidence Intervals: 99 %....set Numbers of Samples:10000....click Continue....click OK.

Ranks

	Group	N	Mean rank	Sum of ranks
Effect treatment	,00	10	14,25	142,50
	1,00	10	6,75	67,50
	Total	20		

Test statistics[a]

			Effect treatment
Mann-Whitney U			12,500
Wilcoxon W			67,500
Z			−2,836
Asymp. Sig. (2-tailed)			,005
Exact Sig. [2*(1-tailed Sig.)]			,003[b]
Monte Carlo Sig. (2-tailed)	Sig.		,002[c]
	99 % confidence interval	Lower bound	,001
		Upper bound	,003
Monte Carlo Sig. (1-tailed)	Sig.		,001[b]
	99 % confidence interval	Lower bound	,000
		Upper bound	,002

[a]Grouping variable: group
[b]Note corrected for ties
[c]Based on 10,000 sampled tables with starting seed 2,000,000

The above Monte Carlo method produced a two-sided p-value of p = 0,002, while the Mann-Whitney test produced a two-sided p-value of only 0,005. Monte Carlo analysis was, thus, again a bit better sensitive than traditional testing (Chap. 5).

10 Conclusion

Monte Carlo methods allow you to examine complex data more easily and more rapidly than advanced mathematics like integrals and matrix algebra. It uses random numbers from your own study. For continuous data a special type of Monte Carlo method is used called bootstrap which is based on random sampling from your own data with replacement. Examples are given.

11 Note

More background, theoretical, and mathematical information of Monte Carlo methods for data analysis is given in Statistics applied to clinical studies 5th edition, Chap. 57, Springer Heidelberg Germany, 2012, from the same authors.