

Latin and Greco-Latin Square Designs

Example in Education Using a Latin Square

Assume you are interested in the achievement of students under three methods of instruction for a required course in biology (self, computer, and classroom), interested in differences of these instruction modes for three colleges within a university (agriculture, education, engineering) and three types of students (in-state, out-of-state, out-of-country). We could use a completely balanced 3-way analysis of variance design with Factor A = instructional mode, Factor B = College and Factor C = type of student. There would be 27 experimental units (samples of subjects) in this design. On the other hand we might employ the following design:

	FACTOR A (Instruction)		
	Self	Computer	Classroom
FACTOR B (College)			
Agriculture	C2	C1	C3
Education	C1	C3	C2
Engineering	C3	C2	C1

In this design C1 is the in-state student unit, C2 is the out-of-state student unit and C3 is the out-of-country student unit. There are only 9 units in this design as contrasted with 27 units in the completely balanced design. Note that each type of student receives each type of instruction. Also note however that, within a college, students of each type do NOT receive each type of instruction. We will have to assume that the interaction of college and type of instruction, the interaction of college and type of student, the interaction of type of instruction and type of student and the triple interaction of College, instruction and student are small or do not exist. We are primarily interested in the main effects, that is differences among student types, types of instruction and colleges on the achievement scores obtained in the biology course. We might use Plan 1 described below.

Plan 1 by B.J. Winer

We have prepared an example file for you to analyze with OpenStat. Open the file labeled LatinSqr.tex in your set of sample data files. We have entered four cases for each unit in our design for instructional mode, college and home residence. Once you have loaded the file, select the Latin squares designs option under the sub-menu for comparisons under the Analyses menu. You should see the form below for selecting the Plan 1 analysis.

Latin and Greco-Latin Square Analyses

X

See B.J. Winer's "Statistical Principles in Experimental Design", McGraw-Hill Book Company, New York, 1962, pages 514-577 for the analyses plans provided in this procedure.

Note: Factor codes should be formatted as integers, data values as floating point values. All cell sizes should be equal and no missing values are allowed.

Winer "Plans":

- ☒ Plan 1. Three Factor (A, B, C) with no interactions.
- ☐ Plan 2. For Factor (A, B, C, D) with partial interactions.
- ☐ Plan 3. Similar to Plan 2 but with different assumptions (partial confounding of interaction ABC.)
- ☐ Greco-Latin with no interactions assumed.
- ☐ Plan 5. Repeated Measures Latin Square (random assignment of groups to rows.)
- ☐ Plan 6. Fractional replication of a three-factor factorial experiment in incomplete blocks.
- ☐ Plan 7. Plan 5 with superimposing an orthogonal Latin square.
- ☐ Plan 9. $A \times B \times C$ (same square used for all levels of Factor C.)

Cancel

OK

Figure 1. Latin and Greco-Latin Squares Form

When you have selected Plan 1 for the analysis, click the OK button to continue. You will then see the form below for entering the specifications for your analysis. We have entered the variables for factors A, B and C and entered the number of cases for each unit:

Latin Squares Analysis Specification Form

File Variables:

Factor A Code Variable: College

Factor B Code Variable: Instruction

Factor C Code Variable: Residence

Dependent Variable: Observed

No. Cases Per Cell: 4

Reset Cancel OK

Figure 2. Latin Squares Analysis Dialog

We have completed the entry of our variables and the number of cases and are ready to continue. When you press the OK button, the following results are presented on the output page:

Latin Square Analysis Plan 1 Results

Source	SS	DF	MS	F	Prob.>F
Factor A	92.389	2	46.194	12.535	0.000
Factor B	40.222	2	20.111	5.457	0.010
Factor C	198.722	2	99.361	26.962	0.000
Residual	33.389	2	16.694	4.530	0.020
Within	99.500	27	3.685		
Total	464.222	35			

Experimental Design

Instruction	1	2	3
College			
1	C2	C3	C1
2	C3	C1	C2
3	C1	C2	C3

Cell means and totals

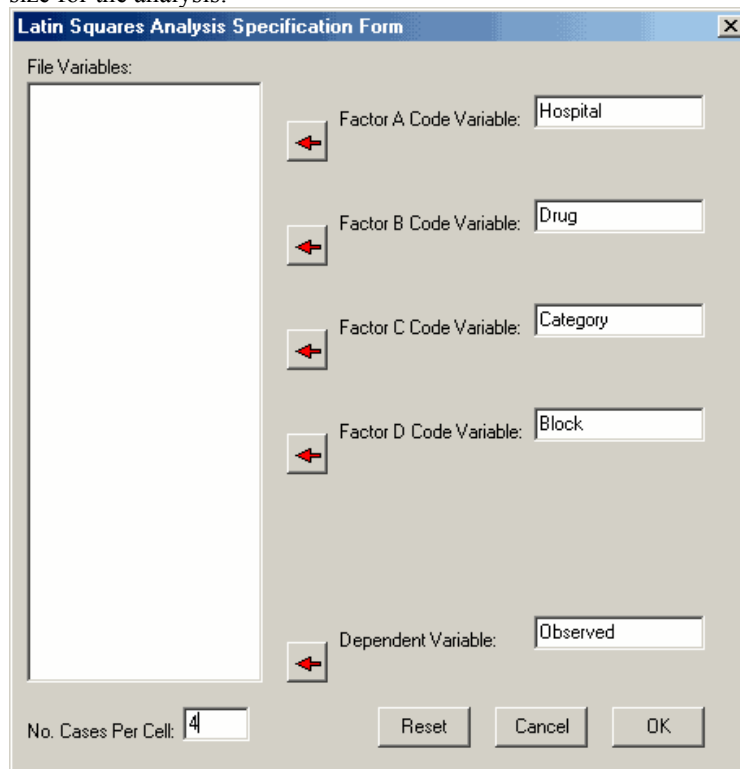
Instruction	1	2	3	Total
College				
1	2.750	10.750	3.500	5.667
2	8.250	2.250	1.250	3.917
3	1.500	1.500	2.250	1.750
Total	4.167	4.833	2.333	3.778

Residence	1	2	3	Total
	2.417	1.833	7.083	3.778

A partial test of the interaction effects can be made by the ratio of the MS for residual to the MS within cells. In our example, it appears that our assumptions of no interaction effects may be in error. In this case, the main effects may be confounded by interactions among the factors. The results may never the less suggest differences do exist and we should complete another balanced experiment to determine the interaction effects.

Plan 2

We have included the file “LatinSqr2.tex” as an example for analysis. Load the file in the grid and select the Latin Square Analyses, Plan 2 design. The form below shows the entry of the variables and the sample size for the analysis:



The image shows a software dialog box titled "Latin Squares Analysis Specification Form". It contains several input fields and buttons. On the left is a large empty box labeled "File Variables:". To its right are four rows, each with a red arrow button pointing left and a text input field. The first row is "Factor A Code Variable:" with "Hospital" entered. The second row is "Factor B Code Variable:" with "Drug" entered. The third row is "Factor C Code Variable:" with "Category" entered. The fourth row is "Factor D Code Variable:" with "Block" entered. Below these is a "Dependent Variable:" label with "Observed" entered in its field. At the bottom left is a "No. Cases Per Cell:" label with the number "4" entered in its field. At the bottom right are three buttons: "Reset", "Cancel", and "OK".

Figure 3. Four Factor Latin Square Design Form

When you click the OK button, you will see the following results:

Latin Square Analysis Plan 2 Results

Source	SS	DF	MS	F	Prob.>F
Factor A	148.028	2	74.014	20.084	0.000
Factor B	5.444	2	2.722	0.739	0.483
Factor C	66.694	2	33.347	9.049	0.000
Factor D	18.000	1	18.000	4.884	0.031
A x D	36.750	2	18.375	4.986	0.010
B x D	75.000	2	37.500	10.176	0.000
C x D	330.750	2	165.375	44.876	0.000
Residual	66.778	4	16.694	4.530	0.003
Within	199.000	54	3.685		
Total	946.444	71			

Experimental Design for block 1

Drug	1	2	3
Hospital			
1	C2	C3	C1
2	C3	C1	C2
3	C1	C2	C3

Experimental Design for block 2

Drug	1	2	3
Hospital			
1	C2	C3	C1
2	C3	C1	C2
3	C1	C2	C3

BLOCK 1

Cell means and totals

Drug	1	2	3	Total
Hospital				
1	2.750	10.750	3.500	5.667
2	8.250	2.250	1.250	3.917
3	1.500	1.500	2.250	1.750
Total	4.167	4.833	2.333	4.278

BLOCK 2

Cell means and totals

Drug	1	2	3	Total
Hospital				
1	9.250	2.250	3.250	4.917
2	3.750	4.500	11.750	6.667
3	2.500	3.250	2.500	2.750
Total	5.167	3.333	5.833	4.278

Category	1	2	3	Total
	2.917	4.958	4.958	4.278

Notice that the interactions with Factor D are obtained. The residual however indicates that some of the other interactions confounded with the main factors may be significant and, again, we do not know the portion of the differences among the main effects that are potentially due to interactions among A, B, and C.

Plan 3 Latin Squares Design

The file “LatinSqr3.tex” contains an example of data for the Plan 3 analysis. Following the previous plans, we show below the specifications for the analysis and results from analyzing this data:

Latin Squares Analysis Specification Form

File Variables:

Factor A Code Variable: Hospital

Factor B Code Variable: Drug

Factor C Code Variable: Category

Factor D Code Variable: Block

Dependent Variable: Observed

No. Cases Per Cell: 4

Reset Cancel OK

Figure 4. Another Latin Square (Plan 3) Dialog Form

Latin Square Analysis Plan 3 Results

Source	SS	DF	MS	F	Prob.>F
Factor A	26.963	2	13.481	3.785	0.027
Factor B	220.130	2	110.065	30.902	0.000
Factor C	213.574	2	106.787	29.982	0.000
Factor D	19.185	2	9.593	2.693	0.074
A x B	49.148	4	12.287	3.450	0.012
A x C	375.037	4	93.759	26.324	0.000
B x C	78.370	4	19.593	5.501	0.001
A x B x C	118.500	6	19.750	5.545	0.000
Within	288.500	81	3.562		
Total	1389.407	107			

Experimental Design for block 1

Drug	1	2	3
Hospital			
1	C1	C2	C3
2	C2	C3	C1
3	C3	C1	C2

Experimental Design for block 2

Drug	1	2	3
Hospital			
1	C2	C3	C1
2	C3	C1	C2
3	C1	C2	C3

Experimental Design for block 3

Drug	1	2	3
Hospital			
1	C3	C1	C2
2	C1	C2	C3
3	C2	C3	C1

BLOCK 1

Cell means and totals

Drug	1	2	3	Total
Hospital				
1	2.750	1.250	1.500	1.833
2	3.250	4.500	2.500	3.417
3	10.250	8.250	2.250	6.917
Total	5.417	4.667	2.083	4.074

BLOCK 2

Cell means and totals

Drug	1	2	3	Total
Hospital				
1	10.750	8.250	2.250	7.083
2	9.250	11.750	3.250	8.083
3	3.500	1.750	1.500	2.250
Total	7.833	7.250	2.333	4.074

BLOCK 3

Cell means and totals

Drug	1	2	3	Total
Hospital				
1	3.500	2.250	1.500	2.417
2	2.250	3.750	2.500	2.833
3	2.750	1.250	1.500	1.833
Total	2.833	2.417	1.833	4.074

Means for each variable

Hospital	1	2	3	Total
	3.778	4.778	3.667	4.074

Drug	1	2	3	Total
	5.361	4.778	2.083	4.074

Category	1	2	3	Total
	4.056	5.806	2.361	4.074

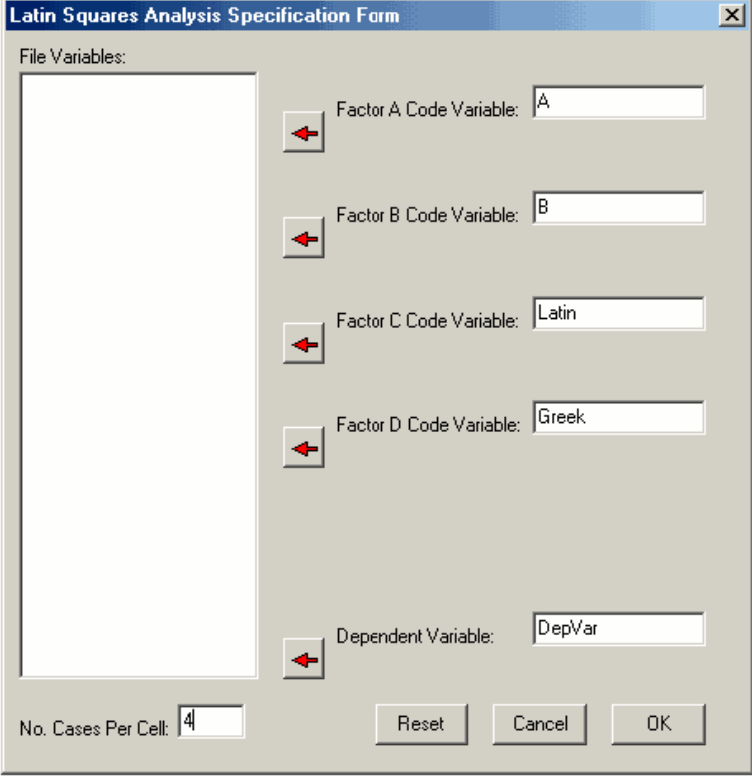
Block	1	2	3	Total
	4.500	4.222	3.500	4.074

Here, the main effect of factor D is partially confounded with the ABC interaction.

Analysis of Greco-Latin Squares

The file labeled “LatinGreco.tex” contains sample data for a Greco-Latin design analysis.

The specifications for the analysis are entered as:



The image shows a dialog box titled "Latin Squares Analysis Specification Form". It contains a "File Variables:" section with a large empty text area. To the right of this area are four rows of input fields, each preceded by a red arrow button. The inputs are: "Factor A Code Variable:" with value "A", "Factor B Code Variable:" with value "B", "Factor C Code Variable:" with value "Latin", and "Factor D Code Variable:" with value "Greek". Below these is a "Dependent Variable:" field with value "DepVar". At the bottom left, there is a "No. Cases Per Cell:" field with value "4". At the bottom right are three buttons: "Reset", "Cancel", and "OK".

Latin Squares Analysis Specification Form

File Variables:

Factor A Code Variable: A

Factor B Code Variable: B

Factor C Code Variable: Latin

Factor D Code Variable: Greek

Dependent Variable: DepVar

No. Cases Per Cell: 4

Reset Cancel OK

Figure 5. Latin Square Design Form

The results are obtained as:

Greco-Latin Square Analysis (No Interactions)

Source	SS	DF	MS	F	Prob.>F
Factor A	64.889	2	32.444	9.733	0.001
Factor B	64.889	2	32.444	9.733	0.001
Latin Sqr.	24.889	2	12.444	3.733	0.037
Greek Sqr.	22.222	2	11.111	3.333	0.051
Residual	-	-	-	-	-
Within	90.000	27	3.333		
Total	266.889	35			

Experimental Design for Latin Square

	B	1	2	3
A				
1		C1	C2	C3
2		C2	C3	C1
3		C3	C1	C2

Experimental Design for Greek Square

	B	1	2	3
A				
1		C1	C2	C3
2		C3	C1	C2
3		C2	C3	C1

Cell means and totals

	B	1	2	3	Total
A					
1		4.000	6.000	7.000	5.667
2		6.000	12.000	8.000	8.667
3		7.000	8.000	10.000	8.333
Total		5.667	8.667	8.333	7.556

Means for each variable

A	1	2	3	Total
	5.667	8.667	8.333	7.556

B	1	2	3	Total
	5.667	8.667	8.333	7.556

Latin	1	2	3	Total
	6.667	7.333	8.667	7.556

Greek	1	2	3	Total
	8.667	7.000	7.000	7.556

Notice that in the case of 3 levels that the residual degrees of freedom are 0 hence no term is shown for the residual in this example. For more than 3 levels the test of the residuals provides a partial check on the assumptions of negligible interactions. The residual is sometimes combined with the within cell variance to provide an over-all estimate of variation due to experimental error.

Plan 5 Latin Square Design

The specifications for the analysis of the sample file “LatinPlan5.tex” is shown below:

Latin Squares Analysis Specification Form

File Variables:

←

Factor A Code Variable: A (Col)

←

Factor B Code Variable: B (Cell)

←

Factor C Code Variable: Subject

←

Group Code Variable: Group (row)

←

Dependent Variable: DepVar

No. Cases Per Cell: 4

Reset

Cancel

OK

Figure 6. Latin Square Plan 5 Form

If you examine the sample file, you will notice that the subject Identification numbers (1,2,3,4) for the subjects in each group are the same even though the subjects in each group are different from group to group. The same ID is used in each group because they become “subscripts” for several arrays in the program. The results for our sample data are shown below:

Sums for ANOVA Analysis

Group (rows) times A Factor (columns) sums with 36 cases.

Variables

	1	2	3	Total
1	14.000	19.000	18.000	51.000
2	15.000	18.000	16.000	49.000
3	14.000	21.000	18.000	53.000
Total	43.000	58.000	52.000	153.000

Group (rows) times B (cells Factor) sums with 36 cases.

Variables

	1	2	3	Total
1	19.000	18.000	14.000	51.000
2	15.000	18.000	16.000	49.000
3	18.000	14.000	21.000	53.000
Total	52.000	50.000	51.000	153.000

Groups (rows) times Subjects (columns) matrix with 36 cases.

Variables

	1	2	3	4
Total				
1	13.000	11.000	13.000	14.000
51.000				
2	10.000	14.000	10.000	15.000
49.000				
3	13.000	9.000	17.000	14.000
53.000				
Total	36.000	34.000	40.000	43.000
153.000				

Latin Squares Repeated Analysis Plan 5 (Partial Interactions)

Source	SS	DF	MS	F	Prob.>F
Betw.Subj.	20.083	11			
Groups	0.667	2	0.333	0.155	0.859
Subj.w.g.	19.417	9	2.157		
Within Sub	36.667	24			
Factor A	9.500	2	4.750	3.310	0.060
Factor B	0.167	2	0.083	0.058	0.944
Factor AB	1.167	2	0.583	0.406	0.672
Error w.	25.833	18	1.435		

Total	56.750	35
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Experimental Design for Latin Square

A (Col)	1	2	3
Group (row)			
1	B3	B1	B2
2	B1	B2	B3
3	B2	B3	B1

Cell means and totals

A (Col)	1	2	3	Total
Group (row)				
1	3.500	4.750	4.500	4.250
2	3.750	4.500	4.000	4.083
3	3.500	5.250	4.500	4.417
Total	3.583	4.833	4.333	4.250

Means for each variable

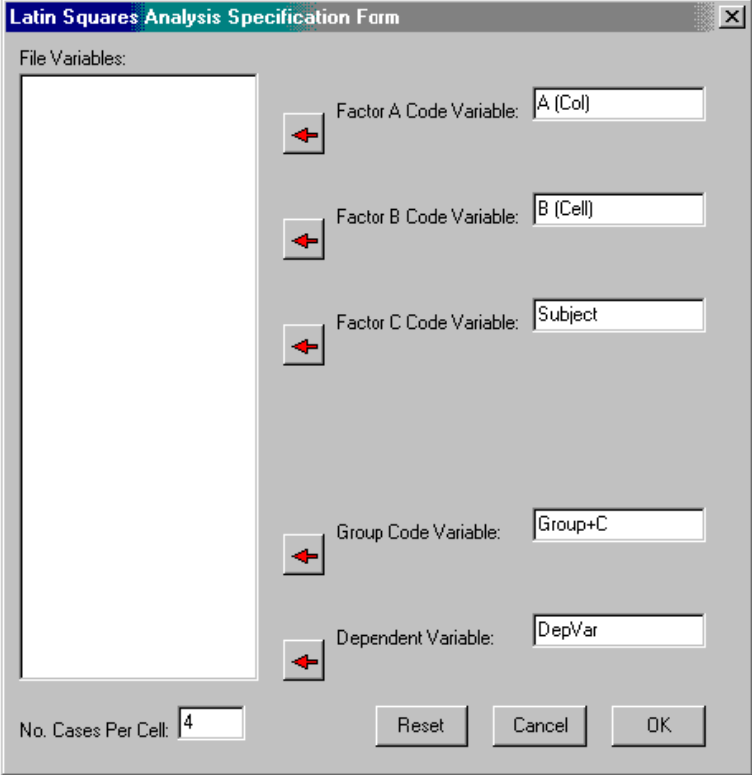
A (Col)	1	2	3	Total
	4.333	4.167	4.250	4.250

B (Cell)	1	2	3	Total
	4.250	4.083	4.417	4.250

Group (row)	1	2	3	Total
	4.250	4.083	4.417	4.250

Plan 6 Latin Squares Design

LatinPlan6.tex is the name of a sample file which you can analyze with the Plan 6 option of the Latin squares analysis procedure. Shown below is the specification form for the analysis of the data in that file:



The image shows a dialog box titled "Latin Squares Analysis Specification Form". It contains a "File Variables:" section with a large empty text area. To the right of this area are five input fields, each preceded by a red arrow button. The input fields are: "Factor A Code Variable:" with the value "A (Col)", "Factor B Code Variable:" with the value "B (Cell)", "Factor C Code Variable:" with the value "Subject", "Group Code Variable:" with the value "Group+C", and "Dependent Variable:" with the value "DepVar". At the bottom left, there is a "No. Cases Per Cell:" label followed by a text box containing the number "4". At the bottom right, there are three buttons: "Reset", "Cancel", and "OK".

Latin Squares Analysis Specification Form

File Variables:

Factor A Code Variable: A (Col)

Factor B Code Variable: B (Cell)

Factor C Code Variable: Subject

Group Code Variable: Group+C

Dependent Variable: DepVar

No. Cases Per Cell: 4

Reset Cancel OK

Figure 7. Latin Square Plan 6 Form

The results obtained when you click the OK button are shown below:

Latin Squares Repeated Analysis Plan 6

Sums for ANOVA Analysis

Group - C (rows) times A Factor (columns) sums with 36 cases.

Variables	1	2	3	Total
1	23.000	16.000	22.000	61.000
2	22.000	14.000	18.000	54.000
3	24.000	21.000	21.000	66.000
Total	69.000	51.000	61.000	181.000

Group - C (rows) times B (cells Factor) sums with 36 cases.

Variables	1	2	3	Total
1	16.000	22.000	23.000	61.000
2	22.000	14.000	18.000	54.000
3	21.000	24.000	21.000	66.000
Total	59.000	60.000	62.000	181.000

Group - C (rows) times Subjects (columns) matrix with 36 cases.

Variables	1	2	3	4
Total				
61.000	16.000	14.000	13.000	18.000
54.000	12.000	13.000	14.000	15.000
66.000	18.000	19.000	11.000	18.000
181.000	46.000	46.000	38.000	51.000

Latin Squares Repeated Analysis Plan 6

Source	SS	DF	MS	F	Prob.>F
Betw.Subj.	26.306	11			
Factor C	6.056	2	3.028	1.346	0.308
Subj.w.g.	20.250	9	2.250		

Within Sub	70.667	24			
Factor A	13.556	2	6.778	2.259	0.133
Factor B	0.389	2	0.194	0.065	0.937
Residual	2.722	2	1.361	0.454	0.642
Error w.	54.000	18	3.000		
Total	96.972	35			

Experimental Design for Latin Square

A (Col)		1	2	3
G C				
1	1	B3	B1	B2
2	2	B1	B2	B3
3	3	B2	B3	B1

Cell means and totals

A (Col)	1	2	3	Total
Group+C				
1	5.750	4.000	5.500	5.083
2	5.500	3.500	4.500	4.500
3	6.000	5.250	5.250	5.500
Total	5.750	4.250	5.083	5.028

Means for each variable

A (Col)	1	2	3	Total
	4.917	5.000	5.167	5.028

B (Cell)	1	2	3	Total
	5.083	4.500	5.500	5.028

Group+C	1	2	3	Total
	5.083	4.500	5.500	5.028

Plan 7 for Latin Squares

Shown below is the specification for analysis of the sample data file labeled LatinPlan7.tex and the results of the analysis:

Latin Squares Analysis Specification Form

File Variables:

Factor A Code Variable: A (Col)

Factor B Code Variable: B (Cell)

Factor C Code Variable: C (Cell)

Factor D Code Variable: Subject

Group Code Variable: Group

Dependent Variable: DepVar

No. Cases Per Cell: 4

Reset Cancel OK

Figure 8. Latin Squares Repeated Analysis Plan 7 (Superimposed Squares)

Sums for ANOVA Analysis

Group (rows) times A Factor (columns) sums with 36 cases.

Variables	1	2	3	Total
1	23.000	16.000	22.000	61.000
2	22.000	14.000	18.000	54.000
3	24.000	21.000	21.000	66.000
Total	69.000	51.000	61.000	181.000

Group (rows) times B (cells Factor) sums with 36 cases.

Variables	1	2	3	Total
1	23.000	16.000	22.000	61.000
2	18.000	22.000	14.000	54.000
3	21.000	21.000	24.000	66.000
Total	62.000	59.000	60.000	181.000

Group (rows) times C (cells Factor) sums with 36 cases.

Variables	1	2	3	Total
1	23.000	22.000	16.000	61.000
2	14.000	22.000	18.000	54.000
3	21.000	21.000	24.000	66.000
Total	58.000	65.000	58.000	181.000

Group (rows) times Subjects (columns) sums with 36 cases.

Variables	1	2	3	4
Total				
1	16.000	14.000	13.000	18.000
61.000				
2	12.000	13.000	14.000	15.000
54.000				
3	18.000	19.000	11.000	18.000
66.000				
Total	46.000	46.000	38.000	51.000
181.000				

Latin Squares Repeated Analysis Plan 7 (superimposed squares)

Source	SS	DF	MS	F	Prob.>F
Betw.Subj.	26.306	11			
Groups	6.056	2	3.028	1.346	0.308
Subj.w.g.	20.250	9	2.250		
Within Sub	70.667	24			
Factor A	13.556	2	6.778	2.259	0.133
Factor B	0.389	2	0.194	0.065	0.937
Factor C	2.722	2	1.361	0.454	0.642
residual	-	0	-		
Error w.	54.000	18	3.000		
Total	96.972	35			

Experimental Design for Latin Square

A (Col)	1	2	3
Group			
5.□	BC11	BC23	BC32
5.□	BC22	BC31	BC13
5.□	BC33	BC12	BC21

Cell means and totals

A (Col)	1	2	3	Total
Group				
1	5.750	4.000	5.500	5.083
2	5.500	3.500	4.500	4.500
3	6.000	5.250	5.250	5.500
Total	5.750	4.250	5.083	5.028

Means for each variable

A (Col)	1	2	3	Total
	5.750	4.250	5.083	5.028

B (Cell)	1	2	3	Total
	5.167	4.917	5.000	5.028

C (Cell)	1	2	3	Total
	4.833	5.417	4.833	5.028







Group	1	2	3	Total
	5.083	4.500	5.500	5.028

Plan 9 Latin Squares

The sample data set labeled “LatinPlan9.tex” is used for the following analysis. The specification form shown below has the variables entered for the analysis. When you click the OK button, the results obtained are as shown following the form.

Latin Squares Analysis Specification Form

File Variables:

	Factor A Code Variable:	FactorA
	Factor B Code Variable:	FactorB
	Factor C Code Variable:	FactorC
	Subject No.	Person
	Group Code Variable:	Group
	Dependent Variable:	DepVar

No. Cases Per Cell: 2

Reset Cancel OK

Figure 9. Latin Squares Repeated Analysis Plan 9

Sums for ANOVA Analysis

ABC matrix

C level 1

	1	2	3
1	13.000	3.000	9.000
2	6.000	9.000	3.000
3	10.000	14.000	15.000

C level 2

	1	2	3
1	18.000	14.000	18.000
2	19.000	24.000	20.000
3	8.000	11.000	10.000

C level 3

	1	2	3
1	17.000	12.000	20.000
2	14.000	13.000	9.000
3	15.000	12.000	17.000

AB sums with 18 cases.

Variables

	1	2	3	Total
1	48.000	29.000	47.000	124.000
2	39.000	46.000	32.000	117.000
3	33.000	37.000	42.000	112.000
Total	120.000	112.000	121.000	353.000

AC sums with 18 cases.

Variables

	1	2	3	Total
1	25.000	50.000	49.000	124.000
2	18.000	63.000	36.000	117.000
3	39.000	29.000	44.000	112.000
Total	82.000	142.000	129.000	353.000

BC sums with 18 cases.

Variables

	1	2	3	Total
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1	29.000	45.000	46.000	120.000
2	26.000	49.000	37.000	112.000
3	27.000	48.000	46.000	121.000
Total	82.000	142.000	129.000	353.000

RC sums with 18 cases.

Variables	1	2	3	Total
1	16.000	42.000	36.000	94.000
2	37.000	52.000	47.000	136.000
3	29.000	48.000	46.000	123.000
Total	82.000	142.000	129.000	353.000

Group totals with 18 valid cases.

Variables	1	2	3	4
5	16.000	37.000	29.000	42.000
52.000				
Variables	6	7	8	9
Total	48.000	36.000	47.000	46.000
353.000				

Subjects sums with 18 valid cases.

Variables	1	2	3	4
5	7.000	9.000	14.000	28.000
15.000				
Variables	6	7	8	9
10	21.000	16.000	21.000	22.000
30.000				
Variables	11	12	13	14
15	28.000	19.000	10.000	19.000
23.000				
Variables	16	17	18	Total
	25.000	28.000	18.000	0.000

Latin Squares Repeated Analysis Plan 9

Source	SS	DF	MS	F	Prob.>F
Betw.Subj.	267.426	17			
Factor C	110.704	2	55.352	5.058	0.034
Rows	51.370	2	25.685	2.347	0.151
C x row	6.852	4	1.713	0.157	0.955
Subj.w.g.	98.500	9	10.944		
Within Sub	236.000	36			
Factor A	4.037	2	2.019	0.626	0.546
Factor B	2.704	2	1.352	0.420	0.664
Factor AC	146.519	4	36.630	11.368	0.000
Factor BC	8.519	4	2.130	0.661	0.627
AB prime	7.148	2	3.574	1.109	0.351
ABC prime	9.074	4	2.269	0.704	0.599
Error w.	58.000	18	3.222		
Total	503.426	53			

Experimental Design for Latin Square

FactorA	1	2	3
Group			
1	B2	B3	B1
2	B1	B2	B3
3	B3	B1	B2
4	B2	B3	B1
5	B1	B2	B3
6	B3	B1	B2
7	B2	B3	B1
8	B1	B2	B3
9	B3	B1	B2

Latin Squares Repeated Analysis Plan 9

Means for ANOVA Analysis

ABC matrix

C level 1

	1	2	3
1	6.500	1.500	4.500
2	3.000	4.500	1.500
3	5.000	7.000	7.500

C level 2

	1	2	3
1	9.000	7.000	9.000
2	9.500	12.000	10.000

3	4.000	5.500	5.000
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C level 3

	1	2	3
1	8.500	6.000	10.000
2	7.000	6.500	4.500
3	7.500	6.000	8.500

AB Means with 54 cases.

Variables

	1	2	3	4
1	8.000	4.833	7.833	6.889
2	6.500	7.667	5.333	6.500
3	5.500	6.167	7.000	6.222
Total	6.667	6.222	6.722	6.537

AC Means with 54 cases.

Variables

	1	2	3	4
1	4.167	8.333	8.167	6.889
2	3.000	10.500	6.000	6.500
3	6.500	4.833	7.333	6.222
Total	4.556	7.889	7.167	6.537

BC Means with 54 cases.

Variables

	1	2	3	4
1	4.833	7.500	7.667	6.667
2	4.333	8.167	6.167	6.222
3	4.500	8.000	7.667	6.722
Total	4.556	7.889	7.167	6.537

RC Means with 54 cases.

Variables

	1	2	3	4
1	2.667	7.000	6.000	5.222
2	6.167	8.667	7.833	7.556
3	4.833	8.000	7.667	6.833

Total	4.556	7.889	7.167	6.537
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Group Means with 54 valid cases.

Variables	1	2	3	4
5				
	2.667	6.167	4.833	7.000
8.667				
Variables	6	7	8	9
Total				
	8.000	6.000	7.833	7.667
6.537				

Subjects Means with 54 valid cases.

Variables	1	2	3	4
5				
	3.500	4.500	7.000	14.000
7.500				
Variables	6	7	8	9
10				
	10.500	8.000	10.500	11.000
15.000				
Variables	11	12	13	14
15				
	14.000	9.500	5.000	9.500
11.500				
Variables	16	17	18	Total
	12.500	14.000	9.000	6.537