5.5 Replicated Latin Square Designs

- The experimenter is concerned with a single factor having p levels where p is small (e.g., $p = 2, 3, 4$).
- For each of these cases the disadvantage of using a latin square design (LSD) is the small number of degrees of freedom for error (df_E). For $p = 2, 3, 4$, the df_E are 0, 2, and 4 for the 2×2, 3×3, and 4×4 latin square designs, respectively.
- Thus when p is small, it is desirable to replicate a $p \times p$ latin square to increase the df_E.
- We will study three forms of a **replicated latin squares design (RLSD)** which are based on whether or not the researcher can use the same row and column blocks across the replicates. For each replicate a random LSD is selected using the process described earlier in the course.
- Suppose a RLSD having n replicates is run. In each of the associated models μ is the baseline mean and y_{ijkl} and ϵ_{ijkl} are the response and random error associated with row i, treatment j, column k in replicate l. We assume $\epsilon_{ijkl} \sim$ IID $N(0, \sigma^2)$.
- We are also assuming that there is no interaction among treatments and replicates. That is, we have an *additive model*.
- Suppose an engineer wants to compare the mean viscosity of 4 different resin compounds. Each compound contains an inert liquefying ingredient (ILI) and a technician must be involved in the resin extruding process. The following designs contain 3 "replicates" defined as follows.
  - **RLSD-1 Design**: 4 random batches of ILI and 4 technicians are selected. A latin square design is run for each replicate. The same 4 batches of ILI and the same 4 technicians are used in each of the 3 replicates.
  - **RLSD-2 Design**: 12 random batches of ILI and 4 technicians are selected. A latin square design is run for each replicate with 4 different batches of ILI used in each replicate. However, the same 4 technicians are used in each of the 3 replicates.
  - **RLSD-3 Design**: 12 random batches of ILI and 12 technicians are selected. A latin square design is run for each replicate. Four different batches of ILI and a 4 different technicians are used in each of the 3 replicates.

RLSD-1: The same row and column blocks appear in each replicate. The model is:

$$y_{ijkl} = \tag{38}$$

where ρ_l is the l^{th} replicate effect, α_i is the i^{th} row block effect, β_k is the k^{th} column block effect, and τ_j is the j^{th} treatment effect.

Analysis of Variance for a Replicated Latin Square, Case 1

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F_0
Treatments	$\frac{1}{np}\sum_{j=1}^{p} y_{\cdot j \cdot \cdot}^2 - \frac{y_{\cdots}^2}{N}$	$p-1$	$\frac{SS_{\text{Treatments}}}{p-1}$	$\frac{MS_{\text{Treatments}}}{MS_E}$
Rows	$\frac{1}{np}\sum_{i=1}^{p} y_{i \cdot \cdot \cdot}^2 - \frac{y_{\cdots}^2}{N}$	$p-1$	$\frac{SS_{\text{Rows}}}{p-1}$	
Columns	$\frac{1}{np}\sum_{k=1}^{p} y_{\cdot \cdot k \cdot}^2 - \frac{y_{\cdots}^2}{N}$	$p-1$	$\frac{SS_{\text{Columns}}}{p-1}$	
Replicates	$\frac{1}{p^2}\sum_{l=1}^{n} y_{\cdot \cdot \cdot l}^2 - \frac{y_{\cdots}^2}{N}$	$n-1$	$\frac{SS_{\text{Replicates}}}{n-1}$	
Error	Subtraction	$(p-1)[n(p+1)-3]$	$\frac{SS_E}{(p-1)[n(p+1)-3]}$	
Total	$\sum\sum\sum\sum y_{ijkl}^2 - \frac{y_{\cdots}^2}{N}$	np^2-1		

RLSD-2: The blocks are identical for one blocking factor but are different for the other blocking factor across the replicates. Without loss of generality, we will assume the column blocks are identical but the row blocks vary across replicates, then the model is:

$$y_{ijkl} = \tag{39}$$

where ρ_l is the l^{th} replicate effect $\alpha_{i(l)}$ is the effect of row block i within replicate l, β_k is the effect of column block k, and τ_j is the j^{th} treatment effect.

Analysis of Variance for a Replicated Latin Square, Case 2

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F_0
Treatments	$\frac{1}{np}\sum_{j=1}^{p} y_{j..}^2 - \frac{y_{....}^2}{N}$	$p-1$	$\frac{SS_{\text{Treatments}}}{p-1}$	$\frac{MS_{\text{Treatments}}}{MS_E}$
Rows	$\frac{1}{p}\sum_{l=1}^{n}\sum_{i=1}^{p} y_{i..l}^2 - \sum_{l=1}^{n}\frac{y_{....}^2}{p^2}$	$n(p-1)$	$\frac{SS_{\text{Rows}}}{n(p-1)}$	
Columns	$\frac{1}{np}\sum_{k=1}^{p} y_{..k.}^2 - \frac{y_{....}^2}{N}$	$p-1$	$\frac{SS_{\text{Columns}}}{p-1}$	
Replicates	$\frac{1}{p^2}\sum_{l=1}^{n} y_{...l}^2 - \frac{y_{....}^2}{N}$	$n-1$	$\frac{SS_{\text{Replicates}}}{n-1}$	
Error	Subtraction	$(p-1)(np-1)$	$\frac{SS_E}{(p-1)(np-1)}$	

RLSD-3: The blocks are different for both blocking factors across the replicates.

$$y_{ijkl} = \tag{40}$$

where ρ_l is the l^{th} replicate effect $\alpha_{i(l)}$ is the effect of row block i within replicate l, $\beta_{k(l)}$ is the effect of column block k within replicate l, and τ_j is the j^{th} treatment effect.

Analysis of Variance for a Replicated Latin Square, Case 3

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F_0
Treatments	$\frac{1}{np}\sum_{j=1}^{p} y_{j..}^2 - \frac{y_{....}^2}{N}$	$p-1$	$\frac{SS_{\text{Treatments}}}{p-1}$	$\frac{MS_{\text{Treatment}}}{MS_E}$
Rows	$\frac{1}{p}\sum_{l=1}^{n}\sum_{i=1}^{p} y_{i..l}^2 - \sum_{l=1}^{n}\frac{y_{...l}^2}{p^2}$	$n(p-1)$	$\frac{SS_{\text{Rows}}}{n(p-1)}$	
Columns	$\frac{1}{p}\sum_{l=1}^{n}\sum_{k=1}^{p} y_{..kl}^2 - \sum_{l=1}^{n}\frac{y_{...l}^2}{p^2}$	$n(p-1)$	$\frac{SS_{\text{Columns}}}{n(p-1)}$	
Replicates	$\frac{1}{p^2}\sum_{l=1}^{n} y_{...l}^2 - \frac{y_{....}^2}{N}$	$n-1$	$\frac{SS_{\text{Replicates}}}{n-1}$	
Error	Subtraction	$(p-1)[n(p-1)-1]$	$\frac{SS_E}{(p-1)[n(p-1)-1]}$	

The following table contains the data for the following RLSD-1 and RLSD-3 examples.

	Replicate 1				Replicate 2			
	Days				Days			
	1	2	3	4	1	2	3	4
Operator	B	C	A	D	D	C	A	B
1	810	1080	700	910	840	1050	775	805
	C	D	B	A	A	D	B	C
2	1100	880	780	600	670	930	720	1035
	D	A	C	B	C	B	D	A
3	840	540	1055	830	980	700	810	610
	A	B	D	C	B	A	C	D
4	650	740	1025	900	860	730	970	900

RLSD-1 Example: A manufacturing firm investigated the breaking strengths of components made from raw materials purchased from 4 suppliers (A, B, C, D). Data was collected from 2 replicates of a 4×4 latin square design. The blocking factors were days and operators. The same four operators were used in both replicates. Each replicate was also run on the same four days with replicated values taken during the morning and afternoons of these four days.

SAS code for RLSD-1 Example

```
DM 'LOG; CLEAR; OUT; CLEAR;';
ODS GRAPHICS ON;
* ODS PRINTER PDF file='C:\COURSES\ST541\RLSD1.PDF';
OPTIONS NODATE NONUMBER;

***********************************************;
***  REPLICATED LATIN SQUARE EXAMPLE RLSD-1 ***;
***********************************************;
DATA rlsd1 ;
     DO rep      = 1 to 2;
     DO operator = 1 TO 4;
     DO day      = 1 TO 4;
        INPUT strength supplier $ @@; OUTPUT;
     END; END; END;
CARDS;
810 B  1080 C  700 A  910 D  1100 C  880 D  780 B  600 A
840 D  540 A  1055 C  830 B  650 A  740 B  1025 D  900 C
840 D  1050 C  775 A  805 B  670 A  930 D  720 B  1035 C
980 C  700 B   810 D  610 A  860 B  730 A  970 C   900 D

PROC GLM DATA=rlsd1 PLOTS=(DIAGNOSTICS);
    CLASS rep operator supplier day;
    MODEL strength = rep operator day supplier / SS3;
    RANDOM rep operator day / TEST ;
    MEANS supplier / BON ;
    MEANS rep operator day ;
TITLE 'Replicated Latin Square RLSD--1 Example';
RUN;
```

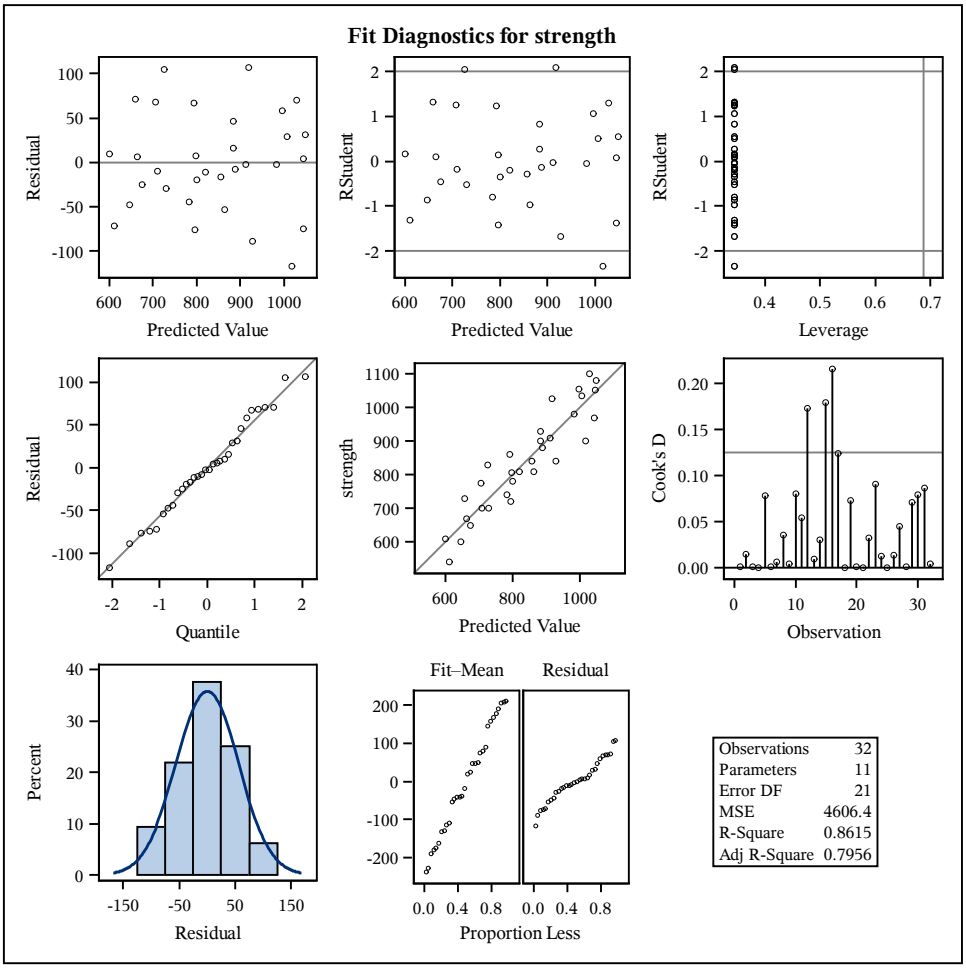
SAS output for RLSD-1 Example

Variable: strength

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	601795.3125	60179.5313	13.06	<.0001
Error	21	96735.1563	4606.4360		
Corrected Total	31	698530.4688			

R-Square	Coeff Var	Root MSE	strength Mean
0.861516	8.096415	67.87073	838.2813

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	1	94.5313	94.5313	0.02	0.8875
operator	3	23852.3438	7950.7813	1.73	0.1923
day	3	4396.0938	1465.3646	0.32	0.8121
supplier	3	573452.3438	191150.7813	41.50	<.0001



Source	Type III Expected Mean Square
rep	Var(Error) + 16 Var(rep)
operator	Var(Error) + 8 Var(operator)
day	Var(Error) + 8 Var(day)
supplier	Var(Error) + Q(supplier)

The GLM Procedure
Tests of Hypotheses for Mixed Model Analysis of Variance

Variable: strength

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	1	94.531250	94.531250	0.02	0.8875
operator	3	23852	7950.781250	1.73	0.1923
day	3	4396.093750	1465.364583	0.32	0.8121
supplier	3	573452	191151	41.50	<.0001
Error: MS(Error)	21	96735	4606.436012		

Bonferroni (Dunn) t Tests for strength

This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	21
Error Mean Square	4606.436
Critical Value of t	2.91209
Minimum Significant Difference	98.823

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**supplier**
A	1021.25	8	C
B	891.88	8	D
C	780.63	8	B
D	659.38	8	A

Level of rep	**N**	**strength**	
		Mean	**Std Dev**
1	16	840.000000	170.029409
2	16	836.562500	132.862319

Level of operator	**N**	**strength**	
		Mean	**Std Dev**
1	8	871.250000	133.490235
2	8	839.375000	177.209269
3	8	795.625000	174.671886
4	8	846.875000	129.033149

Level of day	**N**	**strength**	
		Mean	**Std Dev**
1	8	843.750000	148.028713
2	8	831.250000	186.121120
3	8	854.375000	140.622024
4	8	823.750000	151.108996

RLSD-3 EXAMPLE: A manufacturing firm investigated the breaking strengths of components made from raw materials purchased from 4 suppliers (A, B, C, D). Data was collected from 2 replicates of a 4×4 latin square design. The blocking factors were days and operators. Eight operators were used with four operators randomly assigned to each replicate. The two replicates were run over 8 days with the first 4 days assigned to replicate 1 and the second four days assigned to replicate 2.

SAS code for RLSD-3 Example

```
DM 'LOG; CLEAR; OUT; CLEAR;';
ODS GRAPHICS OFF;
ODS PRINTER PDF file='C:\COURSES\ST541\RLSD3.PDF';
OPTIONS NODATE NONUMBER;

*********************************************;
***  REPLICATED LATIN SQUARE EXAMPLE RLSD-3 ***;
*********************************************;
DATA rlsd3 ;
     DO rep      = 1 to 2;
     DO operator = 1 TO 4;
     DO day      = 1 TO 4;
        INPUT strength supplier $ @@; OUTPUT;
     END; END; END;
CARDS;
810 B  1080 C  700 A  910 D  1100 C  880 D  780 B  600 A
840 D  540 A  1055 C  830 B  650 A  740 B  1025 D  900 C
840 D  1050 C  775 A  805 B  670 A  930 D  720 B  1035 C
980 C  700 B   810 D  610 A  860 B  730 A  970 C   900 D

PROC GLM DATA=rlsd3 PLOTS=(ALL);
    CLASS rep operator supplier day;
    MODEL strength = rep operator(rep) day(rep) supplier / SS3;
    RANDOM rep operator(rep) day(rep) / TEST ;
    MEANS supplier / BON ;
    MEANS rep operator(rep) day(rep) ;
TITLE 'Replicated Latin Square RLSD--3 Example';
RUN;
```

SAS output for RLSD-3 Example

Variable: strength

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	623343.7500	38958.9844	7.77	0.0001
Error	15	75186.7188	5012.4479		
Corrected Total	31	698530.4688			

R-Square	Coeff Var	Root MSE	strength Mean
0.892364	8.445691	70.79864	838.2813

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	1	94.5312	94.5312	0.02	0.8926
operator(rep)	6	29904.6875	4984.1146	0.99	0.4638
day(rep)	6	19892.1875	3315.3646	0.66	0.6817
supplier	3	573452.3438	191150.7813	38.14	<.0001

Source	Type III Expected Mean Square
rep	Var(Error) + 4 Var(day(rep)) + 4 Var(operator(rep)) + 16 Var(rep)
operator(rep)	Var(Error) + 4 Var(operator(rep))
day(rep)	Var(Error) + 4 Var(day(rep))
supplier	Var(Error) + Q(supplier)

Tests of Hypotheses for Mixed Model Analysis of Variance

Variable: strength

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	1	94.531250	94.531250	0.03	0.8864
Error	1.4129	4644.211027	3287.031250		
Error: MS(operator(rep)) + MS(day(rep)) - MS(Error)					

Source	DF	Type III SS	Mean Square	F Value	Pr > F
operator(rep)	6	29905	4984.114583	0.99	0.4638
day(rep)	6	19892	3315.364583	0.66	0.6817
supplier	3	573452	191151	38.14	<.0001
Error: MS(Error)	15	75187	5012.447917		

Bonferroni (Dunn) t Tests for strength

This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	15
Error Mean Square	5012.448
Critical Value of t	3.03628
Minimum Significant Difference	107.48

Means with the same letter are not significantly different.			
Bon Grouping	Mean	N	supplier
A	1021.25	8	C
B	891.88	8	D
C	780.63	8	B
D	659.38	8	A

Level of rep	N	strength	
		Mean	Std Dev
1	16	840.000000	170.029409
2	16	836.562500	132.862319

Level of operator	Level of rep	N	strength	
			Mean	Std Dev
1	1	4	875.000000	161.348484
2	1	4	840.000000	208.486610
3	1	4	816.250000	211.399109
4	1	4	828.750000	166.752061
1	2	4	867.500000	124.532459
2	2	4	838.750000	172.644867
3	2	4	775.000000	159.269164
4	2	4	865.000000	100.829890

Level of day	Level of rep	N	strength	
			Mean	Std Dev
1	1	4	850.000000	186.368810
2	1	4	810.000000	227.742545
3	1	4	890.000000	176.682389
4	1	4	810.000000	144.452991
1	2	4	837.500000	127.638813
2	2	4	852.500000	166.608323
3	2	4	818.750000	107.422453
4	2	4	837.500000	178.629038

RLSD-2 EXAMPLE: A study was performed to compare four baby food formula treatments. A 4×4 latin square design was replicated 4 times. The blocking factors were infants and weeks. (Actually, we have a simple repeated measures with infants receiving all 4 formula treatments.) A total of 16 infants were randomly assigned to the 4 replicates. The replicates were run over the same four weeks. The data is contained in the following tables (from *The Design and Analysis of Clinical Experiments* by J.L. Fleiss). If you temporarily ignore assumptions about the response, does this design meet the conditions to be a RLSD?

SAS code for RLSD-2 Example

```
DM 'LOG; CLEAR; OUT; CLEAR;';
ODS GRAPHICS OFF;
ODS PRINTER PDF file='C:\COURSES\ST541\RLSD2.PDF';
OPTIONS NODATE NONUMBER;

*********************************************;
***  REPLICATED LATIN SQUARE EXAMPLE RLSD-2 ***;
*********************************************;
DATA rlsd2 ;
     DO square = 1 TO 4;
     DO week   = 1 TO 4;
     DO _infant = 1 TO 4;
         infant = 4*(square-1) + _infant;
        INPUT diet formula @@; OUTPUT;
     END; END; END;
CARDS;
0.40 2  0.20 3  1.14 1  1.08 4  1.11 3  1.04 4  1.11 2  1.34 1
1.16 4  0.57 1  1.32 3  1.73 2  0.88 1  0.80 2  1.38 4  1.55 3
1.55 2  0.11 3  0.22 1  0.53 4  0.89 3  1.05 4  0.96 2  1.25 1
0.16 4  0.68 1  1.45 3  0.61 2  0.55 1  0.98 2  0.82 4  1.91 3
0.27 2  0.50 3  0.32 1  0.09 4  1.16 3  0.70 4  1.63 2  0.30 1
0.59 4  0.93 1  0.55 3  1.34 2  0.45 1  0.96 2  0.79 4  1.09 3
0.73 2  0.64 3 -0.03 1  1.05 4  1.21 3  1.38 4  1.04 2  1.11 1
1.21 4  0.82 1  0.57 3  1.00 2  0.77 1  0.79 2  0.55 4  0.50 3
;
PROC GLM DATA=rlsd2 PLOTS=(ALL);
    CLASS square infant formula week;
    MODEL diet = square infant(square) formula week / SS3;
    RANDOM square infant(square) week / TEST;
    MEANS formula / BON;
    MEANS square infant(square) week ;
TITLE 'Replicated Latin Square RLSD2--2 Example';
RUN;
```

Results of a study performed as four replicated Latin squares comparing four formulas fed to newborn infants

Square 1

	Week				
Infant	1	2	3	4	Mean
1	0.40(2)	1.11(3)	1.16(4)	0.88(1)	0.8875
2	0.20(3)	1.04(4)	0.57(1)	0.80(2)	0.6525
3	1.14(1)	1.11(2)	1.32(3)	1.38(4)	1.2375
4	1.08(4)	1.34(1)	1.73(2)	1.55(3)	1.4250
Mean	0.7050	1.1500	1.1950	1.1525	1.050625
Formula	1	2	3	4	
Mean	0.9825	1.0100	1.0450	1.1650	

Square 2

	Week				
Infant	1	2	3	4	Mean
1	1.55(2)	0.89(3)	0.16(4)	0.55(1)	0.7875
2	0.11(3)	1.05(4)	0.68(1)	0.98(2)	0.7050
3	0.22(1)	0.96(2)	1.45(3)	0.82(4)	0.8625
4	0.53(4)	1.25(1)	0.61(2)	1.91(3)	1.0750
Mean	0.6025	1.0375	0.7250	1.0650	0.8575
Formula	1	2	3	4	
Mean	0.6750	1.0250	1.0900	0.6400	

Square 3

	Week				
Infant	1	2	3	4	Mean
1	0.27(2)	1.16(3)	0.59(4)	0.45(1)	0.6175
2	0.50(3)	0.70(4)	0.93(1)	0.96(2)	0.7725
3	0.32(1)	1.63(2)	0.55(3)	0.79(4)	0.8225
4	0.09(4)	0.30(1)	1.34(2)	1.09(3)	0.7050
Mean	0.2950	0.9475	0.8525	0.8225	0.729375
Formula	1	2	3	4	
Mean	0.5000	1.0500	0.8250	0.5425	

Square 4

	Week				
Infant	1	2	3	4	Mean
1	0.73(2)	1.21(3)	1.21(4)	0.77(1)	0.9800
2	0.64(3)	1.38(4)	0.82(1)	0.79(2)	0.9075
3	−0.03(1)	1.04(2)	0.57(3)	0.55(4)	0.5325
4	1.05(4)	1.11(1)	1.00(2)	0.50(3)	0.9150
Mean	0.5975	1.1850	0.9000	0.6525	0.83375
Formula	1	2	3	4	
Mean	0.6675	0.8900	0.7300	1.0475	

Overall

Week	1	2	3	4	Mean
Overall mean	0.550000	1.080000	0.918125	0.923125	0.8678125
Formula	1	2	3	4	Mean
Overall mean	0.70625	0.99375	0.92250	0.84875	0.8678125

Replicated Latin Square RLSD2--2 Example

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
square	4	1 2 3 4
infant	16	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
formula	4	1 2 3 4
week	4	1 2 3 4

Number of Observations Read	64
Number of Observations Used	64

Variable: diet

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	21	6.34661875	0.30221994	2.32	0.0102
Error	42	5.48047500	0.13048750		
Corrected Total	63	11.82709375			

R-Square	Coeff Var	Root MSE	diet Mean
0.536617	41.62541	0.361231	0.867813

Source	DF	Type III SS	Mean Square	F Value	Pr > F
square	3	0.86163125	0.28721042	2.20	0.1021
infant(square)	12	2.33401250	0.19450104	1.49	0.1662
formula	3	0.72506875	0.24168958	1.85	0.1524
week	3	2.42590625	0.80863542	6.20	0.0014

Source	Type III Expected Mean Square
square	Var(Error) + 4 Var(infant(square)) + 16 Var(square)
infant(square)	Var(Error) + 4 Var(infant(square))
formula	Var(Error) + Q(formula)
week	Var(Error) + 16 Var(week)

The GLM Procedure
Tests of Hypotheses for Mixed Model Analysis of Variance

Variable: diet

Source	DF	Type III SS	Mean Square	F Value	Pr > F
square	3	0.861631	0.287210	1.48	0.2704
Error	12	2.334013	0.194501		
Error: MS(infant(square))					

Source	DF	Type III SS	Mean Square	F Value	Pr > F
infant(square)	12	2.334013	0.194501	1.49	0.1662
formula	3	0.725069	0.241690	1.85	0.1524
week	3	2.425906	0.808635	6.20	0.0014
Error: MS(Error)	42	5.480475	0.130487		

Bonferroni (Dunn) t Tests for diet

This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	42
Error Mean Square	0.130487
Critical Value of t	2.76902
Minimum Significant Difference	0.3536

Means with the same letter are not significantly different.			
Bon Grouping	Mean	N	formula
A	0.9938	16	2
A			
A	0.9225	16	3
A			
A	0.8488	16	4
A			
A	0.7063	16	1

Level of square	N	diet	
		Mean	Std Dev
1	16	1.05062500	0.40607830
2	16	0.85750000	0.51014377
3	16	0.72937500	0.42829069
4	16	0.83375000	0.34993095

Level of infant	Level of square	N	diet	
			Mean	Std Dev
1	1	4	0.88750000	0.34711910
2	1	4	0.65250000	0.35752622
3	1	4	1.23750000	0.13275918
4	1	4	1.42500000	0.27982137
5	2	4	0.78750000	0.58937113
6	2	4	0.70500000	0.42790186
7	2	4	0.86250000	0.50638424
8	2	4	1.07500000	0.64319515
9	3	4	0.61750000	0.38465352
10	3	4	0.77250000	0.21561926
11	3	4	0.82250000	0.57151115
12	3	4	0.70500000	0.60379356
13	4	4	0.98000000	0.26608269
14	4	4	0.90750000	0.32469216
15	4	4	0.53250000	0.43805441
16	4	4	0.91500000	0.28029746

Level of week	N	diet	
		Mean	Std Dev
1	16	0.55000000	0.45086583
2	16	1.08000000	0.29691750
3	16	0.91812500	0.42060621
4	16	0.92312500	0.39799026