This is the SAS program for the fabric data that we examined in the beginning of the module on two-way ANOVA. This program is complete, and produces the output shown on the following pages. You have already seen most of this, but I think it is useful for you to see everything that SAS produces, so you can find the parts needed to perform an analysis.

Description of the data:

An experiment was conducted to study the effects of treating fabric with inorganic salts on the flammability of fabric. Two application levels (concentrations) and three salts were used, and a vertical burn test was used on three specimens of cloth for each salt and level combination. The response variable is the temperature at which the fabric specimen ignites.

Source: Hsieh and Hardin, "Effects of Selected Inorganic Salts on Cotton Flammability", Textile Research Journal , Vol. 54, No. 3, 1984, pp. 171-179.

```
options linesize=76 nodate;
```

Options to limit each printed line to 76 characters and don't print the date at the top of each page. If you wish, you may omit this statement and use SAS default settings.

```
data fabric;
input Level Salt $ Temperature;
datalines;
1 CaCO3       733
1 CaCO3       728
1 CaCO3       720
1 CaCl2       725
1 CaCl2       727
1 CaCl2       719
1 Untreated   812
1 Untreated   827
1 Untreated   876
2 CaCO3       786
2 CaCO3       771
2 CaCO3       779
2 CaCl2       756
2 CaCl2       781
2 CaCl2       814
2 Untreated   945
2 Untreated   881
2 Untreated   919
;
proc print data=fabric; run;
```

SAS data step

- creates a dataset called fabric
- variables are Level, Salt and Temperature
- the dollar sign after Salt tells SAS that Salt is a character variable

Each row in the data is one observation.

Be careful that no character variables are misspelled.

```
proc sort data=fabric;
 by Level Salt;
 run;

proc means data=fabric noprint;
 by Level Salt;
 var Temperature;
 output out=means mean=mean;
 run;
proc print data=means; run;
```

When you use a 'by' statement in proc means, SAS expects the dataset to be sorted in the order of the 'by' variables. Use **proc sort** to sort the data before calling proc means.

proc means calculates the cell means and saves them to a dataset called 'means'.

The `noprint` option suppresses printing (a lot of) output. Instead, we use **proc print** to print just what we want to see.

```
ods graphics on;
```

If you are using SAS OnDemand, you must enable the graphics output system before any plots can be generated. This is usually not necessary if you are using SAS that is installed on a local network.

```
axis1 minor=none;
symbol1 i=join value=none line=1 color=black w=2;
symbol2 i=join value=none line=2 color=black w=2;

proc gplot data=means;
 plot mean*Salt=Level / haxis=axis1 vaxis=axis1;
 run;
```

axis and symbol statements control the format of what will be graphed

proc gplot produces the interaction plot

```
title 'Interaction Model: Fabric Data';
proc glm data=fabric;
 class level salt;
 model temperature = level | salt /ss3;
 lsmeans level salt level*salt / stderr cl pdiff;
 contrast 'ContrastName' level 2 -2 level*salt 1 1 0 -1 -1 0;
 run;
```

proc glm is the core of the analysis.
The results of each statement are indicated in the output on the following pages.

```
ods graphics off;
quit;
```

Turn the graphics system off and quit SAS.

Interaction Model: Fabric Data

Obs	Level	Salt	Temperature
1	1	CaCO3	733
2	1	CaCO3	728
3	1	CaCO3	720
4	1	CaCl2	725
5	1	CaCl2	727
6	1	CaCl2	719
7	1	Untreate	812
8	1	Untreate	827
9	1	Untreate	876
10	2	CaCO3	786
11	2	CaCO3	771
12	2	CaCO3	779
13	2	CaCl2	756
14	2	CaCl2	781
15	2	CaCl2	814
16	2	Untreate	945
17	2	Untreate	881
18	2	Untreate	919

This is the result of proc print.

Make sure the data looks okay before proceeding with the analysis.

If you see a lot of dots here, there is probably a problem with the SAS data step. Make sure the data (highlighted in yellow in the code) is separated by spaces and not tabs.

Interaction Model: Fabric Data

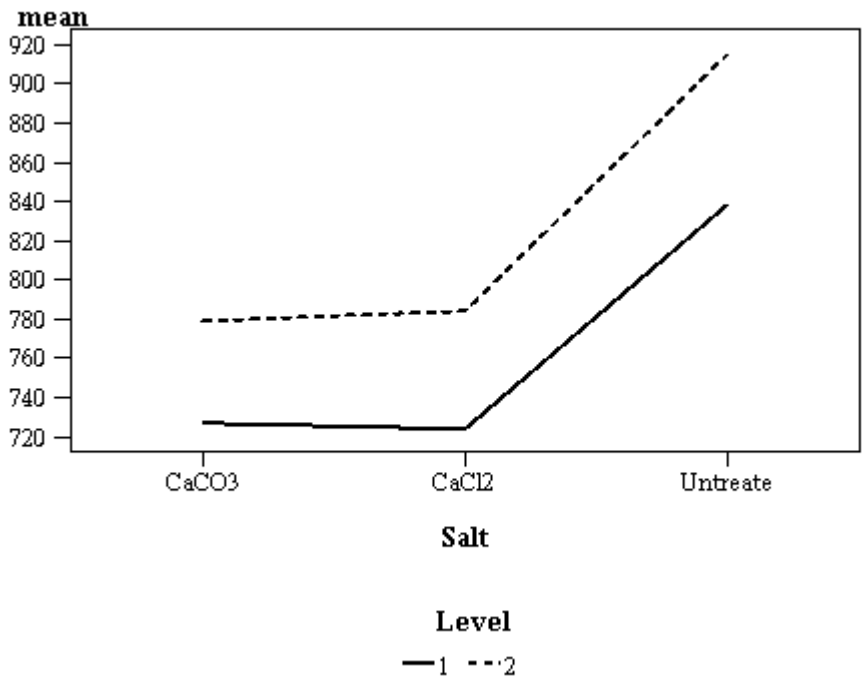
Obs	Level	Salt	_TYPE_	_FREQ_	mean
1	1	CaCO3	0	3	727.000
2	1	CaCl2	0	3	723.667
3	1	Untreate	0	3	838.333
4	2	CaCO3	0	3	778.667
5	2	CaCl2	0	3	783.667
6	2	Untreate	0	3	915.000

proc means does not produce any output because we used the 'noprint' option.

This table is the result of `proc print data=means; run;`

The last column contains the cell (treatment) means.

Interaction Model: Fabric Data



This the interaction plot generated by **proc gplot**.

Interaction Model: Fabric Data

The GLM Procedure

This is the beginning of the output generated by Proc GLM

Class Level Information		
Class	**Levels**	**Values**
Level	2	1 2
Salt	3	CaCO3 CaCl2 Untreate

Number of Observations Read	18
Number of Observations Used	18

The first table tells us what the categorical predictor variables are, and what levels they have. The order of the levels is important when we construct contrast statements.

The second table informs us how many observations are being read and used by GLM. This could be important if there are any missing values in the data. You should always know how many observations you have in the dataset. If the numbers here don't match, you need to make sure the data is being read in correctly.

Interaction Model: Fabric Data

The GLM Procedure

Dependent Variable: Temperature

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	79149.61111	15829.92222	30.45	<.0001
Error	12	6238.66667	519.88889		
Corrected Total	17	85388.27778			

R-Square	Coeff Var	Root MSE	Temperature Mean
0.926938	2.870266	22.80107	794.3889

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Level	1	17734.72222	17734.72222	34.11	<.0001
Salt	2	60928.77778	30464.38889	58.60	<.0001
Level*Salt	2	486.11111	243.05556	0.47	0.6375

The top table is the ANOVA table. There is a single line for the Model. Details of the model are given in the bottom table.

The overall ANOVA F test (in the top table) is testing whether EVERY parameter in the model (except the intercept) is equal to 0. The hypotheses are

H0: all the α's, all the β's, and all the interactions are equal to 0
vs. Ha: at least one of these parameters is not 0.

The information in the bottom table is testing for groups of the parameters.

For "Level', the F test is testing H0: both α's are equal to 0 vs. Ha: at least one α is not 0

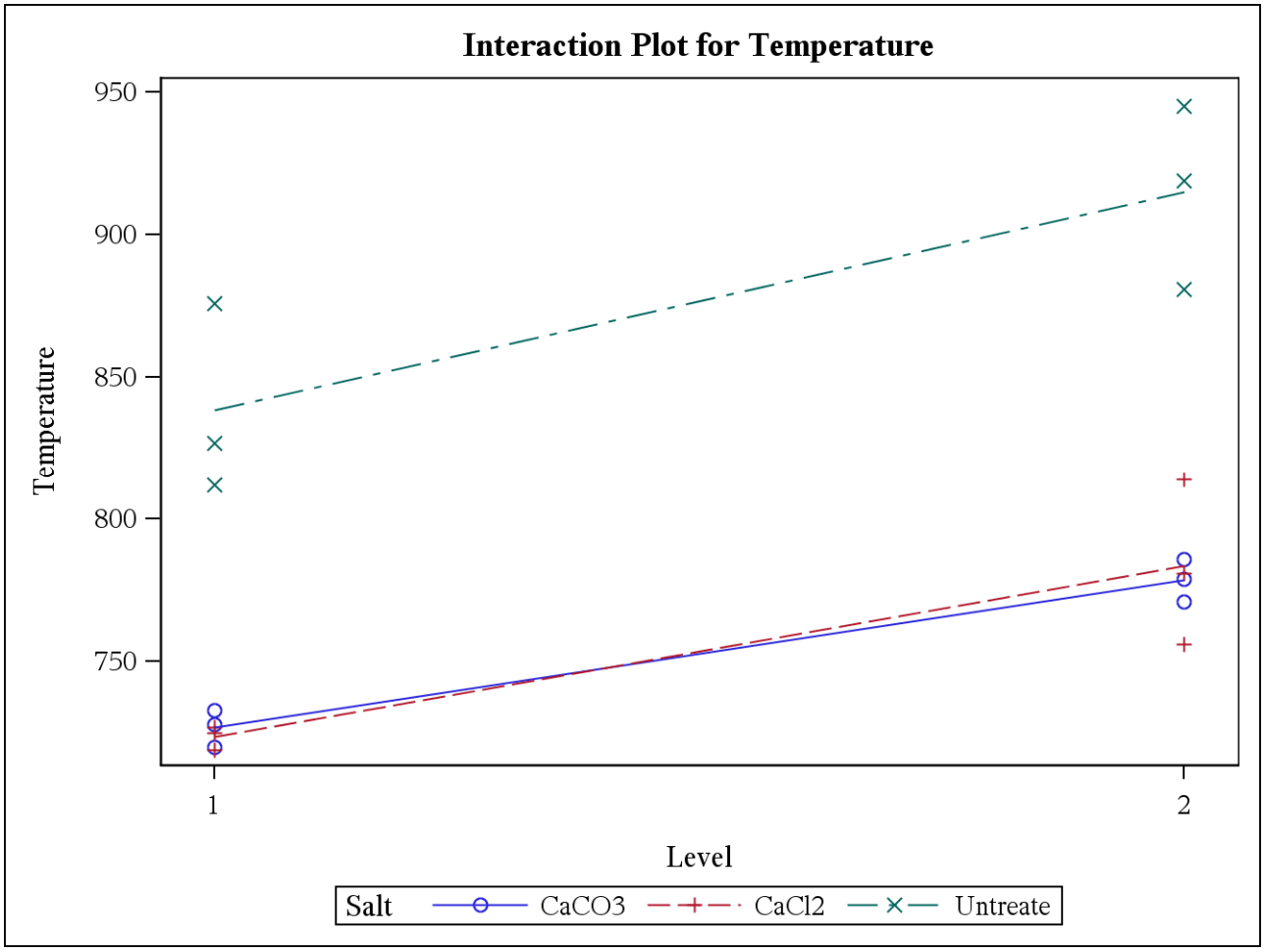
For "Salt", the F test is testing H0: all three β's are equal to 0 vs. Ha: at least one β is not 0.

For "Level*Salt", the F test is testing H0: all of the $(\alpha\beta)$'s are 0 vs. Ha: at least one $(\alpha\beta)$ is not 0.

Interaction Model: Fabric Data

The GLM Procedure

Dependent Variable: Temperature



This is the interaction plot generated by proc glm.

Note that it is different than the one we generated with proc gplot.

In proc gplot, we put Salt on the x-axis and connect the lines according to Level. Proc glm did just the opposite.

Interaction Model: Fabric Data

The GLM Procedure
Least Squares Means

Level	Temperature LSMEAN	Standard Error	H0:LSMEAN=0	H0:LSMean1=LSMean2
			Pr > |t|	Pr > |t|
1	763.000000	7.600357	<.0001	<.0001
2	825.777778	7.600357	<.0001	

Level	Temperature LSMEAN	95% Confidence Limits	
1	763.000000	746.440244	779.559756
2	825.777778	809.218022	842.337534

Least Squares Means for Effect Level				
i	j	Difference Between Means	95% Confidence Limits for LSMean(i)-LSMean(j)	
1	2	-62.777778	-86.196810	-39.358746

These are the least squares means for Level.

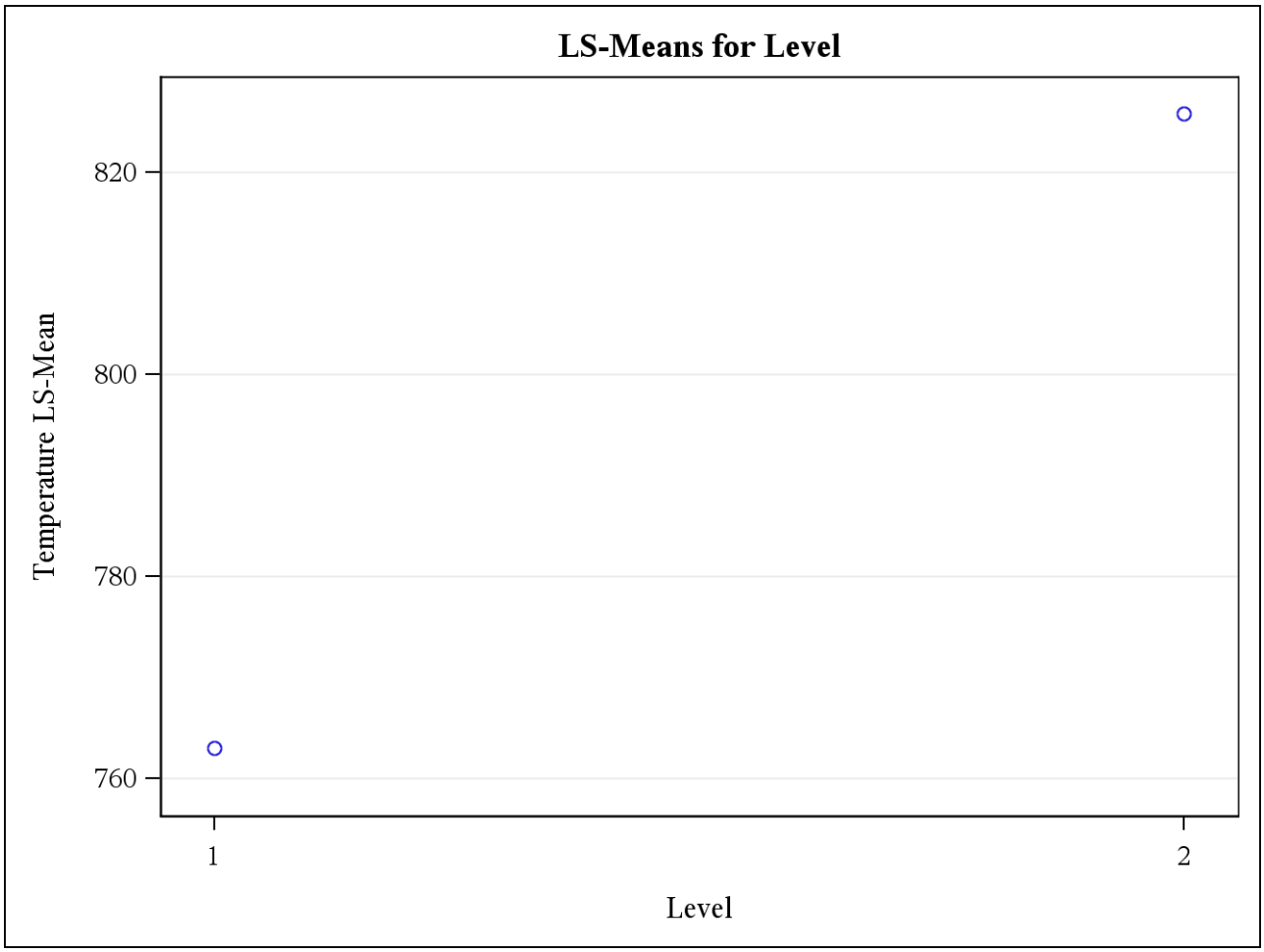
The top table givens the estimate for the marginal mean and the standard error of the estimate. SAS automatically performs the test that compares each mean to 0, and the test that compares these two marginal means.

The second table gives the confidence intervals for the means. This table is the result of the 'cl' option on the lsmeans statement.

The 3rd table gives the estimated difference between the marginal means and confidence interval for the difference. SAS produces this table because we specified both the 'cl' and 'pdiff' options on the lsmeans statement.

Interaction Model: Fabric Data

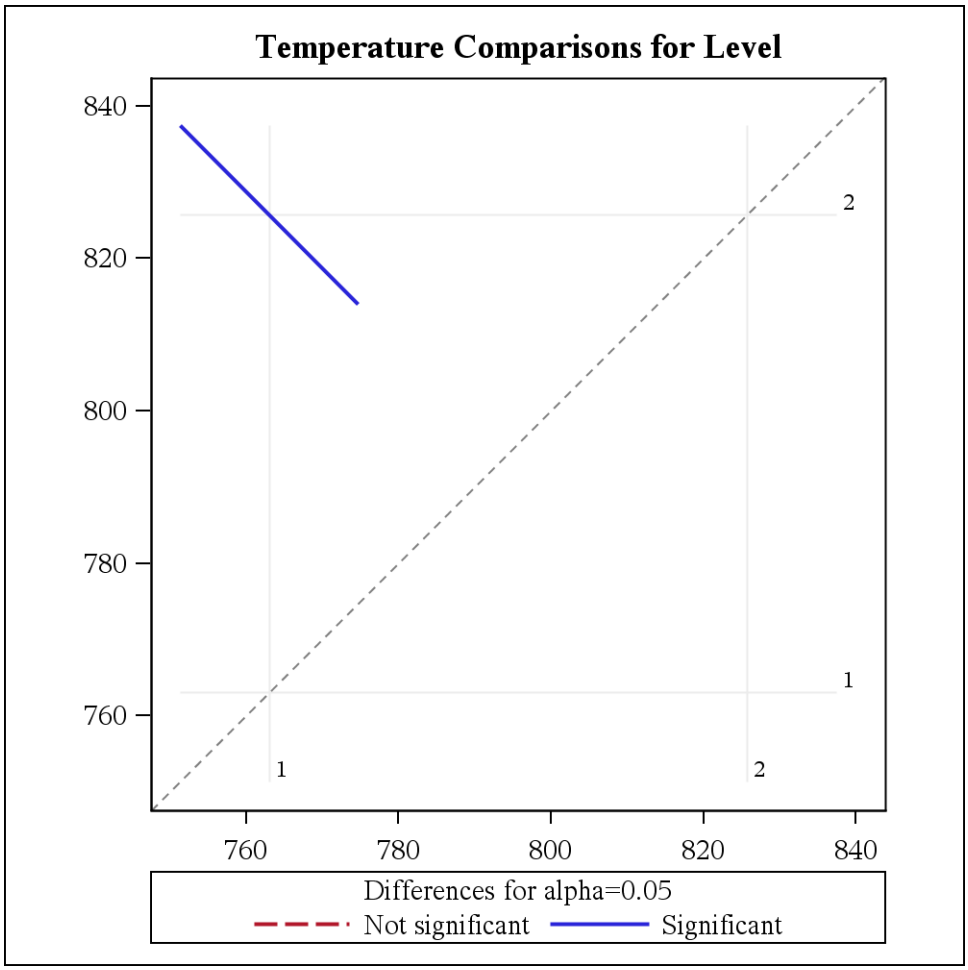
The GLM Procedure
Least Squares Means



A very *un*informative plot. Please ignore this.

Interaction Model: Fabric Data

The GLM Procedure
Least Squares Means



Interaction Model: Fabric Data

The GLM Procedure
Least Squares Means

This begins the output for the marginal means of Salt

This is similar to output for the marginal means of Level, except that there are three levels for Salt. So the pairwise differences are displayed in a matrix (the second table below).

Know how to read this output. If you have any questions, please contact the instructor.

Salt	Temperature LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
CaCO3	752.833333	9.308499	<.0001	1
CaCl2	753.666667	9.308499	<.0001	2
Untreate	876.666667	9.308499	<.0001	3

Least Squares Means for effect Salt
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Temperature

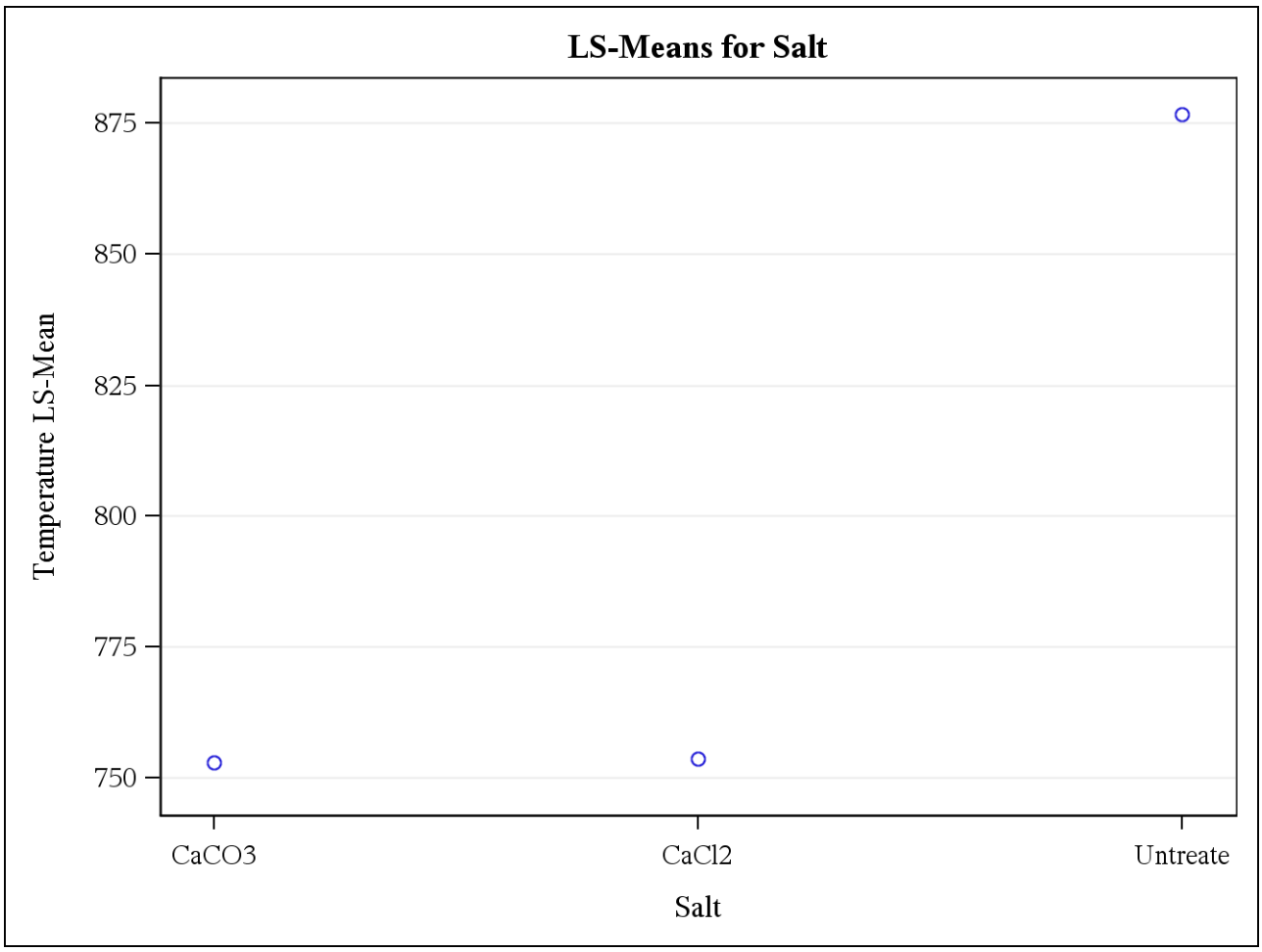
i/j	1	2	3
1		0.9506	<.0001
2	0.9506		<.0001
3	<.0001	<.0001	

Salt	Temperature LSMEAN	95% Confidence Limits	
CaCO3	752.833333	732.551857	773.114810
CaCl2	753.666667	733.385190	773.948143
Untreate	876.666667	856.385190	896.948143

Interaction Model: Fabric Data

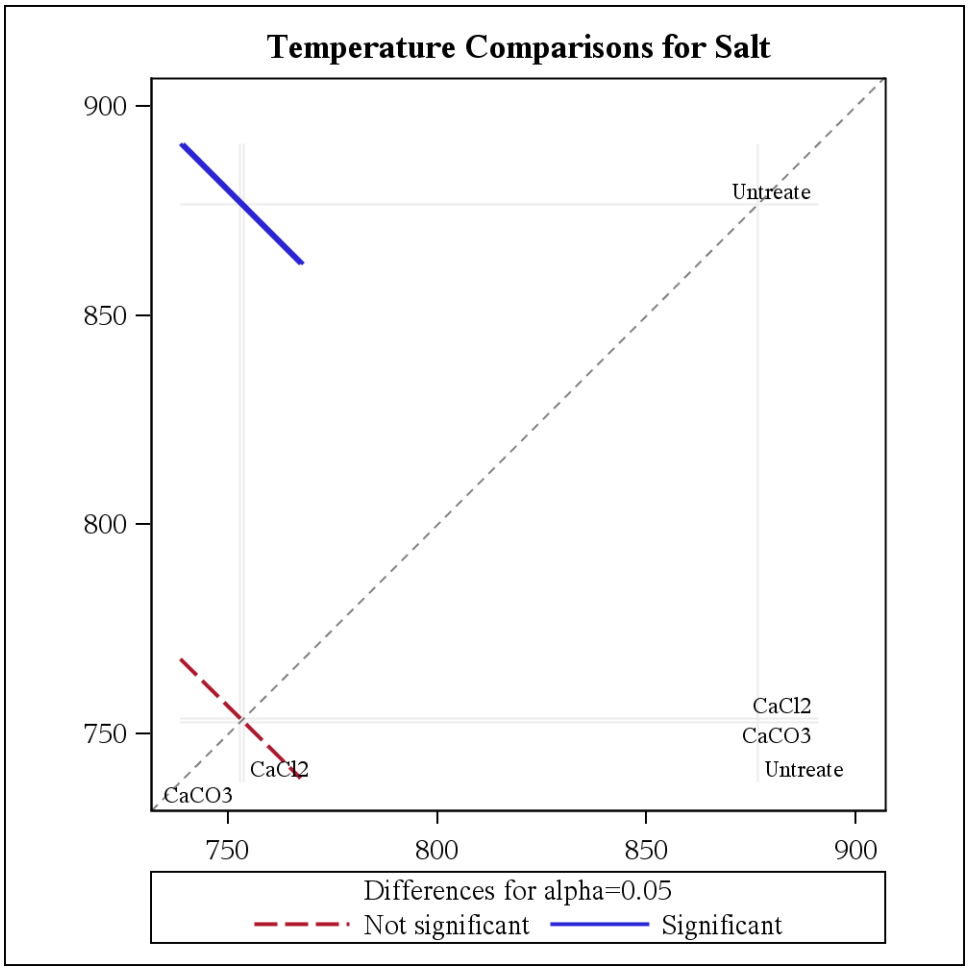
The GLM Procedure
Least Squares Means

Least Squares Means for Effect Salt				
i	j	Difference Between Means	95% Confidence Limits for LSMean(i)-LSMean(j)	
1	2	-0.833333	-29.515672	27.849006
1	3	-123.833333	-152.515672	-95.150994
2	3	-123.000000	-151.682339	-94.317661



Interaction Model: Fabric Data

The GLM Procedure
Least Squares Means



Note: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

Interaction Model: Fabric Data

The GLM Procedure
Least Squares Means

This begins the output for the treatment means.

This is similar to output for the marginal means of Salt.
Tables containing confidence limits are produced because we specified the 'cl' option.
Tables containing the differences of means are produced because we specified the 'pdiff' option.

Know how to read this output. If you have any questions, please contact the instructor.

Level	Salt	Temperature LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	CaCO3	727.000000	13.164205	<.0001	1
1	CaCl2	723.666667	13.164205	<.0001	2
1	Untreate	838.333333	13.164205	<.0001	3
2	CaCO3	778.666667	13.164205	<.0001	4
2	CaCl2	783.666667	13.164205	<.0001	5
2	Untreate	915.000000	13.164205	<.0001	6

Least Squares Means for effect Level*Salt
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Temperature

i/j	1	2	3	4	5	6
1		0.8609	<.0001	0.0168	0.0102	<.0001
2	0.8609		<.0001	0.0120	0.0073	<.0001
3	<.0001	<.0001		0.0076	0.0125	0.0014
4	0.0168	0.0120	0.0076		0.7928	<.0001
5	0.0102	0.0073	0.0125	0.7928		<.0001
6	<.0001	<.0001	0.0014	<.0001	<.0001	

Interaction Model: Fabric Data

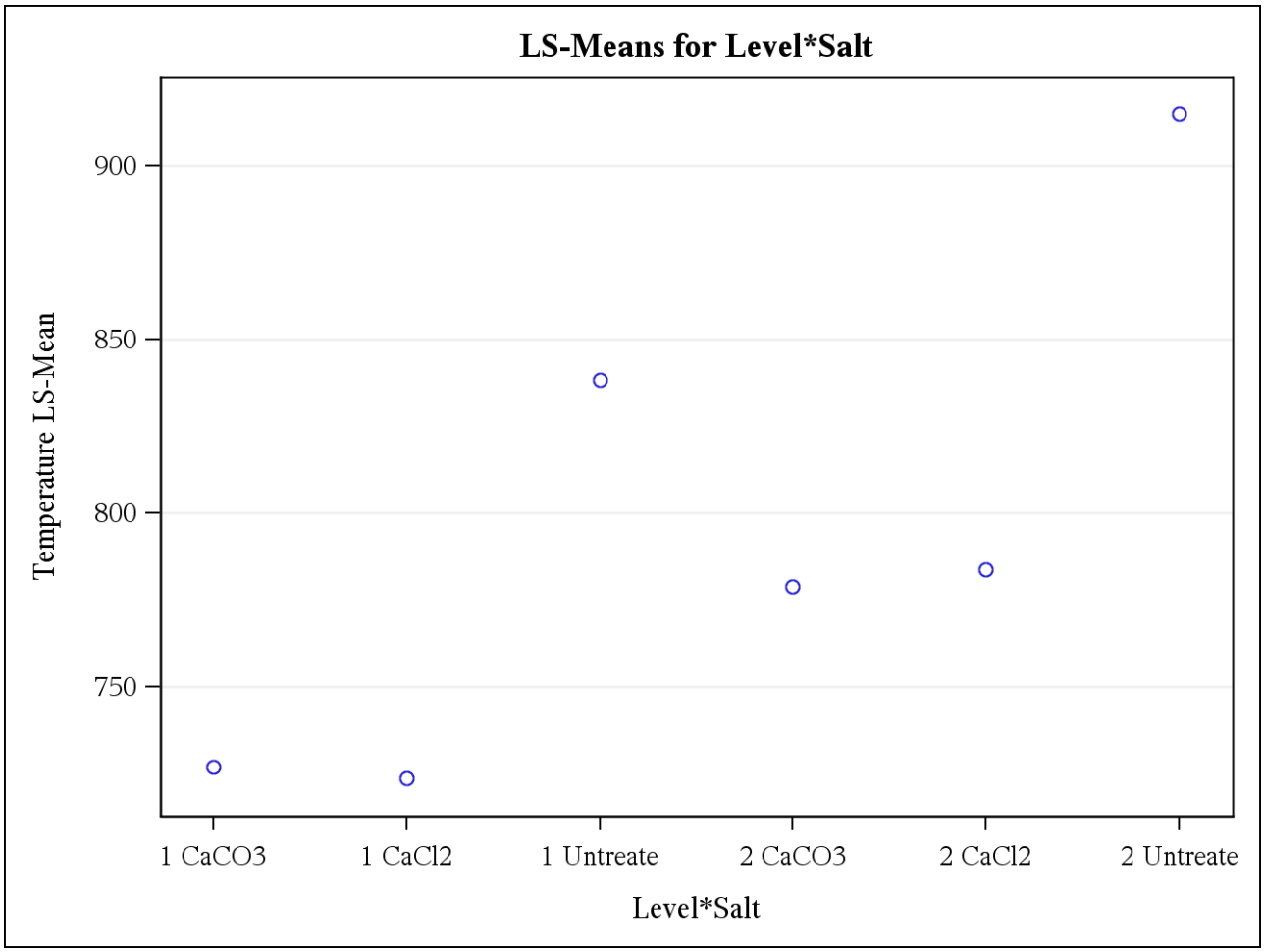
The GLM Procedure
Least Squares Means

Level	Salt	Temperature LSMEAN	95% Confidence Limits	
1	CaCO3	727.000000	698.317661	755.682339
1	CaCl2	723.666667	694.984328	752.349006
1	Untreate	838.333333	809.650994	867.015672
2	CaCO3	778.666667	749.984328	807.349006
2	CaCl2	783.666667	754.984328	812.349006
2	Untreate	915.000000	886.317661	943.682339

Least Squares Means for Effect Level*Salt				
i	j	Difference Between Means	95% Confidence Limits for LSMean(i)-LSMean(j)	
1	2	3.333333	-37.229619	43.896286
1	3	-111.333333	-151.896286	-70.770381
1	4	-51.666667	-92.229619	-11.103714
1	5	-56.666667	-97.229619	-16.103714
1	6	-188.000000	-228.562953	-147.437047
2	3	-114.666667	-155.229619	-74.103714
2	4	-55.000000	-95.562953	-14.437047
2	5	-60.000000	-100.562953	-19.437047
2	6	-191.333333	-231.896286	-150.770381
3	4	59.666667	19.103714	100.229619
3	5	54.666667	14.103714	95.229619
3	6	-76.666667	-117.229619	-36.103714
4	5	-5.000000	-45.562953	35.562953
4	6	-136.333333	-176.896286	-95.770381
5	6	-131.333333	-171.896286	-90.770381

Interaction Model: Fabric Data

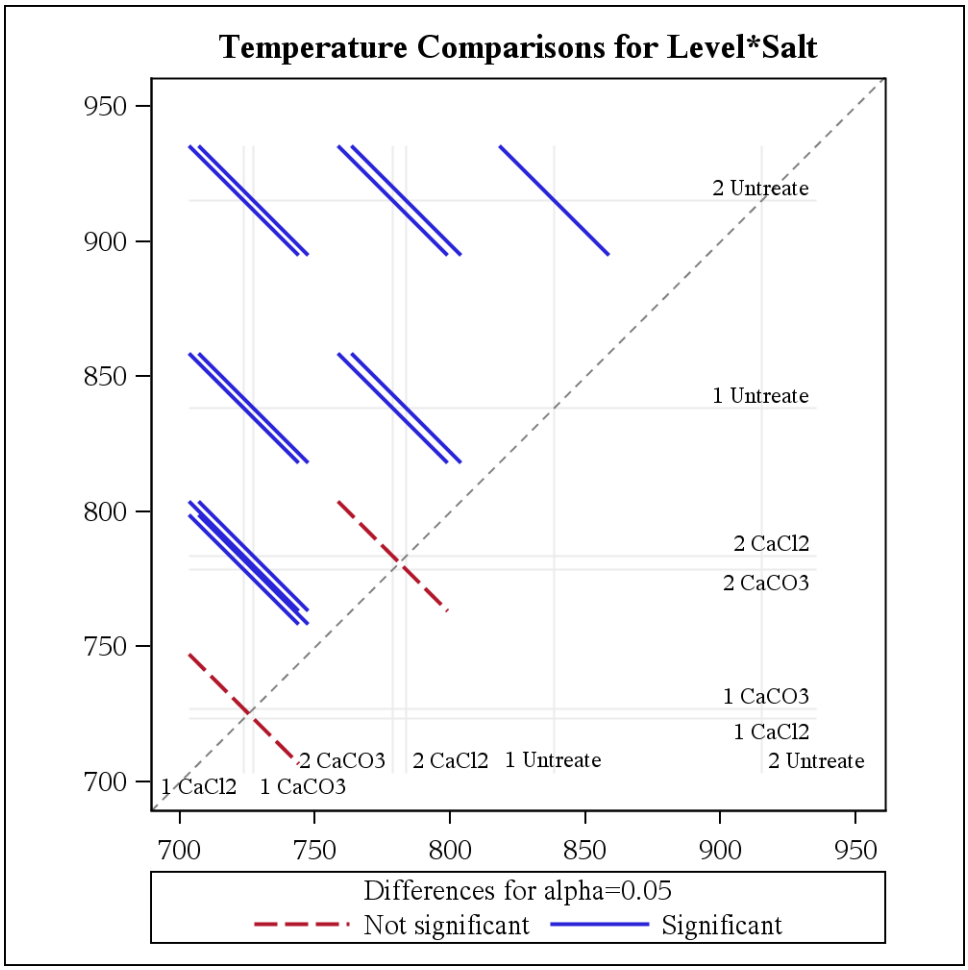
The GLM Procedure
Least Squares Means



Another uninformative graph.

Interaction Model: Fabric Data

The GLM Procedure
Least Squares Means



Note: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

Interaction Model: Fabric Data

The GLM Procedure
Least Squares Means

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
ContrastName	1	9352.083333	9352.083333	17.99	0.0011

This is the result of the 'contrast' statement.

We called this contrast 'ContrastName', but in a real data set you would want to choose a more descriptive name.

In the lecture notes, we calculated the 't' value for this contrast and got -4.241. Square this and you get the F value above.

The F test is testing whether or not the contrast is equal to 0.

Note that SAS does NOT print the contrast coefficients, so you would need to go back to the SAS code to determine exactly what this contrast is.

(until the next example)