

How can I test differences in means using a cell means model in SPSS?

Authored by
stats writer

June 30, 2024

RECOMMENDED CITATION

stats writer (2024). *How can I test differences in means using a cell means model in SPSS?*. PSYCHOLOGICAL SCALES. Retrieved from <https://scales.arabpsychology.com/?p=162258>

The cell means model in SPSS is a statistical method used to analyze and compare the means of different groups or categories within a data set. To test for differences in means using this model, one can follow these steps:

1. Input the data into SPSS and organize it into separate columns for each group.
2. Go to the "Analyze" tab and select "General Linear Model" followed by "Univariate."
3. In the "Dependent Variable" box, enter the variable for which you want to compare the means.
4. In the "Fixed Factors" box, enter the grouping variable that represents the different categories.
5. Click on the "Model" button and select "Custom" from the drop-down menu.
6. In the "Custom Model" window, select "Cell Means Model" and click "Continue."
7. Finally, click on "OK" to run the analysis and view the results, which will include the mean values for each group and any significant differences between them. This method is useful for comparing means when there are multiple groups or factors involved and can provide valuable insights into the differences between them.

How can I test differences in means using a cell means model? | SPSS FAQ

Suppose we have an ANOVA model, and we would like to compare means between one group and another group. This is commonly done with the Imatrix subcommand in SPSS.

Let's look at a simple example using a data set called <https://stats.idre.ucla.edu/wp-content/uploads/2016/02/lemapi2.sav>

. The dependent variable is the school's API index (a continuous variable). The variables mealcat and colcat are categorical variables, both with three levels. These will be used as

the predictor variables. This model is shown below. We have included the emmeans subcommand to get the expected means for each group. This can be helpful if you want to calculate the contrast estimate by hand.

```
glm api00 by collcat mealcat
/design = collcat mealcat collcat*mealcat
/emmeans = tables (collcat*mealcat).
```

Estimated Marginal Means

collcat * Percentage free meals in 3 categories

Dependent Variable:api 2000

collcat	Percentage free meals in 3 categories	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1.00	0-46% free meals	816.914	11.564	794.179	839.649
	47-80% free meals	589.350	15.297	559.275	619.425
	81-100% free meals	493.919	7.953	478.283	509.554
2.00	0-46% free meals	825.651	10.433	805.140	846.162
	47-80% free meals	636.605	10.433	616.093	657.116
	81-100% free meals	508.833	9.874	489.420	528.247
3.00	0-46% free meals	782.151	9.397	763.676	800.626
	47-80% free meals	655.638	8.236	639.446	671.830
	81-100% free meals	541.733	17.664	507.005	576.461

Let's say that we want to look at a simple comparison of group 1

versus 2 and above of collcat when mealcat = 1. One way of doing this using the glm command with Imatrix subcommand. We use the test(Imatrix) option on the print subcommand to have SPSS print out the contrast coefficients that are applied to each group.

```
glm api00 by collcat mealcat
/design = collcat mealcat collcat*mealcat
/print = test(Imatrix)
/Imatrix 'collcat 1 vs 2+ within mealcat = 1'
collcat 1 -.5 -.5
collcat*mealcat 1 0 0
-.5 0 0
-.5 0 0.
```

While this Imatrix subcommand will run the analysis we want, it is a little difficult to write. Another way of accomplishing the same thing is to use a cell means model. A cell means model estimates only one parameter for each cell and sets the intercept to 0.

In general, the cell means model is not used to produce an overall test of model fit, but it is often used to write simpler `lmatrix` subcommands. So, in practice, we need to write the `glm` code twice, once for the model fit and the second time for the estimates. In the code shown below, the first `glm` command is for model fit and the second one with the `lmatrix` subcommand is used to estimate the simple comparison.

In the second call to `glm`, which is a cell means model, the main effects are omitted; only the interaction is included in the model. We use the `exclude` option on the `intercept` subcommand to specify that we are not going to estimate the intercept; therefore, we will estimate one parameter per cell. We use the `test(lmatrix)` option on the `print` subcommand to show us the

contrast codes that were used. This is a useful way to be sure that the contrast codings were assigned as you intended.

*** estimating the overall model.**

```
glm api00 by collcat mealcat  
/design = collcat mealcat collcat*mealcat.
```

*** estimating the cell means model to get the desired estimate.**

```
glm api00 by collcat mealcat  
/design = collcat mealcat collcat*mealcat  
/print = test(lmatrix)  
/lmatrix 'collcat 1 vs 2+ within mealcat = 1'  
collcat 1 -.5 -.5  
collcat*mealcat 1 0 0  
-.5 0 0  
-.5 0 0.
```

Notice that the order of categorical variables on the lmatrix

subcommand decides which variable is the row variable and which is the column variable. For example, in the code above,

collcat will be the row variable and mealcat will be the column variable. Therefore, the simple comparison we are interested in can be formulated as shown in the following table. Writing the numbers in the table one row at a time, we can write our Imatrix subcommand as:

**Imatrix 'simple comparison'
collcat*mealcat 1 0 0 -.5 0 0 -.5 0 0**

collcat /mealcat	mealcat = 1	mealcat = 2	mealcat = 3
collcat = 1	1	0	0
collcat =2	-.5	0	0
collcat = 3	-.5	0	0

If we switch the order of variables on the Imatrix subcommand, we will have to rewrite our terms accordingly. For example, we can rewrite the above Imatrix subcommand as the following; it produces exactly the same result from the Imatrix subcommand, since the corresponding table is simply

being transposed.

mealcat /collcat	collcat = 1	collcat =2	collcat=3
mealcat = 1	1	-.5	-.5
mealcat = 2	0	0	0
mealcat = 3	0	0	0

Let's run the analysis model. Notice that both collcat and the collcat*mealcat interaction need to be specified on the Imatrix subcommand.

```

glm api00 by collcat mealcat
/design = collcat mealcat collcat*mealcat
/print = test(lmatrix)
/lmatrix 'collcat 1 vs 2+ within mealcat = 1'
collcat 1 -.5 -.5
collcat*mealcat 1 0 0
-.5 0 0
-.5 0 0.

```

< some output omitted >

Custom Hypothesis Tests

Contrast Coefficients (L' Matrix)^a

Parameter	Contrast
	L1
Intercept	0
[colcat=1.00]	1
[colcat=2.00]	-.5
[colcat=3.00]	-.5
[mealcat=1]	0
[mealcat=2]	0
[mealcat=3]	0
[colcat=1.00] * [mealcat=1]	1
[colcat=1.00] * [mealcat=2]	0
[colcat=1.00] * [mealcat=3]	0
[colcat=2.00] * [mealcat=1]	-.5
[colcat=2.00] * [mealcat=2]	0
[colcat=2.00] * [mealcat=3]	0
[colcat=3.00] * [mealcat=1]	-.5
[colcat=3.00] * [mealcat=2]	0
[colcat=3.00] * [mealcat=3]	0

The default display of this matrix is the transpose of the corresponding L matrix.

Contrast Results (K Matrix)^a

Contrast		Depende...	
		api 2000	
L1	Contrast Estimate	13.013	
	Hypothesized Value	0	
	Difference (Estimate - Hypothesized)	13.013	
	Std. Error	13.528	
	Sig.	.337	
	95% Confidence Interval for Difference	Lower Bound	-13.583
		Upper Bound	39.610

a. Based on the user-specified contrast coefficients (L) matrix: collcat 1 vs 2+ within mealcat = 1

Test Results

Dependent Variable: api 2000

Source	Sum of Squares	df	Mean Square	F	Sig.
Contrast	4330.793	1	4330.793	.925	.337
Error	1829957.187	391	4680.197		

This simple comparison is not statistically significant ($t = 0.96$, $p = 0.3367$).

Now let's run the cell means model. Notice that only the interaction term is used on the design and the Imatrix subcommands.

```

glm api00 by collcat mealcat
/design = collcat*mealcat
/intercept = exclude
/print = test(lmatrix)

```

```

/matrix = 'colcat 1 vs 2+ within mealcat = 1'
colcat*mealcat 1 0 0 -.5 0 0 -.5 0 0.

```

< some output omitted >

Custom Hypothesis Tests

Contrast Coefficients (L' Matrix)^a

Parameter	Contrast
	L1
[colcat=1.00] * [mealcat=1]	1
[colcat=1.00] * [mealcat=2]	0
[colcat=1.00] * [mealcat=3]	0
[colcat=2.00] * [mealcat=1]	-.5
[colcat=2.00] * [mealcat=2]	0
[colcat=2.00] * [mealcat=3]	0
[colcat=3.00] * [mealcat=1]	-.5
[colcat=3.00] * [mealcat=2]	0
[colcat=3.00] * [mealcat=3]	0

The default display of this matrix is the transpose of the corresponding L matrix.

a. colcat 1 vs 2+ within mealcat = 1

Contrast Results (K Matrix)^a

Contrast		Depende...
		api 2000
L1	Contrast Estimate	13.013
	Hypothesized Value	0
	Difference (Estimate - Hypothesized)	13.013
	Std. Error	13.528
	Sig.	.337
	95% Confidence Interval for Difference	
	Lower Bound	-13.583
Upper Bound	39.610	

a. Based on the user-specified contrast coefficients (L) matrix: collcat 1 vs 2+ within mealcat = 1

Test Results

Dependent Variable: api 2000

Source	Sum of Squares	df	Mean Square	F	Sig.
Contrast	4330.793	1	4330.793	.925	.337
Error	1829957.187	391	4680.197		

Brief summary

Example 2

In our second example, we will compare the means between two cells in the design. Specifically, we will compare collcat=2 at mealcat=1 to collcat=3 at mealcat=2.

collcat /mealcat	mealcat = 1	mealcat = 2	mealcat = 3
collcat = 1	0	0	0

colcat =2	1	0	0
colcat = 3	0	-1	0

The lmatrix subcommand for this comparison is shown below.

```
glm api00 by colcat mealcat
/design = colcat mealcat colcat*mealcat
/print = test(lmatrix)
/lmatrix = 'colcat 2/mealcat 1 vs. colcat 3/mealcat 2'
colcat 0 1 -1
mealcat 1 -1 0
colcat*mealcat 0 0 0
1 0 0
0 -1 0.
```

< some output omitted >

Contrast Coefficients (L' Matrix)^a

Parameter	Contrast
	L1
Intercept	0
[colcat=1.00]	0
[colcat=2.00]	1
[colcat=3.00]	-1
[mealcat=1]	1
[mealcat=2]	-1
[mealcat=3]	0
[colcat=1.00] * [mealcat=1]	0
[colcat=1.00] * [mealcat=2]	0
[colcat=1.00] * [mealcat=3]	0
[colcat=2.00] * [mealcat=1]	1
[colcat=2.00] * [mealcat=2]	0
[colcat=2.00] * [mealcat=3]	0
[colcat=3.00] * [mealcat=1]	0
[colcat=3.00] * [mealcat=2]	-1
[colcat=3.00] * [mealcat=3]	0

The default display of this matrix is the transpose of the corresponding L matrix.

a. colcat 2/mealcat 1 vs. colcat 3/mealcat 2

Contrast Results (K Matrix)^a

Contrast		Depende...	
		api 2000	
L1	Contrast Estimate	170.013	
	Hypothesized Value	0	
	Difference (Estimate - Hypothesized)	170.013	
	Std. Error	13.292	
	Sig.	.000	
	95% Confidence Interval for Difference	Lower Bound	143.881
		Upper Bound	196.146

a. Based on the user-specified contrast coefficients (L) matrix: collcat 2/mealcat 1 vs. collcat 3/mealcat 2

Test Results

Dependent Variable: api 2000

Source	Sum of Squares	df	Mean Square	F	Sig.
Contrast	765713.398	1	765713.398	163.607	.000
Error	1829957.187	391	4680.197		

This comparison is statistically significant ($t = 12.79$, $p < .0001$).

Using the cell means model, the lmatrix subcommand is constructed as shown below.

```
glm api00 by collcat mealcat
/design = collcat*mealcat
/intercept = exclude
/print = test(lmatrix)
```

**/lmatrix = 'collcat 2/mealcat 1 vs. collcat 3/mealcat 2'
collcat*mealcat 0 0 0 1 0 0 0 -1 0.**

< some output omitted >

Custom Hypothesis Tests

Contrast Coefficients (L' Matrix)^a

Parameter	Contrast
	L1
[collcat=1.00] * [mealcat=1]	0
[collcat=1.00] * [mealcat=2]	0
[collcat=1.00] * [mealcat=3]	0
[collcat=2.00] * [mealcat=1]	1
[collcat=2.00] * [mealcat=2]	0
[collcat=2.00] * [mealcat=3]	0
[collcat=3.00] * [mealcat=1]	0
[collcat=3.00] * [mealcat=2]	-1
[collcat=3.00] * [mealcat=3]	0

The default display of this matrix is the transpose of the corresponding L matrix.

a. collcat 2/mealcat 1 vs. collcat 3/mealcat 2

Contrast Results (K Matrix)^a

Contrast		Depende...	
		api 2000	
L1	Contrast Estimate	170.013	
	Hypothesized Value	0	
	Difference (Estimate - Hypothesized)	170.013	
	Std. Error	13.292	
	Sig.	.000	
	95% Confidence Interval for Difference	Lower Bound	143.881
		Upper Bound	196.146

a. Based on the user-specified contrast coefficients (L) matrix: collcat 2/mealcat 1 vs. collcat 3/mealcat 2

Test Results

Dependent Variable: api 2000

Source	Sum of Squares	df	Mean Square	F	Sig.
Contrast	765713.398	1	765713.398	163.607	.000
Error	1829957.187	391	4680.197		

Example 3

In our last example, we will look at a difference in differences. We will take the difference between the difference of (and) and (and).

Remember that a little bit of math needs to be done to get the correct signs of the contrast coefficients: (collcat=1/mealcat=1 - collcat=1/mealcat=3) - (collcat=3/mealcat=1 - collcat=3/mealcat=3) =

**collcat=1/mealcat=1 - collcat=1/mealcat=3
- collcat=3/mealcat=1 + collcat=3/mealcat=3.**

collcat /mealcat	mealcat = 1	mealcat = 2	mealcat = 3
collcat = 1	1	0	-1
collcat =2	0	0	0
collcat = 3	-1	0	1

glm api00 by collcat mealcat

/design = collcat mealcat collcat*mealcat

/print = test(lmatrix)

/lmatrix = 'differences in differences'

collcat*mealcat 1 0 -1

0 0 0

-1 0 1.

< some output omitted >

Contrast Coefficients (L' Matrix)^a

Parameter	Contrast
	L1
Intercept	0
[colcat=1.00]	0
[colcat=2.00]	0
[colcat=3.00]	0
[mealcat=1]	0
[mealcat=2]	0
[mealcat=3]	0
[colcat=1.00] * [mealcat=1]	1
[colcat=1.00] * [mealcat=2]	0
[colcat=1.00] * [mealcat=3]	-1
[colcat=2.00] * [mealcat=1]	0
[colcat=2.00] * [mealcat=2]	0
[colcat=2.00] * [mealcat=3]	0
[colcat=3.00] * [mealcat=1]	-1
[colcat=3.00] * [mealcat=2]	0
[colcat=3.00] * [mealcat=3]	1

The default display of this matrix is the transpose of the corresponding L matrix.

a. differences in differences

Contrast Results (K Matrix)^a

Contrast		Depende...
		api 2000
L1	Contrast Estimate	82.578
	Hypothesized Value	0
	Difference (Estimate - Hypothesized)	82.578
	Std. Error	24.439
	Sig.	.001
	95% Confidence Interval for Difference	Lower Bound 34.529 Upper Bound 130.627

a. Based on the user-specified contrast coefficients (L) matrix: differences in differences

Test Results

Dependent Variable: api 2000

Source	Sum of Squares	df	Mean Square	F	Sig.
Contrast	53432.932	1	53432.932	11.417	.001
Error	1829957.187	391	4680.197		

The comparison is statistically significant ($t = 3.38$, $p = .0008$).

Here is the Imatrix subcommand using the cell means model.

```

glm api00 by collcat mealcat
/design = collcat*mealcat
/intercept = exclude
/print = test(lmatrix)
/lmatrix = 'differences in differences'

```

collcat*mealcat 1 0 -1 0 0 0 -1 0 1.

< some output omitted >

Custom Hypothesis Tests

Contrast Coefficients (L' Matrix)^a

Parameter	Contrast
	L1
[collcat=1.00] * [mealcat=1]	1
[collcat=1.00] * [mealcat=2]	0
[collcat=1.00] * [mealcat=3]	-1
[collcat=2.00] * [mealcat=1]	0
[collcat=2.00] * [mealcat=2]	0
[collcat=2.00] * [mealcat=3]	0
[collcat=3.00] * [mealcat=1]	-1
[collcat=3.00] * [mealcat=2]	0
[collcat=3.00] * [mealcat=3]	1

The default display of this matrix is the transpose of the corresponding L matrix.

a. differences in differences

Contrast Results (K Matrix)^a

Contrast		Depende...	
		api 2000	
L1	Contrast Estimate	82.578	
	Hypothesized Value	0	
	Difference (Estimate - Hypothesized)	82.578	
	Std. Error	24.439	
	Sig.	.001	
	95% Confidence Interval for Difference	Lower Bound	34.529
		Upper Bound	130.627

a. Based on the user-specified contrast coefficients (L) matrix: differences in differences

Test Results

Dependent Variable: api 2000

Source	Sum of Squares	df	Mean Square	F	Sig.
Contrast	53432.932	1	53432.932	11.417	.001
Error	1829957.187	391	4680.197		