Contrasts and Multiple Comparisons

```
/* onewaymath.sas  */
title2 'Oneway with contrasts and multiple comparisons (Exclude Other/DK)';
%include 'readmath.sas';
if ethnic ne 6; /* Otherwise, throw the case out */
proc freq;
     tables ethnic;
proc glm;
     title3 'Do average marks differ significantly by apparent nationality?';
     class ethnic;
     model grade = ethnic / clparm; /* clparm gives CI for contrasts down in
                                        the estimate statement. */
     means ethnic;
     /* Test custom contrasts, or "planned comparisons"
        (Note Alphabetical Order)
              Asian
              East Indian
              Eastern European
              European not Eastern
              Middle-Eastern and Pakistani     */
     contrast 'European_vs_Other' ethnic -2 -2  3  3 -2;
     estimate 'European_vs_Other' ethnic -2 -2  3  3 -2 / divisor=6;
     estimate "EastEurop_vs_OtherEurop" ethnic 0 0 .5 -.5 0;
     contrast 'Non-Europ_Equal?'  ethnic 1 -1 0 0  0,
                                   ethnic 1  0 0 0 -1;
     contrast 'East Indian vs. Middle-Eastern and Pakistani'
                                   ethnic 0 1 0 0 -1;
     contrast 'East Indian vs. Eastern European'
                                   ethnic 0 1 -1 0 0;
     contrast 'ReplicateOverallF=2.45'
              ethnic 1 -1  0  0  0,
              ethnic 1  0 -1  0  0,
              ethnic 1  0  0 -1  0,
              ethnic 1  0  0  0 -1;
     /* Multiple Comparisons */
     lsmeans ethnic / pdiff adjust=bon;
     lsmeans ethnic / pdiff adjust=tukey;
     lsmeans ethnic / pdiff adjust=scheffe;
/* Get Scheffe critical value from proc iml */
proc iml;
     title3 'Scheffe critical value for all possible contrasts';
     numdf = 4;   /* Model degrees of freedom for initial test */
     dendf = 373; /* Error degrees of freedom for initial test */
     alpha = 0.05;
     critval = finv(1-alpha,numdf,dendf);
     scrit = critval * numdf;

     print "Initial test has"  numdf " and " dendf "degrees of freedom."
           "----------------------------------------------------------"
           "Using significance level alpha = " alpha
           "------------------------------------------------"
           "Critical value for the initial test is " critval
           "------------------------------------------------"
           "Critical value for Scheffe tests is " scrit
           "------------------------------------------------";
```

Here is **onewaymath.lst**

The FREQ Procedure

Judged Nationality of name

ethnic	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Asian	131	24.30	131	24.30
Eastern European	63	11.69	194	35.99
European not Eastern	195	36.18	389	72.17
Middle-Eastern and Pakistani	72	13.36	461	85.53
East Indian	78	14.47	539	100.00

Do average marks differ significantly by apparent nationality?

The GLM Procedure

Class Level Information

Class	Levels	Values
ethnic	5	Asian East Indian Eastern European European not Eastern Middle-Eastern and Pakistani

Number of Observations Read   539
Number of Observations Used   378

Do average marks differ significantly by apparent nationality?

The GLM Procedure

Dependent Variable: grade   Final mark (if any)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	3640.6607	910.1652	2.45	0.0458
Error	373	138545.4478	371.4355		
Corrected Total	377	142186.1085			

```
          R-Square     Coeff Var      Root MSE      grade Mean

          0.025605      32.80823       19.27266       58.74339


Source                    DF      Type I SS     Mean Square   F Value   Pr > F

ethnic                     4    3640.660655      910.165164      2.45   0.0458


Source                    DF     Type III SS    Mean Square   F Value   Pr > F

ethnic                     4    3640.660655      910.165164      2.45   0.0458
```

          Do average marks differ significantly by apparent nationality?

                        The GLM Procedure

```
    Level of                              ------------grade------------
    ethnic                        N             Mean            Std Dev

    Asian                         87       60.0574713         20.9314253
    East Indian                   53       65.1886792         18.5317364
    Eastern European              46       55.7608696         20.2771736
    European not Eastern         142       56.2816901         17.8581353
    Middle-Eastern  and Pakistani 50       59.3600000         19.9691190
```

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          lsmeans output appears next – skip for now and come back to it.

Do average marks differ significantly by apparent nationality?

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Bonferroni

ethnic	grade LSMEAN	LSMEAN Number
Asian	60.0574713	1
East Indian	65.1886792	2
Eastern European	55.7608696	3
European not Eastern	56.2816901	4
Middle-Eastern and Pakistani	59.3600000	5

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

Dependent Variable: grade

i/j	1	2	3	4	5
1		1.0000	1.0000	1.0000	1.0000
2	1.0000		0.1567	0.0432	1.0000
3	1.0000	0.1567		1.0000	1.0000
4	1.0000	0.0432	1.0000		1.0000
5	1.0000	1.0000	1.0000	1.0000	

Deleting some output ...

Adjustment for Multiple Comparisons: Tukey-Kramer

i/j	1	2	3	4	5
1		0.5449	0.7380	0.6028	0.9996
2	0.5449		0.1103	0.0349	0.5410
3	0.7380	0.1103		0.9999	0.8914
4	0.6028	0.0349	0.9999		0.8680
5	0.9996	0.5410	0.8914	0.8680	

Adjustment for Multiple Comparisons: Scheffe

i/j	1	2	3	4	5
1		0.6747	0.8273	0.7228	0.9998
2	0.6747		0.2096	0.0854	0.6713
3	0.8273	0.2096		0.9999	0.9334
4	0.7228	0.0854	0.9999		0.9181
5	0.9998	0.6713	0.9334	0.9181	

        Do average marks differ significantly by apparent nationality?

                            The GLM Procedure

Dependent Variable: grade   Final mark (if any)

        Contrast   DF   Contrast SS

        European_vs_Other   1   2377.061841
        Non-Europ_Equal?   2   1123.948886
        East Indian vs. Middle-Eastern and Pakistani 1   874.075530
        East Indian vs. Eastern European   1   2188.870763
        ReplicateOverallF=2.45   4   3640.660655

Contrast   Mean Square   F Value   Pr > F

European_vs_Other   2377.061841   6.40   0.0118
Non-Europ_Equal?   561.974443   1.51   0.2216
East Indian vs. Middle-Eastern and Pakistani 874.075530   2.35   0.1259
East Indian vs. Eastern European   2188.870763   5.89   0.0157
ReplicateOverallF=2.45   910.165164   2.45   0.0458

                                    Standard
Parameter   Estimate   Error   t Value   Pr > |t|

European_vs_Other   -5.51410365   2.17969837   -2.53   0.0118
EastEurop_vs_OtherEurop   -0.26041029   1.63481102   -0.16   0.8735

            Parameter   95% Confidence Limits

            European_vs_Other   -9.80014111 -1.22806619
            EastEurop_vs_OtherEurop -3.47501161   2.95419103

_____

        Scheffe critical value for all possible contrasts

                    numdf   dendf

    Initial test has   4   and   373 degrees of freedom.
        ----
                                            alpha

        Using significance level alpha =   0.05
        ----
                                            critval

    Critical value for the initial test is 2.3958734
    ----
                                            scrit

        Critical value for Scheffe tests is 9.5834935