```
1  title 'Testing Diagonal Covariance Matrix with the Metric Cars Data';
2  title2 'Jerry Brunner:  Student Number 999999999';
3
4  data auto;
5       infile '/folders/myfolders/431s15/mcars4.data' firstobs=2 ;  /* Skipping the header */
6       input id country $ lper100k weight length;
7
8  proc corr nosimple;
9       title3 'Correlation matrix';
10      var lper100k weight length;
11
12 proc corr nosimple nocorr cov vardef=n out=S;
13      title3 'Covariance matrix';
14      var lper100k weight length;
15
16 proc print;
17       title3 'Look at the output data set';
18
19 proc iml;
20      title3 'Compute the test statistic with proc iml';
21      use S;
22       read all var {lper100k weight length} where(_type_ = 'COV') into SigmaHat;
23       /* Will need n also */
24       read all var {lper100k} where(_type_ = 'N') into n;
25       print SigmaHat; print n;
26       G2 = n * ( trace(log(SigmaHat)) - log(det(SigmaHat)) );
27       Pvalue = 1 - probchi(G2,3);
28       print G2 Pvalue;
29
30 proc calis data = auto;
31       title3 'Test with proc calis';
32       mstruct var = lper100k weight length;
33       matrix _COV_
34       [1,1] = sigmasquared1, [2,2] = sigmasquared2, [3,3] = sigmasquared3;
35       /* Unmentioned matrices (the mean) are unrestricted. Once a matrix is
36          mentioned, if any elements are specified then the unspecified ones
37           are assumed zero.   */
38
39
```

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Correlation matrix

The CORR Procedure

3 Variables:	lper100k weight length

Pearson Correlation Coefficients, N = 100 Prob > |r| under H0: Rho=0			
	lper100k	**weight**	**length**
lper100k	1.00000	0.83423 <.0001	0.82141 <.0001
weight	0.83423 <.0001	1.00000	0.94604 <.0001
length	0.82141 <.0001	0.94604 <.0001	1.00000

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Covariance matrix

The CORR Procedure

3 Variables:	lper100k weight length

Covariance Matrix, DF = 100			
	lper100k	**weight**	**length**
lper100k	10.7291	984.0896	1.4722
weight	984.0896	129698.9859	186.4175
length	1.4722	186.4175	0.2994

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Look at the output data set

Obs	_TYPE_	_NAME_	lper100k	weight	length
1	COV	lper100k	10.729	984.09	1.472
2	COV	weight	984.090	129698.99	186.417
3	COV	length	1.472	186.42	0.299
4	MEAN		12.278	1413.21	4.849
5	STD		3.276	360.14	0.547
6	N		100.000	100.00	100.000

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Compute the test statistic with proc iml

SigmaHat		

10.729116	984.08962	1.4721524
984.08962	129698.99	186.41747
1.4721524	186.41747	0.2993794

n
100

G2	Pvalue
347.71588	0

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Test with proc calis

The CALIS Procedure
Covariance Structure Analysis: Model and Initial Values

Modeling Information	
Maximum Likelihood Estimation	
Data Set	WORK.AUTO
N Records Read	100
N Records Used	100
N Obs	100
Model Type	MSTRUCT
Analysis	Covariances

Variables in the Model
lper100k weight length
Number of Variables = 3

Initial MSTRUCT _COV_ Matrix			
	lper100k	**weight**	**length**
lper100k	. [sigmasquared1]	0	0
weight	0	. [sigmasquared2]	0
length	0	0	. [sigmasquared3]

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Test with proc calis

The CALIS Procedure
Covariance Structure Analysis: Descriptive Statistics

Simple Statistics		
Variable	**Mean**	**Std Dev**
lper100k	12.27800	3.29203
weight	1413	361.95176
length	4.84920	0.54991

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Test with proc calis

The CALIS Procedure
Covariance Structure Analysis: Optimization

Initial Estimation Method	
1	Observed Moments of Variables

Optimization Start Parameter Estimates			
N	Parameter	Estimate	Gradient
1	sigmasquared1	10.83749	1.5124E-17
2	sigmasquared2	131009	0
3	sigmasquared3	0.30240	0
Value of Objective Function = 3.4771588345			

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Test with proc calis

The CALIS Procedure
Covariance Structure Analysis: Optimization

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	3
Functions (Observations)	6

Optimization Start			
Active Constraints	0	Objective Function	3.4771588345
Max Abs Gradient Element	1.512421E-17	Radius	1

Optimization Results			
Iterations	0	Function Calls	4
Jacobian Calls	1	Active Constraints	0
Objective Function	3.4771588345	Max Abs Gradient Element	1.512421E-17
Lambda	0	Actual Over Pred Change	0
Radius	1		

Convergence criterion (ABSGCONV=0.00001) satisfied.

Note: The Moore-Penrose inverse is used in computing the covariance matrix for parameter estimates.

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Test with proc calis

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Summary		
Modeling Info	Number of Observations	100
	Number of Variables	3
	Number of Moments	6
	Number of Parameters	3
	Number of Active Constraints	0
	Baseline Model Function Value	3.4772
	Baseline Model Chi-Square	344.2387
	Baseline Model Chi-Square DF	3
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	Fit Function	3.4772
	Chi-Square	344.2387
	Chi-Square DF	3
	Pr > Chi-Square	<.0001
	Z-Test of Wilson & Hilferty	14.4524
	Hoelter Critical N	3
	Root Mean Square Residual (RMR)	413.0284
	Standardized RMR (SRMR)	0.6145
	Goodness of Fit Index (GFI)	0.3983
Parsimony Index	Adjusted GFI (AGFI)	-0.2033
	Parsimonious GFI	0.3983
	RMSEA Estimate	1.0719
	RMSEA Lower 90% Confidence Limit	0.9779
	RMSEA Upper 90% Confidence Limit	1.1690
	Probability of Close Fit	<.0001
	ECVI Estimate	3.5403
	ECVI Lower 90% Confidence Limit	2.9509
	ECVI Upper 90% Confidence Limit	4.2078
	Akaike Information Criterion	350.2387
	Bozdogan CAIC	361.0542
	Schwarz Bayesian Criterion	358.0542
	McDonald Centrality	0.1816
Incremental Index	Bentler Comparative Fit Index	0.0000
	Bentler-Bonett NFI	0.0000
	Bentler-Bonett Non-normed Index	0.0000
	Bollen Normed Index Rho1	0.0000
	Bollen Non-normed Index Delta2	0.0000
	James et al. Parsimonious NFI	0.0000

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Test with proc calis

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

MSTRUCT _COV_ Matrix: Estimate/StdErr/t-value/p-value			

	lper100k	weight	length
lper100k	10.8375 1.5404 7.0356 <.0001 [sigmasquared1]	0	0
weight	0	131009 0 Infty . [sigmasquared2]	0
length	0	0	0.3024 0.0430 7.0356 <.0001 [sigmasquared3]

Testing Diagonal Covariance Matrix with the Metric Cars Data
Jerry Brunner: Student Number 999999999
Test with proc calis

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Standardized MSTRUCT _COV_ Matrix: Estimate/StdErr/t-value/p-value			
	lper100k	**weight**	**length**
lper100k	1.0000 [sigmasquared1]	0	0
weight	0	1.0000 [sigmasquared2]	0
length	0	0	1.0000 [sigmasquared3]

16572	1	1	48	53	66	167	183	140	522	.77	399	120	103	1682	359
16573	1	1	35	42	61	138	188	138	535	.73	393	123	108	1699	357
16579	1	1	47	69	88	204	189	137	542	.72	393	129	118	1620	330
16580	1	1	53	74	84	211	186	140	543	.75	409	131	118	1611	328
16604	1	1	35	68	92	195	185	145	549	.78	430	126	128	1503	298
16603	1	1	42	61	86	189	186	140	550	.75	414	125	148	1551	293
16612	1	1	34	42	73	149	183	151	544	.83	449	129	110	1562	326
16611	1	1	26	38	68	132	185	147	545	.79	433	126	92	1550	343
16630	1	1	49	71	95	215	174	145	534	.83	445	128	124	1614	324
16631	1	1	38	72	97	207	186	143	543	.77	417	128	120	1630	330
16650	1	1	50	90	122	262	191	143	551	.75	413	131	116	1736	356
16651	1	1	46	82	101	229	191	141	552	.74	407	135	114	1710	351
16656	1	1	25	30	42	97	184	143	511	.78	397	122	112	1551	322
16657	1	1	28	37	43	108	186	143	535	.77	411	122	103	1556	332
16660	1	1	25	74	64	163	180	146	532	.81	432	130	122	1603	323
16661	1	1	41	78	65	184	179	144	527	.80	424	131	120	1579	320
16691	1	1	23	19	52	94	193	146	560	.76	424	134	119	1680	342
16690	1	1	23	36	59	118	191	145	551	.76	418	132	113	1696	351
16695	1	1	26	40	61	127	174	139	505	.80	403	125	86	1552	352
16694	1	1	16	37	50	103	174	138	500	.79	397	126	87	1548	349
16699	1	1	40	63	88	191	183	150	544	.82	446	128	115	1622	334
16698	1	1	40	54	90	184	192	147	556	.77	426	128	122	1624	327
16713	1	1	43	53	58	154	178	147	531	.83	439	130	114	1650	340
16712	1	1	48	60	85	193	177	150	534	.85	453	135	122	1659	334

```
1  /*********     twinread.sas   ******************/
2  title 'Twin Data';
3
4  proc format;
5       value sexfmt  0 = 'Male'   1 = 'Female';
6       value idfmt   0 = 'Fraternal' 1 = 'Identical';
7
8  data times2;
9     infile'/folders/myfolders/431s15/twins.data.txt';
10    input subno1 sex ident progmat1 reason1 verbal1 total1
11          headlng1 headbrd1 headcir1 cephal1 headar1 bizyg1
12          weight1 height1 pondrl1
13          subno2 sex2 ident2 progmat2 reason2 verbal2 total2
14          headlng2 headbrd2 headcir2 cephal2 headar2 bizyg2
15          weight2 height2 pondrl2;
16 /* 1 means for twin 1, 2 means for twin 2 */
17     label ident    =  'Identical or fraternal';
18     label progmat1 =  'Progressive matrices 1 (M)';
19     label reason1  =  'Reasoning Ability 1 (R)';
20     label verbal1  =  'Verbal Ability 1 (V)';
21     label total1   =  'Total Psych test score 1 (T)';
22     label headlng1 =  'Head Length 1 (L)';
23     label headbrd1 =  'Head breadth 1 (B)';
24     label headcir1 =  'Head Circumference 1 (C)';
25     label cephal1  =  'Cephalic index 1 (I): head breadth/length';
26     label headar1  =  'Head area 1 (E): Cephalic index * headcir';
27     label bizyg1   =  'Bizygomatic Breadth (Z): Dist betw eyes?';
28     label weight1  =  'Weight of twin 1 (W)';
29     label height1  =  'Height of twin 1 (S)';
30     label pondrl1  =  'Height/weight**1/3 for twin 1 (P)';
31                      /* Reciprocal ponderal index */
32     label progmat2 =  'Progressive matrices 2 (M)';
33     label reason2  =  'Reasoning Ability 2 (R)';
34     label verbal2  =  'Verbal Ability 2 (V)';
35     label total2   =  'Total Psych test score 2 (T)';
36     label headlng2 =  'Head Length 2 (L)';
37     label headbrd2 =  'Head breadth 2 (B)';
38     label headcir2 =  'Head Circumference 2 (C)';
39     label cephal2  =  'Cephalic index 2 (I): head breadth/length';
40     label headar2  =  'Head area 2 (E): Cephalic index * headcir';
41     label bizyg2   =  'Bizygomatic Breadth (Z): Dist betw eyes?';
42     label weight2  =  'Weight of twin 2 (W)';
43     label height2  =  'Height of twin 2 (S)';
44     label pondrl2  =  'Height/weight**2/3 for twin 2 (P)';
45                /* Reciprocal ponderal index */
46      format sex sex2 sexfmt.;
```

```
47      format ident ident2 idfmt.;
48
49      /* Average scores  */
50      progmat = (progmat1 + progmat2)/2;
51      reason  = (reason1 + reason2)/2;
52      verbal  = (verbal1 + verbal2)/2;
53      total   = (total1 + total2)/2;
54      headlng = (headlng1 + headlng2)/2;
55      headbrd = (headbrd1 + headbrd2)/2;
56      headcir = (headcir1 + headcir2)/2;
57      cephal  = (cephal1 + cephal2)/2;
58      headar  = (headar1 + headar2)/2;
59      bizyg   = (bizyg1 + bizyg2)/2;
60      weight  = (weight1 + weight2)/2;
61      height  = (height1 + height2)/2;
62      pondrl  = (pondrl1 + pondrl2)/2;
63     label
64         progmat = 'Progressive matrices  (M)'
65         reason  = 'Reasoning Ability  (R)'
66         verbal  = 'Verbal Ability  (V)'
67         total   = 'Total Psych test score  (T)'
68         headlng = 'Head Length  (L)'
69         headbrd = 'Head breadth  (B)'
70         headcir = 'Head Circumference  (C)'
71         cephal  = 'Cephalic index  (I): head breadth/length'
72         headar  = 'Head area  (E): Cephalic index * headcir'
73         bizyg   = 'Bizygomatic Breadth (Z): Dist betw eyes?'
74         weight  = 'Weight of twin  (W)'
75         height  = 'Height of twin  (S)'
76         pondrl  = 'Height/weight**1/3  (P)';
77  run;
78
79
```

```
1  /*  bodymind.sas */
2  title2 'Test association between body and mind';
3  %include '/folders/myfolders/431s15/twinread.sas';
4  proc calis;
5        mstruct var = progmat reason verbal
6                      headlng headbrd headcir bizyg height weight;
7       matrix _COV_
8       [1,1] = v11,
9       [2,1] = v12, [2,2] = v22,
10      [3,1] = v31, [3,2] = v32, [3,3] = v33,
11
12      [4,4] = v44,
13      [5,4] = v54, [5,5] = v55,
14      [6,4] = v64, [6,5] = v65, [6,6] = v66,
15      [7,4] = v74, [7,5] = v75, [7,6] = v76,  [7,7] = v77,
16      [8,4] = v84, [8,5] = v85, [8,6] = v86,  [8,7] = v87, [8,8] = v88,
17      [9,4] = v94, [9,5] = v95, [9,6] = v96,  [9,7] = v97, [9,8] = v98, [9,9] = v99;
18       /* Unmentioned matrices (the mean) are unrestricted. Once a matrix is
19         mentioned, unmentioned elements of that matrix are assumed zero. */
20
21 proc corr nosimple;
22      title3 'Which variables are correlated?';
23      var  headlng headbrd headcir bizyg height weight;
24      with progmat reason verbal;
25
```

Twin Data

The CALIS Procedure
Covariance Structure Analysis: Model and Initial Values

Modeling Information	
Maximum Likelihood Estimation	
Data Set	WORK.TIMES2
N Records Read	80
N Records Used	74
N Obs	74
Model Type	MSTRUCT
Analysis	Covariances

Variables in the Model
progmat reason verbal headlng headbrd headcir bizyg height weight
Number of Variables = 9

Initial MSTRUCT _COV_ Matrix									
	progmat	**reason**	**verbal**	**headlng**	**headbrd**	**headcir**	**bizyg**	**height**	**weight**
progmat	. [v11]	. [v12]	. [v31]	0	0	0	0	0	0
reason	. [v12]	. [v22]	. [v32]	0	0	0	0	0	0
verbal	. [v31]	. [v32]	. [v33]	0	0	0	0	0	0
headlng	0	0	0	. [v44]	. [v54]	. [v64]	. [v74]	. [v84]	. [v94]
headbrd	0	0	0	. [v54]	. [v55]	. [v65]	. [v75]	. [v85]	. [v95]
headcir	0	0	0	. [v64]	. [v65]	. [v66]	. [v76]	. [v86]	. [v96]
bizyg	0	0	0	. [v74]	. [v75]	. [v76]	. [v77]	. [v87]	. [v97]
height	0	0	0	. [v84]	. [v85]	. [v86]	. [v87]	. [v88]	. [v98]
weight	0	0	0	. [v94]	. [v95]	. [v96]	. [v97]	. [v98]	. [v99]

Twin Data

The CALIS Procedure
Covariance Structure Analysis: Descriptive Statistics

Simple Statistics			
Variable		**Mean**	**Std Dev**
progmat	Progressive matrices (M)	37.98649	8.64203
reason	Reasoning Ability (R)	53.35135	16.51063
verbal	Verbal Ability (V)	74.72297	24.21764
headlng	Head Length (L)	186.37838	7.08887
headbrd	Head breadth (B)	146.87838	6.16653
headcir	Head Circumference (C)	543.48649	16.59117

bizyg	Bizygomatic Breadth (Z): Dist betw eyes?	130.55405	5.88856
weight	Weight of twin (W)	121.70946	21.80848
height	Height of twin (S)	1651	83.54899

Twin Data

The CALIS Procedure
Covariance Structure Analysis: Optimization

Initial Estimation Method	
1	Observed Moments of Variables

Optimization Start Parameter Estimates			
N	**Parameter**	**Estimate**	**Gradient**
1	**v11**	74.68475	0
2	**v12**	78.52194	0
3	**v22**	272.60089	0
4	**v31**	128.42086	0
5	**v32**	301.38291	0
6	**v33**	586.49412	0
7	**v44**	50.25213	4.444E-19
8	**v54**	13.12199	1.2755E-18
9	**v55**	38.02610	9.1516E-19
10	**v64**	98.03943	-1.283E-18
11	**v65**	69.31683	-1.841E-18
12	**v66**	275.26694	9.2629E-19
13	**v74**	18.95529	-1.597E-18
14	**v75**	29.21557	-2.292E-18
15	**v76**	70.80553	2.3055E-18
16	**v77**	34.67512	1.4346E-18
17	**v84**	350.33515	-1.467E-19
18	**v85**	237.44474	-2.105E-19
19	**v86**	847.62856	2.1181E-19
20	**v87**	326.22205	2.636E-19
21	**v88**	6980	1.2109E-20
22	**v94**	88.03952	1.6592E-18
23	**v95**	66.46418	2.3809E-18
24	**v96**	250.18780	-2.395E-18
25	**v97**	84.36866	-2.981E-18
26	**v98**	1217	-2.739E-19
27	**v99**	475.60964	1.5486E-18
Value of Objective Function = 0.4299059628			

Twin Data

The CALIS Procedure
Covariance Structure Analysis: Optimization

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	27
Functions (Observations)	45

Optimization Start			
Active Constraints	0	**Objective Function**	0.4299059628
Max Abs Gradient Element	2.981059E-18	**Radius**	1

Optimization Results			
Iterations	0	**Function Calls**	4
Jacobian Calls	1	**Active Constraints**	0
Objective Function	0.4299059628	**Max Abs Gradient Element**	2.981059E-18
Lambda	0	**Actual Over Pred Change**	0
Radius	1		

Convergence criterion (ABSGCONV=0.00001) satisfied.

Twin Data

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Summary		
Modeling Info	**Number of Observations**	74
	Number of Variables	9
	Number of Moments	45
	Number of Parameters	27
	Number of Active Constraints	0
	Baseline Model Function Value	7.0926
	Baseline Model Chi-Square	517.7599
	Baseline Model Chi-Square DF	36
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	**Fit Function**	0.4299
	Chi-Square	31.3831
	Chi-Square DF	18
	Pr > Chi-Square	0.0260
	Z-Test of Wilson & Hilferty	1.9433
	Hoelter Critical N	68
	Root Mean Square Residual (RMR)	85.0111
	Standardized RMR (SRMR)	0.1430
	Goodness of Fit Index (GFI)	0.9197
Parsimony Index	**Adjusted GFI (AGFI)**	0.7993
	Parsimonious GFI	0.4599
	RMSEA Estimate	0.1009
	RMSEA Lower 90% Confidence Limit	0.0349
	RMSEA Upper 90% Confidence Limit	0.1585

	Probability of Close Fit	0.0858
	ECVI Estimate	1.2870
	ECVI Lower 90% Confidence Limit	1.1429
	ECVI Upper 90% Confidence Limit	1.5744
	Akaike Information Criterion	85.3831
	Bozdogan CAIC	174.5929
	Schwarz Bayesian Criterion	147.5929
	McDonald Centrality	0.9135
Incremental Index	Bentler Comparative Fit Index	0.9722
	Bentler-Bonett NFI	0.9394
	Bentler-Bonett Non-normed Index	0.9444
	Bollen Normed Index Rho1	0.8788
	Bollen Non-normed Index Delta2	0.9732
	James et al. Parsimonious NFI	0.4697

Twin Data

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

MSTRUCT _COV_ Matrix: Estimate/StdErr/t-value/p-value									
	progmat	reason	verbal	headlng	headbrd	headcir	bizyg	height	weight
progmat	74.6847 12.3619 6.0415 <.0001 [v11]	78.5219 19.0618 4.1193 <.0001 [v12]	128.4209 28.7393 4.4685 <.0001 [v31]	0	0	0	0	0	0
reason	78.5219 19.0618 4.1193 <.0001 [v12]	272.6009 45.1212 6.0415 <.0001 [v22]	301.3829 58.6037 5.1427 <.0001 [v32]	0	0	0	0	0	0
verbal	128.4209 28.7393 4.4685 <.0001 [v31]	301.3829 58.6037 5.1427 <.0001 [v32]	586.4941 97.0772 6.0415 <.0001 [v33]	0	0	0	0	0	0
headlng	0	0	0	50.2521 8.3178 6.0415 <.0001 [v44]	13.1220 5.3418 2.4565 0.0140 [v54]	98.0394 17.9209 5.4707 <.0001 [v64]	18.9553 5.3658 3.5326 0.000411 [v74]	350.3352 80.5390 4.3499 <.0001 [v84]	88.0395 20.8226 4.2281 <.0001 [v94]
headbrd	0	0	0	13.1220 5.3418 2.4565 0.0140 [v54]	38.0261 6.2941 6.0415 <.0001 [v55]	69.3168 14.4640 4.7924 <.0001 [v65]	29.2156 5.4548 5.3559 <.0001 [v75]	237.4447 66.3963 3.5762 0.000349 [v85]	66.4642 17.5574 3.7855 0.000153 [v95]
headcir	0	0	0	98.0394 17.9209 5.4707 <.0001 [v64]	69.3168 14.4640 4.7924 <.0001 [v65]	275.2669 45.5625 6.0415 <.0001 [v66]	70.8055 14.1219 5.0139 <.0001 [v76]	847.6286 190.1678 4.4573 <.0001 [v86]	250.1878 51.4866 4.8593 <.0001 [v96]
bizyg	0	0	0	18.9553 5.3658 3.5326 0.000411 [v74]	29.2156 5.4548 5.3559 <.0001 [v75]	70.8055 14.1219 5.0139 <.0001 [v76]	34.6751 5.7395 6.0415 <.0001 [v77]	326.2220 69.0908 4.7216 <.0001 [v87]	84.3687 17.9840 4.6913 <.0001 [v97]

height	0	0	0	350.3352 80.5390 4.3499 <.0001 [v84]	237.4447 66.3963 3.5762 0.000349 [v85]	847.6286 190.1678 4.4573 <.0001 [v86]	326.2220 69.0908 4.7216 <.0001 [v87]	6980 1155 6.0415 <.0001 [v88]	1217 256.4256 4.7444 <.0001 [v98]
weight	0	0	0	88.0395 20.8226 4.2281 <.0001 [v94]	66.4642 17.5574 3.7855 0.000153 [v95]	250.1878 51.4866 4.8593 <.0001 [v96]	84.3687 17.9840 4.6913 <.0001 [v97]	1217 256.4256 4.7444 <.0001 [v98]	475.6096 78.7235 6.0415 <.0001 [v99]

Twin Data

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Standardized MSTRUCT _COV_ Matrix: Estimate/StdErr/t-value/p-value

	progmat	reason	verbal	headlng	headbrd	headcir	bizyg	height	weight
progmat	1.0000 [v11]	0.5503 0.0816 6.7444 <.0001 [v12]	0.6136 0.0730 8.4085 <.0001 [v31]	0	0	0	0	0	0
reason	0.5503 0.0816 6.7444 <.0001 [v12]	1.0000 [v22]	0.7537 0.0505 14.9118 <.0001 [v32]	0	0	0	0	0	0
verbal	0.6136 0.0730 8.4085 <.0001 [v31]	0.7537 0.0505 14.9118 <.0001 [v32]	1.0000 [v33]	0	0	0	0	0	0
headlng	0	0	0	1.0000 [v44]	0.3002 0.1065 2.8187 0.004821 [v54]	0.8336 0.0357 23.3399 <.0001 [v64]	0.4541 0.0929 4.8876 <.0001 [v74]	0.5915 0.0761 7.7739 <.0001 [v84]	0.5695 0.0791 7.2009 <.0001 [v94]
headbrd	0	0	0	0.3002 0.1065 2.8187 0.004821 [v54]	1.0000 [v55]	0.6775 0.0633 10.7006 <.0001 [v65]	0.8046 0.0413 19.4923 <.0001 [v75]	0.4609 0.0922 4.9996 <.0001 [v85]	0.4942 0.0885 5.5874 <.0001 [v95]
headcir	0	0	0	0.8336 0.0357 23.3399 <.0001 [v64]	0.6775 0.0633 10.7006 <.0001 [v65]	1.0000 [v66]	0.7247 0.0556 13.0429 <.0001 [v76]	0.6115 0.0733 8.3448 <.0001 [v86]	0.6915 0.0611 11.3200 <.0001 [v96]
bizyg	0	0	0	0.4541 0.0929 4.8876 <.0001 [v74]	0.8046 0.0413 19.4923 <.0001 [v75]	0.7247 0.0556 13.0429 <.0001 [v76]	1.0000 [v77]	0.6631 0.0656 10.1107 <.0001 [v87]	0.6570 0.0665 9.8756 <.0001 [v97]
height	0	0	0	0.5915 0.0761 7.7739 <.0001 [v84]	0.4609 0.0922 4.9996 <.0001 [v85]	0.6115 0.0733 8.3448 <.0001 [v86]	0.6631 0.0656 10.1107 <.0001 [v87]	1.0000 [v88]	0.6677 0.0649 10.2940 <.0001 [v98]
weight	0	0	0	0.5695 0.0791 7.2009 <.0001 [v94]	0.4942 0.0885 5.5874 <.0001 [v95]	0.6915 0.0611 11.3200 <.0001 [v96]	0.6570 0.0665 9.8756 <.0001 [v97]	0.6677 0.0649 10.2940 <.0001 [v98]	1.0000 [v99]

Twin Data

Which variables are correlated?

The CORR Procedure

3 With Variables:	progmat reason verbal
6 Variables:	headlng headbrd headcir bizyg height weight

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	headlng	headbrd	headcir	bizyg	height	weight
progmat Progressive matrices (M)	0.31380 0.0065 74	0.16095 0.1707 74	0.33140 0.0039 74	0.18434 0.1159 74	0.28396 0.0142 74	0.22900 0.0497 74
reason Reasoning Ability (R)	0.18124 0.1076 80	0.07721 0.4960 80	0.28165 0.0114 80	0.23269 0.0378 80	0.14222 0.2082 80	0.18026 0.1096 80
verbal Verbal Ability (V)	0.26356 0.0182 80	0.12990 0.2508 80	0.32007 0.0038 80	0.22935 0.0407 80	0.20567 0.0672 80	0.20097 0.0739 80

```
> # Bonferroni corrected significance level for 18 tests
> 0.05/18
[1] 0.002777778
```

```
1  /********************* marks.sas *************************/
2  title 'Marks in a Statistics class: Crude repeated measures with proc calis';
3  title2 'Jerry Brunner:  Student Number 999999999';
4
5  data STA302;
6       infile '/folders/myfolders/431s15/marks.data.txt' firstobs=2 ;  /* Skipping the header */
7       input id quiz computer midterm final;
8
9  proc corr;
10      var quiz computer midterm final;
11
12 proc calis;
13       mstruct var = quiz computer midterm final;
14      matrix _mean_ = mu mu mu mu; /* H0: All 4 means are equal */
15      matrix _cov_ ; /* Variances and covariances are unconstrained and get generic names. */
16
```

Marks in a Statistics class: Crude repeated measures with proc calis
Jerry Brunner: Student Number 999999999

The CORR Procedure

4 Variables:	quiz computer midterm final

Simple Statistics						
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
quiz	58	72.56897	10.97223	4209	46.00000	96.00000
computer	58	84.00000	11.60762	4872	46.00000	99.00000
midterm	58	68.87931	14.94561	3995	10.00000	95.00000
final	58	49.44828	16.51599	2868	15.00000	87.00000

Pearson Correlation Coefficients, N = 58 Prob > |r| under H0: Rho=0				
	quiz	computer	midterm	final
quiz	1.00000	0.49314 <.0001	0.36652 0.0047	0.39598 0.0021
computer	0.49314 <.0001	1.00000	0.16008 0.2300	0.03313 0.8050
midterm	0.36652 0.0047	0.16008 0.2300	1.00000	0.40364 0.0017
final	0.39598 0.0021	0.03313 0.8050	0.40364 0.0017	1.00000

Marks in a Statistics class: Crude repeated measures with proc calis
Jerry Brunner: Student Number 999999999

The CALIS Procedure
Mean and Covariance Structures: Model and Initial Values

Modeling Information	
Maximum Likelihood Estimation	
Data Set	WORK.STA302
N Records Read	58
N Records Used	58
N Obs	58
Model Type	MSTRUCT
Analysis	Means and Covariances

Variables in the Model
quiz computer midterm final
Number of Variables = 4

Initial MSTRUCT _MEAN_ Vector		
Variable	Parameter	Estimate
quiz	mu	.
computer	mu	.
midterm	mu	.

final	mu	.

Initial MSTRUCT _COV_ Matrix				
	quiz	**computer**	**midterm**	**final**
quiz	. [_Parm01]	. [_Parm02]	. [_Parm04]	. [_Parm07]
computer	. [_Parm02]	. [_Parm03]	. [_Parm05]	. [_Parm08]
midterm	. [_Parm04]	. [_Parm05]	. [_Parm06]	. [_Parm09]
final	. [_Parm07]	. [_Parm08]	. [_Parm09]	. [_Parm10]

Marks in a Statistics class: Crude repeated measures with proc calis
Jerry Brunner: Student Number 999999999

The CALIS Procedure
Mean and Covariance Structures: Descriptive Statistics

Simple Statistics		
Variable	**Mean**	**Std Dev**
quiz	72.56897	10.97223
computer	84.00000	11.60762
midterm	68.87931	14.94561
final	49.44828	16.51599

Marks in a Statistics class: Crude repeated measures with proc calis
Jerry Brunner: Student Number 999999999

The CALIS Procedure
Mean and Covariance Structures: Optimization

Initial Estimation Method	
1	Observed Moments of Variables

Optimization Start Parameter Estimates			
N	**Parameter**	**Estimate**	**Gradient**
1	**_Parm01**	120.38990	-0.0003125
2	**_Parm02**	62.80702	-0.00371
3	**_Parm03**	134.73684	-0.01099
4	**_Parm04**	60.10496	-0.0007428
5	**_Parm05**	27.77193	-0.00441
6	**_Parm06**	223.37114	-0.0004414
7	**_Parm07**	71.75802	0.00302
8	**_Parm08**	6.35088	0.01791
9	**_Parm09**	99.63400	0.00359
10	**_Parm10**	272.77798	-0.00730
11	**mu**	68.72414	-0.11618
Value of Objective Function = 3.3193561714			

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The CALIS Procedure
Mean and Covariance Structures: Optimization

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	11
Functions (Observations)	14

Optimization Start			
Active Constraints	0	Objective Function	3.3193561714
Max Abs Gradient Element	0.1161775825	Radius	1

Iteration		Restarts	Function Calls	Active Constraints		Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
1		0	4	0		1.96160	1.3578	0.0409	1.997	0.576
2		0	6	0		1.57575	0.3858	0.00420	0.432	0.716
3		0	8	0		1.44163	0.1341	0.00666	0.105	0.783
4		0	10	0		1.40702	0.0346	0.00415	0	0.879
5		0	12	0		1.40515	0.00187	0.00508	0	1.823
6		0	14	0		1.40375	0.00141	0.00314	0	1.821
7		0	16	0		1.40268	0.00106	0.00384	0	1.821
8		0	18	0		1.40188	0.000800	0.00237	0	1.821
9		0	20	0		1.40128	0.000603	0.00290	0	1.821
10		0	22	0		1.40083	0.000455	0.00179	0	1.820
11		0	24	0		1.40048	0.000343	0.00218	0	1.820
12		0	26	0		1.40022	0.000258	0.00135	0	1.820
13		0	28	0		1.40003	0.000195	0.00165	0	1.820
14		0	30	0		1.39988	0.000147	0.00102	0	1.820
15		0	32	0		1.39977	0.000110	0.00124	0	1.820
16		0	34	0		1.39969	0.000083	0.000765	0	1.820
17		0	36	0		1.39963	0.000063	0.000934	0	1.820
18		0	38	0		1.39958	0.000047	0.000576	0	1.820
19		0	40	0		1.39954	0.000036	0.000704	0	1.820
20		0	42	0		1.39952	0.000027	0.000434	0	1.820
21		0	44	0		1.39950	0.000020	0.000530	0	1.820
22		0	46	0		1.39948	0.000015	0.000327	0	1.820
23		0	48	0		1.39947	0.000011	0.000399	0	1.820
24		0	50	0		1.39946	8.624E-6	0.000246	0	1.820
25		0	52	0		1.39946	6.496E-6	0.000301	0	1.820
26		0	54	0		1.39945	4.893E-6	0.000186	0	1.820
27		0	56	0		1.39945	3.686E-6	0.000227	0	1.820
28		0	58	0		1.39944	2.776E-6	0.000140	0	1.820

29		0	60	0		1.39944	2.091E-6	0.000171	0	1.820
30		0	62	0		1.39944	1.575E-6	0.000105	0	1.820
31		0	64	0		1.39944	1.187E-6	0.000129	0	1.820
32		0	66	0		1.39944	8.939E-7	0.000079	0	1.820
33		0	68	0		1.39944	6.733E-7	0.000097	0	1.820
34		0	70	0		1.39944	5.072E-7	0.000060	0	1.820
35		0	72	0		1.39944	3.82E-7	0.000073	0	1.820
36		0	74	0		1.39944	2.878E-7	0.000045	0	1.820
37		0	76	0		1.39944	2.168E-7	0.000055	0	1.820
38		0	78	0		1.39944	1.633E-7	0.000034	0	1.820
39		0	80	0		1.39944	1.23E-7	0.000041	0	1.820
40		0	82	0		1.39944	9.265E-8	0.000026	0	1.820
41		0	84	0		1.39944	6.979E-8	0.000031	0	1.820
42		0	86	0		1.39944	5.257E-8	0.000019	0	1.820
43		0	88	0		1.39944	3.96E-8	0.000023	0	1.820
44		0	90	0		1.39944	2.983E-8	0.000014	0	1.820
45		0	92	0		1.39944	2.247E-8	0.000018	0	1.820
46		0	94	0		1.39944	1.693E-8	0.000011	0	1.820
47		0	96	0		1.39944	1.275E-8	0.000013	0	1.820
48		0	98	0		1.39944	9.604E-9	8.221E-6	0	1.820

Optimization Results			
Iterations	48	**Function Calls**	101
Jacobian Calls	50	**Active Constraints**	0
Objective Function	1.3994358159	**Max Abs Gradient Element**	8.2211326E-6
Lambda	0	**Actual Over Pred Change**	1.8196557944
Radius	0.0005129746		

Convergence criterion (GCONV=1E-8) satisfied.

Marks in a Statistics class: Crude repeated measures with proc calis
Jerry Brunner: Student Number 999999999

The CALIS Procedure
Mean and Covariance Structures: Maximum Likelihood Estimation

Fit Summary		
Modeling Info	**Number of Observations**	58
	Number of Variables	4
	Number of Moments	14
	Number of Parameters	11
	Number of Active Constraints	0
	Baseline Model Function Value	0.7330
	Baseline Model Chi-Square	41.7818
	Baseline Model Chi-Square DF	6
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	**Fit Function**	1.3994
	Chi-Square	79.7678

	Chi-Square DF	3
	Pr > Chi-Square	<.0001
	Z-Test of Wilson & Hilferty	7.5645
	Hoelter Critical N	6
	Root Mean Square Residual (RMR)	172.6045
	Standardized RMR (SRMR)	0.8516
	Goodness of Fit Index (GFI)	0.9816
Parsimony Index	Adjusted GFI (AGFI)	0.9143
	Parsimonious GFI	0.4908
	RMSEA Estimate	0.6700
	RMSEA Lower 90% Confidence Limit	0.5476
	RMSEA Upper 90% Confidence Limit	0.8009
	Probability of Close Fit	<.0001
	Akaike Information Criterion	101.7678
	Bozdogan CAIC	135.4327
	Schwarz Bayesian Criterion	124.4327
	McDonald Centrality	0.5159
Incremental Index	Bentler Comparative Fit Index	0.0000
	Bentler-Bonett NFI	-0.9092
	Bentler-Bonett Non-normed Index	-3.2909
	Bollen Normed Index Rho1	-2.8183
	Bollen Non-normed Index Delta2	-0.9795
	James et al. Parsimonious NFI	-0.4546

Marks in a Statistics class: Crude repeated measures with proc calis
Jerry Brunner: Student Number 999999999

The CALIS Procedure
Mean and Covariance Structures: Maximum Likelihood Estimation

MSTRUCT _Mean_ Vector					
Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
quiz	mu	73.30805	1.17699	62.2843	<.0001
computer	mu	73.30805	1.17699	62.2843	<.0001
midterm	mu	73.30805	1.17699	62.2843	<.0001
final	mu	73.30805	1.17699	62.2843	<.0001

MSTRUCT _COV_ Matrix: Estimate/StdErr/t-value/p-value				
	quiz	computer	midterm	final
quiz	120.9354 22.6533 5.3385 <.0001 [_Parm01]	54.9100 24.1109 2.2774 0.0228 [_Parm02]	63.3754 24.2072 2.6180 0.008844 [_Parm04]	89.3794 43.8941 2.0363 0.0417 [_Parm07]
computer	54.9100 24.1109 2.2774 0.0228 [_Parm02]	249.0659 46.6543 5.3385 <.0001 [_Parm03]	-19.5766 32.6871 -0.5989 0.5492 [_Parm05]	-248.7636 69.0293 -3.6037 0.000314 [_Parm08]

midterm	63.3754 24.2072 2.6180 0.008844 [_Parm04]	-19.5766 32.6871 -0.5989 0.5492 [_Parm05]	242.9802 45.5144 5.3385 <.0001 [_Parm06]	205.2878 65.7937 3.1202 0.001807 [_Parm09]
final	89.3794 43.8941 2.0363 0.0417 [_Parm07]	-248.7636 69.0293 -3.6037 0.000314 [_Parm08]	205.2878 65.7937 3.1202 0.001807 [_Parm09]	842.0416 157.7288 5.3385 <.0001 [_Parm10]

Marks in a Statistics class: Crude repeated measures with proc calis
Jerry Brunner: Student Number 999999999

The CALIS Procedure
Mean and Covariance Structures: Maximum Likelihood Estimation

Standardized MSTRUCT _COV_ Matrix: Estimate/StdErr/t-value/p-value

	quiz	computer	midterm	final
quiz	1.0000 [_Parm01]	0.3164 0.1192 2.6544 0.007946 [_Parm02]	0.3697 0.1143 3.2332 0.001224 [_Parm04]	0.2801 0.1221 2.2946 0.0218 [_Parm07]
computer	0.3164 0.1192 2.6544 0.007946 [_Parm02]	1.0000 [_Parm03]	-0.0796 0.1316 -0.6046 0.5454 [_Parm05]	-0.5432 0.0934 -5.8177 <.0001 [_Parm08]
midterm	0.3697 0.1143 3.2332 0.001224 [_Parm04]	-0.0796 0.1316 -0.6046 0.5454 [_Parm05]	1.0000 [_Parm06]	0.4538 0.1052 4.3154 <.0001 [_Parm09]
final	0.2801 0.1221 2.2946 0.0218 [_Parm07]	-0.5432 0.0934 -5.8177 <.0001 [_Parm08]	0.4538 0.1052 4.3154 <.0001 [_Parm09]	1.0000 [_Parm10]