

Intro to Mx

Mx class 2004

General Comments

- case insensitive, except for filenames under Unix
- comments: anything following a !
- blank lines
- commands: identified by first 2 letters, BUT recommended to use full words



Job Structure

- three types of groups:
 - Data, Calculation, Constraint
- number of groups indicated by
 - #NGroups 3
 - at the beginning of job
- jobs can be stacked in one run



Group Structure

- Title
- Group type: data, calculation, constraint
- [Read observed data, Select, Labels]
- Matrices declaration
- [Specify numbers, parameters, etc.]
- Algebra section and/or Model statement
- [Options]
- End

Read Observed Data

- Data NObservations=123 NInputvars=2
- CMatrix/ Means/ CTable/
 - summary statistics
 - read from script / file (File=filename)
- Rectangular/ Ordinal / VLength
 - raw data
 - read from script / file (File=filename)
- Select variables ; [by number/label]
- Labels variables

Matrix Declaration

- Begin Matrices; = Group 1*
- C Full 2 3 Free = A1
- ! [name type rows columns free]
- ! default element is fixed at 0
- ! ... more matrices
- End Matrices;

- * copies all matrices from group 1

Matrix Types (Mx manual p.56)

Type	Structure	Shape	Free
Zero	Null (zeros)	Any	0
Unit	Unit (ones)	Any	0
Iden	Identity	Square	0
Diag	Diagonal	Square	r
S Diag	Subdiagonal	Square	$r(r-1)/2$
Stand	Standardized	Square	$r(r-1)/2$
Symm	Symmetric	Square	$r(r+1)/2$
Lower	Lower triangular	Square	$r(r+1)/2$
Full	Full	Any	$r \times c$
Computed	Equated to	Any	0

Matrices

Example Command	Specification Matrix	Values
A Zero 2 3 Free	0 0 0 0 0 0	0 0 0 0 0 0
B Unit 2 3 Free	0 0 0 0 0 0	1 1 1 1 1 1
C Iden 3 3 Free	0 0 0 0 0 0 0 0 0	1 0 0 0 1 0 0 0 1
D Izero 2 5 Free	0 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 1 0 0 0
E Ziden 2 5 Free	0 0 0 0 0 0 0 0 0 0	0 0 0 1 0 0 0 0 0 1

Matrices II

Example Command	Specification Matrix	Values
F Diag 3 3 Free	1 0 0 0 2 0 0 0 3	? 0 0 0 ? 0 0 0 ?
G SDiag 3 3 Free	0 0 0 1 0 0 2 3 0	0 0 0 ? 0 0 ? ? 0
H Stand 3 3 Free	0 1 2 1 0 3 2 3 0	1 ? ? ? 1 ? ? ? 1

Matrices III

Example Command	Specification Matrix	Values
I Symm 3 3 Free	1 2 4 2 3 5 4 5 6	??? ??? ???
J Lower 3 3 Free	1 0 0 2 3 0 4 5 6	? 0 0 ? ? 0 ? ? ?
K Full 2 4 Free	1 2 3 4 5 6 7 8	???? ????

Constrained Matrices *

Syntax	Matrix Quantity	Dimensions
%On	Observed covariance matrix	NI x NI
%En	Expected covariance matrix	NI x NI
%Mn	Expected mean vector	1 x NI
%Pn	Expected proportions	NR x NC
%Fn	Function value	1 x 1

* to special quantities in previous groups

Matrix Algebra / Model

- Begin Algebra;
- $B = A * A'$;
- $C = B + B$;
- ...
- End Algebra;

- Means [continuous] / Thresholds [categorical] X;
- Covariances X;
- Weight / Frequency X;

X: matrix or matrix formula

Unary Matrix Operations

Symbol	Name	Function	Example	Priority
\sim	Inverse	Inversion	$A\sim$	1
$`$	Transpose	Transposition	$A`$	1

Binary Matrix Operations

Symbol	Name	Function	Example	Priority
\wedge	Power	Element powering	$A \wedge B$	2
*	Star	Multiplication	$A * B$	3
.	Dot	Dot multiplication	$A . B$	3
@	Kronecker	Kronecker product	$A @ B$	3
&	Quadratic	Quadratic product	$A \& B$	3
%	Eldiv	Element division	$A \% B$	3
+	Plus	Addition	$A + B$	4
-	Minus	Subtraction	$A - B$	4
	Bar	Horizontal adhesion	$A B$	4
_	Underscore	Vertical adhesion	$A _ B$	4

Matrix Operations (Mx p.59)

Symbol	Name	Function	Example	Priority
~	Inverse	Inversion	A^{-1}	1
`	Transpose	Transposition	A^T	1
^	Power	Element powering	A^B	2
*	Star	Multiplication	$A*B$	3
.	Dot	Dot multiplication	$A.B$	3
@	Kronecker	Kronecker product	$A@B$	3
&	Quadratic	Quadratic product	$A&B$	3
%	Eldiv	Element division	$A\%B$	3
+	Plus	Addition	$A+B$	4
-	Minus	Subtraction	$A-B$	4
	Bar	Horizontal adhesion	$A B$	4
_	Underscore	Vertical adhesion	A_B	4

Matrix Functions (Mx p. 64)

Keyword	Function	Restrictions	Dimensions
<code>\tr()</code>	Trace	$r=c$	1×1
<code>\det()</code>	Determinant	$r=c$	1×1
<code>\sum()</code>	Sum	None	1×1
<code>\prod()</code>	Product	None	1×1
<code>\max()</code>	Maximum	None	1×1
<code>\min()</code>	Minimum	None	1×1
<code>\abs()</code>	Absolute value	None	$r \times c$
<code>\exp()</code>	Exponent	None	$r \times c$
<code>\ln()</code>	Natural logarithm	None	$r \times c$
<code>\sqrt{}</code>	Square root	None	$r \times c$

Matrix Functions II

Keyword	Function	Restrictions	Dimensions
<code>\stand()</code>	Standardize	$r=c$	$r \times c$
<code>\mean()</code>	Mean of columns	None	$1 \times c$
<code>\cov()</code>	Covariance of cols	None	$c \times c$
<code>\pdfnor()</code>	Mv normal density	$r=c+2$	1×1
<code>\mnor()</code>	Mv normal integral	$r=c+3$	1×1
<code>\pchisq()</code>	Probability of Chi ²	$r=1 \ c=2$	1×2
<code>\d2v()</code>	Diagonal to vector	None	$\text{Min}(r,c) \times 1$
<code>\m2v()</code>	Matrix to vector	None	$rc \times 1$
<code>\part()</code>	Extract part of vector	None	variable

Specify Numbers/ Parameters

- Numbers
 - Matrix <name> <number list>
 - Start/Value <name> <value> <element list>
- Parameters
 - Fix/Free <value> <element list>
 - Equate <name GRC> <name GRC>
 - Specify <name> <integer list>
 - Bound low high <parameter list/element list>
- Label Matrices
 - Label Row/Column <name> <label list>

Options

- Statistical Output
 - Suppressing output: No_Output
 - Appearance: NDecimals=n
 - Residuals: RSiduals
 - Adjusting Degrees of Freedom: DFreedom=n
 - Power Calculations: Power=alpha,df
 - Confidence Intervals:
 - Interval {@value} <matrix element list>

Options

- Optimization options
 - Bootstrap Estimates
 - Randomizing Starting Values: THard=n
 - Automatic Cold Restart: THard=-n
 - Jiggling Parameter Starting Values: Jiggle
 - Confidence Intervals on Fit Statistics
 - Comparative Fit Indices: Null
 - Likelihood-Ratio Statistics of Submodels: Issat/ Sat
 - Check Identification of Model: Check

Fitting Submodels

- Multiple Fit
- Option Multiple: Matrix/ Value/ Start/ Equate/ Fix/ Free/ Options
- Drop {@value} <parlist> <element list>
- Binary Save/Get <filename>
- Writing Matrices to Files: MXn = <filename>
- Writing Individual Likelihood Statistics to Files: MX%P = <filename>



Mx

- Graphical Interface
- Language







Practical Example

- Dataset: NH&MRC Twin Register
- 1981 questionnaire
- BMI: weight/ height squared
- Young cohort: 18-30 years
- N MZFY: 534, DZFY: 328

Raw Dataset ozbmi2.rec

115 21 1 2 58 57 1.7000 1.7000 20.0692 19.7232 20.9943 20.8726
121 24 1 2 54 53 1.6299 1.6299 20.3244 19.9481 21.0828 20.9519
158 21 1 2 55 50 1.6499 1.6799 20.2020 17.7154 21.0405 20.1210
172 21 1 2 66 76 1.5698 1.6499 26.7759 27.9155 23.0125 23.3043
182 19 1 2 50 48 1.6099 1.6299 19.2894 18.0662 20.7169 20.2583
199 26 1 2 60 60 1.5999 1.5698 23.4375 24.3418 22.0804 22.3454
221 23 1 2 65 65 1.7500 1.7698 21.2245 20.7476 21.3861 21.2270
239 29 1 2 40 39 1.5598 1.5298 16.4366 16.6603 19.5966 19.6912
246 24 1 2 60 57 1.7598 1.7698 19.3698 18.1940 20.7460 20.3076
251 28 1 2 76 64 1.7000 1.7300 26.2976 21.3839 22.8863 21.4385
262 29 1 2 48 51 1.5198 1.5698 20.7756 20.6905 21.2365 21.2077
284 19 1 2 70 67 1.6799 1.6799 24.8016 23.7387 22.4764 22.1697
524 20 1 2 53 50 1.6199 1.6299 20.1951 18.8189 21.0381 20.5440
535 22 1 2 57 55 1.5798 1.5999 22.8329 21.4844 21.8974 21.4713
582 26 1 2 62 61 1.6799 1.6399 21.9671 22.6800 21.6268 21.8504
587 28 1 2 60 58 1.6299 1.6399 22.5827 21.5645 21.8203 21.4974
588 19 1 2 55 55 1.5698 1.5698 22.3133 22.3133 21.7363 21.7363
621 21 1 2 46 49 1.5698 1.5498 18.6620 20.3954 20.4854 21.1072
630 27 1 1 54 55 1.7698 . 17.2364 . 19.9292 .
631 28 1 2 58 60 1.6899 1.6899 20.3074 21.0077 21.0769 21.3142

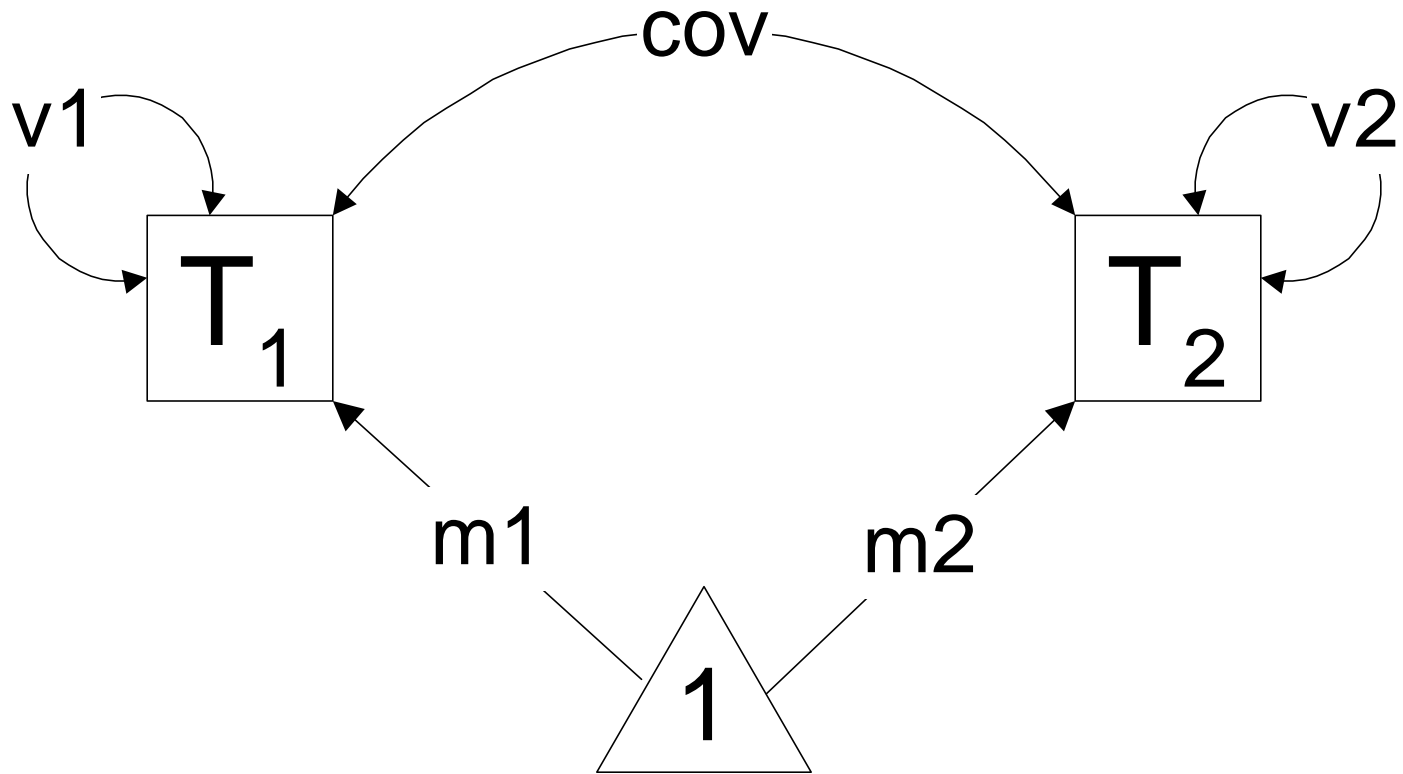
Zygoty in Australian Twins

	MZF	MZM	DZF	DZM	DZFM
Young	1	2	3	4	5
Old	6	7	8	9	10

Dat File: ozbmi2.dat

- Data NInput=12
- Rectangular File=ozbmi2.rec
- Labels fam age zyg part wt1 wt2 ht1 ht2
htwt1 htwt2 bmi1 bmi2

Saturated Model



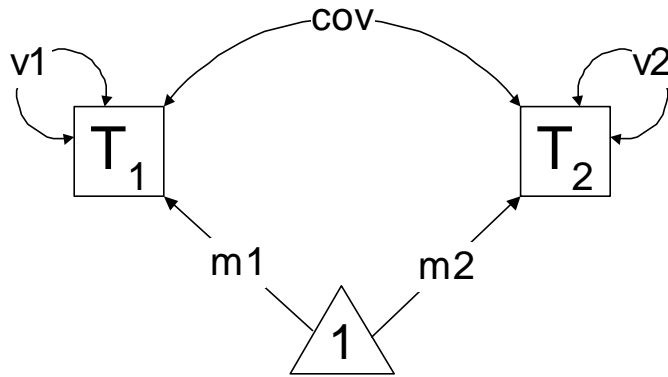
! Estimate means and variances - Saturated model

! OZ BMI data - young females

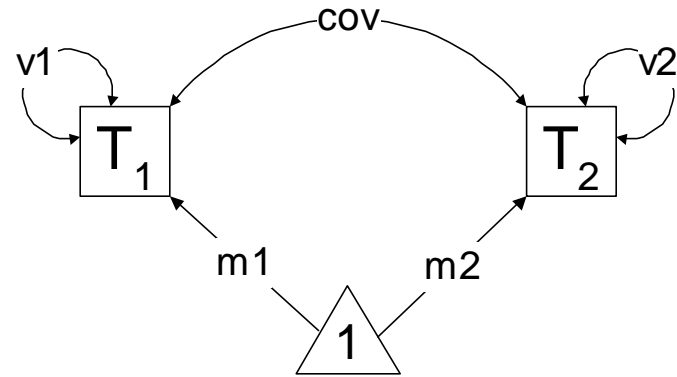
- #NGroups 2
 - #define nvar2 2

 - Title 1: MZ data
 - #include ozbmi.dat
 - Select if zyg =1
 - Select bmi 1 bmi 2 ;
 - Begin Matrices;
 - M Full 1 nvar2 Free
 - X Symm nvar2 nvar2 Free
 - End Matrices;
 - Start 20 M 1 1 - M 1 nvar2
 - Start 1 X 1 1 X 2 2
 - Means M;
 - Covariance X;
 - Option RSiduals
 - End
- Title 2: DZ data
 - #include ozbmi.dat
 - Select if zyg =3
 - Select bmi 1 bmi 2 ;
 - Begin Matrices;
 - M Full 1 nvar2 Free
 - X Symm nvar2 nvar2 Free
 - End Matrices;
 - Start 20 M 1 1 - M 1 nvar2
 - Start 1 X 1 1 X 2 2
 - Means M;
 - Covariance X;
 - Option RSiduals
 - End

Equality of means, variances



MZ twins



DZ twins

10 parameters

Tests

- Saturated model
- Equality of means
 - Is $m_1 = m_2$?
 - Is $m_{1MZ} = m_{1DZ}$?
- Equality of variances
 - Is $v_1 = v_2$?
 - Is $v_{1MZ} = v_{1DZ}$?

Equality tests

-
 - Option Multiple Issat
 - End

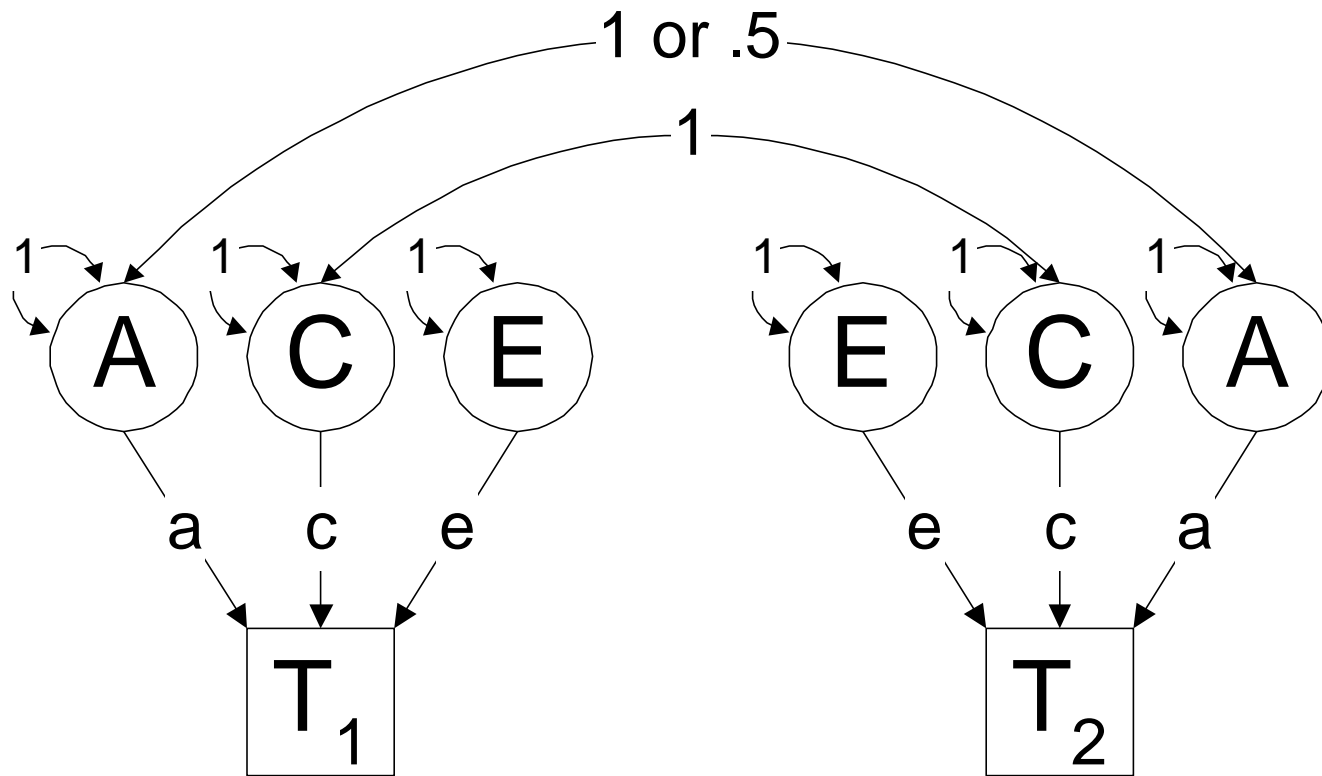
 - Save ozbmi sat. mxs
 - ! equate means and variances
 - Equate M 1 1 1 M 1 1 2 M 2 1 1 M 2 1 2
 - Equate X 1 1 1 X 1 2 2 X 2 1 1 X 2 2 2
 - End
- Get ozbmi sat. mxs
 - ! equate means within zygoty groups
 - Equate M 1 1 1 M 1 1 2
 - Equate M 2 1 1 M 2 1 2
 - End

 - ! equate means across zygoty groups
 - Equate M 1 1 1 M 1 1 2 M 2 1 1 M 2 1 2
 - End

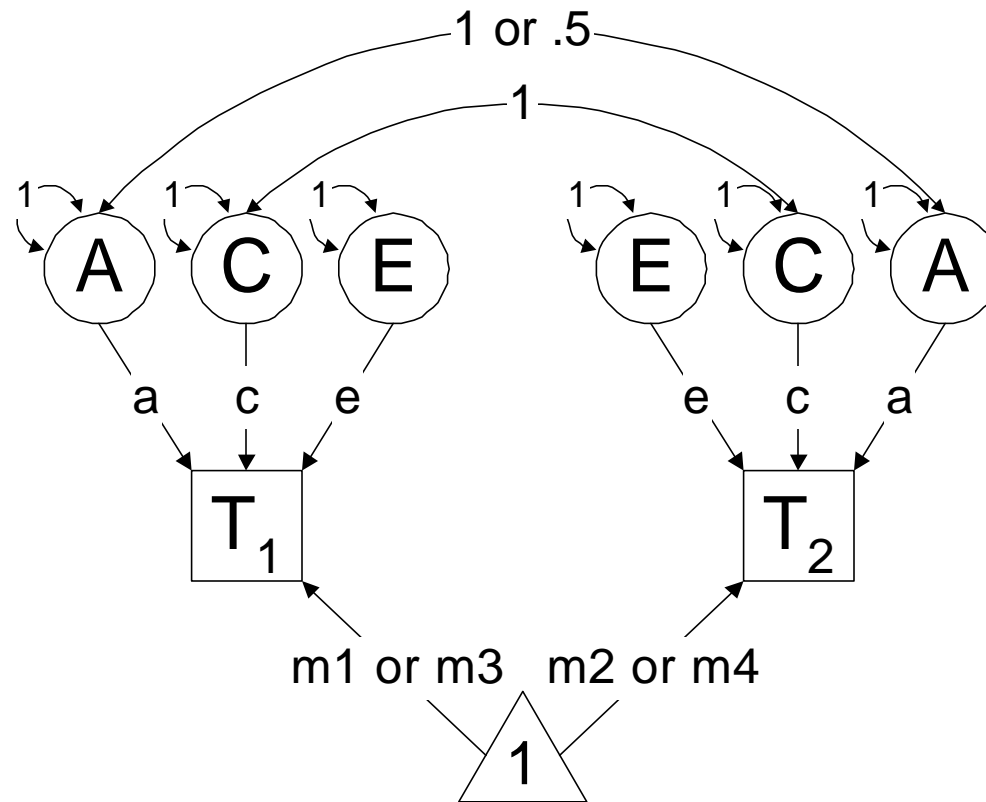
 - ! equate variances within zygoty groups
 - Equate X 1 1 1 X 1 2 2
 - Equate X 2 1 1 X 2 2 2
 - End

 - ! equate variances across zygoty groups
 - Equate X 1 1 1 X 1 2 2 X 2 1 1 X 2 2 2
 - End

ACE Model



ACE Model + Means



Tests

- ACE model
- Is a significant ? -> CE model
- Is c significant ? -> AE model
- Is there significant family resemblance ?
-> E model

- ADE model

! Estimate variance components - ACED model

! OZ BMI data - younger females

- #NGroups 4
 - #define nvar 1
 - #define nvar2 2

 - Title 1: Model Parameters
 - Calculation
 - Begin Matrices;
 - X Lower nvar nvar Free ! a
 - Y Lower nvar nvar ! c
 - Z Lower nvar nvar Free ! e
 - W Lower nvar nvar Free ! d
 - H Full 1 1 ! 0.5
 - Q Full 1 1 ! 0.25
 - End Matrices;
 - Matrix H .5
 - Matrix Q .25
- Label Row X add_gen
 - Label Row Y com_env
 - Label Row Z spec_env
 - Label Row W dom_gen
 - Begin Algebra;
 - A= X*X' ; ! a^2
 - C= Y*Y' ; ! c^2
 - E= Z*Z' ; ! e^2
 - D= W*W ; ! d^2
 - End Algebra;
 - End

! Estimate variance components - ACED model

! OZ BMI data - younger females II

- Title 2: MZ data
 - #include ozbmi.dat
 - Select if zyg =1
 - Select bmi 1 bmi 2 ;
 - Begin Matrices = Group 1;
 - M Full 1 nvar2 Free
 - Means M;
 - Covariance
 - A+C+E+D | A+C+D _
 - A+C+D | A+C+E+D;
 - Option RSiduals;
 - End
- Title 3: DZ data
 - #include ozbmi.dat
 - Select if zyg =3
 - Select bmi 1 bmi 2 ;
 - Begin Matrices = Group 1;
 - M Full 1 nvar2 Free
 - End Matrices;
 - Means M;
 - Covariance
 - A+C+E+D | H@A+C+Q@D _
 - H@A+C+Q@D | A+C+E+D;
 - Option RSiduals
 - End

! Estimate variance components - ACED model

! OZ BMI data - younger females III

- Title 4: Standardization
- Calculation
- Begin Matrices = Group 1;
- End Matrices;
- Start .6 all
- Start 20 M 2 1 1 - M 2 1 nvar2
- Start 20 M 3 1 1 - M 3 1 nvar2
- Begin Algebra;
- $V=A+C+E+D;$! total variance
- $P=A|C|E|D;$! concatenate parameter estimates
- $S=P@V~;$! standardized parameter estimates
- End Algebra;
- !ADE model
- Interval S 1 1 - S 1 4
- Option NDecimals=4
- Option Sat=4055.935, 1767
- End