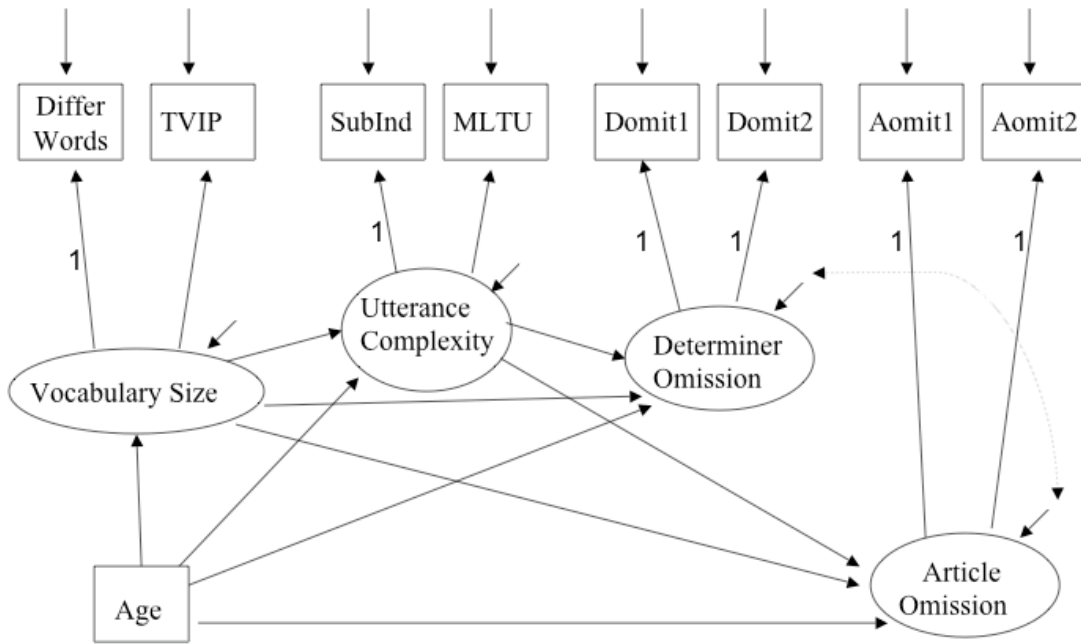


Language Development Study



```

/* cread3.sas  Read Castilla's language development data */
options nodate linesize=79 noovp formdlim=' ';
title "Castilla's Language development Study";

proc format;
  value agfmt 3 = '33 to 39 months'
             4 = '44 to 51 months'
             5 = '57 to 62 months';
  value ynfmt 0 = 'No' 1 = 'Yes';
  value sexfmt 0 = 'Male' 1 = 'Female';

data babble; /* Use if you don't want to see variable labels */
  infile 'Castilla3.data'
         delimiter=',' /* Comma-delimited test from an Excel .csv file */
         firstobs=2; /* Skip the first line */
  input AgeGroup Code $ Gender $ Age DifWords TTR TVIP SubInd MLTU
        Domit2 Domit1 Aomit2 Aomit1;
  if 0 < Domit1 <= 100 then AnyDom1 = 1; else AnyDom1=Domit1;
  if 0 < Domit2 <= 100 then AnyDom2 = 1; else AnyDom2=Domit2;
  if 0 < Aomit1 <= 100 then AnyAom1 = 1; else AnyAom1=Aomit1;
  if 0 < Aomit2 <= 100 then AnyAom2 = 1; else AnyAom2=Aomit2;
  if gender = 'M' then sex = 0; else if gender = 'F' then sex = 1;
  agegrp = agegroup;
  format agegroup agfmt.;
  format AnyDom1 AnyDom2 AnyAom1 AnyAom2 ynfmt.;
  format sex sexfmt.;

data babytalk;
  set babble;
  label
    Age          = "Child's age in months"
    Difwords    = "# Different Words"
    TTR         = 'Type-token ratio (Vocab size)'
    TVIP       = 'Number correct on a standardized vocabulary test'
    Subind     = 'Subordination Index: Sentence complexity from lang sample'
    MLTU       = 'Mean length of utterance from lang sample'
    Domit1     = 'Determiner ommission (OmisClitic): Set 1'
    Domit2     = 'Determiner ommission (OmisClitic): Set 2'
    Aomit1     = 'Article ommission: Set 1'
    Aomit2     = 'Article ommission: Set 2'
    AnyDom1    = 'Any Determiner ommission in Set 1?'
    AnyDom2    = 'Any Determiner ommission in Set 2?'
    AnyAom1    = 'Any Article ommission in Set 1?'
    AnyAom2    = 'Any Article ommission in Set 2?'
    sex        = '0=M, 1=F'
    agegrp     = 'Numeric agegroup';

```

```

/* csem4.sas SEM for Castilla's language development data */
%include 'cread3.sas';
title2 'Likelihood ratio tests';

proc calis cov;
  /* Analyze the covariance matrix (Default is corr). */
  title3 'Full Model';
  /* Name the observed variables */
  var age difwords tvip subind mltu domit1 domit2 aomit1 aomit2;
  lineqs
    /* Structural Model */
    Fvsize = gamma1 age + e1,
    Fucomp = gamma2 age + b21 Fvsize + e2,
    Fdomit = gamma3 age + b31 Fvsize + b32 Fucomp + e3,
    Faomit = gamma4 age + b41 Fvsize + b42 Fucomp + e4,
    /* Measurement model */
    difwords = Fvsize + delta1,
    tvip = lambda1 Fvsize + delta2,
    subind = Fucomp + delta3,
    mltu = lambda2 Fucomp + delta4,
    domit1 = Fdomit + delta5,
    domit2 = Fdomit + delta6,
    aomit1 = Faomit + delta7,
    aomit2 = Faomit + delta8;
  std /* Variances (not standard deviations). Colon means
      fill in the numbers. */
      age = phi, e1-e4 = 4 * psi: , delta1-delta8 = 8 * omega: ;
  bounds 0.0 < phi psi1-psi4 omeg1-omega8; /* Variances are positive */

/* Fvsize is Latent vocabulary size
Fucomp is Latent utterance complexity
Fdomit is Latent tendency to omit determiners
Faomit is Latent tendency to omit articles
*/

%include 'csemfull.sas';
title3 'Reduced model for H0: g4=b41=b42=0';
lincon gamma4=0,b41=0,b42=0;
/* Got G = 35.4261 - 30.2680 = 5.1581, df=3, p = 0.1605797 */
/* Commented out for now: Results compatible with "t"-tests

%include 'csemfull.sas';
title3 'Reduced model for H0: gamma1=0';
lincon gamma1=0;

%include 'csemfull.sas';
title3 'Reduced model for H0: gamma2=0';
lincon gamma2=0;

%include 'csemfull.sas';
title3 'Reduced model for H0: gamma3=0';
lincon gamma3=0;

%include 'csemfull.sas';
title3 'Reduced model for H0: gamma4=0';
lincon gamma4=0;

```

```

%include 'csemfull.sas';
title3 'Reduced model for H0: b42=0';
lincon b42=0;

```

Castilla's Language development Study
Likelihood ratio tests
Full Model

1

The CALIS Procedure
Covariance Structure Analysis: Pattern and Initial Values

LINEQS Model Statement

	Matrix	Rows	Columns	-----Matrix Type-----	
Term 1	1 <u>_SEL_</u>	9	25	SELECTION	
	2 <u>_BETA_</u>	25	25	EQSBETA	IMINUSINV
	3 <u>_GAMMA_</u>	25	13	EQSGAMMA	
	4 <u>_PHI_</u>	13	13	SYMMETRIC	

The 12 Endogenous Variables

Manifest	DifWords	TVIP	SubInd	MLTU	Domit1
	Domit2	Aomit1	Aomit2		
Latent	Fvsize	Fucomp	Fdomit	Faomit	

The 13 Exogenous Variables

Manifest	Age				
Latent					
Error	e1	e2	e3	e4	delta1
	delta2	delta3	delta4	delta5	delta6
	delta7	delta8			

Set Covariances of Exogenous Manifest Variables

Age

NOTE: Some initial estimates computed by instrumental variable method.

NOTE: Some initial estimates computed by two-stage LS method.

NOTE: Some initial estimates computed by McDonald's method.

Castilla's Language development Study
 Likelihood ratio tests
 Full Model

6

The CALIS Procedure
 Covariance Structure Analysis: Maximum Likelihood Estimation

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates 24
 Functions (Observations) 45
 Lower Bounds 13
 Upper Bounds 0

Optimization Start

Active Constraints 0 Objective Function 2.3171754524
 Max Abs Gradient Element 280.12348431 Radius 65948.295723

Iter	Rest arts	Func Calls	Act Con	Objective Function	Obj Fun Change	Max Abs Gradient Element	Lambda	Actual Over Pred Change
1	0	2	1	0.86742	1.4498	91.6874	0	1.051
2	0	3	0	0.44074	0.4267	140.6	0	1.524
3	0	4	0	0.29946	0.1413	27.0677	0	0.626
4	0	5	0	0.29090	0.00856	7.1529	0	0.543
5	0	6	0	0.28887	0.00204	5.3190	0	0.539
6	0	7	0	0.28842	0.000450	1.7630	0	0.526
7	0	8	0	0.28830	0.000113	1.2241	0	0.529
8	0	9	0	0.28828	0.000027	0.4389	0	0.526
9	0	10	0	0.28827	6.695E-6	0.2944	0	0.526
10	0	11	0	0.28827	1.631E-6	0.1091	0	0.524
11	0	12	0	0.28827	4.002E-7	0.0715	0	0.523
12	0	13	0	0.28827	9.791E-8	0.0271	0	0.521
13	0	14	0	0.28827	2.4E-8	0.0174	0	0.520
14	0	15	0	0.28827	5.88E-9	0.00674	0	0.519
15	0	16	0	0.28827	1.442E-9	0.00425	0	0.518
16	0	17	0	0.28827	3.53E-10	0.00167	0	0.517

Optimization Results

Iterations 16 Function Calls 18
 Jacobian Calls 17 Active Constraints 0
 Objective Function 0.2882670705 Max Abs Gradient Element 0.0016712054
 Lambda 0 Actual Over Pred Change 0.5174070536
 Radius 0.0003400933

GCONV convergence criterion satisfied.

NOTE: At least one element of the (projected) gradient is greater than 1e-3.

Castilla's Language development Study
Likelihood ratio tests
Full Model

7

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.2883
Goodness of Fit Index (GFI)	0.9423
GFI Adjusted for Degrees of Freedom (AGFI)	0.8763
Root Mean Square Residual (RMR)	14.4928
Parsimonious GFI (Mulaik, 1989)	0.5497
Chi-Square	30.2680
Chi-Square DF	21
Pr > Chi-Square	0.0867
Independence Model Chi-Square	386.09
Independence Model Chi-Square DF	36
RMSEA Estimate	0.0648
RMSEA 90% Lower Confidence Limit	.
RMSEA 90% Upper Confidence Limit	0.1127
ECVI Estimate	0.7935
ECVI 90% Lower Confidence Limit	.
ECVI 90% Upper Confidence Limit	0.9797
Probability of Close Fit	0.2926
Bentler's Comparative Fit Index	0.9735
Normal Theory Reweighted LS Chi-Square	28.9355
Akaike's Information Criterion	-11.7320
Bozdogan's (1987) CAIC	-88.6642
Schwarz's Bayesian Criterion	-67.6642
McDonald's (1989) Centrality	0.9572
Bentler & Bonett's (1980) Non-normed Index	0.9546
Bentler & Bonett's (1980) NFI	0.9216
James, Mulaik, & Brett (1982) Parsimonious NFI	0.5376
Z-Test of Wilson & Hilferty (1931)	1.3626
Bollen (1986) Normed Index Rho1	0.8656
Bollen (1988) Non-normed Index Delta2	0.9746
Hoelter's (1983) Critical N	115

Castilla's Language development Study
Likelihood ratio tests
Full Model

8

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

DifWords =	1.0000 Fvsize	+	1.0000 delta1
TVIP =	0.3824*Fvsize	+	1.0000 delta2
Std Err	0.0491 lambda1		
t Value	7.7925		

SubInd = 1.0000 Fucomp + 1.0000 delta3
 MLTU = 14.2659*Fucomp + 1.0000 delta4
 Std Err 1.5796 lambda2
 t Value 9.0313
 Domit1 = 1.0000 Fdomit + 1.0000 delta5
 Domit2 = 1.0000 Fdomit + 1.0000 delta6
 Aomit1 = 1.0000 Faomit + 1.0000 delta7
 Aomit2 = 1.0000 Faomit + 1.0000 delta8

Castilla's Language development Study
 Likelihood ratio tests
 Full Model

9

The CALIS Procedure
 Covariance Structure Analysis: Maximum Likelihood Estimation

Latent Variable Equations with Estimates

Fvsize = 1.6389*Age + 1.0000 e1
 Std Err 0.2312 gamma1
 t Value 7.0898

Fucomp = 0.00323*Fvsize + -0.00042*Age + 1.0000 e2
 Std Err 0.000583 b21 0.00106 gamma2
 t Value 5.5476 -0.3946

Fdomit = -0.4426*Fvsize + 38.4377*Fucomp + 0.2376*Age
 Std Err 0.1875 b31 41.1169 b32 0.2054 gamma3
 t Value -2.3612 0.9348 1.1571
 + 1.0000 e3

Faomit = -0.1931*Fvsize + -2.6269*Fucomp + 0.0623*Age
 Std Err 0.2135 b41 50.3312 b42 0.2772 gamma4
 t Value -0.9044 -0.0522 0.2247
 + 1.0000 e4

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
Age	phi	91.30198	12.60087	7.25
e1	psi1	409.81396	83.55661	4.90
e2	psi2	0.00270	0.0008994	3.00
e3	psi3	104.21005	29.70751	3.51
e4	psi4	282.76195	59.77392	4.73
delta1	omega1	109.57165	51.86804	2.11
delta2	omega2	109.69069	16.81207	6.52
delta3	omega3	0.00602	0.00108	5.60
delta4	omega4	0.25685	0.14322	1.79
delta5	omega5	180.75806	33.62914	5.38
delta6	omega6	109.41777	27.14055	4.03
delta7	omega7	217.24969	53.92680	4.03
delta8	omega8	296.67708	60.70932	4.89

Castilla's Language development Study 13
Likelihood ratio tests
Reduced model for H0: g4=b41=b42=0

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

WARNING: There are 3 active constraints at the solution. The standard errors and Chi-Square test statistic assume the solution is located in the interior of the parameter space and hence do not apply if it is likely that some different set of inequality constraints could be active.

NOTE: The degrees of freedom are increased by the number of active constraints (see Dijkstra, 1992). The number of parameters in calculating fit indices is decreased by the number of active constraints. To turn off the adjustment, use the NOADJDF option.

Castilla's Language development Study 14
Likelihood ratio tests
Reduced model for H0: g4=b41=b42=0

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.3374
Goodness of Fit Index (GFI)	0.9329
GFI Adjusted for Degrees of Freedom (AGFI)	0.8742
Root Mean Square Residual (RMR)	31.7456
Parsimonious GFI (Mulaik, 1989)	0.6219
Chi-Square	35.4261
Chi-Square DF	24
Pr > Chi-Square	0.0623

etc.