Confirmatory factor analysis (確認的因子分析)

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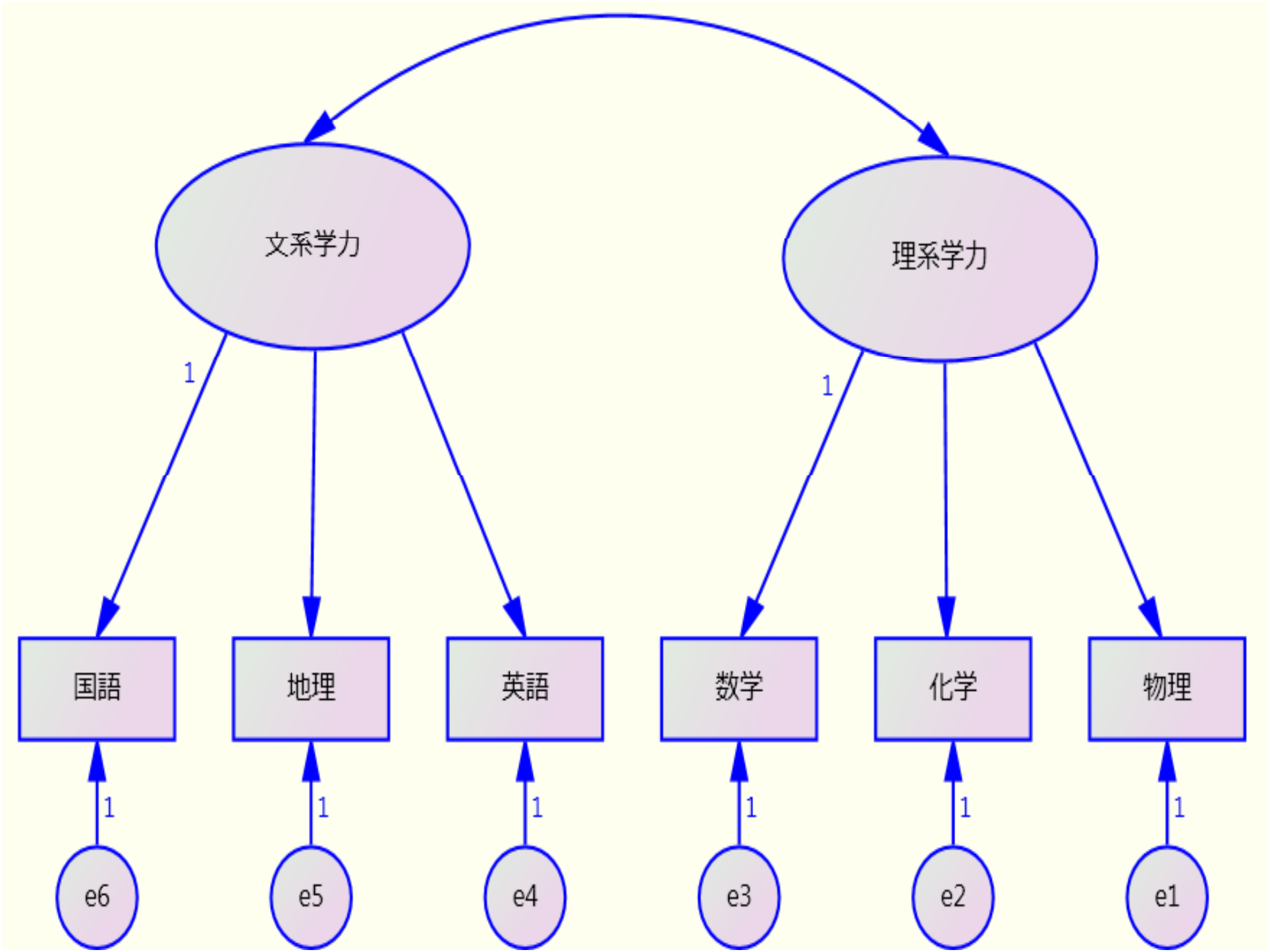
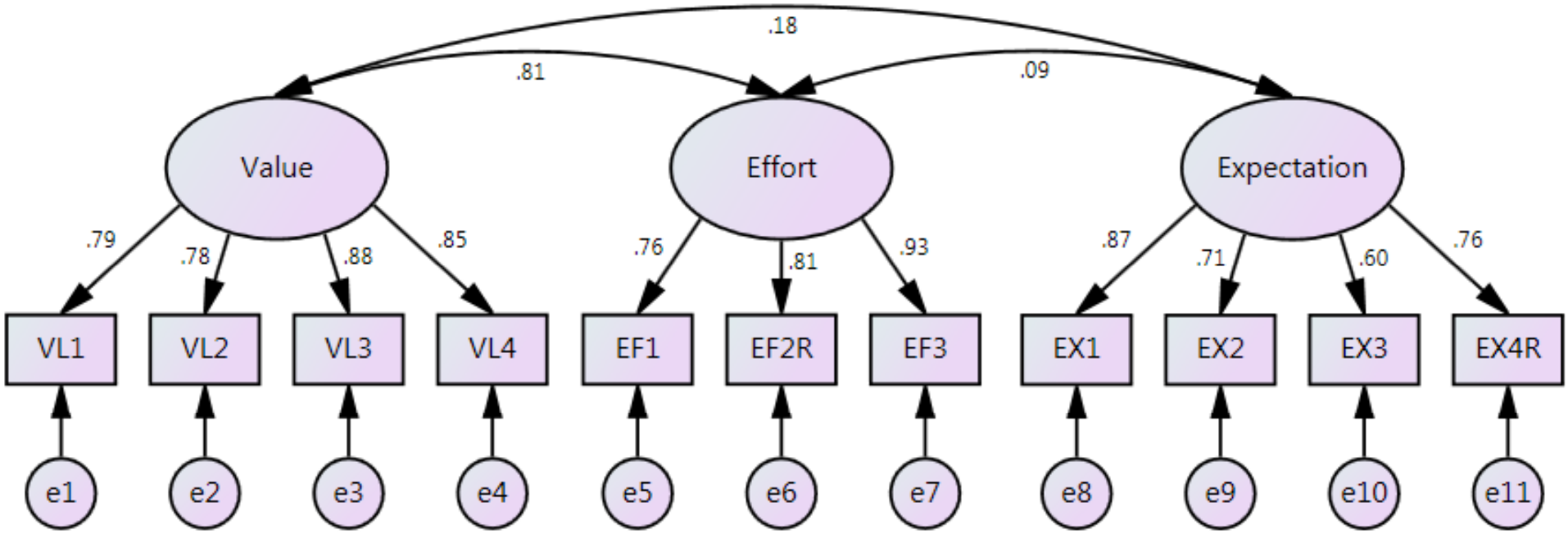
A bit about myself

- MA & PhD from Tsukuba
- Language testing
  - Test method (task type, response format) effect on language test performance
  - Construct validation study of a test/instrument/questionnaire (e.g., research into factorial/structural relationships among variables)
  - Meta-analytic inquiry into the variability of effects
  - Longitudinal measurement of change in language proficiency
  - Secondary analysis of survey and administrative datasets
  - Application of measurement models to language test data (especially, meta-analysis and structural equation modeling)
- 理系に比べると、正確な測定・分析が難しい
  - 「英語能力」をどう測る？
  - TOEIC はリスニングとリーディング力を測定している？

Overview

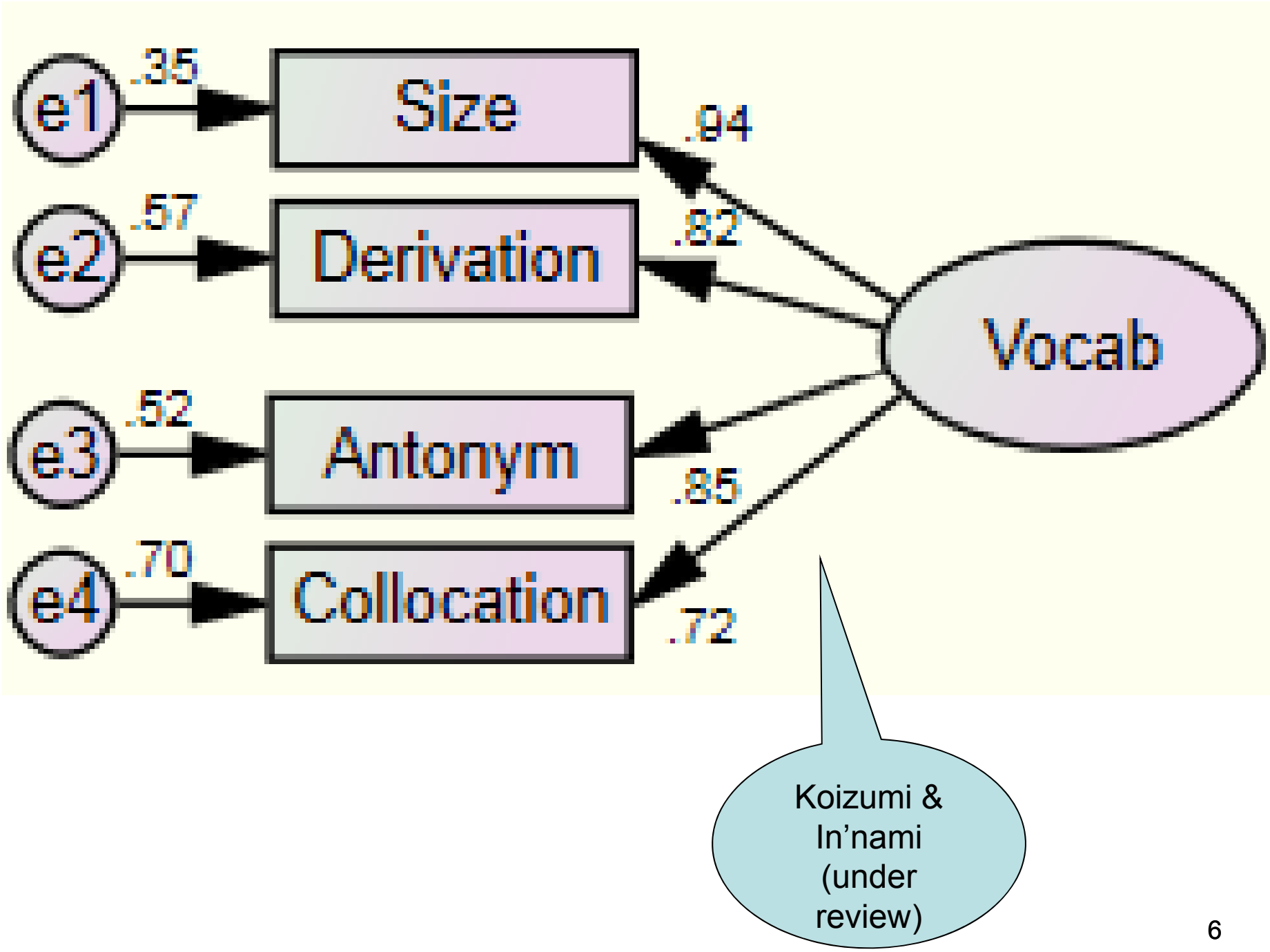
- **Confirmatory factor analysis (CFA) basics**
- CFA demo
- (Break)
- Applications
  - Higher-order models
  - Multitrait-multimethod (MTMM) models
  - Multi-sample models
- Structural equation modeling


文系学力
理系学力
1
1
国語
地理
英語
数学
化学
物理
1
1
1
1
1
1
e6
e5
e4
e3
e2
e1



VL1: この活動を行うことは、大きな意味があると思う。
VL2: この活動は、とても重要だと思う。
VL3: この活動は、多くの利益をもたらしてくれるだろう。
VL4: この活動は、今後の英語学習に重要なものだと思う。
EF1: この活動には多くの努力を費やせるだろう。
EF2: この活動に対して、あまりがんばらないと思う。(R)
EF3: この活動に対して全力で挑めると思う。
EX1: 他の人に比べて、この活動がうまくできると思う。
EX2: この活動の結果に満足できると思う。
EX3: この活動が終わった後、充実感を得られそうだ。
EX4: この活動をうまくできないと思う。(R)

Konno & Hirai (2012)


e1
e2
e3
e4
.35
.57
.52
.70
Size
Derivation
Antonym
Collocation
.94
.82
.85
.72
Vocab
Koizumi & In'nami (under review)

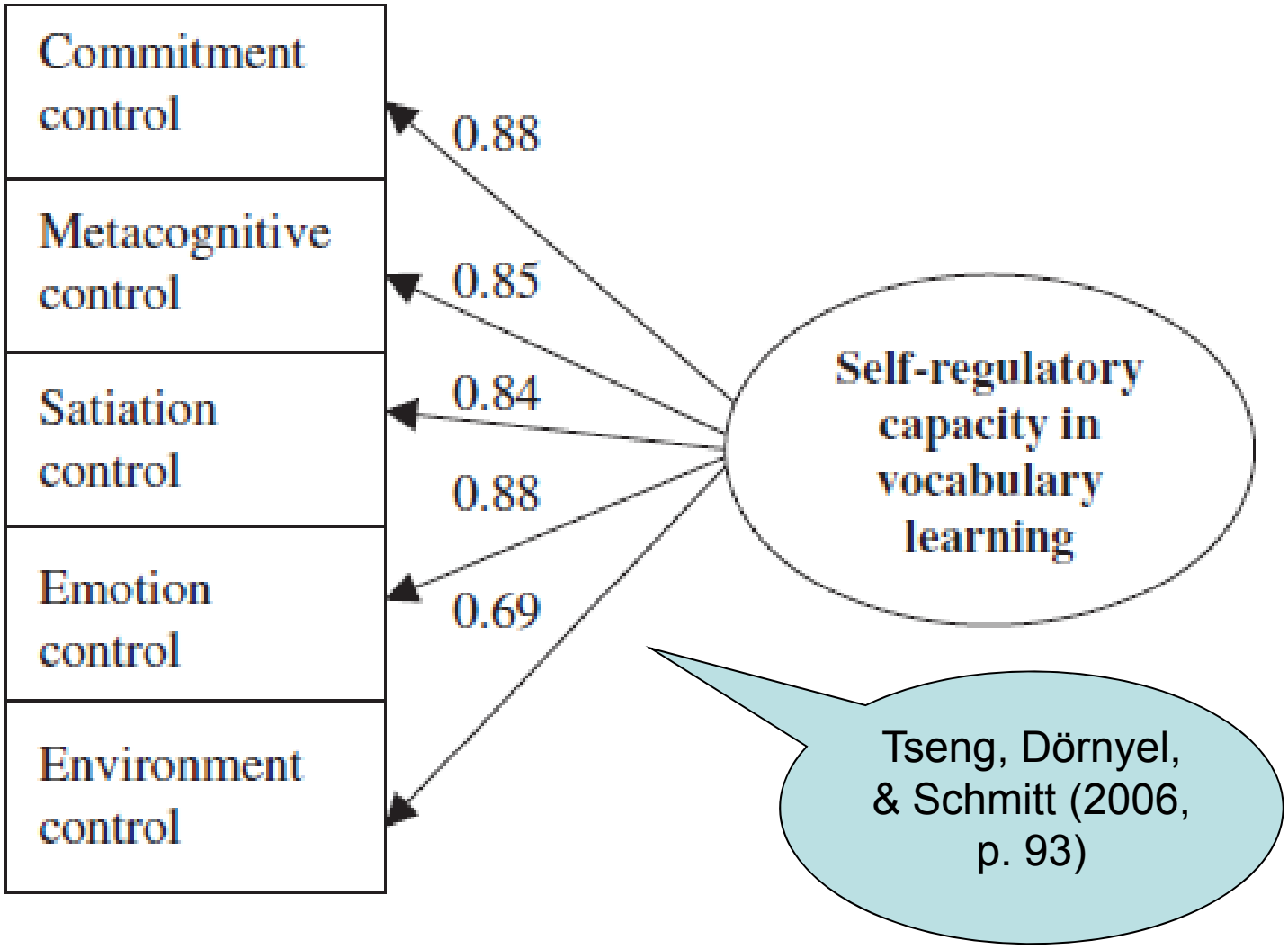
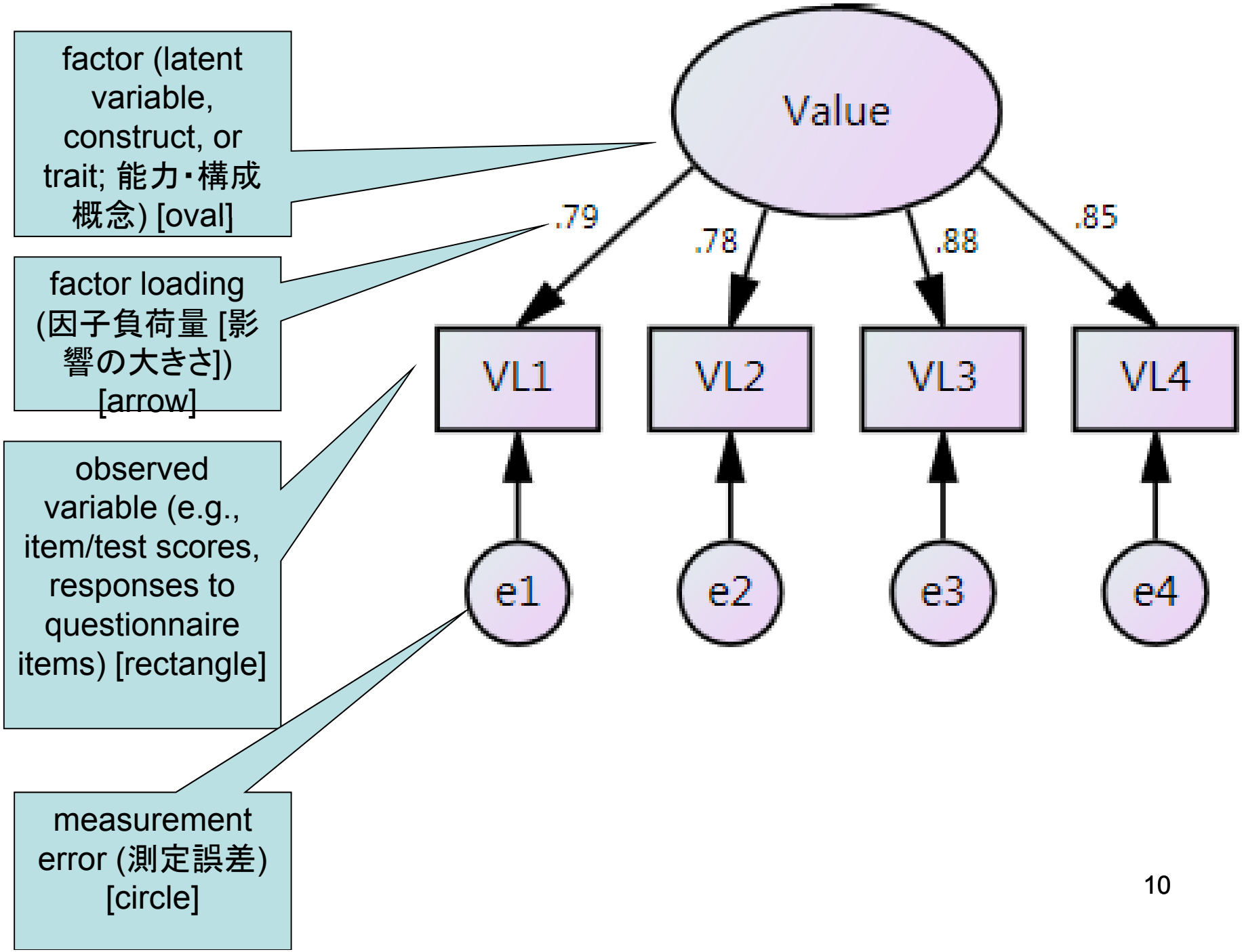


Figure 1: Confirmatory factor analysis of the hypothesized model

- Confirmatory factor analysis (確認的因子分析、検証的因子分析)
  - A statistical technique for examining the relationships between observed measures and unobserved variables (i.e., factors)
  - Test the hypothesis whether a test/questionnaire measures what it claims to measure
    - A confirmatory, hypothesis-testing approach to the data
    - Construct validation of a test/questionnaire
  - Suitable for visually presenting study findings
  - Can be extended to models such as higher-order, multitrait-multimethod (MTMM), and multi-sample models

- Confirmatory factor analysis
  - Particularly widely used in language testing
    - Over 20 studies in the past 30 years
    - Construct validation of…; Trait structure of…


factor (latent variable, construct, or trait; 能力・構成概念) [oval]
factor loading (因子負荷量 [影響の大きさ]) [arrow]
observed variable (e.g., item/test scores, responses to questionnaire items) [rectangle]
measurement error (測定誤差) [circle]
Value
.79
.78
.88
.85
VL1
VL2
VL3
VL4
e1
e2
e3
e4

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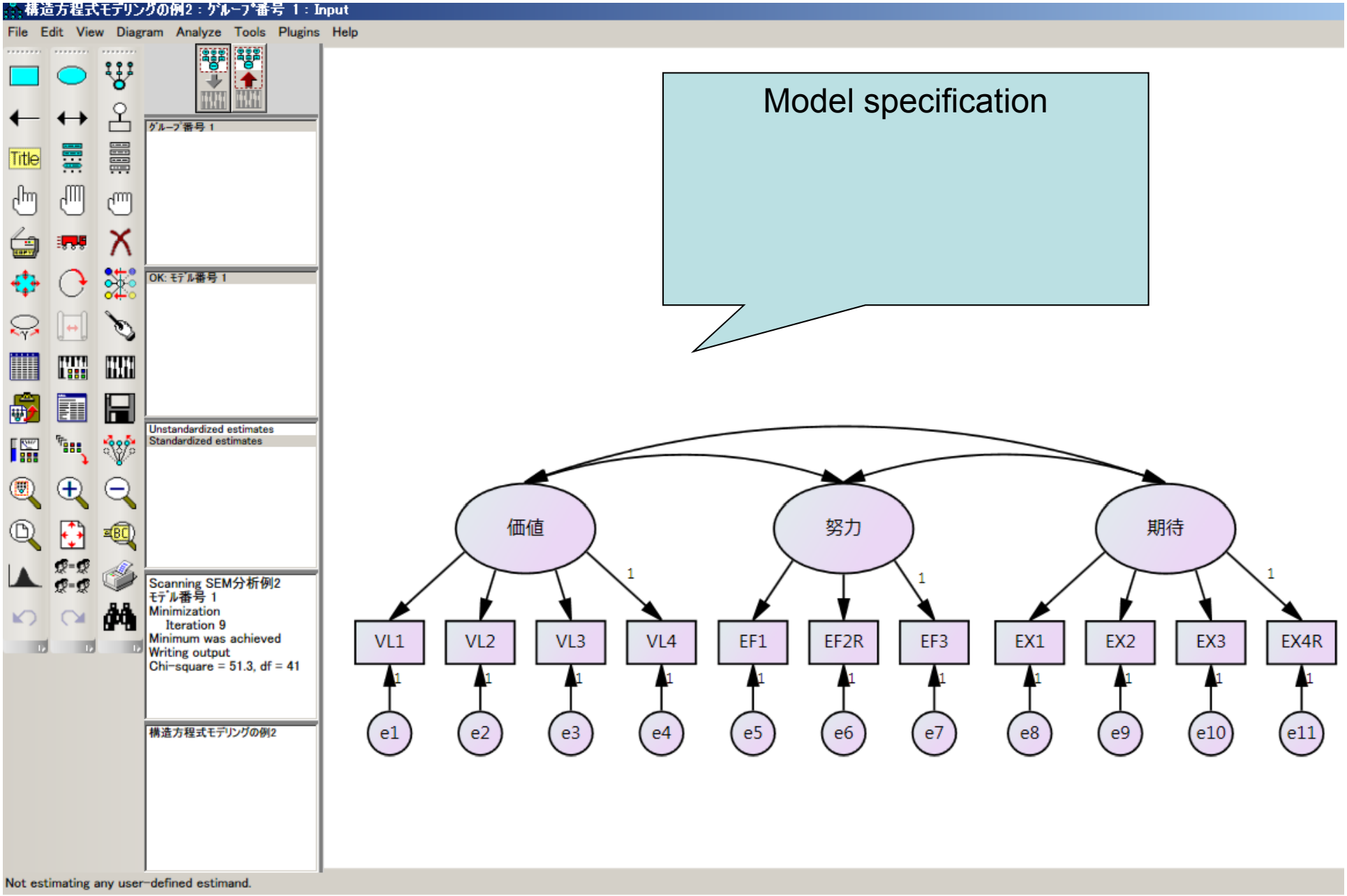
CFA demo

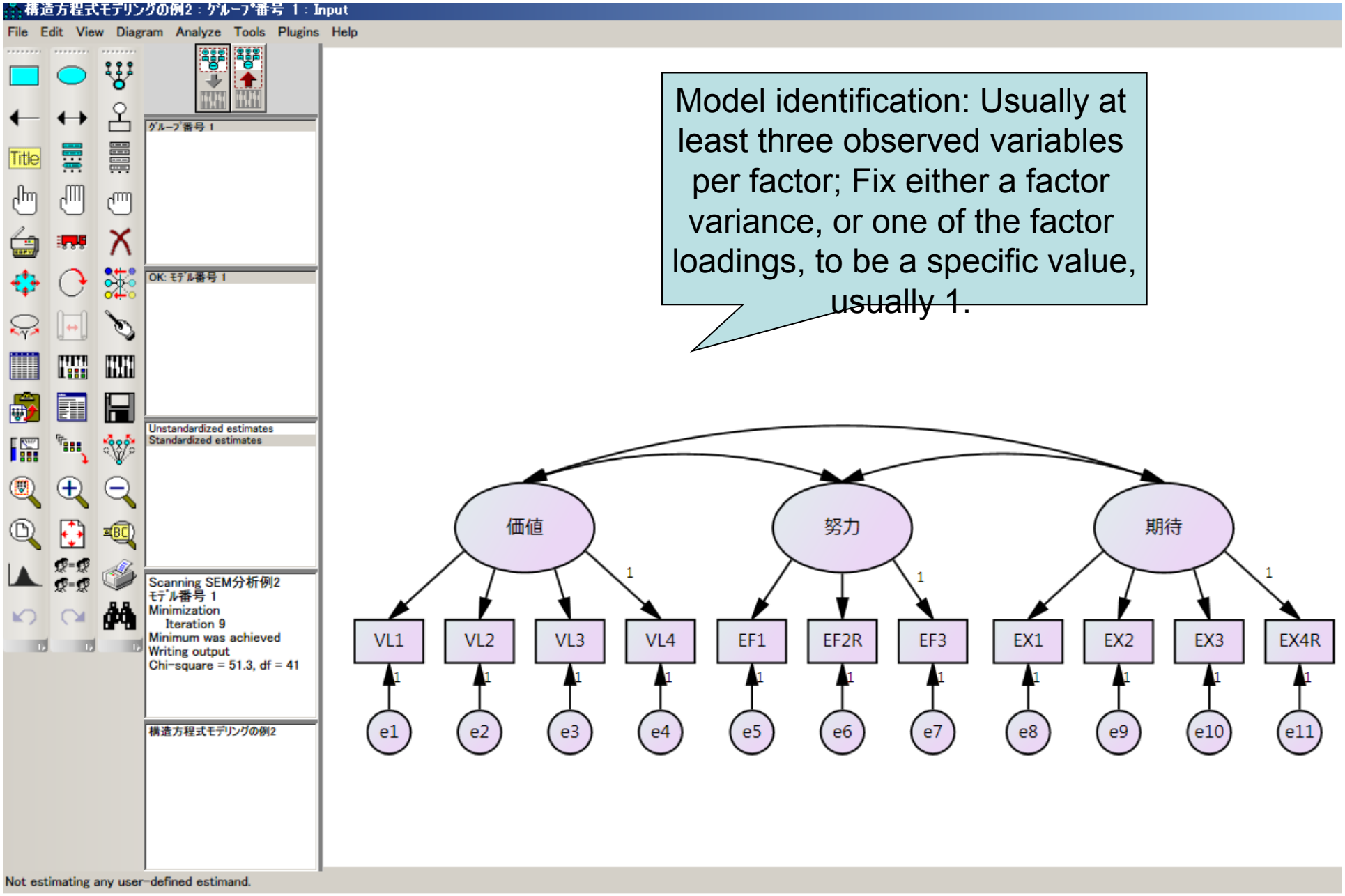
- Five steps (e.g., Bollen & Long, 1993)
  - (1) model specification
  - (2) model identification
  - (3) parameter estimation
  - (4) model fit
  - (5) model respecification

CFA demo

- A task questionnaire (Konno & Hirai, 2012)
  - Data available at http://www.tokyo-tosho.co.jp/books/ISBN978-4-489-02128-2.html
- Sample size: 248
- 11 variables
  - VL1, VL2, VL3, and VL4 for value
  - EF1, EF2R, and EF3 for effort
  - EX1, EX2, EX3, and EX4R for expectation
  - 1-5 score points available for each variable
- Expected findings
  - There are three latent factors: One each for value, effort, and expectation
  - The three factors are correlated with each other
- Software: Amos (version 20)

- Requirements:
  - Sample size: 200+
  - Normality
    - Univariate skewness & kurtosis
    - Multivariate kurtosis
  - Missing data
  - No multicolinearity


構造方程式モデリングの例2 : ｸﾞﾙｰﾌﾟ番号 1 : Input
File Edit View Diagram Analyze Tools Plugins Help
Title
ｸﾞﾙｰﾌﾟ番号 1
OK: ﾓﾃﾞﾙ番号 1
Unstandardized estimates
Standardized estimates
Scanning SEM分析例2
ﾓﾃﾞﾙ番号 1
Minimization
Iteration 9
Minimum was achieved
Writing output
Chi-square = 51.3, df = 41
構造方程式モデリングの例2
Not estimating any user-defined estimand.
Model specification
価値
努力
期待
VL1
VL2
VL3
VL4
EF1
EF2R
EF3
EX1
EX2
EX3
EX4R
e1
e2
e3
e4
e5
e6
e7
e8
e9
e10
e11
1


構造方程式モデリングの例2：ｸﾞﾙｰﾌﾟ番号 1：Input
File Edit View Diagram Analyze Tools Plugins Help
Title
ｸﾞﾙｰﾌﾟ番号 1
OK: ﾓﾃﾞﾙ番号 1
Unstandardized estimates
Standardized estimates
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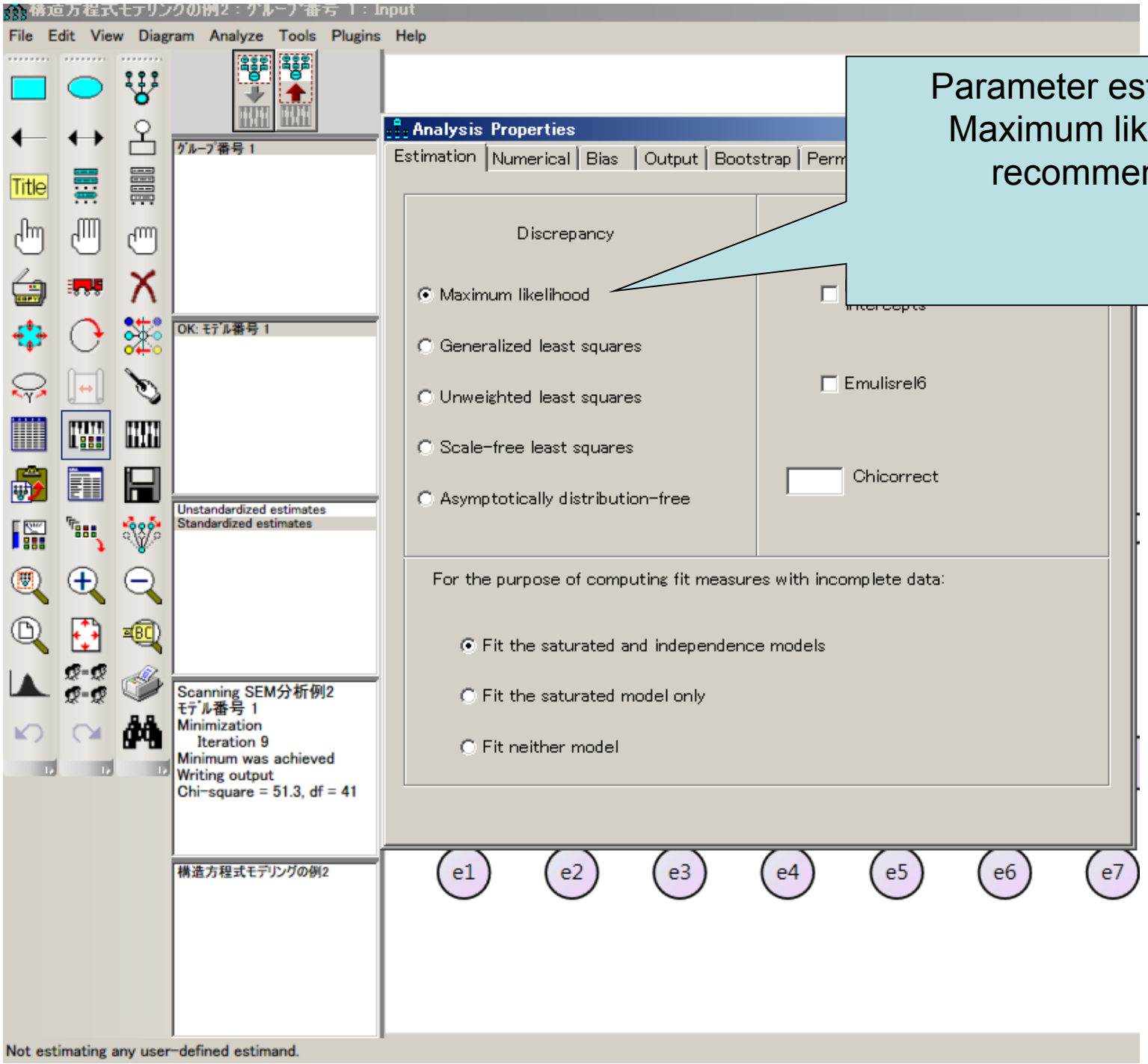
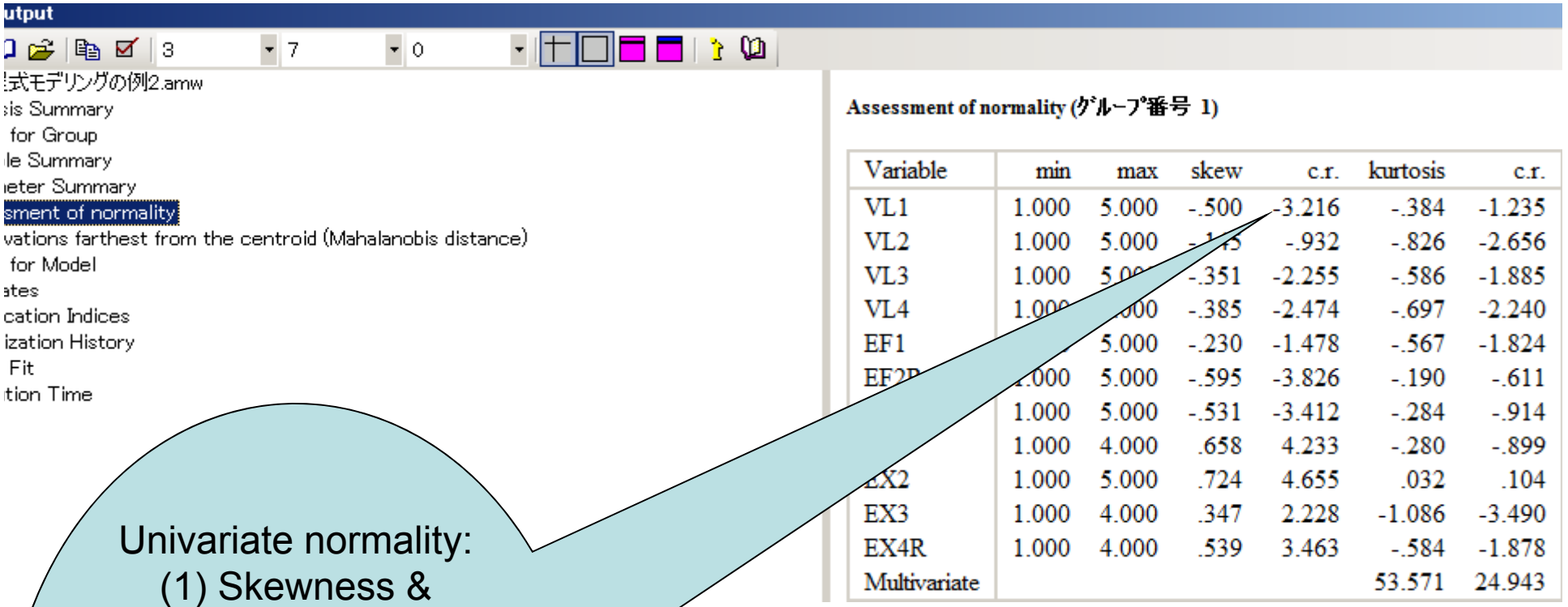
Minimization
Iteration 9
Minimum was achieved
Writing output
Chi-square = 51.3, df = 41
構造方程式モデリングの例2
Not estimating any user-defined estimand.
Model identification: Usually at least three observed variables per factor; Fix either a factor variance, or one of the factor loadings, to be a specific value, usually 1.
価値
努力
期待
VL1
VL2
VL3
VL4
EF1
EF2R
EF3
EX1
EX2
EX3
EX4R
e1
e2
e3
e4
e5
e6
e7
e8
e9
e10
e11



Parameter estimation: Maximum likelihood recommended



Univariate normality: (1) Skewness & kurtosisis, c.r. (critical ratio) =< +-1.96/3.29. (2) When N >=200, check instead if skewness & kurtosis values themselves are near zero &/or draw graphs to ensure normality (Field, 2005, p. 72)。

Multivariate normality: (1) c.r. (critical ratio) =< +-1.96/3.29, (2) c.r. values > 5.00 indicate nonnormal distribution (Bentler, 2005, p. 106; Byrne, 2010, p. 104).

Amos Output

構造方程式モデリングの例2.amw
- Analysis Summary
- Notes for Group
- Variable Summary
- Parameter Summary
- Assessment of normality
- Observations farthest from the centroid (Mahalanobis distance)
- Notes for Model
- Estimates
- Modification Indices
- Minimization History
- Model Fit
- Execution Time

Model fit

グループ番号 1

モデル番号 1

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
モデル番号 1	25	51.301	41	.130	1.251
Saturated model	66	.000	0		
Independence model	11	1586.728	55	.000	28.850

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
モデル番号 1	.040	.965	.943	.599
Saturated model	.000	1.000		
Independence model	.473	.349	.219	.291

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
モデル番号 1	.968	.957	.993	.991	.993
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

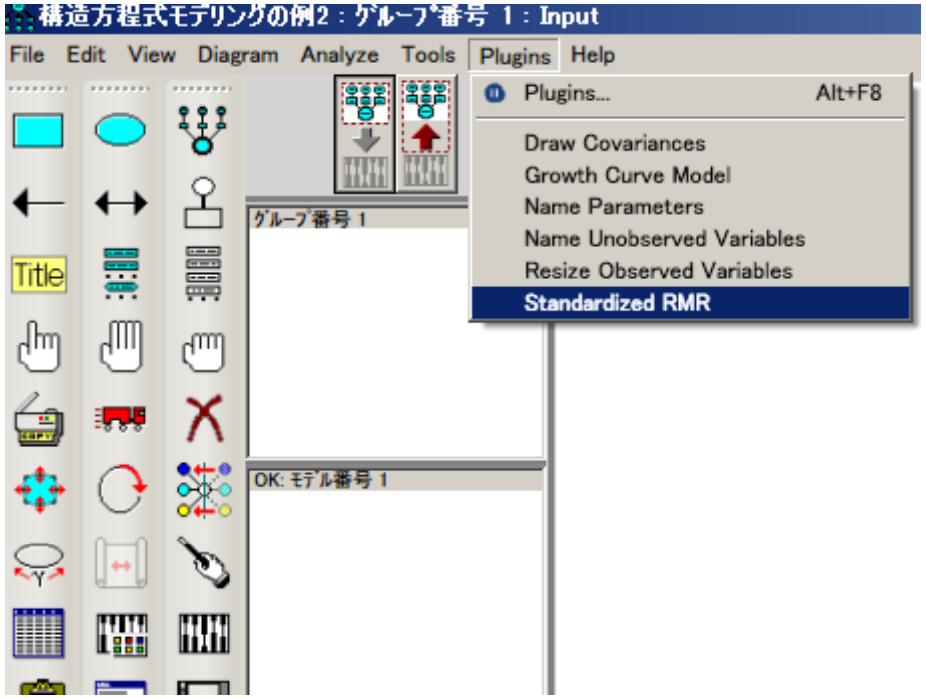
Model	PRATIO	PNFI	PCFI
モデル番号 1	.745	.721	.740
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

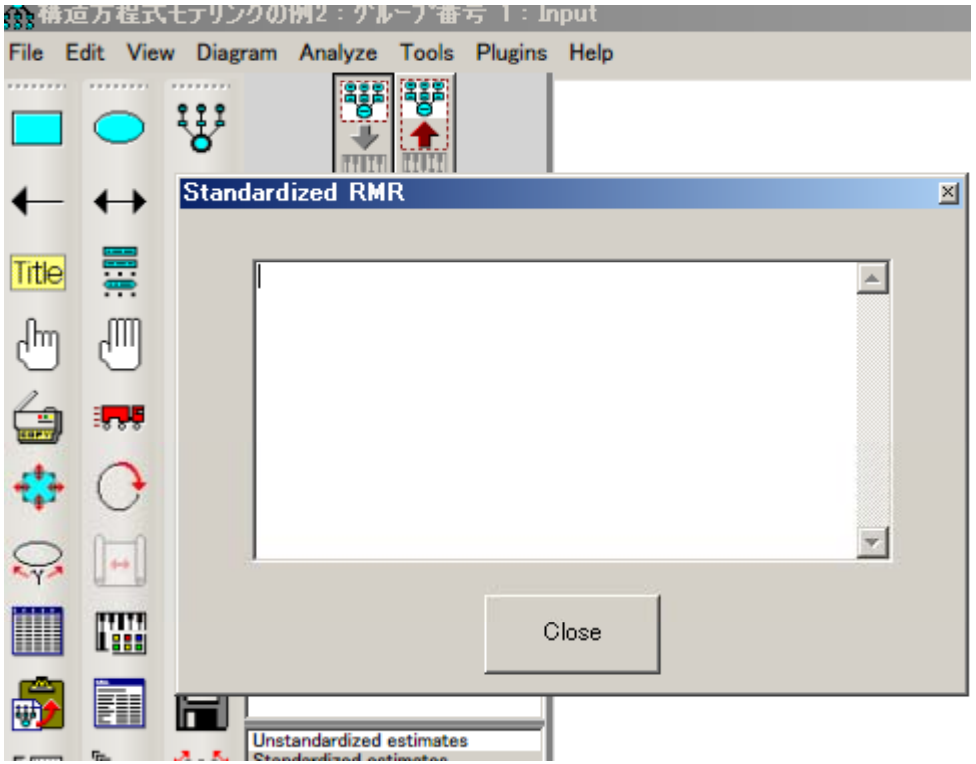
NCP

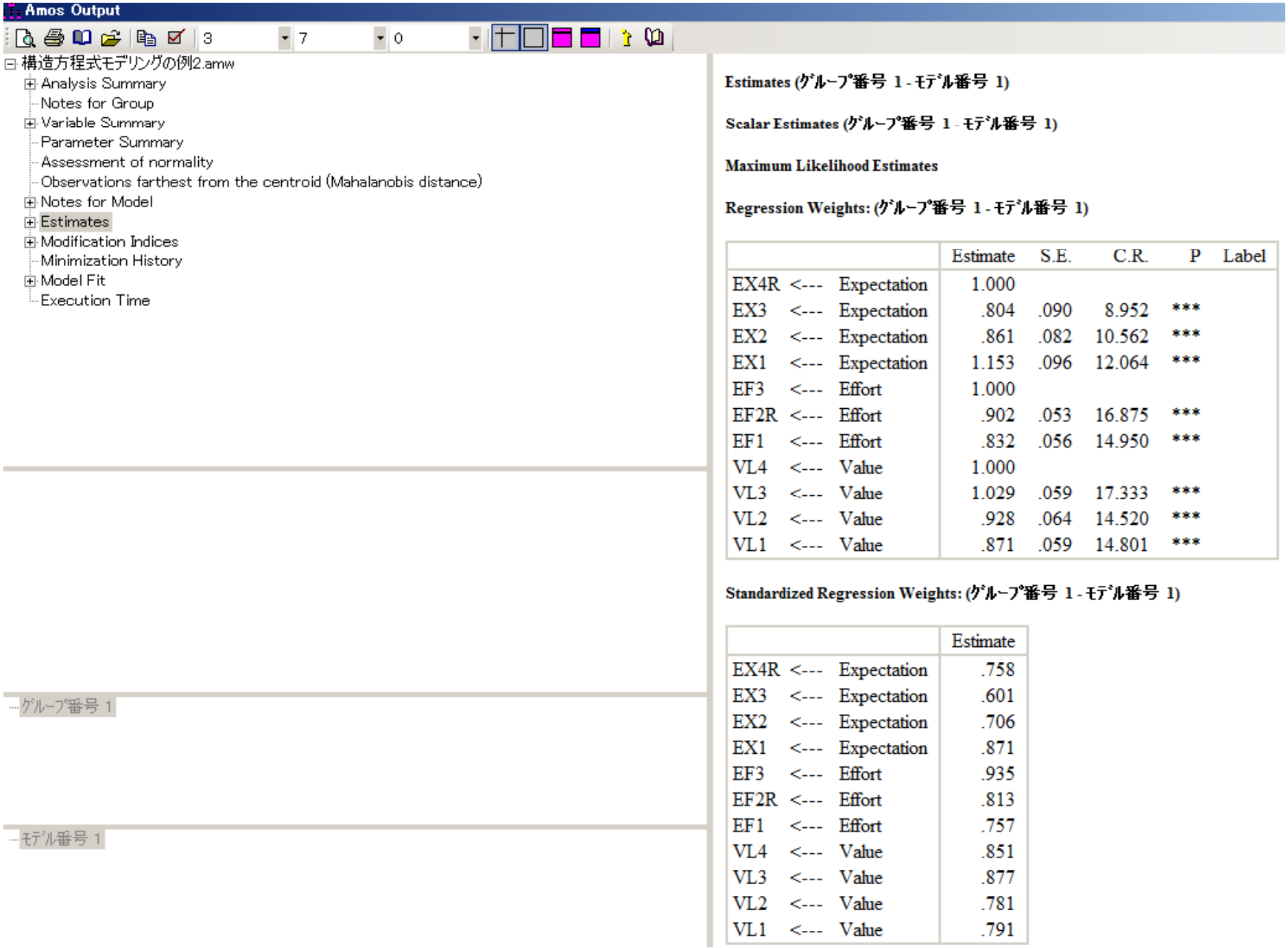
Model	NCP	LO 90	HI 90
モデル番号 1	10.301	.000	32.723

	X2 (CMIN)	Df	p	CFI	TLI	RMSEA (90% CI)	$p_{close-fit\ H0}$	SRMR
Model	51.301	41	.130	.993	0.991	0.032 (0.000, 0.057)	.871	.040
Criteria	The smaller, the better	The bigger, the better	=> 0.05	> .95	Near 1.00	=< 0.05	> .05	=< .08

This tests the null hypothesis that the population RMSEA is no greater than .05.


構造方程式モデリングの例2：グループ番号 1：Input
File Edit View Diagram Analyze Tools Plugins Help
Plugins... Alt+F8
Draw Covariances
Growth Curve Model
Name Parameters
Name Unobserved Variables
Resize Observed Variables
Standardized RMR
グループ番号 1
OK: モデル番号 1
Title


File Edit View Diagram Analyze Tools Plugins Help
Standardized RMR
Close
Title
Unstandardized estimates



Estimates (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

Scalar Estimates (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

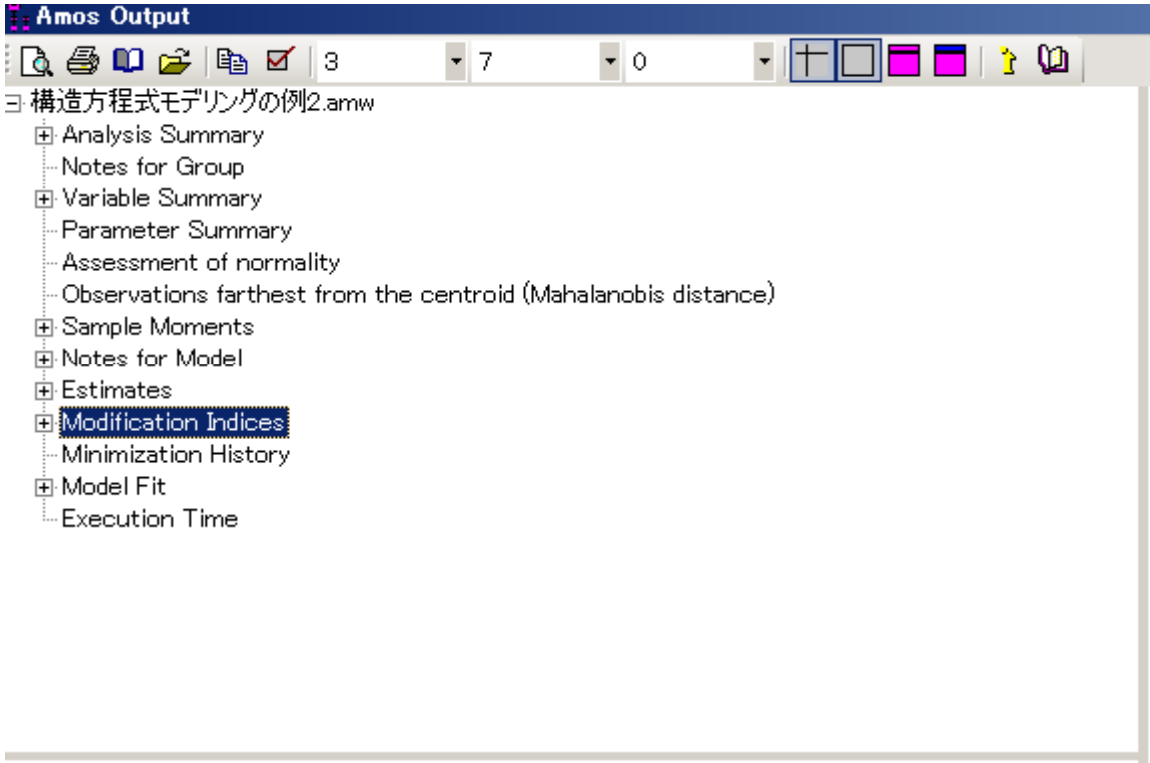
Maximum Likelihood Estimates

Regression Weights: (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

			Estimate	S.E.	C.R.	P	Label
EX4R	<---	Expectation	1.000				
EX3	<---	Expectation	.804	.090	8.952	***	
EX2	<---	Expectation	.861	.082	10.562	***	
EX1	<---	Expectation	1.153	.096	12.064	***	
EF3	<---	Effort	1.000				
EF2R	<---	Effort	.902	.053	16.875	***	
EF1	<---	Effort	.832	.056	14.950	***	
VL4	<---	Value	1.000				
VL3	<---	Value	1.029	.059	17.333	***	
VL2	<---	Value	.928	.064	14.520	***	
VL1	<---	Value	.871	.059	14.801	***	

Standardized Regression Weights: (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

			Estimate
EX4R	<---	Expectation	.758
EX3	<---	Expectation	.601
EX2	<---	Expectation	.706
EX1	<---	Expectation	.871
EF3	<---	Effort	.935
EF2R	<---	Effort	.813
EF1	<---	Effort	.757
VL4	<---	Value	.851
VL3	<---	Value	.877
VL2	<---	Value	.781
VL1	<---	Value	.791



Modification Indices (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

Covariances: (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

			M.I.	Par Change
e2	<-->	Expectation	7.745	.097
e4	<-->	Expectation	6.880	-.081
e8	<-->	e4	4.774	-.055

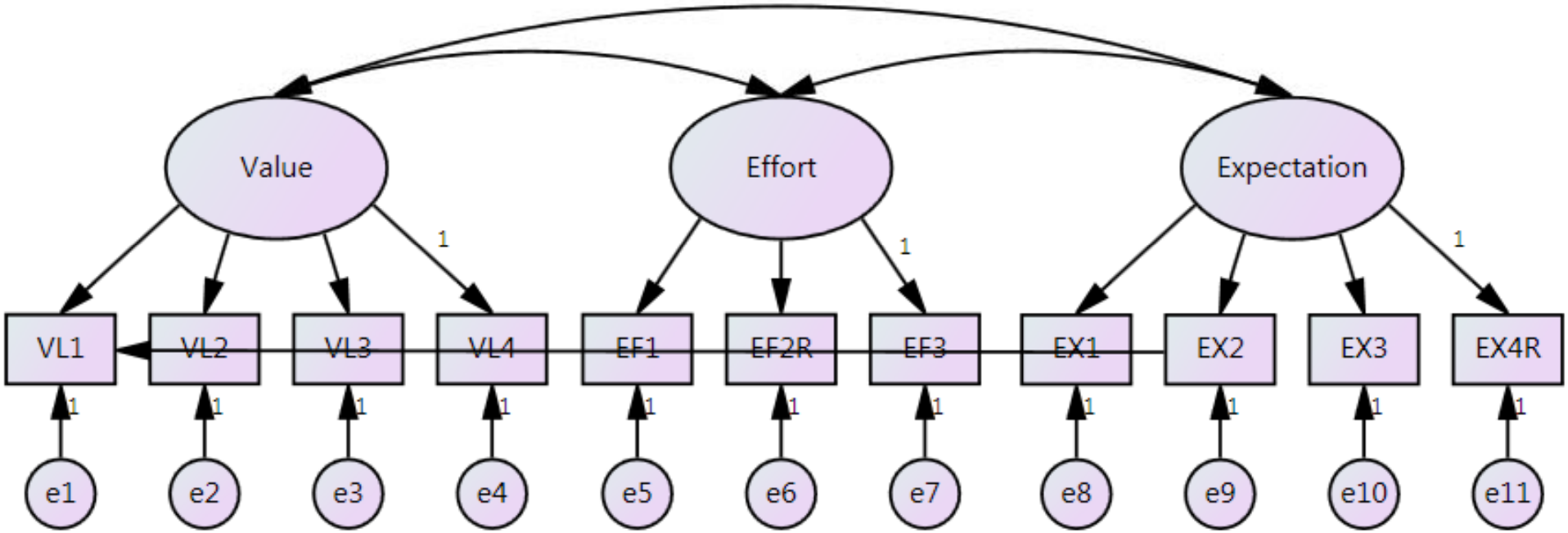
Variances: (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

	M.I.	Par Change

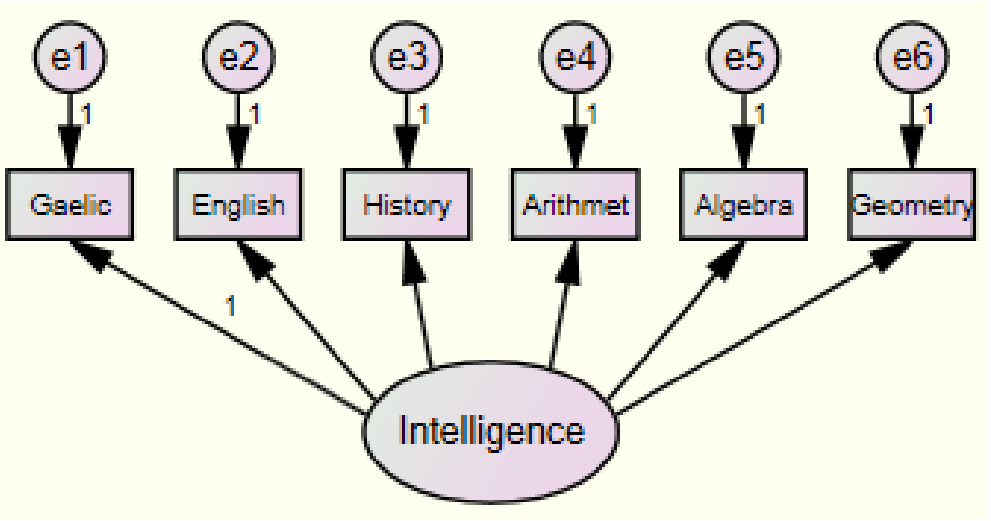
Regression Weights: (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

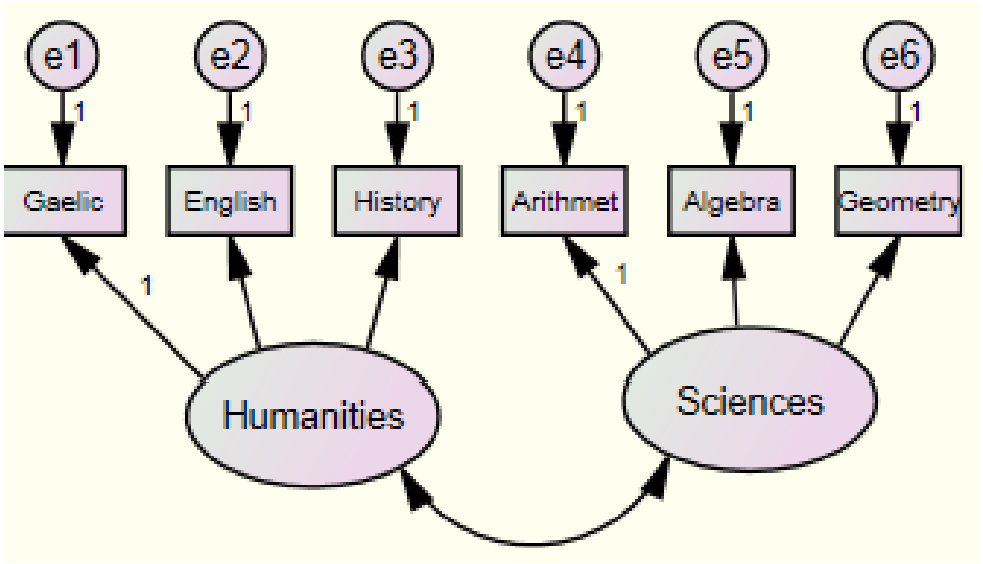
			M.I.	Par Change
VL1	<---	EX2	4.625	-.126
VL2	<---	Expectation	6.914	.222
VL2	<---	EX1	7.550	.162
VL2	<---	EX2	7.137	.171
VL3	<---	EX4R	4.567	.106
VL4	<---	Expectation	7.007	-.196
VL4	<---	EX1	8.627	-.152
VL4	<---	EX4R	5.646	-.123

Model respecification: The path from EX2 to VL1 will decrease the χ2 by 4.625 with the predicted path size of -.126. This change must be theoretically supported.

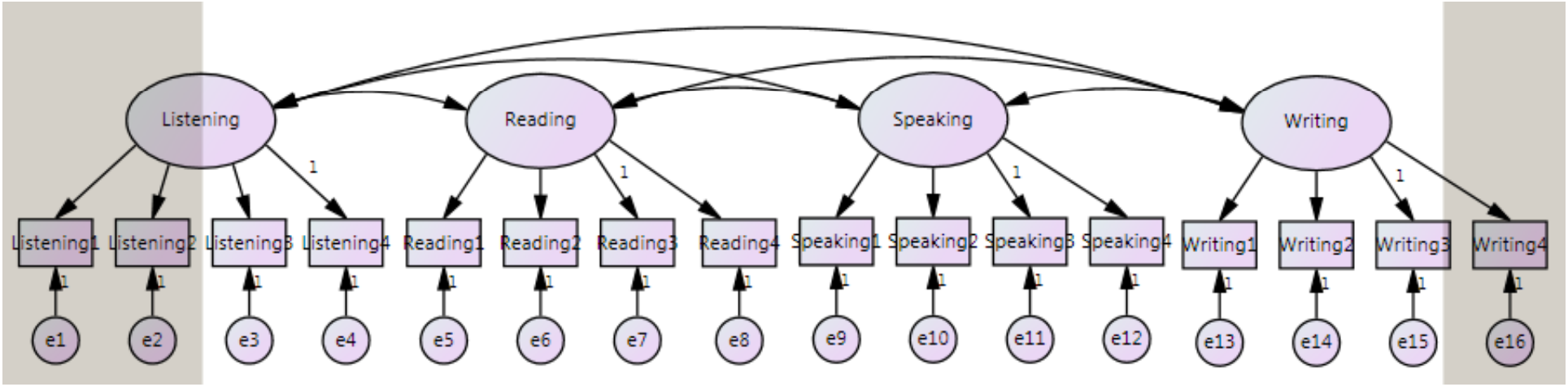

Value
Effort
Expectation
1
1
1
VL1
VL2
VL3
VL4
EF1
EF2R
EF3
EX1
EX2
EX3
EX4R
1
1
1
1
1
1
1
1
1
1
1
e1
e2
e3
e4
e5
e6
e7
e8
e9
e10
e11

- Task
  - LawleyMaxwell.sav
  - Test the two models presented here
  - Interpret the results





- Task
  - Byrne_2006_ch3.sav
    - Variable names changed from the original data
  - Test the model presented here
  - Interpret the results



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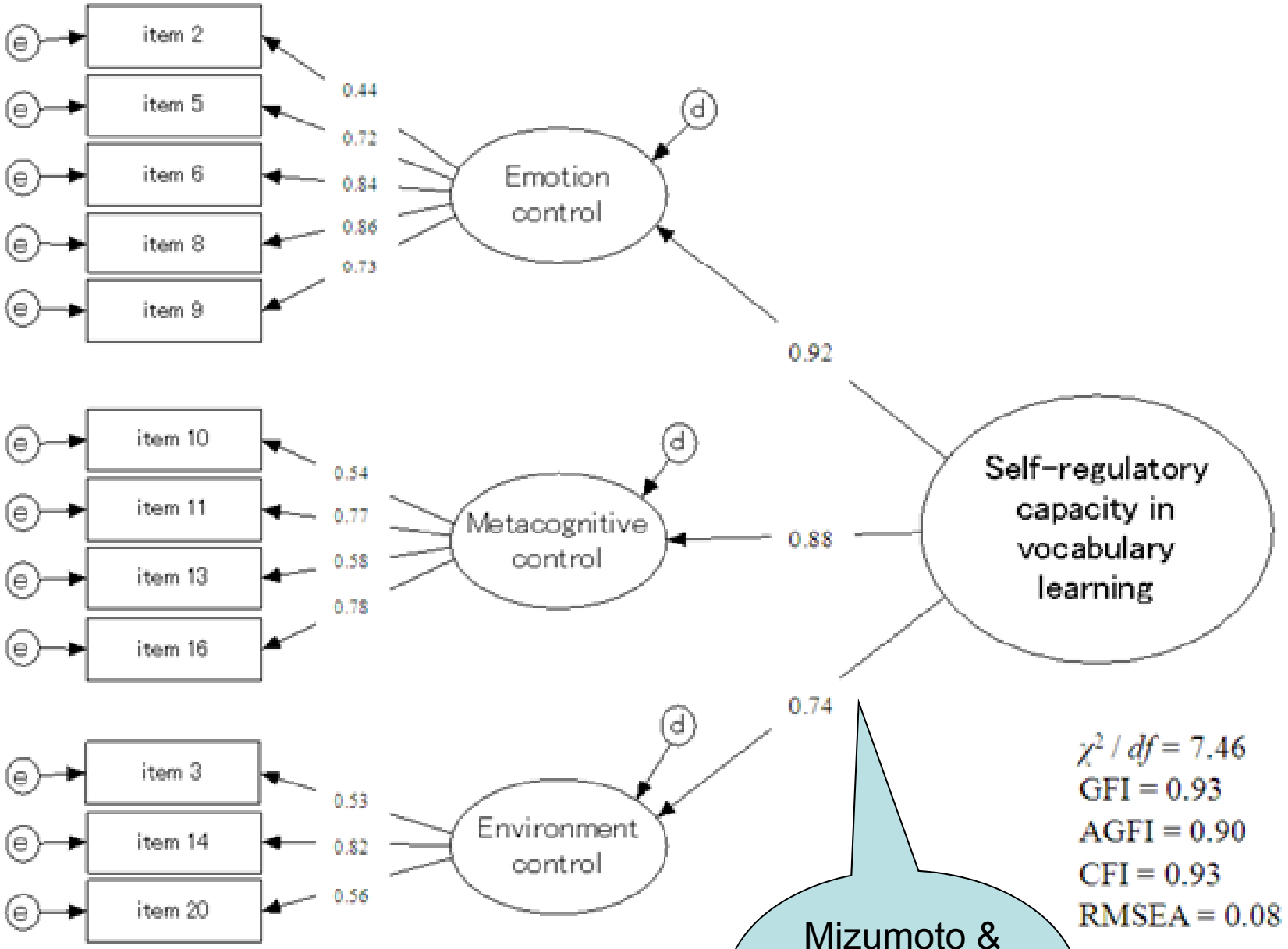

Figure 3: CFA of SRCvoc in the main study.

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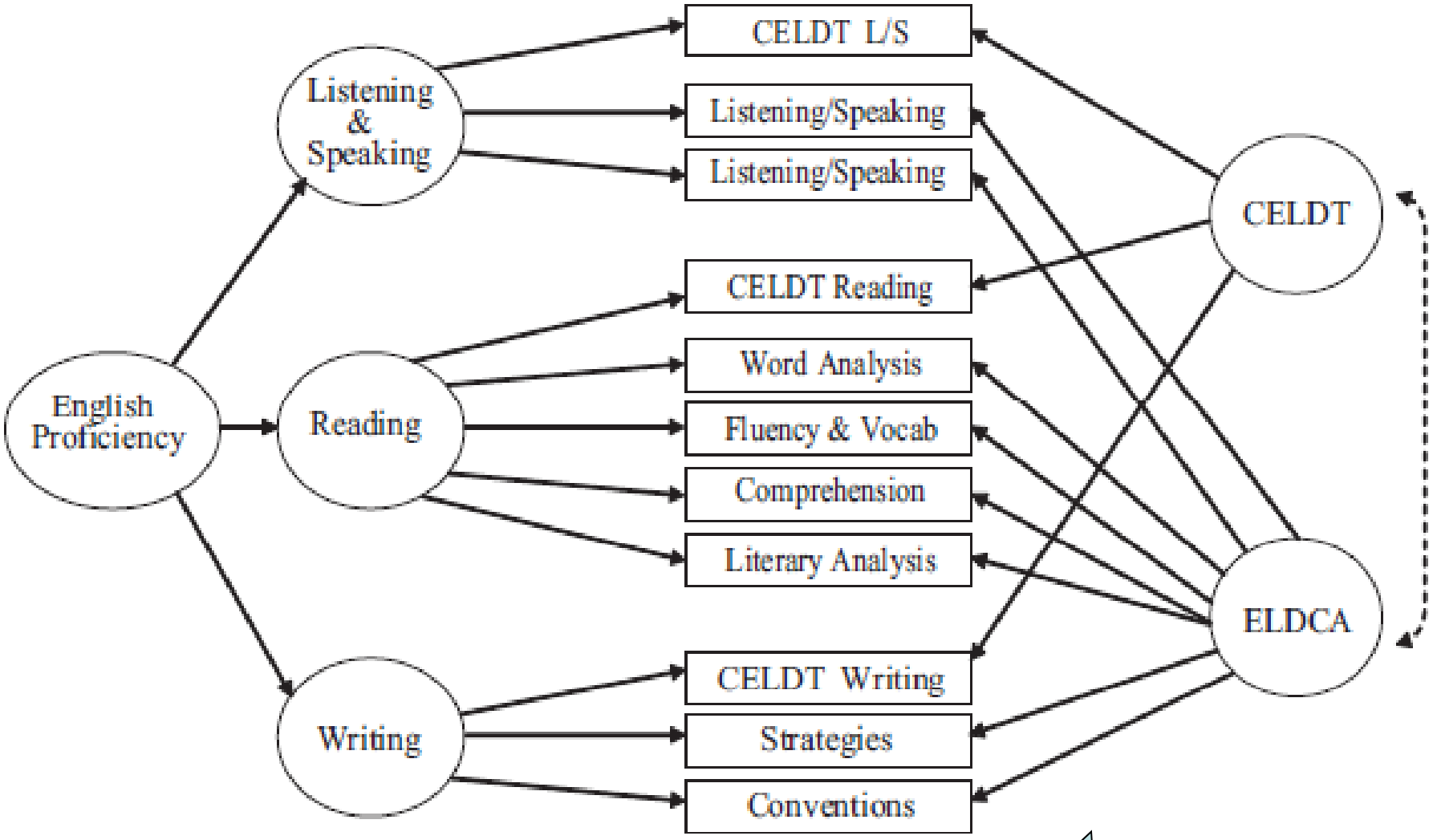


Figure 1 A CFA model of multitrait-multimethod data

Llosa (2007)

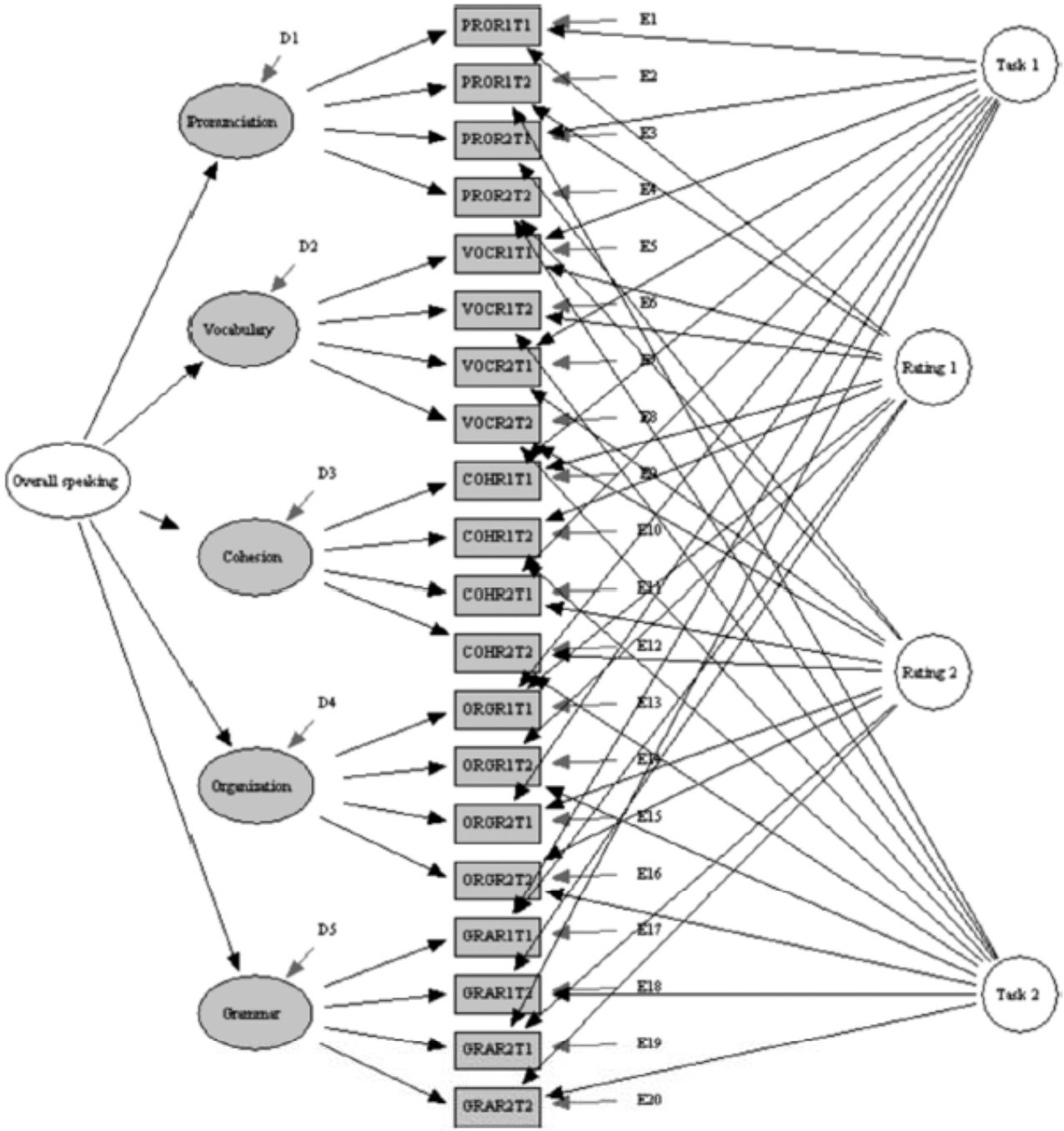


Figure 2 Final CFA model (Higher-order Trait Factor model)

Sawaki (2007)

- Multitrait multimethod (MTMM) design
  - Two or more traits (abilities, constructs) are measured with two or more methods.
  - Used for test validation
    - Model fit
    - Trait factor loadings > method factor loadings
  - Often faces problems
    - No convergence
    - Negative error variance
    - Excessive standard error

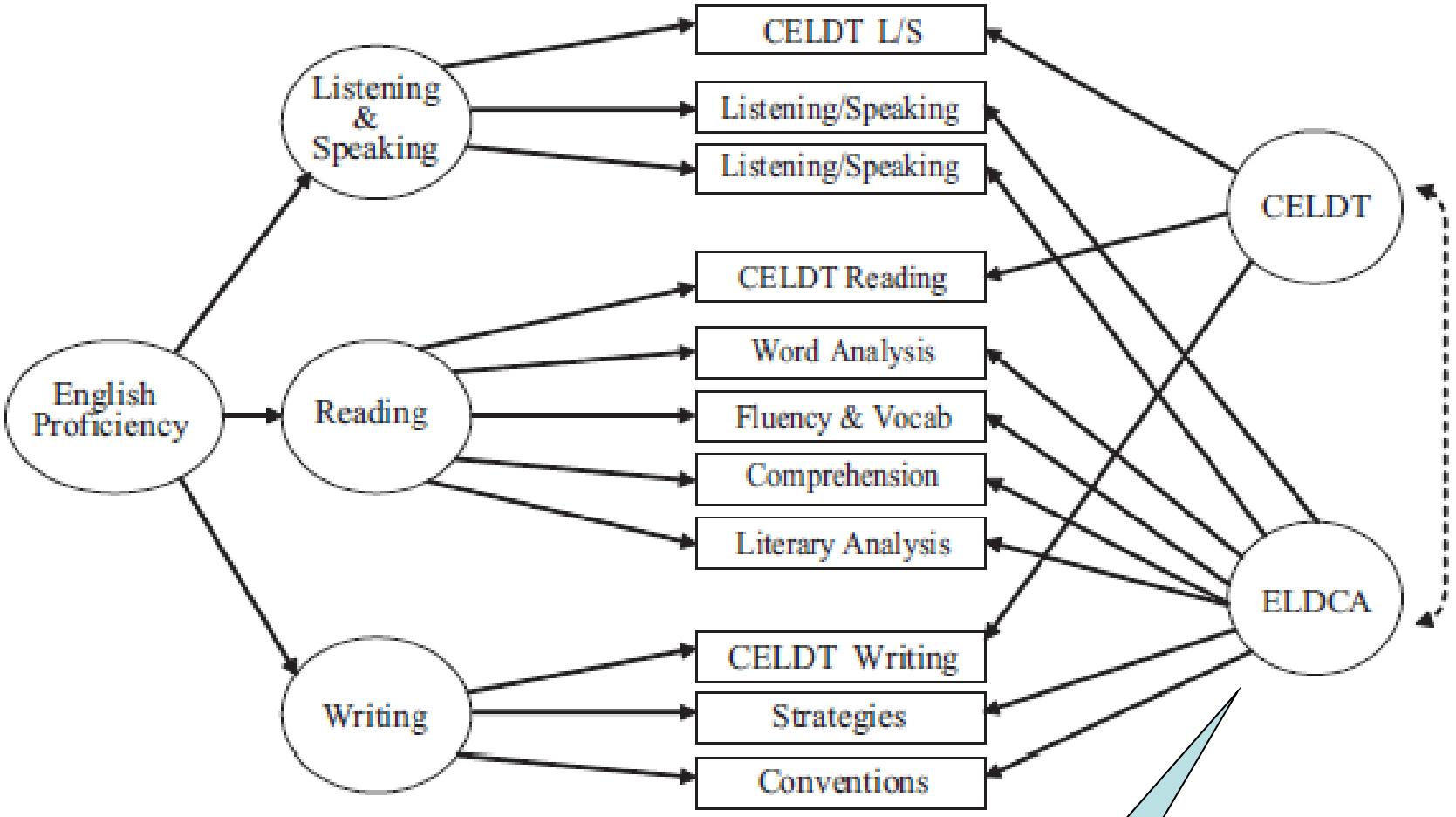


Figure 1 A CFA model of multitrait-multimethod data

3 (4) traits

2 methods

Llosa (2007)

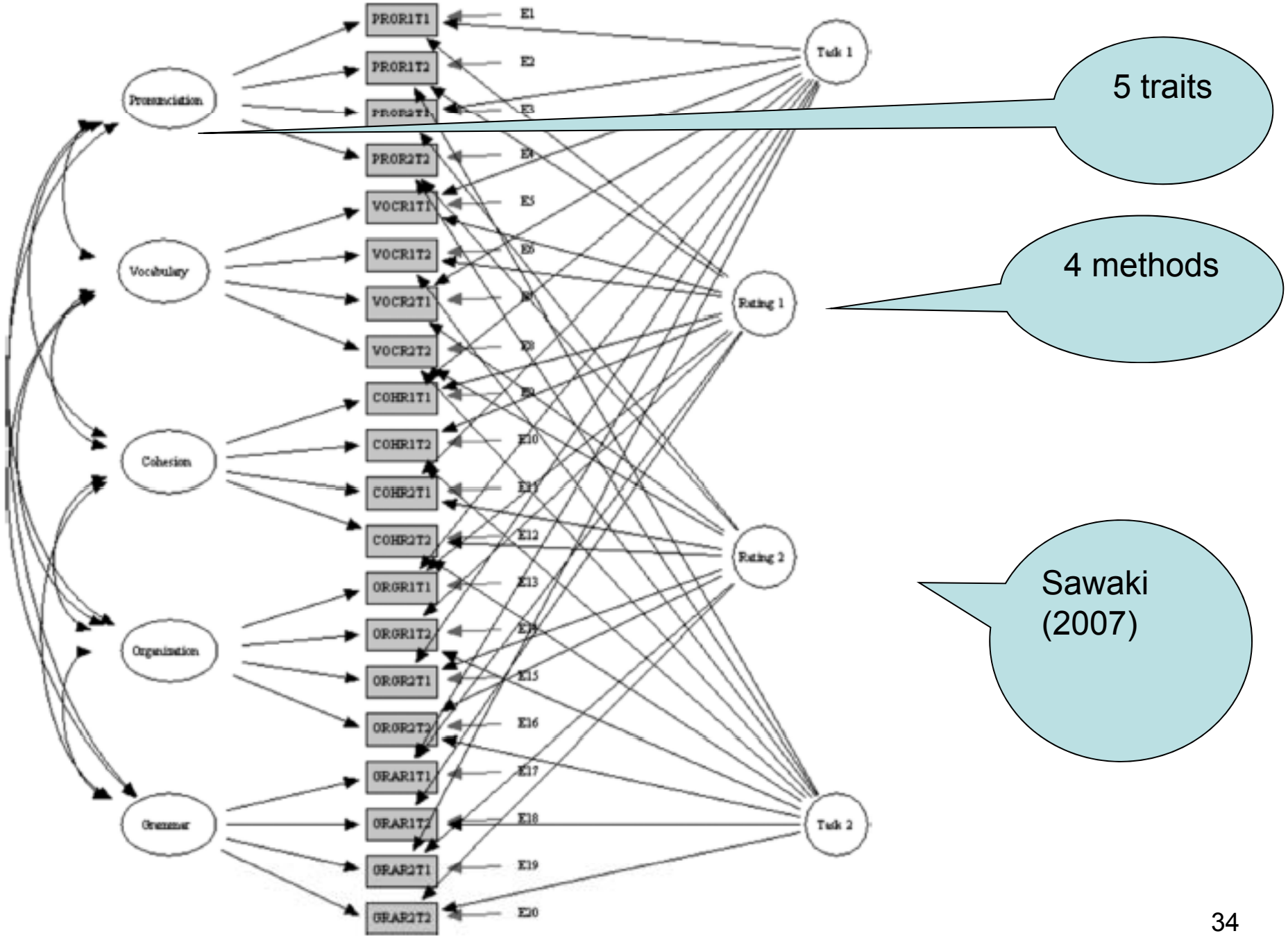
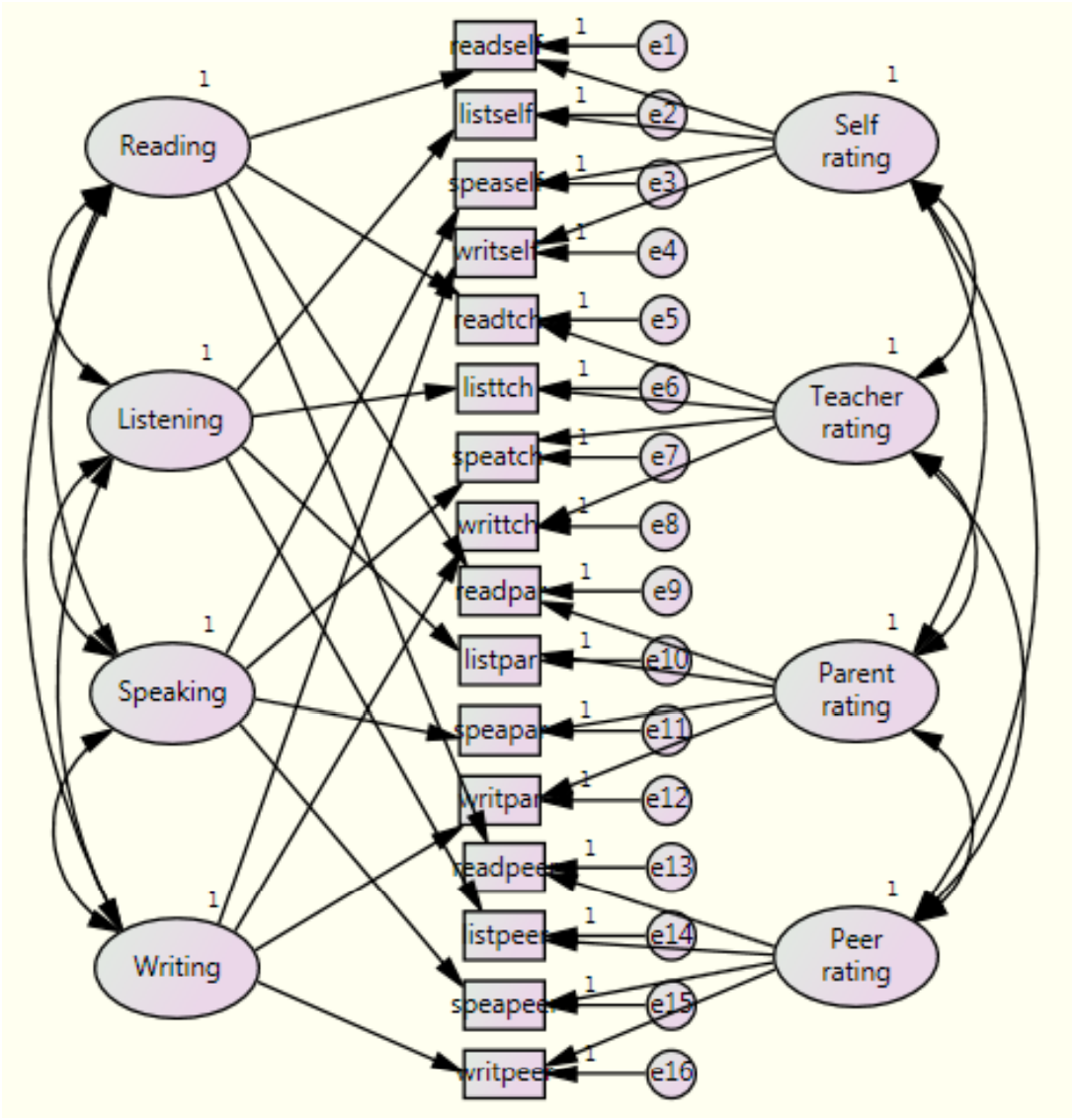


Figure 1 Initial CFA model (Correlated Trait Factor Model)

- Byrne2010_Ch10
- ind7mt_Innami.SAV
  - Label changed from the original dataset



Notes for Model (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

The following variances are negative. (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

	e2
	-.124

The following covariance matrix is not positive definite (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

	Writing	Speaking	Listening	Reading
Writing	1.000			
Speaking	.380	1.000		
Listening	.863	.893	1.000	
Reading	.211	.147	.319	1.000

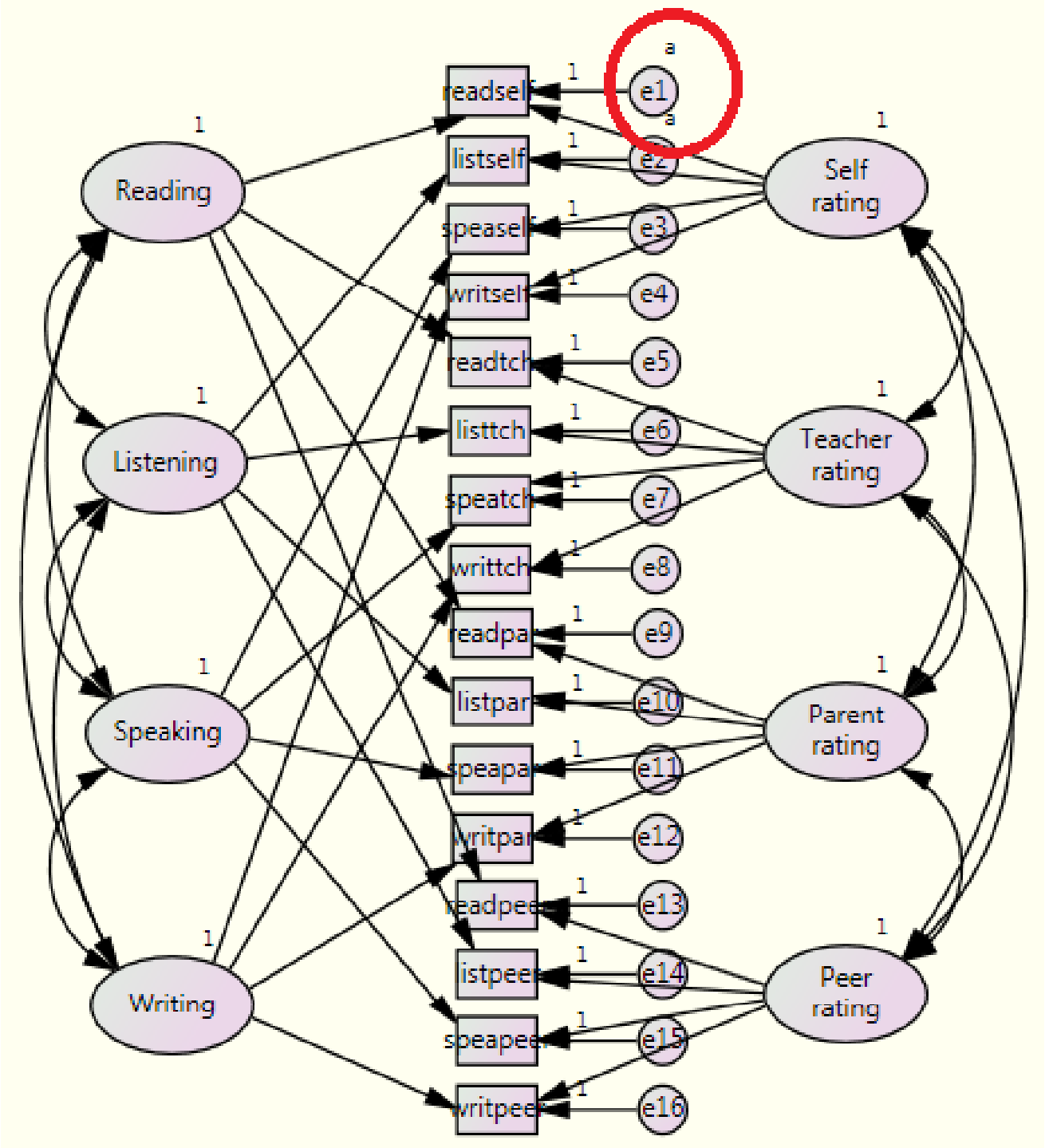
Notes for Group/Model (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

This solution is not admissible.

Variances: (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

	Estimate	S.E.	C.R.	P	Label
Reading	1.000				
Listening	1.000				
Speaking	1.000				
Writing	1.000				
Self_rating	1.000				
Teacher_rating	1.000				
Parent_rating	1.000				
Peer_rating	1.000				
e1	.141	.060	2.327	.020	
e2	-.124	.135	-.916	359	
e3	.099	.043	2.293	.022	
e4	.222	.043	5.099	***	
e5	.352	.039	8.987	***	
e6	.056	.025	2.233	.026	
e7	.198	.031	6.433	***	
e8	.301	.038	7.878	***	
e9	.341	.054	6.329	***	
e10	.140	.026	5.411	***	
e11	.189	.038	4.937	***	
e12	.164	.042	3.921	***	
e13	.911	.100	9.143	***	
e14	.103	.057	1.793	.073	
e15	.542	.064	8.412	***	
e16	.436	.057	7.717	***	

Constrain e2 to e1. (Or fix e2 to 0 or 0.1, 0.2, 0.3 if it is nonsignificant. Fixing to 0 may be inadequate as this suggests no measurement error. Try several near-zero values to test for stability of a model.)


Reading
Listening
Speaking
Writing
Self rating
Teacher rating
Parent rating
Peer rating
readself
listself
speasel
writself
readtch
listtch
speatch
writtch
readpa
listpar
speapa
writpar
readpee
listpee
speapee
writpee
e1
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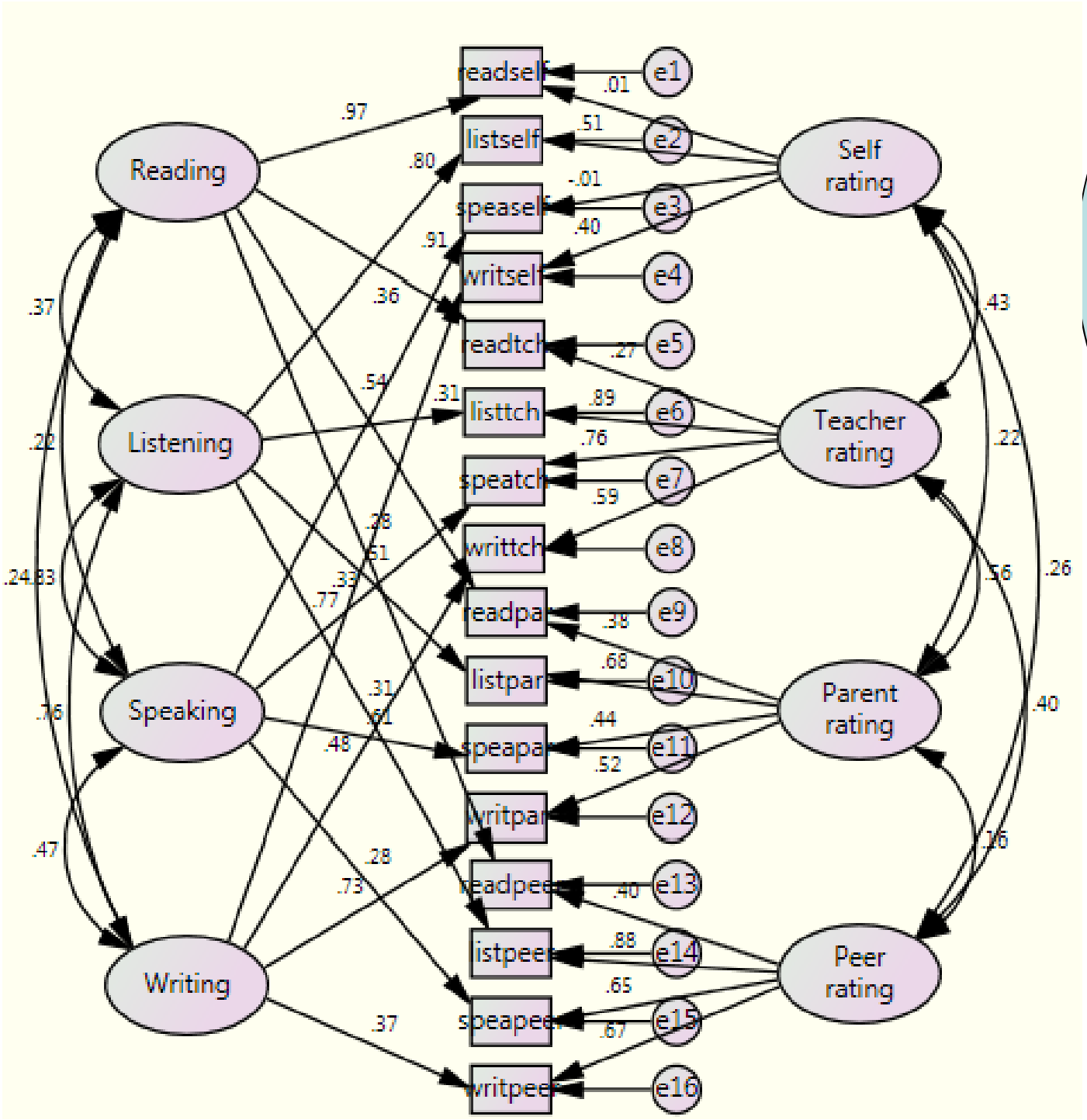
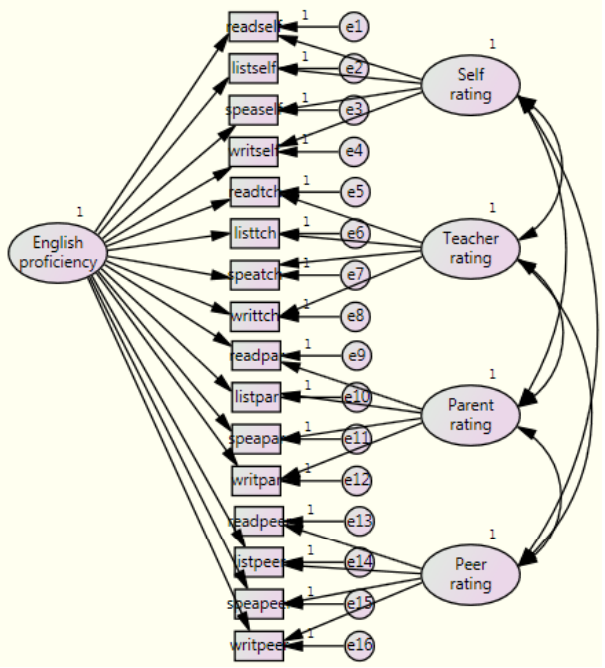
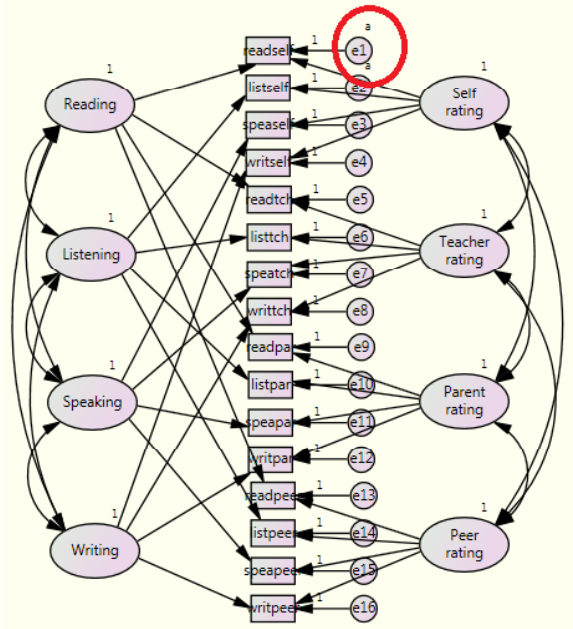
e13
e14
e15
e16
a
a
1

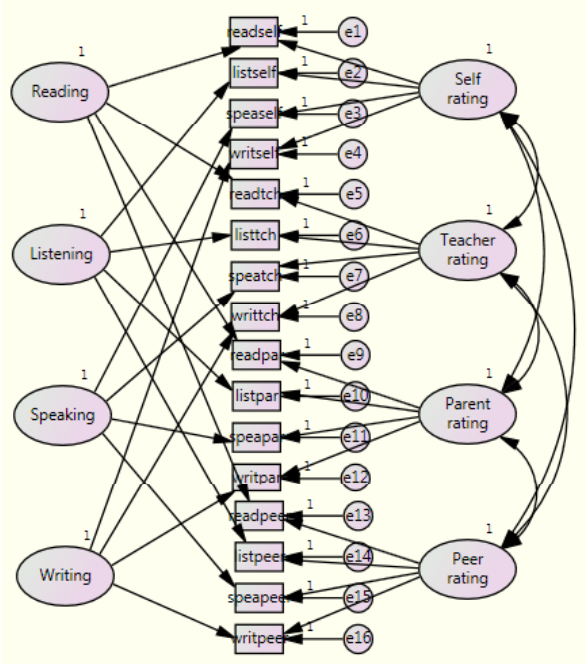


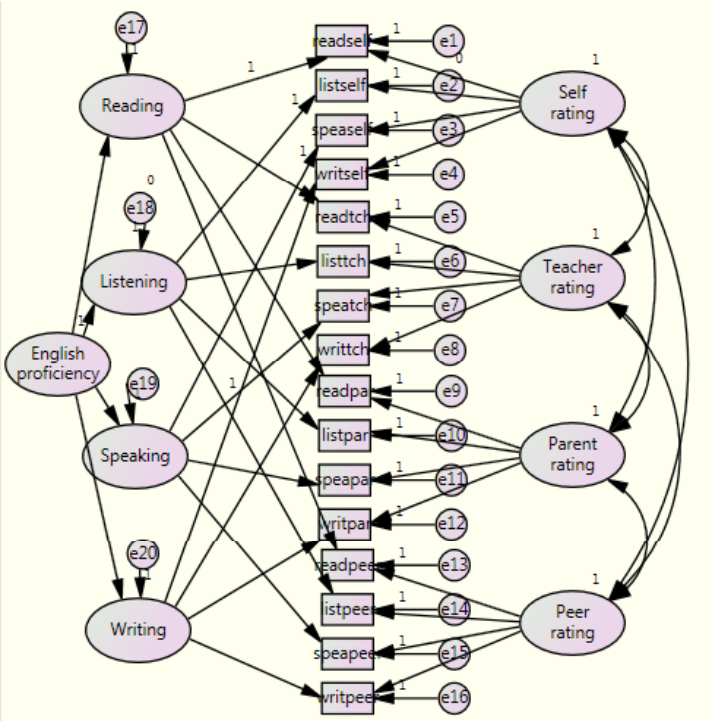
X2 = 78.721,
df = 77,
p = .424,
CFI = .999,
TLI = .998,
RMSEA = .011
(.000, .043),
$p_{close\text{-}fit\ H0}$
= .987, SRMR
= .0491

- SEM, including MTMM designs, allows for comparison of rival models.
- Test the three models presented here





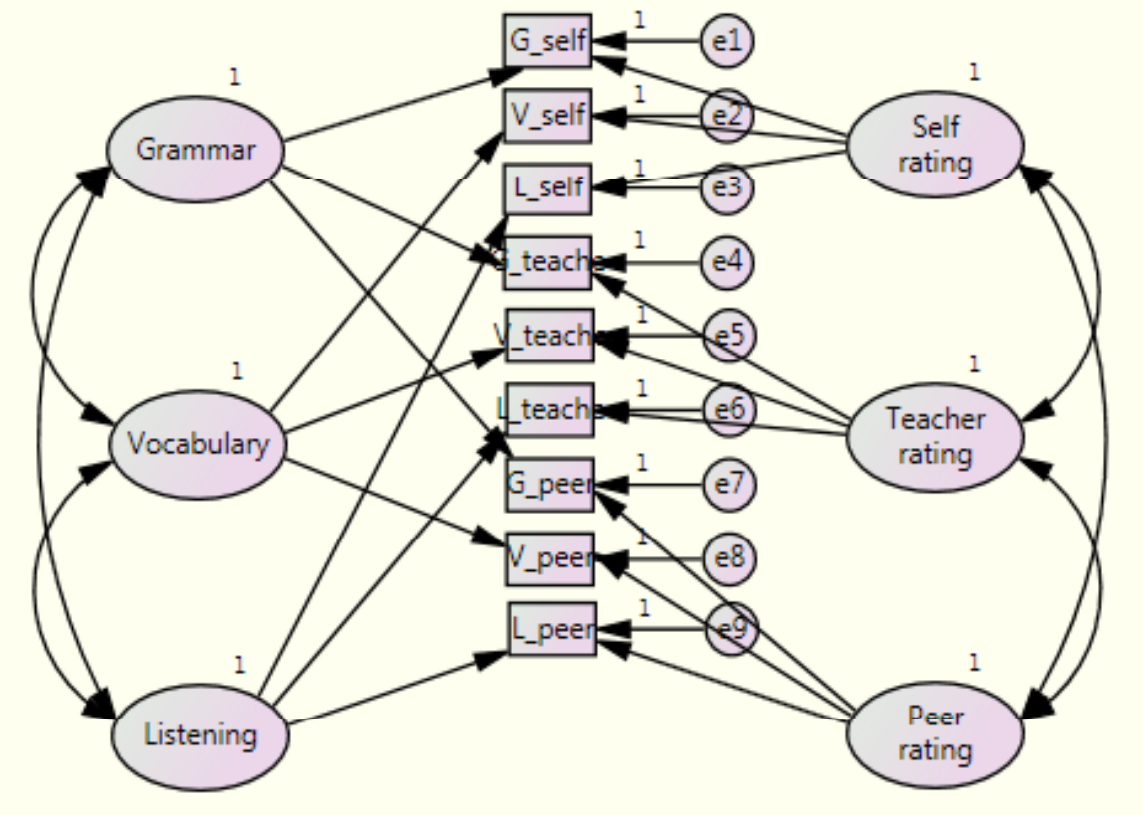




	X2	Df	p	CFI	TLI	RMSEA (90% CI)	$p_{\text{close-fit H0}}$	SRMR
Correlated	78.721	77	.424	.999	0.998	0.011 (0.000, 0.043)	.987	.0491
Uncorrelated	86.042	84	.418	.999	0.998	0.011 (0.000, 0.042)	.990	.0438
Unitary	206.941	83	.000	.910	0.870	0.088 (0.073, 0.103)	.000	.0705
Higher-order	86.859	80	.281	.995	0.993	0.021 (0.000, 0.047)	.972	.0510
Criteria			nonsig	> .95	Near 1.00	=< 0.05	> .05	=< .08

	X2 difference	Df difference	p
Correlated			
Vs. Uncorrelated	7.321 (78.721-86.042)	7 (77-84)	Nonsig (< 14.067)
Vs. Unitary	128.22 (78.721-206.941)	6 (77-83)	Sig (> 12.592)
Vs. Higher-order	8.138 (78.721-86.859)	3 (77-8	Nonsig (< 7.815)

Chi-square difference tests: Although the Correlated model is theoretically most plausible, it is not statistically more appropriate than the Uncorrelated or Higher-order model.



- Task
  - Brown2006_Ch6
  - Read the data from SPSS and construct the model above
  - “This solution is not admissible.”
    - Identify and rectify the problem.

Variances: (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

	Estimate	S.E.	C.R.	P	Label
Grammar	1.000				
Vocabulary	1.000				
Listening	1.000				
Self_rating	1.000				
Teacher_rating	1.000				
Peer_rating	1.000				
e1	5.657	.470	12.034	***	
e2	3.467	.456	7.609	***	
e3	-1.438	1.134	-1.268	.205	
e4	2.716	.331	8.209	***	
e5	3.940	.383	10.300	***	
e6	-26.697	590.560	-.045	.964	
e7	1.338	.180	7.446	***	
e8	.559	.315	1.776	.076	
e9	-.169	.447	-.378	.706	

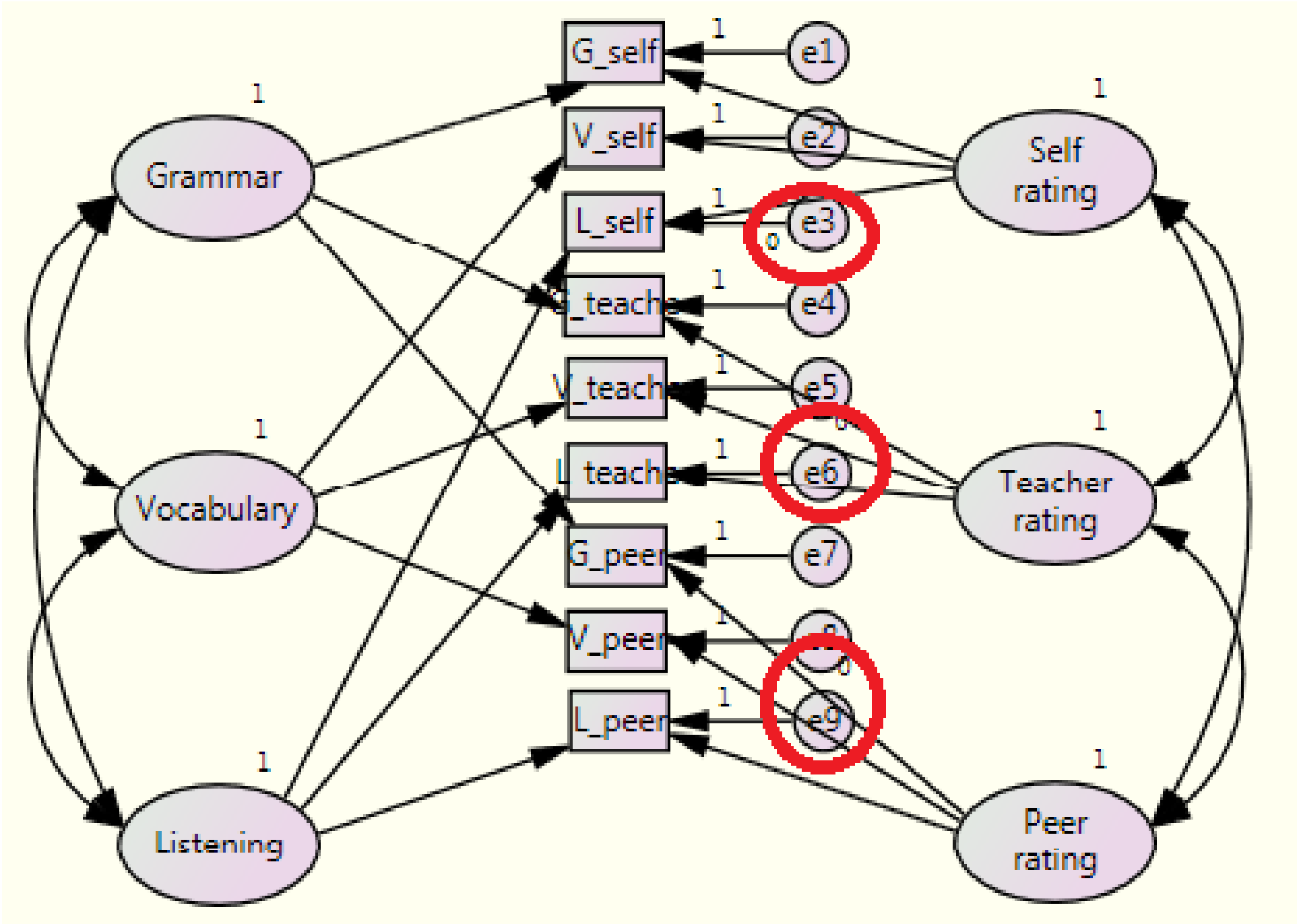
Notes for Model (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

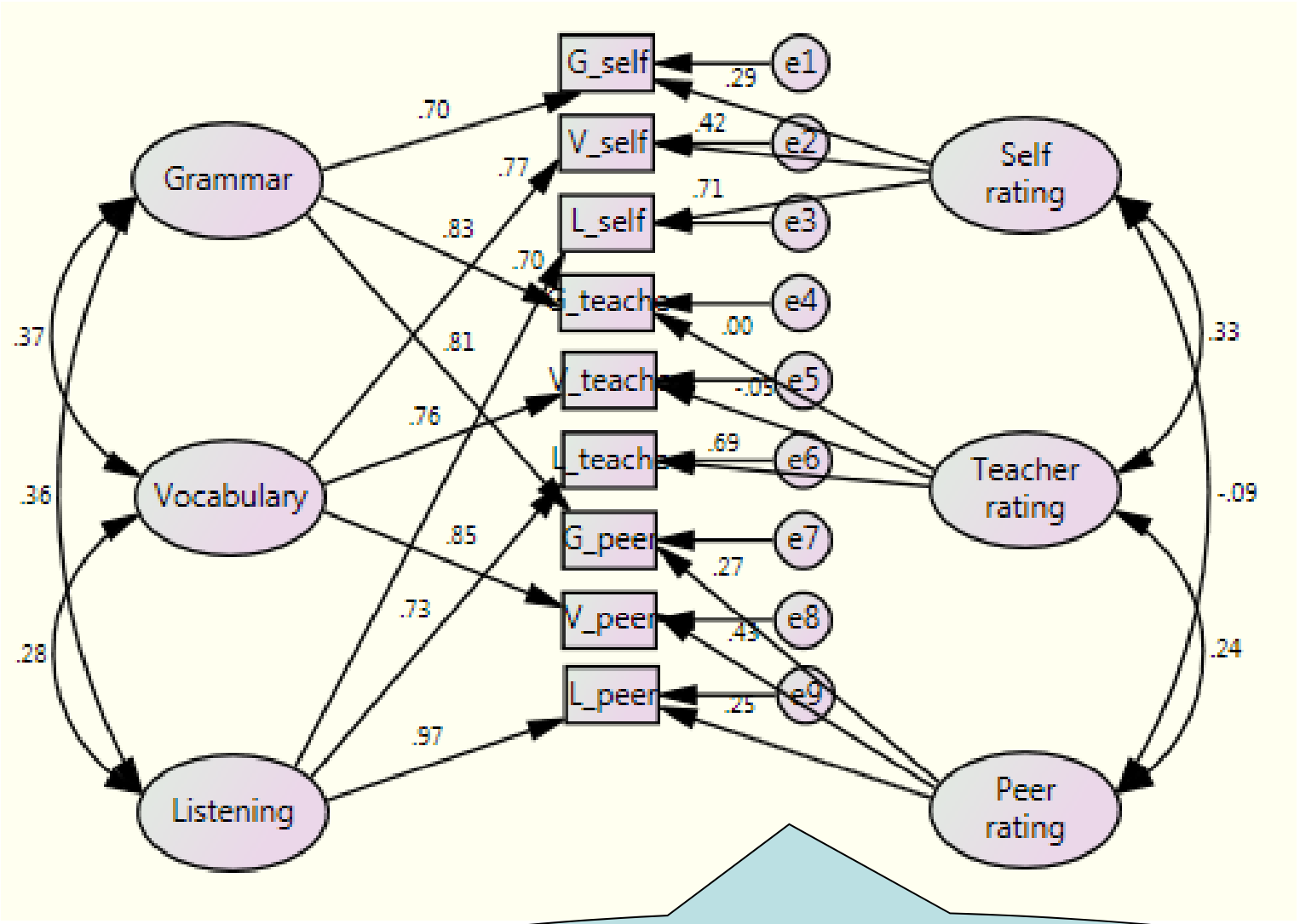
The following variances are negative. (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

	e3	e6	e9
	-1.438	-26.697	-.169

Notes for Group/Model (ｸﾞﾙｰﾌﾟ番号 1 - ﾓﾃﾞﾙ番号 1)

This solution is not admissible.


Grammar
Vocabulary
Listening
G_self
V_self
L_self
G_teache
V_teach
L_teache
G_peer
V_peer
L_peer
e1
e2
e3
e4
e5
e6
e7
e9
Self rating
Teacher rating
Peer rating
1
0



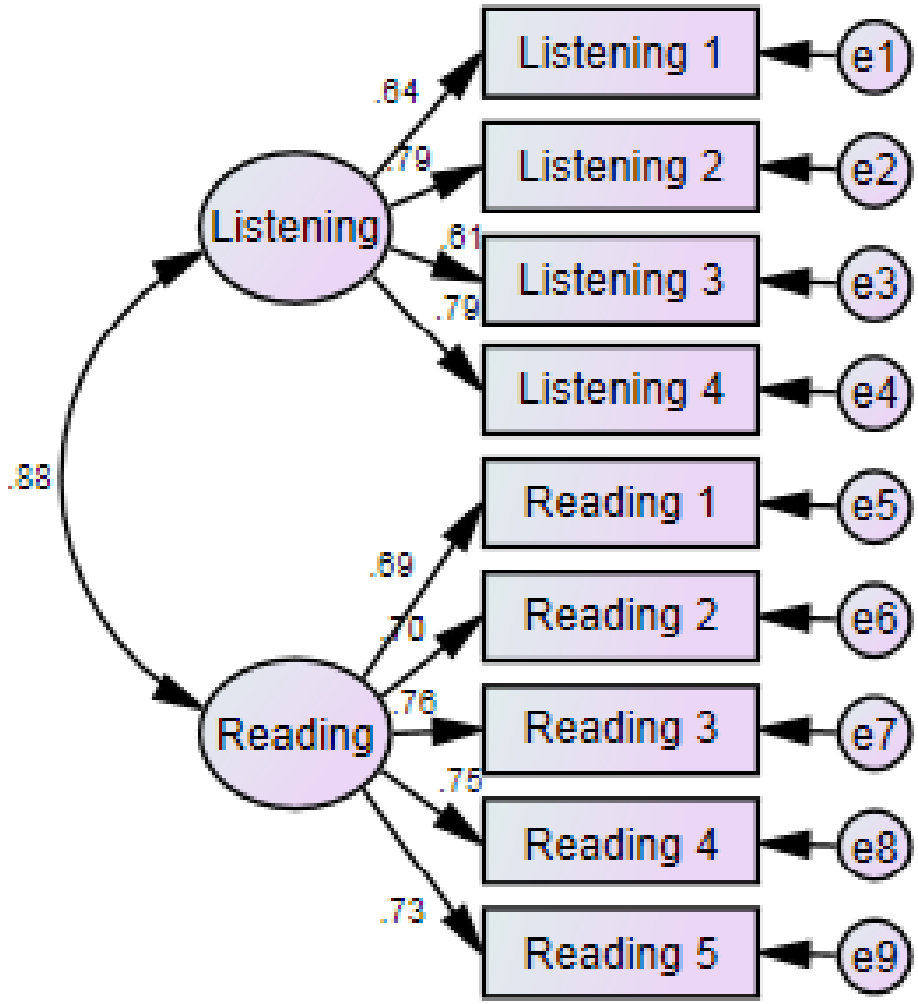
X2 = 13.332, df = 15, p = .577, CFI = 1.000, TLI = 1.002, RMSEA = .000 (.000, .038), $p_{\text{close-fit H0}}$ = .993, SRMR = .0153

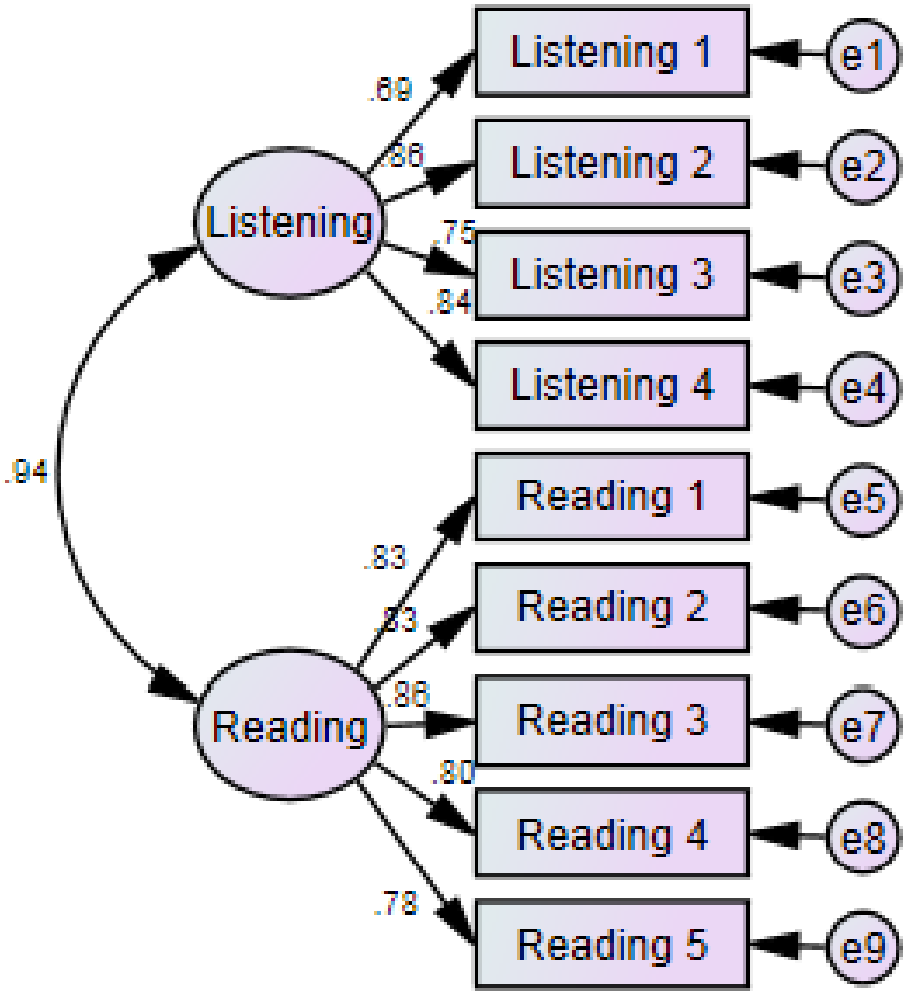
- Task
  - Make a list of test methods. How close are they to each other?
  - How do methods of measurement compromise the validity of measurement of skills such as reading and listening? Are some methods of measurement more likely to reduce construct validity?

Overview

- Confirmatory factor analysis (CFA) basics
- CFA demo
- (Break)
- Applications
  - Higher-order models
  - Multitrait-multimethod (MTMM) models
  - **Multi-sample models**
- Structural equation modeling

- Multi-sample models
  - Examine whether and to what extent measurement instruments (tests and questionnaires) function equally across (the same/different) groups, or, put another way, whether and to what extent the factor structure of a measurement instrument or theoretical construct of interest holds true across groups
    - Across the same groups
      - One group randomly split into two
    - Across different groups
      - High, intermediate, low proficiency learners
      - Tertiary education, secondary education, primary education
      - Indo-European, non-Indo-European
      - Male, female
      - White, African American, Hispanic, Asian American, Native American


Listening
Reading
.88
.64
.79
.61
.79
.69
.70
.76
.75
.73
Listening 1
Listening 2
Listening 3
Listening 4
Reading 1
Reading 2
Reading 3
Reading 4
Reading 5
e1
e2
e3
e4
e5
e6
e7
e8
e9


Listening
Reading
.94
.69
.86
.75
.84
.83
.83
.86
.80
.78
Listening 1
Listening 2
Listening 3
Listening 4
Reading 1
Reading 2
Reading 3
Reading 4
Reading 5
e1
e2
e3
e4
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e6
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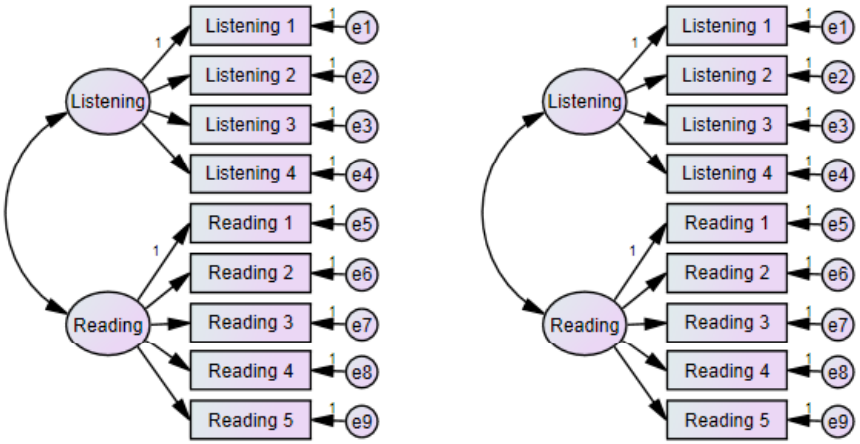
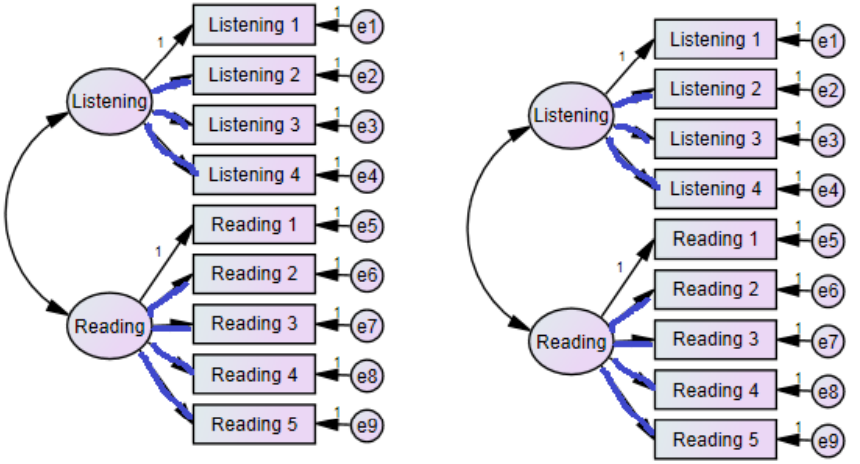
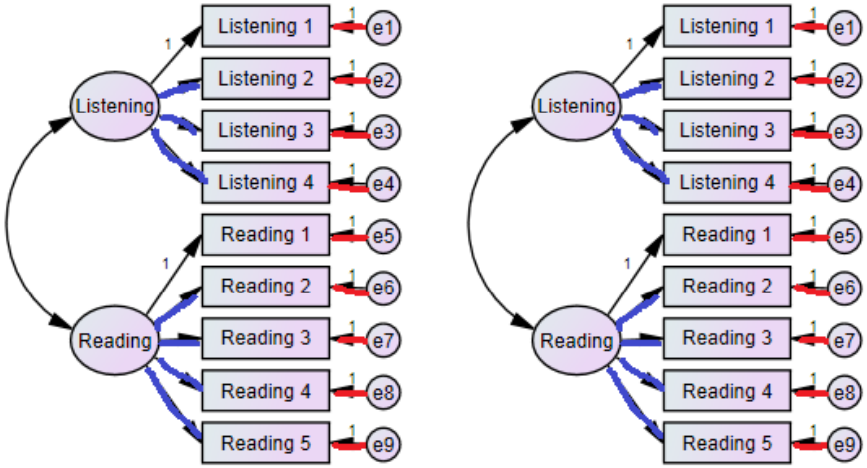
e8
e9



Baseline



Factor loadings equal

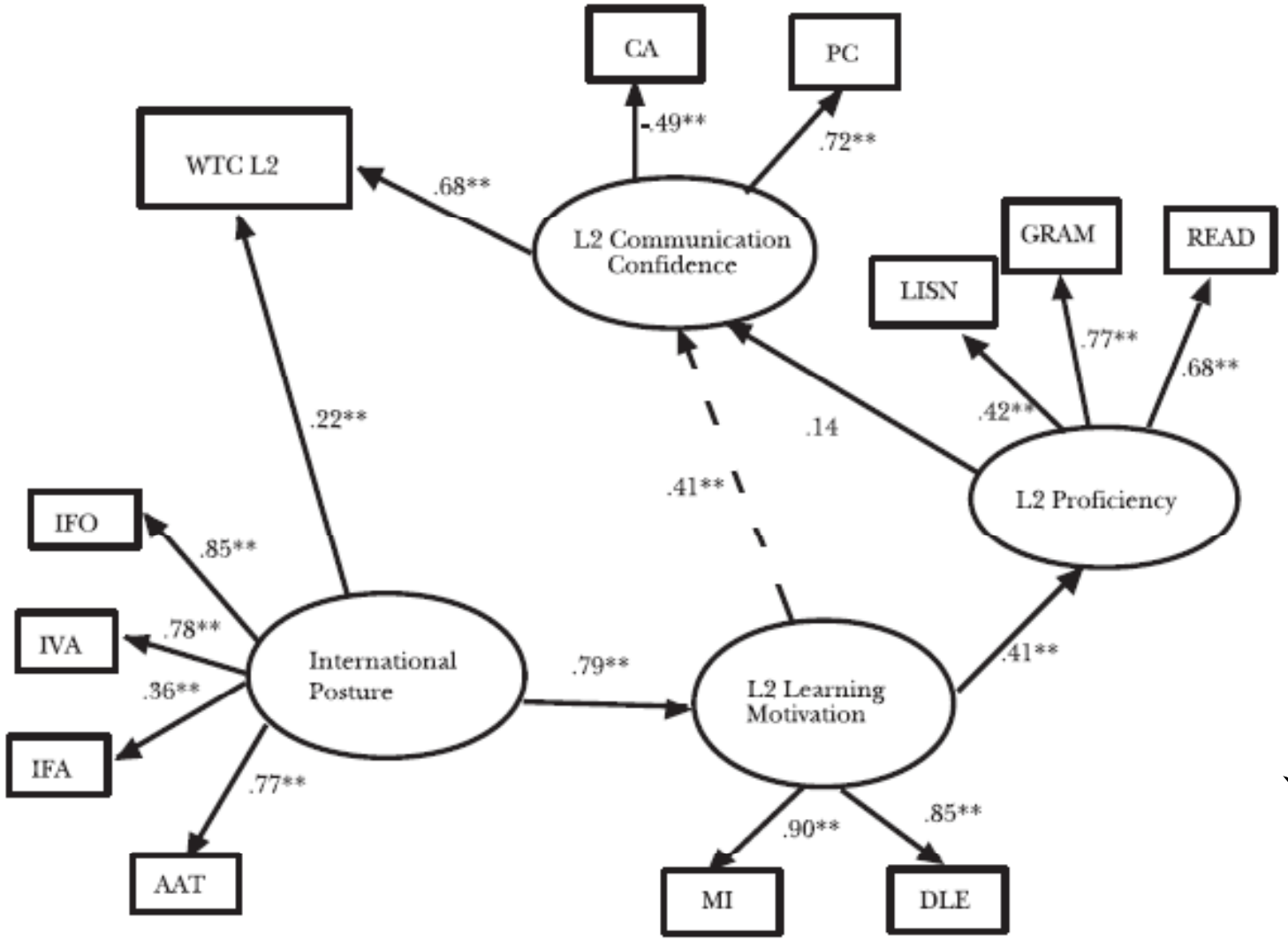


Factor loadings + error variances equal

Overview

- Confirmatory factor analysis (CFA) basics
- CFA demo
- (Break)
- Applications
  - Higher-order models
  - Multitrait-multimethod (MTMM) models
  - Multi-sample models
- **Structural equation modeling**

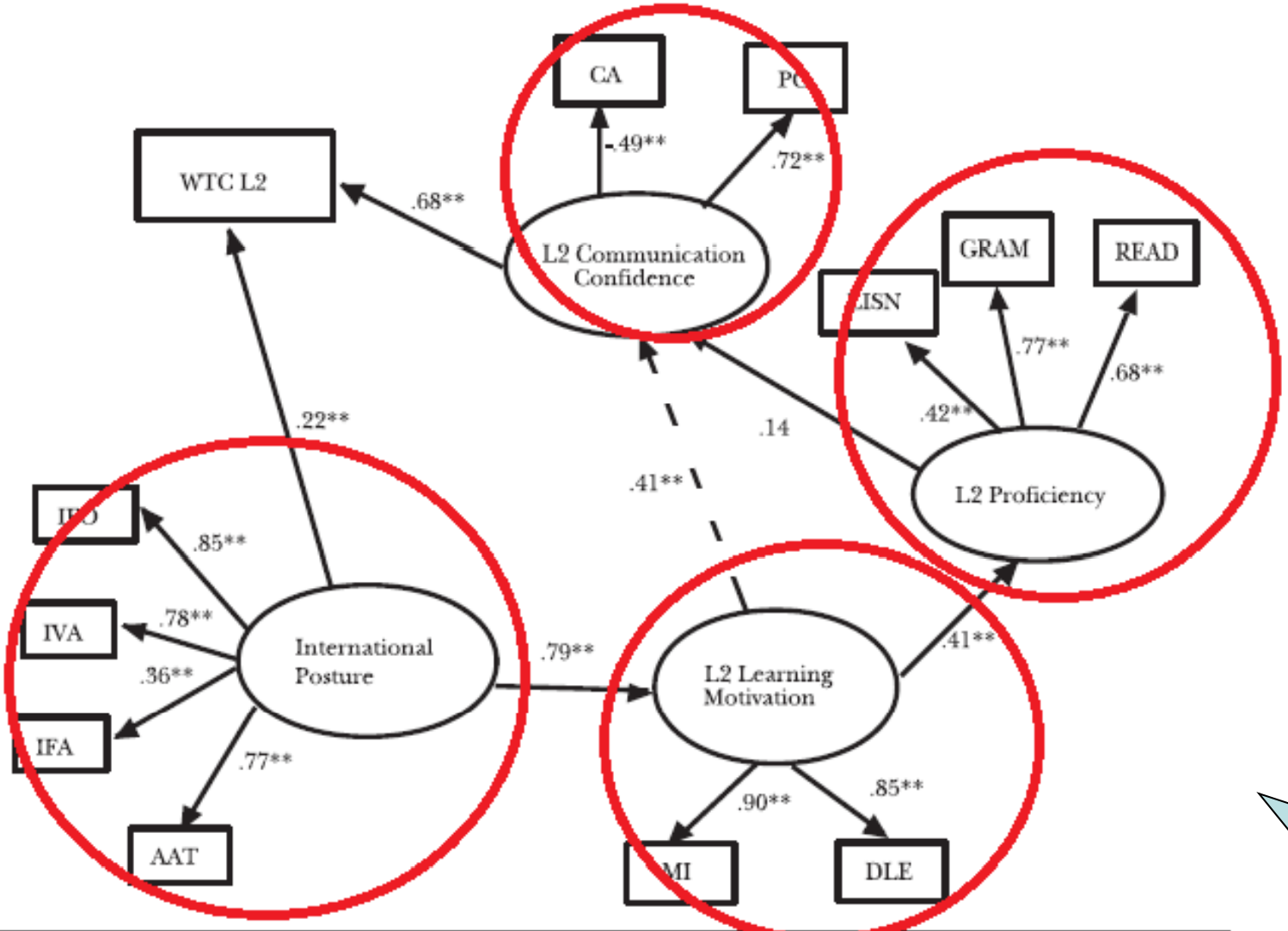
L2 Communication Model in the Japanese EFL Context with Standardized Estimates



Note. $^{**}p < .01$; χ^2 (49) = 62.63, n.s.; GFI = 0.97; AGFI = 0.95; CFI = 0.99; RMSEA = 0.031; WTC L2: Willingness to Communicate in L2; CA: Communication Anxiety in L2; PC: Perceived Communication Competence in L2; LISN: Listening Comprehension; GRAM: Grammar & Vocabulary; READ: Reading Comprehension; IFO: Intercultural Friendship Orientation in Learning English; IVA: Interest in International Vocation/Activities; IFA: Interest in Foreign Affairs; AAT: Intergroup Approach Avoidance Tendency; MI: Motivational Intensity; DLE: Desire to Learn English.

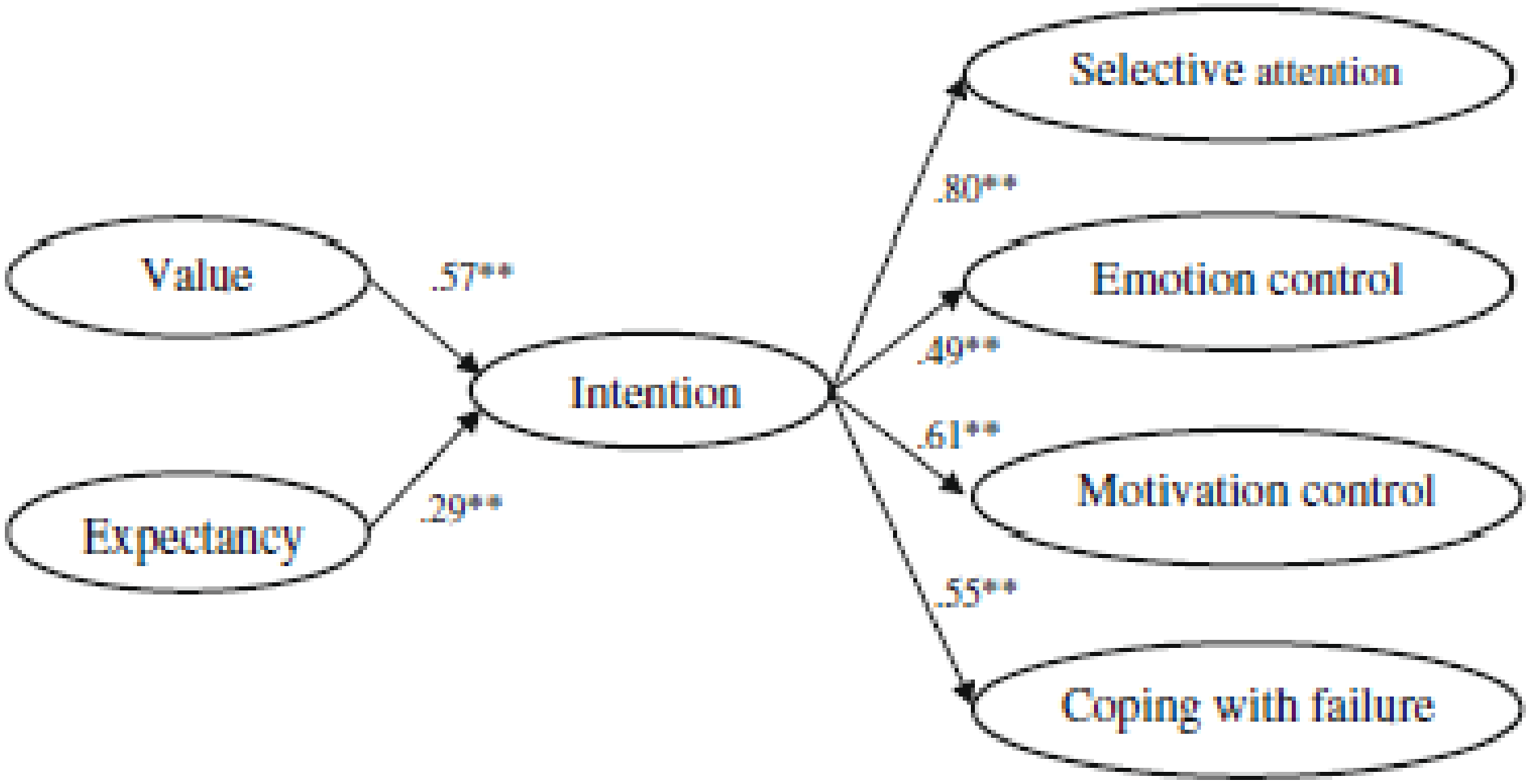
Yashima (2002)

L2 Communication Model in the Japanese EFL Context with Standardized Estimates



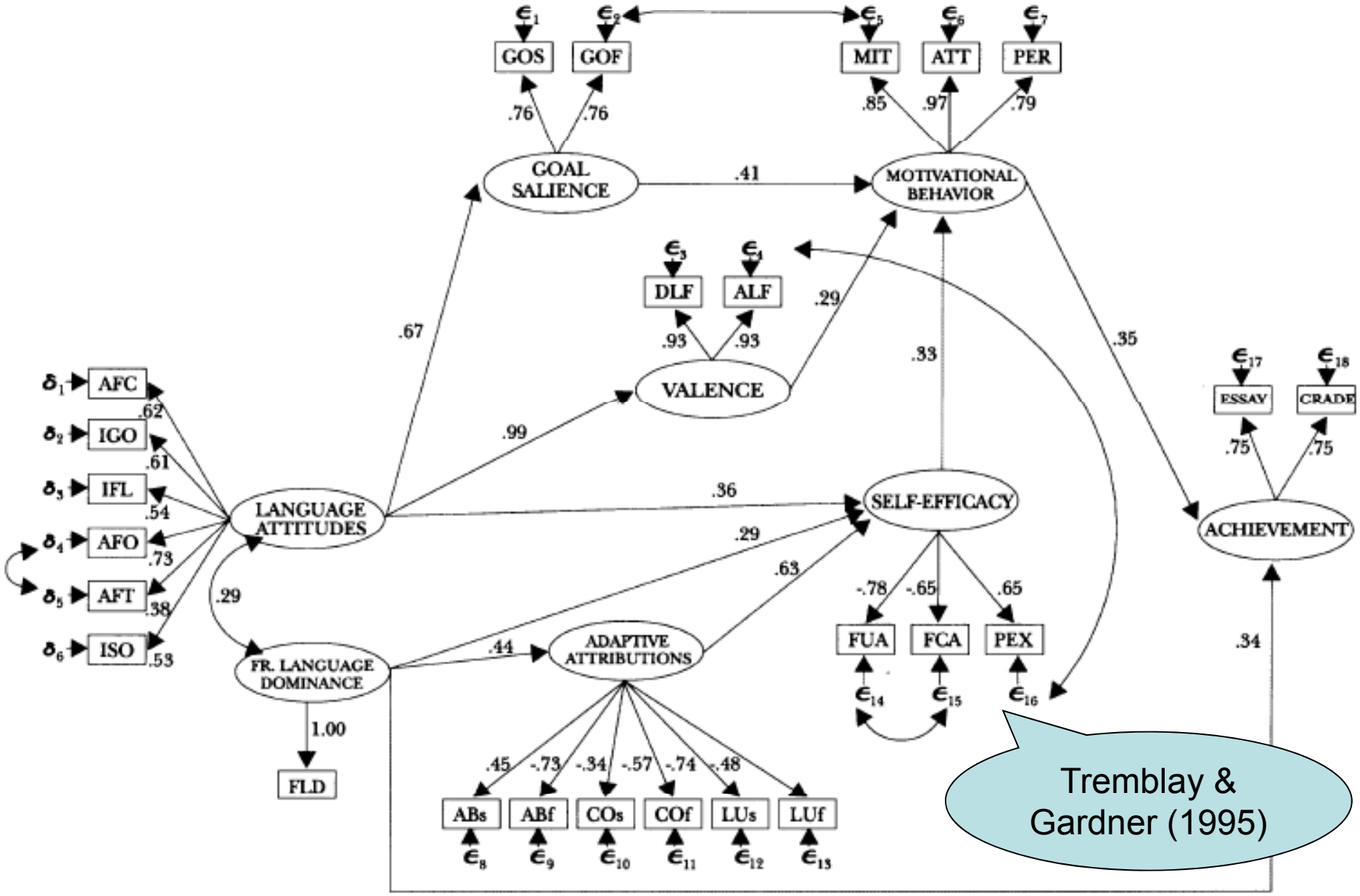
Note. $^{**}p < .01$; χ^2 (49) = 62.63, n.s.; GFI = 0.97; AGFI = 0.95; CFI = 0.99; RMSEA = 0.031; WTC L2: Willingness to Communicate in L2; CA: Communication Anxiety in L2; PC: Perceived Communication Competence in L2; LISN: Listening Comprehension; GRAM: Grammar & Vocabulary; READ: Reading Comprehension; IFO: Intercultural Friendship Orientation in Learning English; IVA: Interest in International Vocation/Activities; IFA: Interest in Foreign Affairs; AAT: Intergroup Approach Avoidance Tendency; MI: Motivational Intensity; DLE: Desire to Learn English.

Yashima (2002)



Hiromori (2009)

FIGURE 2
The LISREL Model



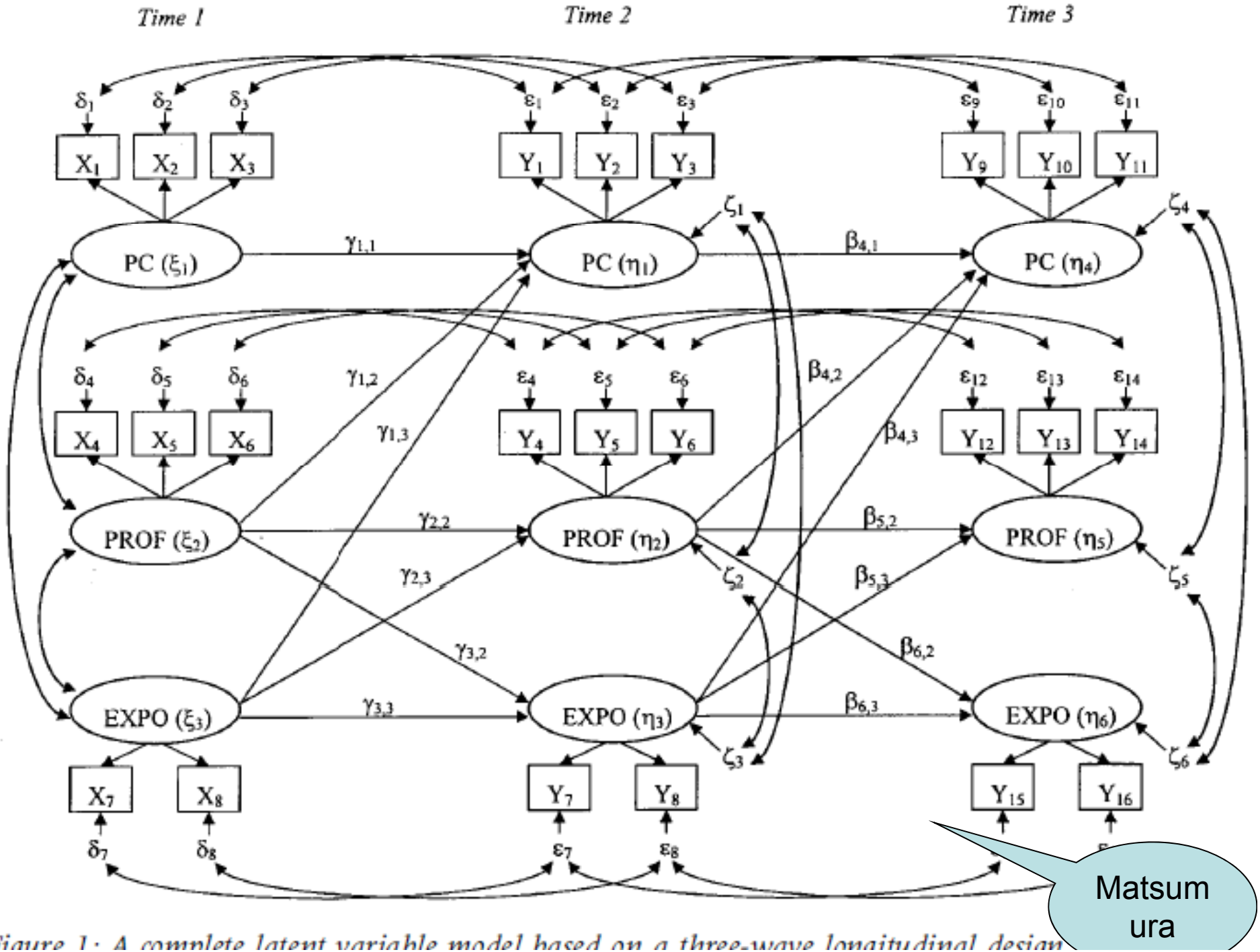


Figure 1: A complete latent variable model based on a three-wave longitudinal design

- 因子分析を適用する際のサンプル数、解釈などにおける注意点、条件などについて知りたいです。
  - Sample size for exploratory factor analysis: Fabriger et al. (1999), Floyd & Widaman (1995), Tabachnick & Fidell (2007)
  - Sample size for confirmatory factor analysis: Brown (2006), Kline (2011)

- 確認的因子分析が効果的なのは、どんな場合か？（セミナーでわかることとは思いますが、、、。不必要な場合でも使われる例があると聞くので。）
  - モデルが適切かを様々な観点から調べたいとき
    - CFI, RMSEA…
  - Higher-order models
  - Multitrait-multimethod (MTMM) models
  - Multi-sample models

- 因子分析のときに（探索的ということだと思いますが、確認的因子分析が探索的因子分析とどのように違うのかすら分かっていません）、バリマックス回転とプロマックス回転とどちらを使うか、本によって様々なようですが、バリマックス回転できれいに因子が抽出できない場合にプロマックス回転で行うということで良いでしょうか。因子内の信頼性係数はどれくらい以上ならば大丈夫と見なせるでしょうか。.7を下回って、.6の後半では駄目でしょうか。また、ある本の中の実証的研究として、2つの因子に負荷量が　.4以上でまたがっているのを見かけたのですが　（例えば、因子1には .76あるのですが、因子2にも .43とか）、各因子ごとに独立していなければならないかと思っていたのですが、そうではないのでしょうか。独学でやっているので、自分でこうだと思ったことが確かかどうか分からないことが多々あります。お教えいただければ有難いです。

EFA vs. CFA (1)

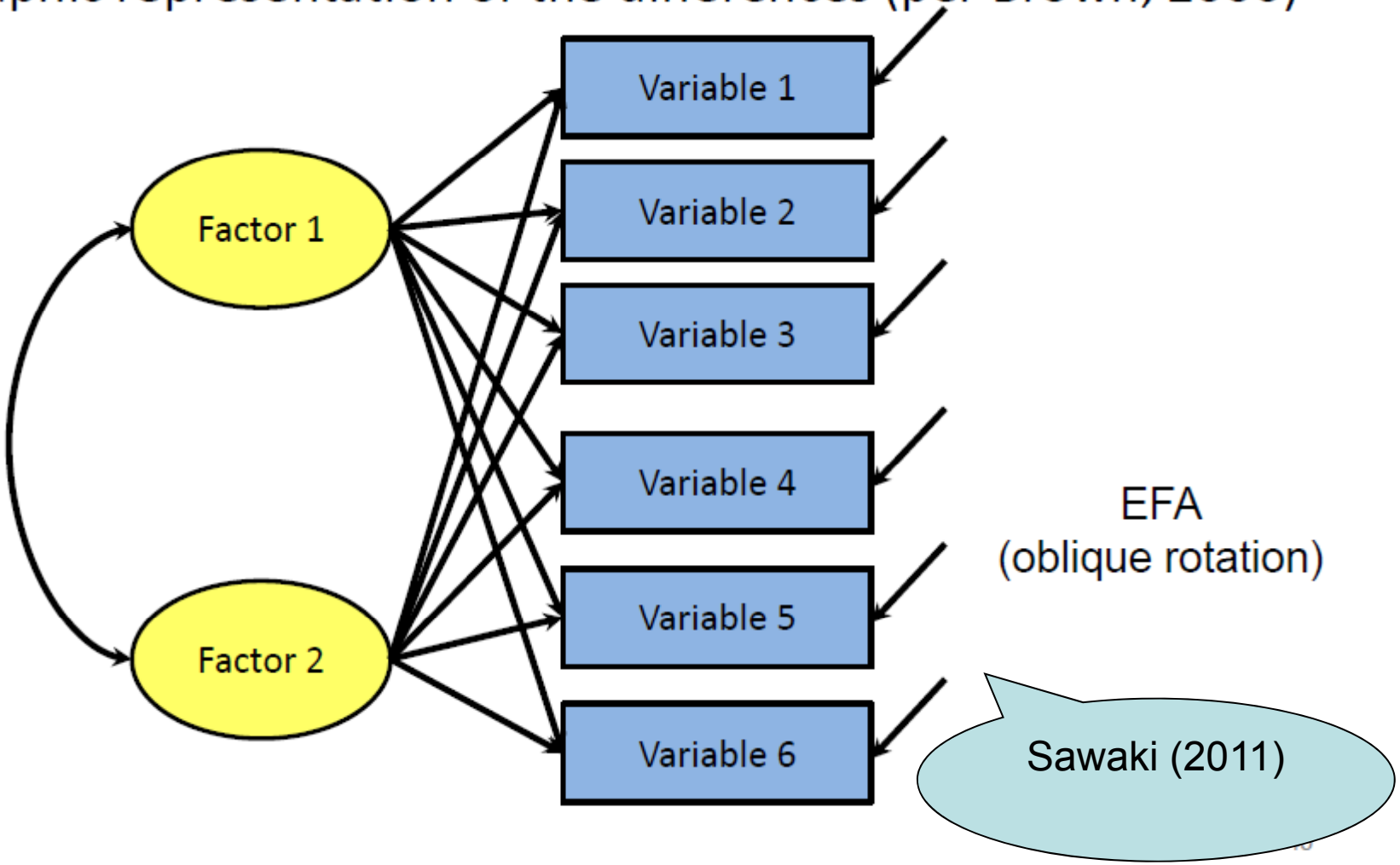
Differences in approaches

- Exploratory factor analysis (EFA; 探索的因子分析)
  - Data-driven approach
  - Often used in early stages of an investigation
- Confirmatory factor analysis (CFA; 検証的/確認的因子分析)
  - Theory-driven approach
  - Often used in later stages of an investigation to confirm specific hypotheses

Sawaki (2011)

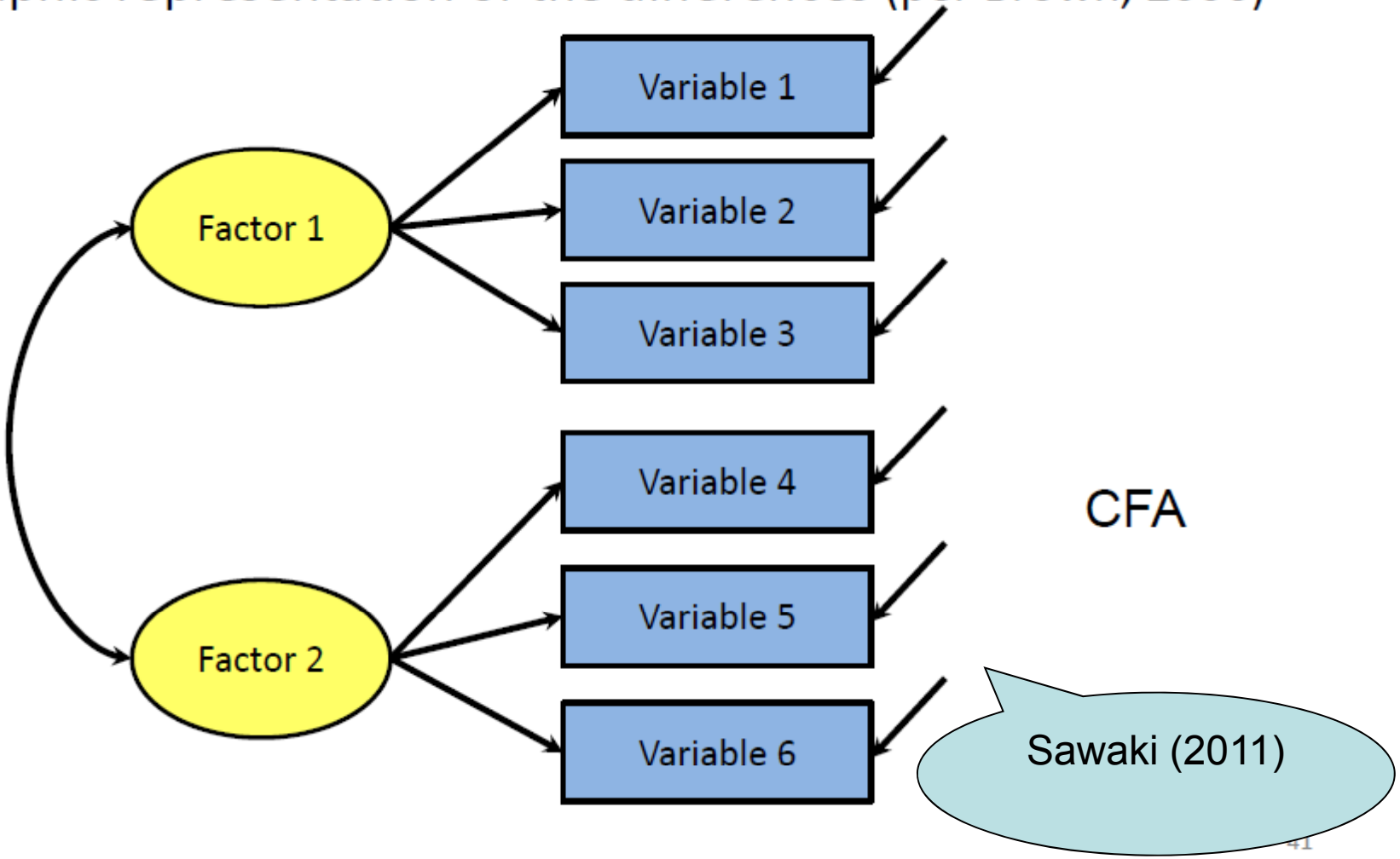
EFA vs. CFA (2)

Graphic representation of the differences (per Brown, 2006)



EFA vs. CFA (3)

Graphic representation of the differences (per Brown, 2006)



- Which fit indices should I report?
  - χ^2, *df*, *p*, CFI, TLI, RMSEA+CI, SRMR
  - Hu & Bentler (1999)
  - Kline (2011)
    - χ^2, *df*, *p*
    - Correlation residual matrix (at least describe the pattern of residuals for a large model; locate the larger residuals and their signs)
    - RMSEA+CI+the p value for the close-fit hypothesis, GFI, CFI, SRMR
    - If you respecify the initial model, explain your rationale for doing so.
    - If no model is retained, explain the implications for the theory in your analysis.

Fit Indices Recommended in the Literature

	Basic	*Incremental*								*Absolute*		*Residual*	
	χ^2	*CFI*	*Gamma Hat*	*IFI*	*MC*	*NFI*	*RNI*	*TLI*	*URFI*	*GFI*	*AGFI*	*RMR*	*RMSEA [CI]*
articles													
entler (1998, 1999)		x	x	x	x		x	x					x
icles													
Panter (1995)	x	x		x			x	x		x			
ıa (2000)[a]	x							x					x [x]
lum & Austin (2000)								x					x [x]
ıld & Ho (2002)		x							x	x		x	x
(2002)		x		x	x		x	x					x
(2005)		x		x				x					x
006)	x	x						x					x [x]
gton & Whittaker (2006)	x	x											x [x]
et al. (2009)		x	x	x	x		x	x					x
t al. (2009)	x	x						x					x
y textbooks													
005)	x	x											x [x]
2006)		x						x					x
(2007)[b]		x											x
& Hancock (2008)	x	x				x		x		x	x		x [x]
s & Finney (2010)	x	x						x					x [x]
2010)	x									x			x
& Hancock (2010)		x				x		x					x [x]
n (2010)	x	x						x					x
	10	17	3	6	4	2	5	15	1	4	1	1	19 [8]
mendation	x	x						x					x [x]

Software

	GUI	Detailed yet readable manual	Fast & dependable technical support	Missing data	Nonnormal data	Availability	User
Amos	x	x		x	(x)	commercial	novice
EQS	x	xx	xxx	x	x	commercial	intermediate
LISREL	x	x	xx	x	x	commercial	intermediate, advanced
Mplus		x	xxx	x	x	commercial	intermediate, advanced
R (lavaan)		?	?	x	x	free	intermediate

- GUI = graphic user interface.

SEMNET

The Structural Equation Modeling Discussion Network

Researchers who study or apply structural equation modeling methods may be interested in an electronic mail network called SEMNET. Operating over the Internet, SEMNET is an open forum for ideas and questions about the methodology that includes analysis of covariance structures, path analysis, and confirmatory factor analysis. SEMNET bridges the gaps between users, between disciplines, and between conferences. SEMNET was founded in February 1993. As of November 1998, SEMNET had more than 1,500 subscribers around the world.

SEMNET is for sharing ideas about this methodology with other interested researchers. SEMNET is also for researchers who are just learning (or re-learning) about structural equation modeling, or who are facing problems in applying these techniques to their own research.

The current postmaster/list owner for SEMNET is Dr. Carl E. Ferguson, Jr. (CFERGUSO@ALSTON.CBA.UA.EDU), professor of marketing at The University of Alabama, in Tuscaloosa. SEMNET is sponsored by the Seebeck Computer Center at The University of Alabama.

TOPICS:

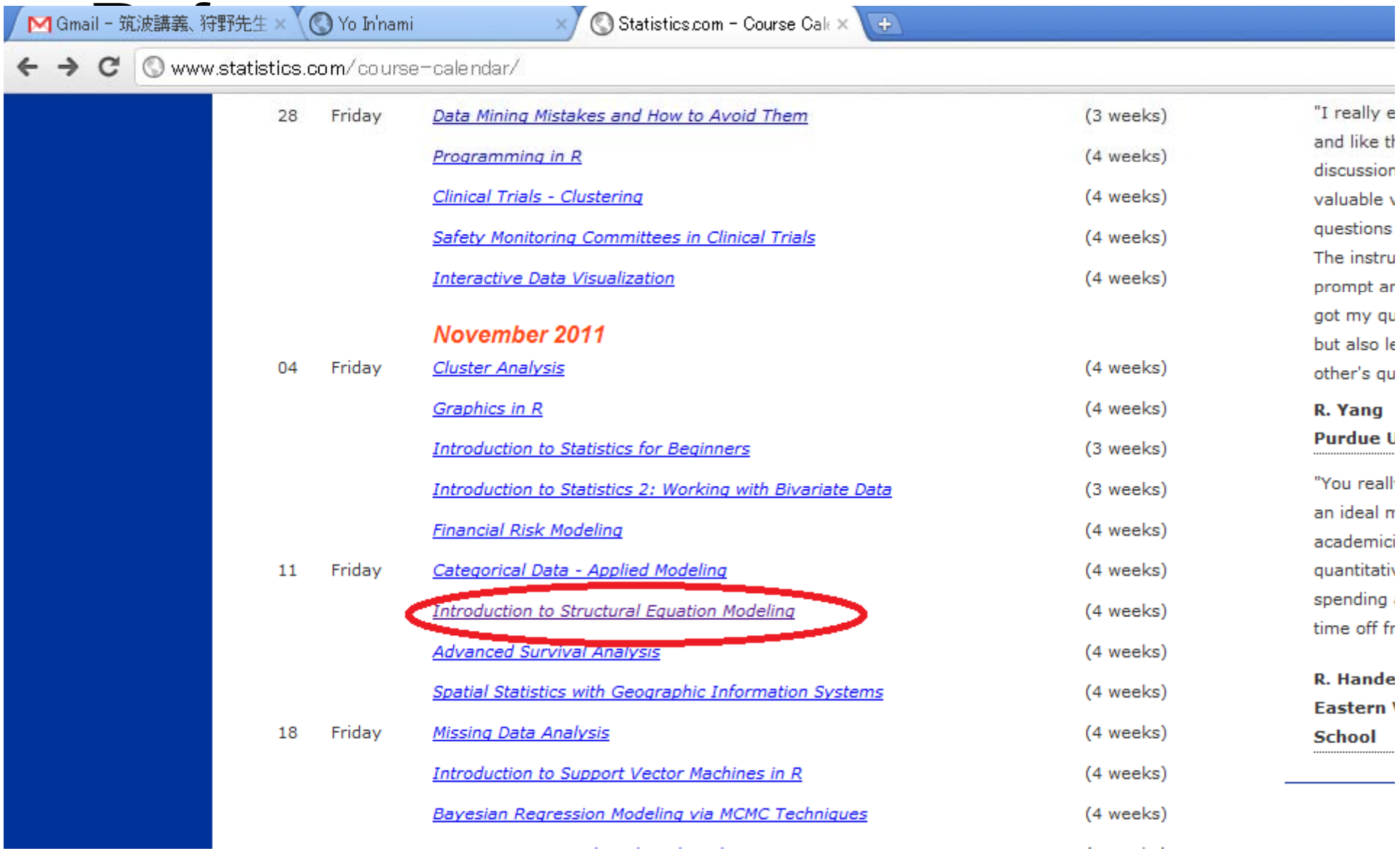
COMMANDS VS. MESSAGES

Interacting with SEMNET involves sending two different types of e-mail: **commands** and **messages**.
Users send **commands** to acquire information about the list or to start, stop, or change the parameters of their subscription to the list. By contrast, users send **messages** to the list to be distributed to the list's other subscribers. For **commands**, users do not need to provide a subject. The commands themselves go in the body section of the e-mail. The same e-mail may contain several commands, but each command must be on a separate line.
For **messages**, providing a descriptive subject line shows consideration for other list subscribers.

ADDRESSES

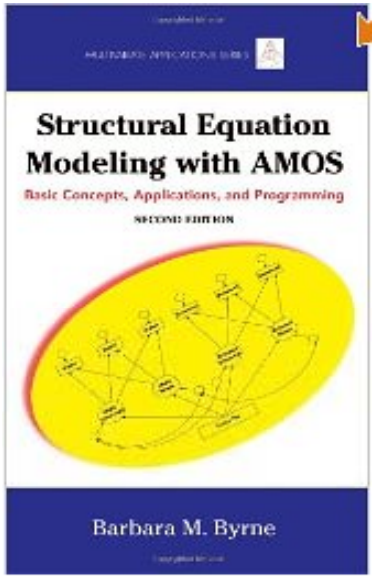
SEMNET users need to remember two different e-mail addresses--one for **commands** and one for **messages**.
Commands are always sent to the **LISTSERV** address:

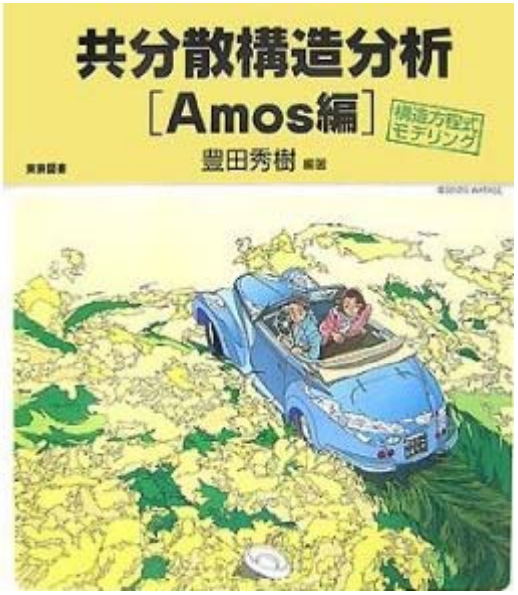
LISTSERV@BAMA.UA.EDU

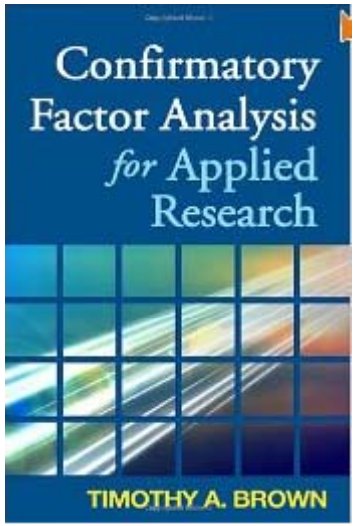

Gmail - 筑波講義、狩野先生
Yo In'nami
Statistics.com - Course Cal
www.statistics.com/course-calendar/
28 Friday Data Mining Mistakes and How to Avoid Them (3 weeks)
Programming in R (4 weeks)
Clinical Trials - Clustering (4 weeks)
Safety Monitoring Committees in Clinical Trials (4 weeks)
Interactive Data Visualization (4 weeks)
November 2011
04 Friday Cluster Analysis (4 weeks)
Graphics in R (4 weeks)
Introduction to Statistics for Beginners (3 weeks)
Introduction to Statistics 2: Working with Bivariate Data (3 weeks)
Financial Risk Modeling (4 weeks)
11 Friday Categorical Data - Applied Modeling (4 weeks)
Introduction to Structural Equation Modeling (4 weeks)
Advanced Survival Analysis (4 weeks)
Spatial Statistics with Geographic Information Systems (4 weeks)
18 Friday Missing Data Analysis (4 weeks)
Introduction to Support Vector Machines in R (4 weeks)
Bayesian Regression Modeling via MCMC Techniques (4 weeks)
"I really e
and like th
discussion
valuable v
questions
The instru
prompt ar
got my qu
but also le
other's qu
R. Yang
Purdue U
"You reall
an ideal m
academici
quantitativ
spending
time off fr
R. Hande
Eastern
School

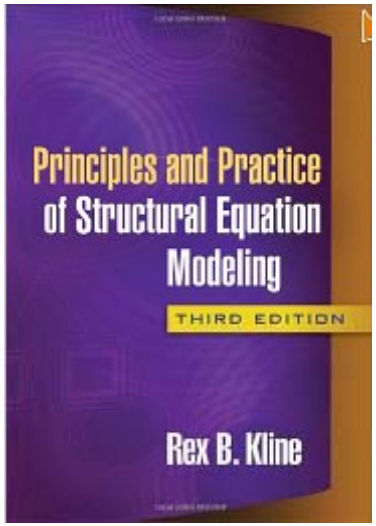

外国語
教育研究
ハンドブック


教育・心理系研究のための
データ分析入門
理論と実践から学ぶSPSS活用法
平井明代 編著
東京図書


Structural Equation Modeling with AMOS
Basic Concepts, Applications, and Programming
Barbara M. Byrne


共分散構造分析
[Amos編]
構造方程式モデリング
豊田秀樹 編著


Confirmatory Factor Analysis for Applied Research
TIMOTHY A. BROWN


Principles and Practice of Structural Equation Modeling
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