DOCUMENT RESUME

ED 418 126 TM 028 220

AUTHOR Dawson, Thomas E.
TITLE Structural Equation Modeling versus Ordinary Least Squares Canonical Analysis: Some Heuristic Comparisons.
PUB DATE 1998-04-13
NOTE 42p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Diego, CA, April 1998).
PUB TYPE Reports - Evaluative (142) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Correlation; Equations (Mathematics); Heuristics; *Least Squares Statistics; Mathematical Models; *Multivariate Analysis; *Structural Equation Models

ABSTRACT

This paper describes structural equation modeling (SEM) in comparison with another overarching analysis within the general linear model (GLM) analytic family: canonical correlation analysis. The uninitiated reader can gain an understanding of SEM's basic tenets and applications. Latent constructs discovered via a measurement model are explored and the structural models that "connect" latent constructs are described. In addition to reviewing SEM constructs, the paper uses the analysis of a heuristic data set to show how SEM as the most general analytic approach subsumes canonical correlation analysis (CCA) as a special case, even though canonical correlation analysis in turn itself subsumes other parametric methods (e.g., t-tests, analysis of variance, regression, multivariate analysis of variance, and discriminant analysis) as special cases. An appendix contains an illustration that SEM subsumes CCA. (Contains 1 table, 4 figures, and 21 references.) (Author/SLD)

dawson.wp1 3/18/98

Running head: SEM

Structural Equation Modeling versus Ordinary Least Squares Canonical Analysis: Some Heuristic Comparisons

Thomas E. Dawson

Texas A&M University 77843-4225

Paper presented at the annual meeting of the American Educational Research Association, San Diego, April 13, 1998.

ABSTRACT

The present paper describes structural equation modeling (SEM) in comparison with another overarching analysis within the general linear model (GLM) analytic family: canonical correlation analysis. From the paper the uninitiated reader will gain an understanding of SEM's basic tenets and applications. Latent constructs discovered via a measurement model will be explored and the structural models that "connect" the latent constructs will be described. In addition to reviewing SEM concepts, via analysis of a heuristic data set the paper shows how SEM as the most general analytic approach subsumes canonical correlation analysis as a special case, even though canonical correlation analysis in turn itself subsumes other parametric methods (e.g., *t*-tests, ANOVA, regression, MANOVA, discriminant analysis) as special cases.

"Variables, variables, variables; why so many variables?"; thus Wampold (1987) begins his article on covariance structure analysis. In fact, multiple variables are more a reflection of reality than are events taking place in isolation, i.e., one independent variable influencing one dependent variable where both are observable. Indeed, with the complexity of most of the constructs found in behavioral and social research, measures that are useful for testing theories are frequently multidimensional and multidirectional. Thus, multivariate methods have become the panacea for questions of this sort (Thompson, 1994). And according to Wampold (1987), structural equation modeling (SEM, also called covariance structure analysis) is the "Gucci" of multivariate measures. Further, Lomax (1989) stated that "The development of methodologies to test hypotheses regarding the structure underlying covariance matrices [e.g., structural equation modeling] appears to be the single-most important contribution of statistics to the social and behavioral sciences during the past 20 years" (p. 171).

Jöreskog (1994) argued for the utility of structural equation modeling in solving many substantive research questions in the social and behavioral sciences. Further, he pointed out that the methodology underlying many 'different' models, e.g., simultaneous equations systems, linear causal analysis, confirmatory factor analysis, path analysis, structural equation models, recursive and non-recursive models for cross-sectional and longitudinal data, and covariance structure models, are in fact quite similar, if not exactly the same. The practice of giving different labels to the same processes has been previously revealed by Thompson (1995) as an attempt "mainly to obfuscate the commonalities of parametric methods, and to confuse graduate students" (p. 87).

It is unclear whether the myriad labels applied to structural equation modeling is the sole, or only a partial reason why structural equation modeling continues to be misunderstood by many. This is in stark contrast to the statistical sophistication commonly applied to analyzing data by evaluating mean differences, correlational coefficients, tabular data and an occasional factor structure. Even though 10 years ago, Biddle and Marlin (1987) stated in reference to structural equation modeling that, "Misuse of these techniques have appeared in major journals. Users have made inappropriate claims for findings generated through these procedures and have applied them *mindlessly* in data analysis" (p. 4, italics added), these problems have persisted nonetheless.

The misconceptions and errors in applying and interpreting structural equation models are partially a result of these models being considered by many as "causal models" in the literal sense (Lomax, 1989). Causal modeling is thought to improve the ability to make causal inferences from field-study data. Because a predetermined statement of causal relationships among variables is required in structural equation modeling, one might assume that if a theoretical model "fits" data, then the fit is a function of causation (Biddle & Marlin, 1987). But in fact, evidence of a "fit" is merely an indication of an association and/or possible temporal relationship. As Biddle and Marlin (1987) stated: "Readers do not have to be reminded that correlation does not imply causality, [but in fact] causal modelers are occasionally *tricked* into this belief by the word causal" (p. 9, italics added).

One other related semantic misunderstanding deals with the use of the term, "confirmed." Some of the users of structural equation modeling apparently erroneously believe that confirmation of model fit means "proof" that the model exemplifies reality and "truth," and further, that a confirmed model is exclusive in its explanation of the variables in question (Biddle & Marlin, 1987). Clearly, this is not the case. Confirmation of a model is one explanation of the model, but by no means is that model necessarily the only explanation of the variables. In fact, innumerable models may *all* fit a given data set, just as innumerable different models may also not fit the same data.

The present paper will delineate the underlying theory and application of structural equation modeling. Additionally, as it has been previously demonstrated that all classical univariate and multivariate methods are special cases (Fan, 1996; Knapp, 1978; Thompson, 1991) of canonical correlation analysis (Thompson, 1984), here a heuristic data set will be utilized to exemplify that structural equation modeling subsumes canonical correlation analysis. This will further support Fan's (1997) claim that, "Hierarchically, the relationship between the two analytic approaches [canonical correlation analysis and structural equation modeling] suggests that SEM stands to be a[n even] more general analytic approach" (p. 65).

Theory of SEM

A structural equation model consists of a measurement model and a structural model. The measurement portion of the model is an attempt to explain relationships among a set of observations (i.e., "measured" or "observed" variables) in terms of a smaller set of unobserved variables (i.e., "latent" or "synthetic" variables) (Long, 1983). This is accomplished by utilizing factor analysis to reproduce the interrelationships among a set of observed variables through a fewer number of synthetic variables (common factors) (Lomax, 1989). The relationships among the observed variables are determined by the covariances among the variables, found in variance/covariance (sometimes simply called, covariance) matrices. This matrix assumes that the unobserved variables are producing the pattern of relationship between the observed variables. A measurement model is utilized to link the unobserved latent or synthetic variables to the observed measured variables (Long, 1983). The structural model, in turn, specifies how the latent constructs are correlated with or influenced by other latent variables.

<u>The Measurement Model</u>

As noted previously, the aim of factor analysis is to explain the relationships between observed variables via common factors. The common factors are linear combinations of the measured variables that have substantive meaning. One way to specify the confirmatory factor analysis (CFA) model is by equation 3.10 from Jöreskog and Sörbom (1989, p. 97, illustrative subscripts added) in the context of population parameter matrices:

$$\Sigma_{(9 \times 9)} = \Lambda_{(9 \times 3)} \Phi_{(3 \times 3)} \Lambda'_{(3 \times 9)} + \theta_{(9 \times 9)} \quad (2\ [3.10])$$

where $\Lambda_{(9 \times 3)}$ is the factor pattern coefficient matrix, $\Phi_{(3 \times 3)}$ is the matrix of correlation coefficients among the three factors, $\theta_{(9 \times 9)}$ is the unique variance in the measured variables (usually associated with measurement error in a correctly specified model) and the covariances of these errors, and $\Sigma_{(9 \times 9)}$ is the matrix of covariances or correlation coefficients among the nine measured or observed variables.

Two heuristic diagrams of measurement models are provided in Figure 1 and Figure 2 to clarify the relationships between the observed indicator variables (in Figure 1, variables named "V1" through "V12", conventionally denoted in the *squares*; in Figure 2, variables named "A1" through "C4"), the unobserved common factors (all latent/synthetic constructs are denoted by the *oval shapes*, by convention) and the error terms associated with each measured or observed indicator variable.

Insert Figure 1 and Figure 2 about here

An exploratory factor analysis imposes somewhat different specifications on the data (i.e., observed variables are a function of *all* the common factors, each observed variable is also partly a function of a unique factor, unique factors are always *uncorrelated*, and the common factors often are uncorrelated, as well) than a confirmatory factor analysis. In a confirmatory factor analysis, the researcher sets predetermined constraints on the model. For example the researcher may specify, (a) which observed variables are a function of which common factors, (b) which observed variables are a function of a unique factor, and (c) which common and which unique factors are correlated (Lomax, 1989). There are three major assumptions to accompany these specifications, (a) x (the observed variable(s)), ξ (the unobserved variable(s)), and δ (the error terms) are measured as deviations from their means, (b) q (observed) > n (unobserved), and (c) the common factors are uncorrelated with the unique factors (Long, 1983).

Model "identification" must be resolved before one can estimate the parameters of the model. Identification involves whether the parameters of the model can be uniquely determined or estimated based on the sample covariance matrix (S). If the model is not identified, then the parameters can not be uniquely defined, i.e., many different combinations of values can be placed into the above equation to equally well estimate the population covariance matrix Σ. So, by imposing constraints on the factor model, identification can be accomplished. If enough constraints are imposed on the model until only one set of values remain, then the model is said to be "identified" (Lomax, 1989). Of course, as Mulaik (1987) pointed out, allowing the parameters to be "fixed and freed" in a trial and error fashion until the model fits the data ignores the fact that the resulting model may or may not be meaningful.

The Structural Model

While the measurement model specifies how the latent or synthetic variables (i.e., hypothetical constructs) are measured in terms of observed variables, the structural model specifies the hypothesized casual relationships among the latent variables (Anderson, 1987). A distinction is made between two types of common factors, the latent independent variable (or latent exogenous variable) and latent dependent variables (or latent endogenous variables). If we designate η_2 (m x 1) as a vector of the latent endogenous variables etas and ξ (n x 1) as a vector of the latent exogenous variables, then a system of linear structure equations is:

$$\eta_1 = B\ \eta_2 + \Gamma\xi + \zeta,$$

where B (m x m) and Γ (m x n) are matrices of structure coefficients (or weights) relating the endogenous variables to one another and the exogenous variables to each other, and ζ (m x 1) is a residual (error or disturbance) vector (Anderson, 1987; Lomax, 1989). It is assumed that ζ is uncorrelated with ξ and that I - B is non-singular (Jöreskog, 1994). A heuristic diagram is provided in Figure 3 linking the two measurement models provided in Figures 1 and 2 and describing how the constructs impact upon each other.

Insert Figure 3 about here

To help clarify the above formula in relation to the structural model found in Figure 3, Figure 4 is provided showing the actualization of these abstract concepts. In Figure 4, type of attachment is hypothesized to impact psychological well-being. In this example, only depression will be utilized as representing well-being for the sake of clarity.

Insert Figure 4 about here

As can be seen in Figure 4, only a secure and ambivalent attachment affects depression. For illustrative purposes, the regression coefficients are shown on the paths going from these two attachment styles toward the construct of depression (secure = .4, ambivalent = .2). If a path did not achieve a certain predetermined level of effect on the depression construct, then it would have been deleted from the final diagram.

Method of SEM

Parameter Estimation

Maximum-likelihood estimates of the model parameters can be generated by the LISREL computer program (Jöreskog & Sörbom, 1984) or other popular SEM computer packages (e.g., AMOS, EQS). LISREL has probably been the most widely used statistical program to estimate linear structural relationships among a set of variables, although for various reasons other packages are becoming increasingly popular. LISREL is designed to estimate parameters and test the validity of a wide range of models that contain measurement error, specification error, reciprocal causation, variables measured at several points in time, and latent (unobserved) variables (Anderson, 1987; Jöreskog, 1994).

Variance-covariance matrices or other matrices of association are analyzed by LISREL. The program outputs the parameter estimates derived using least squares, maximum-likelihood, or some other statistical theory.

Assessing Goodness of Fit

The squared correlation coefficient is computed for each structural equation. These consist of separate R^2s for each of the equations in the model. (These R^2s are different from the ones in regression in that they do not have an intercept term usually found in the output of regression models). A total coefficient of determination is computed for all the structural equations *simultaneously*, for example in Figure 4, the equation would be expressed as:

Depression = Secure (.4) + Ambivalent (.2)....

This result indicates the amount of variance in the endogenous variables jointly accounted for by the model.

The LISREL model provides a chi-square statistic to test the fit of the model to the data. The chi-square statistic is a function of the difference between the observed covariance matrix and a predicted population matrix based on the model *and* sample size. To interpret the test, the residual covariance matrix that results when comparing the observed and predicted values is examined to see if it differs from zero. But because the chi-square statistic is also a function of sample size, then almost any model is likely to be rejected if the sample is large enough (Anderson, 1987).

Literally dozens of alternative fit statistics have been proposed. We are only beginning to understand (cf. Fan, Thompson & Wang, in press; Fan, Wang & Thompson, 1997) how these statistics perform under different conditions (e.g., degrees of multivariate normality, model specification) and what values may be reasonable for deeming that a model has adequate fit. Examples of the more common fit statistics used are provided in Table 1.

Insert Table 1 about here

In using fit statistics, the baseline model must first be employed. The baseline or null model (Bentler & Bonett, 1980) posits that the variables are mutually exclusive and that certain variances and covariances are known. The baseline model is then used to determine how much of the observed variance-covariance matrix can be reproduced solely by the knowledge of zero-order correlations among the exogenous variables and the unique variances of the endogenous variables. The baseline or null model fit statistics are then used to calculate other fit statistics, as shown in Table 1.

In addition to the model chi square reported in Table 1, the Goodness of Fit Index (GFI), and the Adjusted Goodness of Fit Index (AGFI) are examples of other fit statistics, and also can be found in Table 1. The AGFI is adjusted for sample size. The Parsimony Ratio is used primarily to compare models; the more parameters estimated by a model, the less parsimonious is the model. The Parsimony Ratio can be used to weight other fit statistics to create an index that jointly considers both model fit and model parsimony. The CFI is compared to the null model to discern how the results compare to the null model. And finally, the Root Mean Square Residual (RMSR) and the Root Mean Square Error of Approximation (RMSEA) are important fit statistics. Desirable values for the fit statistics referenced in Table 1 are: GFI = >.9 or >.95; AGFI = > .9; the greater the value the parsimony ratio achieves, the better--if "0" is obtained, then there is no parsimony. For the CFI, values greater than .9 are desirable, and for the RMSEA, a value of less than .05 is optimal.

<u>SEM and Canonical Correlation Analysis</u>

Canonical correlation analysis (CCA) summarizes the relationship between two sets of variables. These two sets of variables are linearly combined to produce pairs of synthetic variables (canonical variates) that have maximum bivariate correlation and are orthogonal to each other (Thompson, 1984, 1991). As mentioned earlier, CCA has been heralded as a unifying parametric statistical testing method for both univariate and multivariate problems (Fan, 1997), and *all* other univariate and multivariate parametric techniques can be subsumed under the auspices of CCA (Thompson, 1997). However, the present section illustrates that SEM subsumes CCA as an even more general statistical model. Using the same heuristic data set, a CCA will be performed, followed by a SEM, thereby concretely showing the greater generality of the SEM approach.

In the appendix, a CCA was applied to the Holzinger and Swineford (1939) data set. Utilizing variables T6 and T7 as dependent variables (found on physical page 2 of the appendix), and variables T2, T4, T20, T21, and T22 as the indicator variables (found on the Appendix pages labelled "Page 7" through "Page 10"), two functions result in this CCA as the number in the smaller set is two (Fan, 1997). The function coefficient for each variable is found in the **bolded** areas on the respective pages of the appendix, e.g., for T6, the function coefficients are .44962 and -1.40007 for function I and II respectively, and so on.

It will now be illustrated how the bolded canonical results can be reproduced as the corresponding bolded values from the SEM analysis also presented in the Appendix. The demonstration is a heuristic to show that SEM is the most general case of the general linear model (cf. Fan, 1996, 1997).

To apply a SEM, the PRELIS program found subsequently in the Appendix was first used to compute the correlation matrix. Then this correlation matrix from PRELIS was used to run four LISREL analyses, to reproduce the canonical function coefficients for both variables sets on both functions.

Note that the subsequent bolded four sets of LISREL coefficients for the "gamma" matrix exactly match (within rounding error) the canonical function coefficients presented previously in the printout. The only exception is that all the signs for the SEM second canonical function coefficients must be "reflected." "Reflecting" a function (changing *all* the signs on a given function, factor, or equation) is *always* permissible, because the scaling of psychological constructs is arbitrary. Thus, as can be seen from the data set found in the appendix, the SEM and the canonical analysis derived the same results.

Although this demonstration was primarily heuristic, to illustrate SEM's generality, there may also be some practical advantages to using SEM to compute canonical results. For example, within the SEM approach statistical significance testing of individual canonical function coefficients and structure coefficients is possible, and individual canonical coefficients can be tested (Fan, 1997). This is not readily accomplished in conventional canonical analysis (Thompson, 1984).

Conclusions

Structural equation modeling has become an increasingly popular statistical tool. Unfortunately, there is a direct positive correlation between statistical sophistication and the density and abstractness of the methods employed. In that vein, a less recondite, almost rudimentary approach to structural equation modeling has been put forth through this paper. The basic tenets of structural equation modeling have been described and applied using heuristic path diagrams. Further, for the uninitiated, the formulas inherent in SEM have been operationalized and "tied" into their place in the diagrams. Lastly, to exemplify that SEM is the most general linear approach to statistics, a data set was used to juxtapose the CCA and the SEM approaches to analysis, thus deriving the exact same results.

References

Anderson, J. G. (1987). Structural equation models in the social and behavioral sciences: Model building. Child Development, 58, 49-64.

Biddle, B. J. & Marlin, M. M. (1987). Causality, confirmation, credulity, and structural equation modeling. Child Development, 58, 4-17.

Fan, X. (1996). Canonical correlation analysis as a general analytic model. In B. Thompson (Ed.), Advances in social science methodology (Vol. 4, pp. 71-94). Greenwich, CT: JAI.

Fan, X. (1997). Canonical correlation analysis and structural equation modeling: What do they have in common? Structural Equation Modeling, 4, 65-79.

Fan, X., Thompson, B., & Wang, L. (in press). The effects of sample size, estimation methods, and model specification on SEM fit indices. Structural Equation Modeling.

Fan, X., Wang, L., & Thompson, B. (1997, March). Effects of data nonnormality on fit indices and parameter estimates for true and misspecified SEM models. Paper presented at the annual meeting of the American Educational Research Association, Chicago. (ERIC Document Reproduction Service No. ED 408 299)

Holzinger, K. L. & Swineford, F. (1939). A study in factor analysis: The stability of a bi-factor solution (No. 48). Chicago: University of Chicago.

Jöreskog, K. G. (1994). Structural equation modeling with ordinal variables. In T. W. Anderson, K. T. Fang, & I. Olkin (Eds.), Multivariate analysis and its applications (pp. 297-310).

Hayward, CA: Institute of Mathematical Statistics.

Jöreskog, K. G., & Sörbom, D. (1989). LISREL 7: A guide to the program and applications (2nd ed.). Chicago: SPSS.

Jöreskog, K. G. & Sörbom, D. (1984). LISREL IV: Analysis of linear structural equation relationships by maximum likelihood, instrumental variables, and least square methods. Upsula, Sweden: University of Upsula, Department of Statistics.

Knapp, T. R. (1978). Canonical correlation analysis: A general parametric significance testing system. Psychological Bulletin, 85, 410-416.

Lomax, R. G. (1989). Covariance structure analysis: Extensions and developments. In B. Thompson (Ed.), Advances in social science methodology (V. 1, pp. 171-204). Greenwich, CT: JAI Press.

Long, J. S. (1983). Covariance structure models: An introduction to LISREL. Beverly Hills: Sage.

Martin, J. A. (1987). Structural equation modeling: A guide for the perplexed. Child Development, 58, 33-37.

Mulaik, S. A. (1987). Toward a conception of causality applicable to experimentation and causal modeling. Child Development, 58, 18-32.

Thompson, B. (1984). Canonical correlation analysis: Use and interpretation. Beverly Hills: Sage.

Thompson, B. (1991). A primer on the logic and use of canonical correlation analysis. Measurement and Evaluation in Counseling and Development, 24, 80-95.

Thompson, B. (1994, February). Why multivariate methods are usually vital in research: Some basic concepts. Paper presented as a

Featured Speaker at the biennial meeting of the Southwestern Society for research in Human Development, Austin, TX. (ERIC Document Reproduction Service No. ED 367 687)

Thompson, B. (1995). Exploring the replicability of a study's results: Bootstrap statistics for the multivariate case. Educational and Psychological Measurement, 55, 84-94.

Thompson, B. (1997). The importance of structure coefficients in structural equation modeling confirmatory factor analysis. Educational and Psychological Measurement, 57, 5-19.

Wampold, B. E. (1987). Covariance structure analysis: Seduced by sophistication? The Counseling Psychologist, 15, 311-315.

Table 1
Illustrative Model Fit Statistics

Statistic	Model #1	Model #2
v	18	18
n	780	780
Null chi sq	2519.24	2519.24
Null df	153	153
Noncentrality	2366.24	2366.24[a]
Model chi sq	205.78	748.95
Model df	128	135
Noncentrality	77.78	613.95[a]
NC / df	0.607656	4.547777[b]
GFI	0.960	0.699
Pars Ratio	0.748538	0.789473[c]
GFI*Pars	0.718596	0.551842[d]
CFI	0.967129	0.740537[e]
Pars Ratio	0.836601	0.882352[f]
CFI*Pars	0.809101	0.653415[g]
RMSR	0.005	0.199
RMSEA	0.000780	0.005837[h]

[a]Noncentrality = χ^2 - df

[b]Noncentrality / df

[c]Parsimony Ratio = Model df / [(v̲ariables * (v̲ariables + 1)) / 2]

[d]GFI * Parsimony Ratio

[e]CFI = $\frac{[(\text{Null } \chi^2 - \text{Null df}) - (\text{Model } \chi^2 - \text{Model df})]}{(\text{Null } \chi^2 - \text{Null df})}$

[f]Parsimony Ratio = Model df / [(v̲ariables * (v̲ariables - 1)) / 2]

[g]CFI * Parsimony Ratio

[h]RMSEA = $[(\text{Model } \chi^2 - \text{Model df}) / (\text{Model df} * (n - 1))]^{.5}$

Figure1.

ATTACHMENT MEASUREMENT MODEL

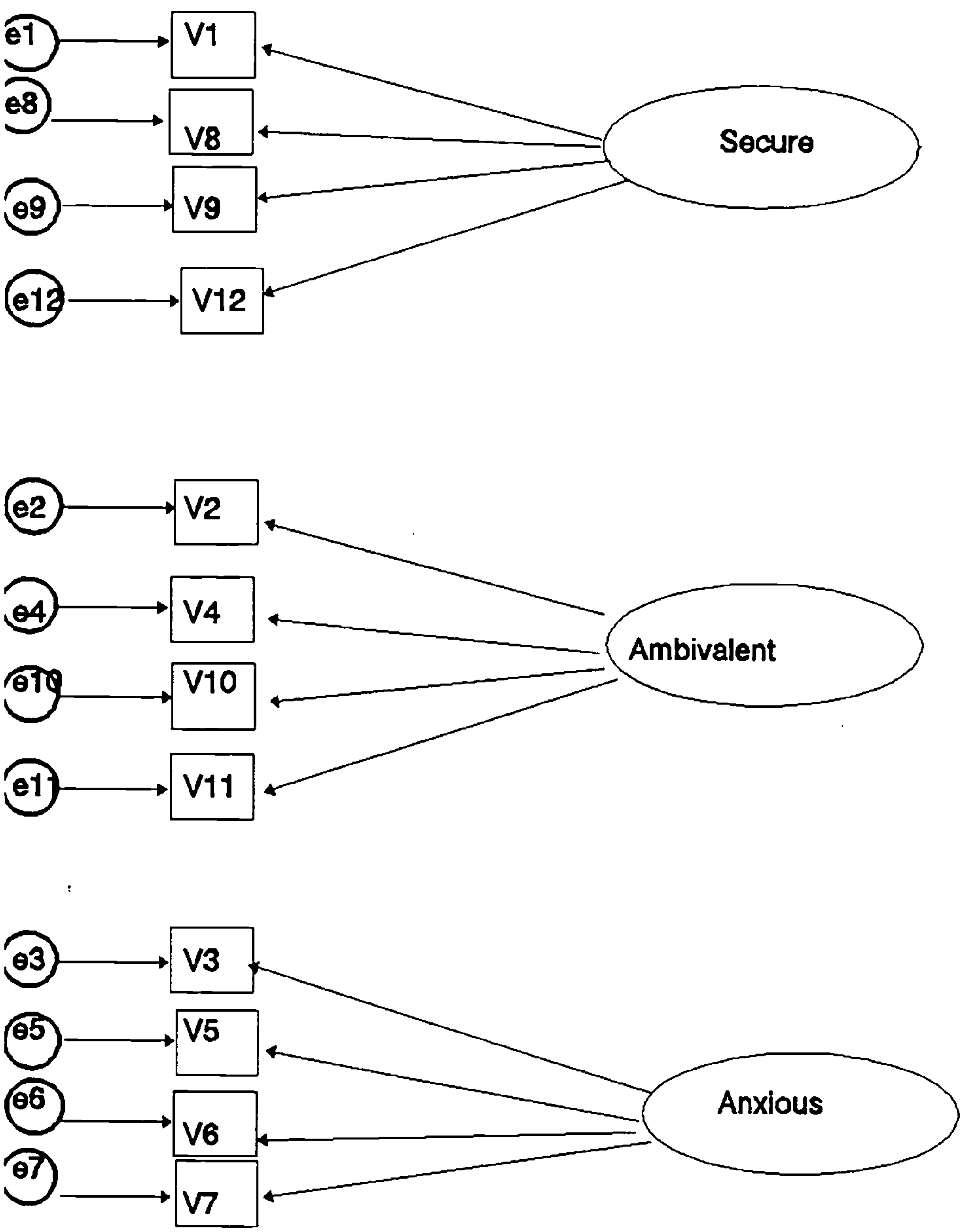


Figure 2.

WELL-BEING MEASUREMENT MODEL

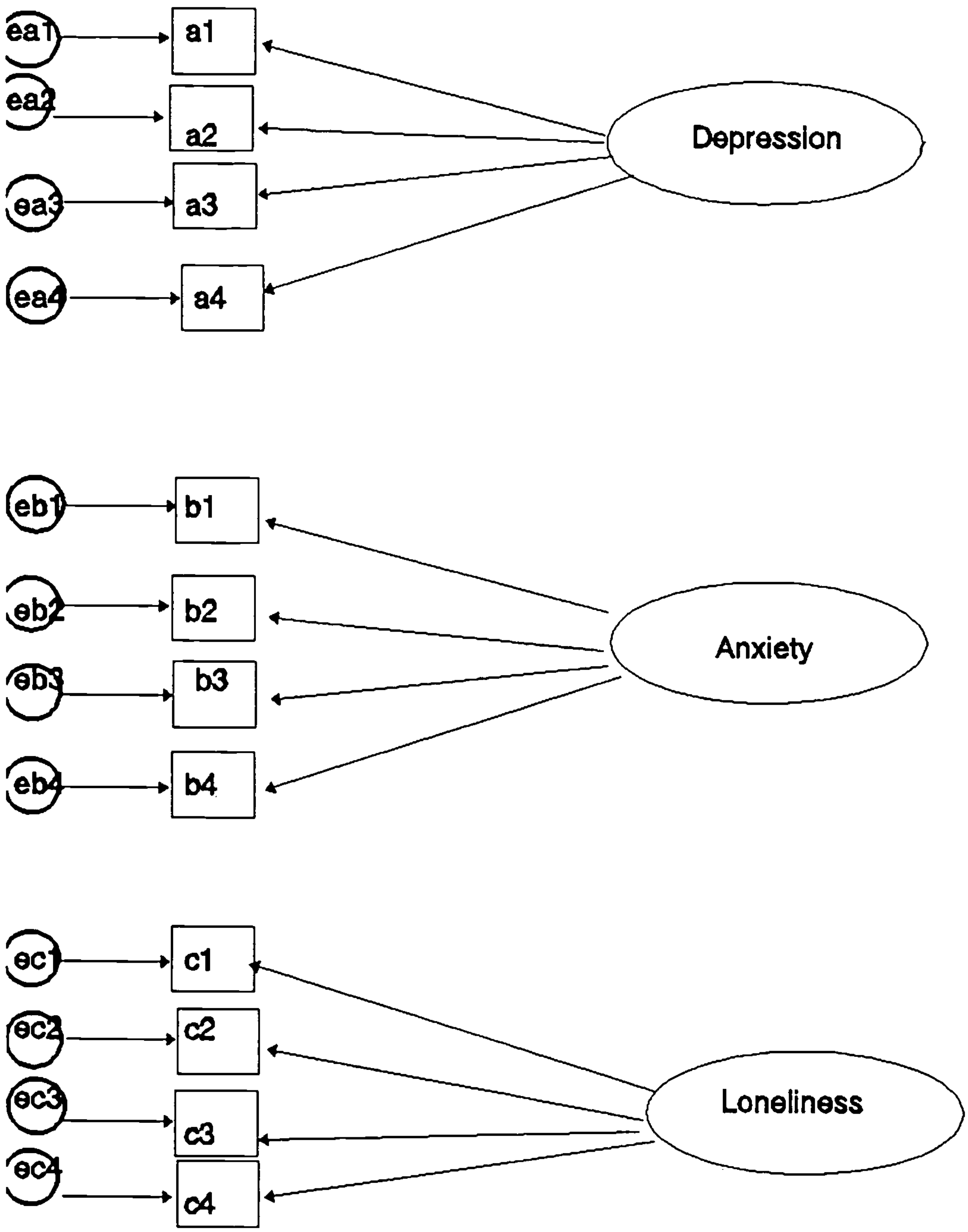
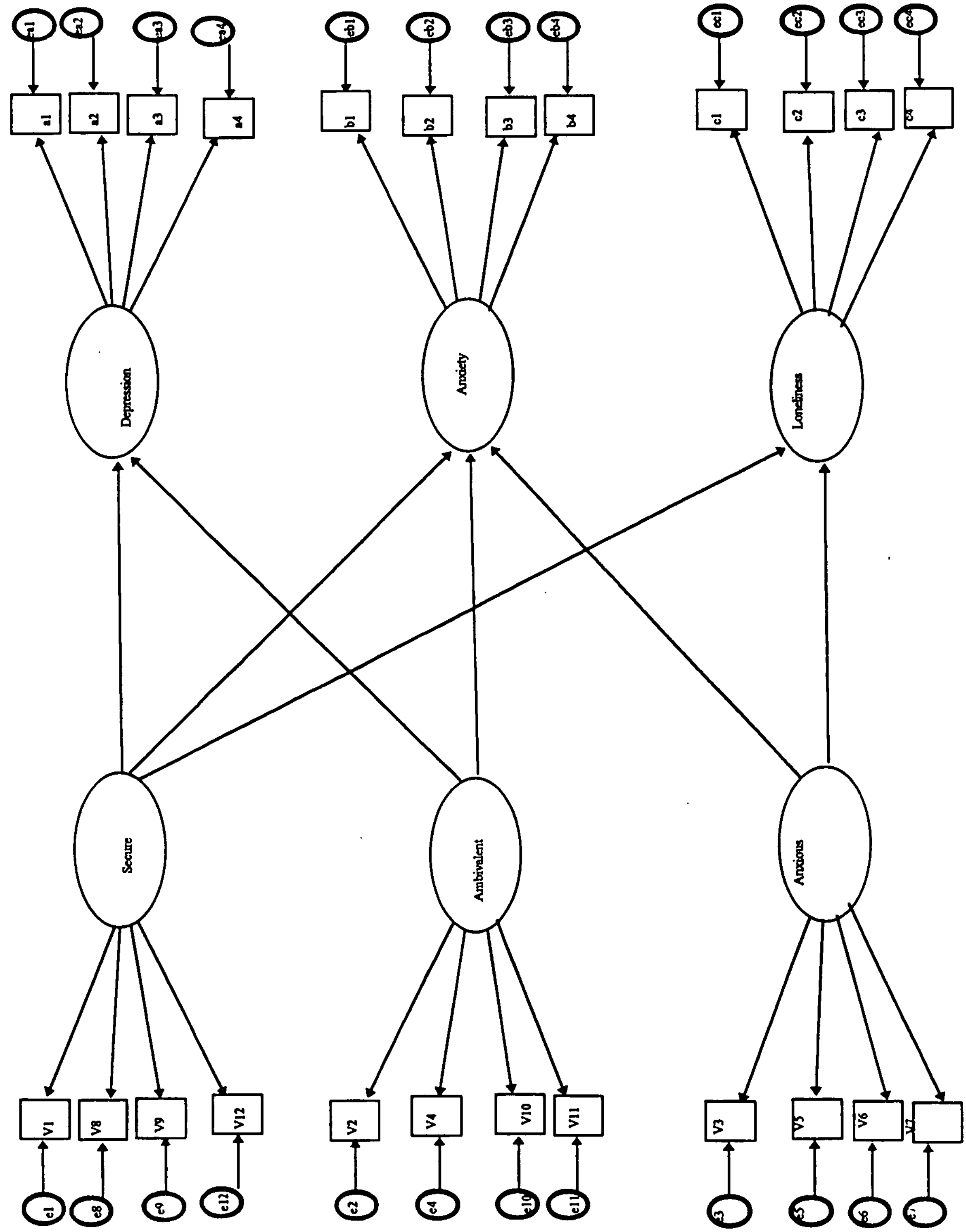


Figure 3.

STRUCTURAL MODEL



STRUCTURAL MODEL

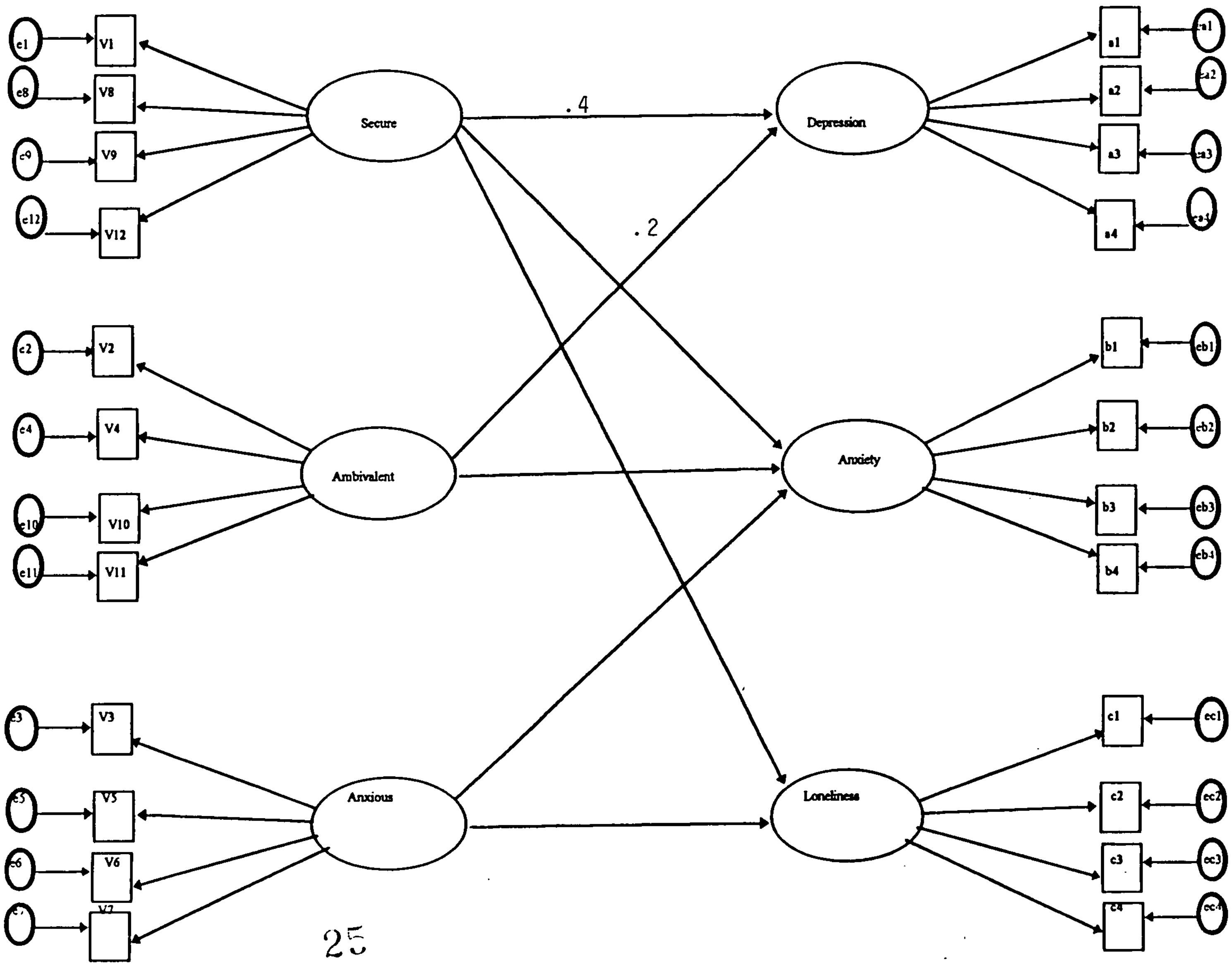


Figure 4.

APPENDIX
Illustration that SEM Subsumes CCA

```
aercanli.aer 12/7/97

07-Dec-97    SPSS RELEASE 4.1 FOR IBM OS/MVS                                       Page    1
07:52:44     TEXAS A&M UNIVERSITY: CIS       IBM 3090-400J    MVS/ESA/JES3

For MVS/ESA/JES3          TEXAS A&M UNIVERSITY: CIS          License Number 1267
This software is functional through August 31, 1998.

   1  0  TITLE 'CANLISRL.SPS  Holzinger & Swineford (1939) Data **'.
   2  0  COMMENT ******************************************************************.
   3  0  COMMENT Holzinger, K.J., & Swineford, F. (1939). A study in factor analysis:.
   4  0  COMMENT   The stability of a bi-factor solution (No. 48). Chicago, IL:.
   5  0  COMMENT   University of Chicago. (data on pp. 81-91).
   6  0  COMMENT ******************************************************************.
   7  0  SET BLANKS=SYSMIS UNDEFINED=WARN.
   8  0  DATA LIST
   9  0    FILE=abc FIXED RECORDS=2 TABLE
  10  0    /1 id 1-3 sex 4-4 ageyr 6-7
  11  0    agemo 8-9 t1 11-12 t2 14-15 t3 17-18 t4 20-21 t5 23-24 t6 26-27 t7 29-30 t8
  12  0    32-33 t9 35-36 t10 38-40 t11 42-44 t12 46-48 t13 50-52 t14 54-56 t15 58-60
  13  0    t16 62-64 t17 66-67 t18 69-70 t19 72-73 t20 74-76 t21 78-79 /2 t22 11-12
  14  0    t23 14-15 t24 17-18 t25 20-21 t26 23-24 .
This command will read 2 records from 'E100BT.HOLZINGR.DTA'
Variable    Rec   Start     End         Format

ID            1       1       3         F3.0
SEX           1       4       4         F1.0
AGEYR         1       6       7         F2.0
AGEMO         1       8       9         F2.0
T1            1      11      12         F2.0
T2            1      14      15         F2.0
T3            1      17      18         F2.0
T4            1      20      21         F2.0
T5            1      23      24         F2.0
T6            1      26      27         F2.0
T7            1      29      30         F2.0
T8            1      32      33         F2.0
T9            1      35      36         F2.0
T10           1      38      40         F3.0
T11           1      42      44         F3.0
T12           1      46      48         F3.0
T13           1      50      52         F3.0
T14           1      54      56         F3.0
T15           1      58      60         F3.0
T16           1      62      64         F3.0
T17           1      66      67         F2.0
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **                    Page    2
07:52:45     TEXAS A&M UNIVERSITY: CIS       IBM 3090-400J    MVS/ESA/JES3

T18           1      69      70         F2.0
T19           1      72      73         F2.0
T20           1      74      76         F3.0
T21           1      78      79         F2.0
T22           2      11      12         F2.0
T23           2      14      15         F2.0
T24           2      17      18         F2.0
T25           2      20      21         F2.0
T26           2      23      24         F2.0
  15  0  EXECUTE.
```

This program was writren by Bruce Thompson, and is used here with ission.

```
  16  0  COMPUTE SCHOOL=1.
  17  0  IF (ID GT 200)SCHOOL=2.
  18  0  IF (ID GE 1 AND ID LE 85)GRADE=7.
  19  0  IF (ID GE 86 AND ID LE 168)GRADE=8.
  20  0  IF (ID GE 201 AND ID LE 281)GRADE=7.
  21  0  IF (ID GE 282 AND ID LE 351)GRADE=8.
  22  0  IF (ID GE 1 AND ID LE 44)TRACK=2.
  23  0  IF (ID GE 45 AND ID LE 85)TRACK=1.
  24  0  IF (ID GE 86 AND ID LE 129)TRACK=2.
  25  0  IF (ID GE 130)TRACK=1.
  26  0  PRINT FORMATS SCHOOL TO TRACK(F1.0).
  27  0  VALUE LABELS SCHOOL(1)PASTEUR (2) GRANT-WHITE/
  28  0    TRACK (1)JUNE PROMOTIONS (2)FEB PROMOTIONS/.
  29  0  VARIABLE LABELS T1 VISUAL PERCEPTION TEST FROM SPEARMAN VPT, PART III
  30  0    T2 CUBES, SIMPLIFICATION OF BRIGHAM'S SPATIAL RELATIONS TEST
  31  0    T3 PAPER FORM BOARD--SHAPES THAT CAN BE COMBINED TO FORM A TARGET
  32  0    T4 LOZENGES FROM THORNDIKE--SHAPES FLIPPED OVER THEN IDENTIFY TARGET
  33  0    T5 GENERAL INFORMATION VERBAL TEST
  34  0    T6 PARAGRAPH COMPREHENSION TEST
  35  0    T7 SENTENCE COMPLETION TEST
  36  0    T8 WORD CLASSIFICATION--WHICH WORD NOT BELONG IN SET
  37  0    T9 WORD MEANING TEST
  38  0    T10 SPEEDED ADDITION TEST
  39  0    T11 SPEEDED CODE TEST--TRANSFORM SHAPES INTO ALPHA WITH CODE
  40  0    T12 SPEEDED COUNTING OF DOTS IN SHAPE
  41  0    T13 SPEEDED DISCRIM STRAIGHT AND CURVED CAPS
  42  0    T14 MEMORY OF TARGET WORDS
  43  0    T15 MEMORY OF TARGET NUMBERS
  44  0    T16 MEMORY OF TARGET SHAPES
  45  0    T17 MEMORY OF OBJECT-NUMBER ASSOCIATION TARGETS
  46  0    T18 MEMORY OF NUMBER-OBJECT ASSOCIATION TARGETS
  47  0    T19 MEMORY OF FIGURE-WORD ASSOCIATION TARGETS
  48  0    T20 DEDUCTIVE MATH ABILITY
  49  0    T21 MATH NUMBER PUZZLES
  50  0    T22 MATH WORD PROBLEM REASONING
  51  0    T23 COMPLETION OF A MATH NUMBER SERIES
  52  0    T24 WOODY-MCCALL MIXED MATH FUNDAMENTALS TEST
  53  0    T25 REVISION OF T3--PAPER FORM BOARD
  54  0    T26 FLAGS--POSSIBLE SUBSTITUTE FOR T4 LOZENGES.
  55  0  SUBTITLE 'CCA ##############'.
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **            Page    3
07:52:45    CCA ##############

  56  0  correlations variables=t6 t7 t2 t4 t20 t21 t22/
  57  0    statistics=all .
PEARSON CORR problem requires 1,120 bytes of workspace.
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **            Page    4
07:52:45    CCA ##############
```

Variable	Cases	Mean	Std Dev
T6	301	9.1827	3.4923
T7	301	17.3621	5.1619
T2	301	24.3522	4.7098
T4	301	18.0033	9.0478
T20	301	26.8904	19.3339
T21	301	14.2492	4.5623
T22	301	26.2392	9.1972

```
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **            Page    5
07:52:45    CCA ##############
```

Variables		Cases	Cross-Prod Dev	Variance-Covar	Variables		Cases	Cross-Prod Dev	Variance-Covar
T6	T7	301	3965.0831	13.2169	T6	T2	301	754.6312	2.5154
T6	T4	301	1503.8173	5.0127	T6	T20	301	6969.0299	23.2301
T6	T21	301	1532.2957	5.1077	T6	T22	301	4312.8439	14.3761
T7	T2	301	1016.6146	3.3887	T7	T4	301	1081.6379	3.6055
T7	T20	301	10080.9502	33.6032	T7	T21	301	2133.8405	7.1128
T7	T22	301	6690.9269	22.3031	T2	T4	301	4344.6478	14.4822
T2	T20	301	7681.6213	25.6054	T2	T21	301	1568.5880	5.2286
T2	T22	301	3653.6445	12.1788	T4	T20	301	17017.1096	56.7237
[illegible]	T21	301	4098.7508	13.6625	T4	T22	301	7643.7608	25.4792
[illegible]	T21	301	10317.2226	34.3907	T20	T22	301	21056.8937	70.1896

T21 T22 301 4742.0598 15.8069

07-Dec-97 CANLISRL.SPS Holzinger & Swineford (1939) Data ** Page 6
07:52:45 CCA ##############

- - Correlation Coefficients - -

	T6	T7	T2	T4	T20	T21	T22
T6	1.0000	.7332**	.1529**	.1586**	.3440**	.3206**	.4476**
T7	.7332**	1.0000	.1394*	.0772	.3367**	.3020**	.4698**
T2	.1529**	.1394*	1.0000	.3398**	.2812**	.2433**	.2812**
T4	.1586**	.0772	.3398**	1.0000	.3243**	.3310**	.3062**
T20	.3440**	.3367**	.2812**	.3243**	1.0000	.3899**	.3947**
T21	.3206**	.3020**	.2433**	.3310**	.3899**	1.0000	.3767**
T22	.4476**	.4698**	.2812**	.3062**	.3947**	.3767**	1.0000

* - Signif. LE .05 ** - Signif. LE .01 (2-tailed) " . " printed if a coefficient cannot be computed

07-Dec-97 CANLISRL.SPS Holzinger & Swineford (1939) Data ** Page 7
07:52:45 CCA ##############

Preceding task required .07 seconds CPU time; .21 seconds elapsed.

```
  58  0  manova t6 t7 with t2 t4 t20 t21 t22/
  59  0     print=signif(multiv eigen dimenr)/
  60  0     discrim=stan cor alpha(.999)/design .
  61  0
```

07-Dec-97 CANLISRL.SPS Holzinger & Swineford (1939) Data ** Page 8
07:52:45 CCA ##############

* * * * * * * * * * * * * * * * * A N A L Y S I S O F V A R I A N C E * * * * * * * * * * * * * * * * * *

301 cases accepted.
0 cases rejected because of out-of-range factor values.
0 cases rejected because of missing data.
1 non-empty cell.
1 design will be processed.

- -

07-Dec-97 CANLISRL.SPS Holzinger & Swineford (1939) Data ** Page 9
07:52:46 CCA ##############

* * * * * * * * * * * * * * * * * A N A L Y S I S O F V A R I A N C E -- DESIGN 1 * * * * * * * * * * * * * * * * * * *

EFFECT .. WITHIN CELLS Regression
Multivariate Tests of Significance (S = 2, M = 1 , N = 146)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.31623	11.08083	10.00	590.00	.000
Hotellings	.44521	13.04463	10.00	586.00	.000
Wilks	.68860	12.05883	10.00	588.00	.000
Roys	.30014				

Note.. F statistic for WILK'S Lambda is exact.

- -

Eigenvalues and Canonical Correlations

Root No.	Eigenvalue	Pct.	Cum. Pct.	Canon Cor.	Sq. Cor
1	.42885	96.32657	96.32657	.54785	.30014
2	.01635	3.67343	100.00000	.12685	.01609

- -

Dimension Reduction Analysis

Roots	Wilks L.	F	Hypoth. DF	Error DF	Sig. of F
1 TO 2	.68860	12.05883	10.00	588.00	.000
[illegible]	.98391	1.20614	4.00	295.00	.308

EFFECT .. WITHIN CELLS Regression (Cont.)
Univariate F-tests with (5,295) D. F.

Variable	Sq. Mul. R	Mul. R	Adj. R-sq.	Hypoth. MS	Error MS	F	Sig. of F
T6	.24924	.49924	.23652	182.39270	9.31182	19.58722	.000
T7	.27358	.52305	.26127	437.37920	19.68350	22.22060	.000

Standardized canonical coefficients for DEPENDENT variables
Function No.

Variable	1	2
T6	.44962	-1.40007
T7	.62246	1.33225

07-Dec-97 CANLISRL.SPS Holzinger & Swineford (1939) Data ** Page 10
07:52:46 CCA ##############

* * * * * * * * * * * * * * * * * * A N A L Y S I S O F V A R I A N C E -- DESIGN 1 * * * * * * * * * * * * * * * * * *

Correlations between DEPENDENT and canonical variables
Function No.

Variable	1	2
T6	.90599	-.42330
T7	.95211	.30576

Variance explained by canonical variables of DEPENDENT variables

CAN. VAR.	Pct Var DEP	Cum Pct DEP	Pct Var COV	Cum Pct COV
1	86.36628	86.36628	25.92187	25.92187
2	13.63372	100.00000	.21938	26.14126

Standardized canonical coefficients for COVARIATES
CAN. VAR.

COVARIATE	1	2
T2	-.01468	.06704
T4	-.20012	-1.00653
T20	.34100	-.02762
T21	.26772	-.17401
T22	.73104	.35974

Correlations between COVARIATES and canonical variables
CAN. VAR.

Covariate	1	2
T2	.28388	-.22399
T4	.21791	-.94015
T20	.66492	-.26099
T21	.60625	-.36609
T22	.90109	-.00605

Variance explained by canonical variables of the COVARIATES

CAN. VAR.	Pct Var DEP	Cum Pct DEP	Pct Var COV	Cum Pct COV
1	10.50305	10.50305	34.99398	34.99398
2	.36567	10.86872	22.72448	57.71846

```
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:46    CCA ##############


11152 bytes of memory are needed for MANOVA execution.
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:46    CCA ##############

Preceding task required .13 seconds CPU time;  1.08 seconds elapsed.

  62  0  SUBTITLE 'Function I   2nd Variate n=301 v=7'.
  63  0  execute .
Preceding task required .01 seconds CPU time;  .03 seconds elapsed.

  64  0  PRELIS
  65  0    /VARIABLES
  66  0    t2 (CO) t4 (CO) t20 (CO) t21 (CO) t22 (CO)
  67  0    t6 (CO) t7 (CO)
  68  0    /TYPE=CORRELATION
  69  0    /MATRIX=OUT(CR1)
Time stamp on saved file:  07-DEC-97 07:52:47
File contains 9 variables, 72 bytes per case before compression
There are 3,044,392 bytes of memory available.
The largest contiguous area has 3,037,808 bytes.


                    P R E L I S    A PREPROCESSOR FOR LISREL

                    PROGRAM VERSION 1.12       DISTRIBUTED BY

                            SCIENTIFIC SOFTWARE, INC.
                            1369 NEITZEL ROAD
                            MOORESVILLE, INDIANA 46158
                            (317) 831-6336


                  THIS COPY AUTHORIZED FOR USE IN SPSS-X
              PROGRAM COPYRIGHT 1987-89 BY SCIENTIFIC SOFTWARE, INC.,
                            (A MICHIGAN CORPORATION).
  DISTRIBUTION OR USE UNAUTHORIZED BY SCIENTIFIC SOFTWARE, INC. IS PROHIBITED.
                             MVS - P R E L I S  1.12
                                       BY
                         KARL G JORESKOG AND DAG SORBOM


THE FOLLOWING PRELIS CONTROL LINES HAVE BEEN READ :


CANLISRL.SPS  HOLZINGER & SWINEFORD (1939) DATA **;
DA NI=7 NO=0 MI= -0.989898D+37 MC=1 TR=LI
LA
   T2        T4        T20       T21       T22       T6        T7
RA FI=PLDDRAW
CO T2
CO T4
CO T20
CO T21
CO T22
CO T6
CO T7
OU MA=KM SM=PLDDMAT WP

TOTAL SAMPLE SIZE =  301
UNIVARIATE SUMMARY STATISTICS FOR CONTINUOUS VARIABLES
```

VARIABLE	MEAN	ST. DEV.	SKEWNESS	KURTOSIS	MINIMUM	FREQ.	MAXIMUM	FREQ.
T2	24.352	4.710	0.475	0.377	9.000	1	37.000	5
T4	18.003	9.048	0.387	-0.879	2.000	1	36.000	6
T20	26.890	19.334	0.493	0.199	-18.000	1	87.000	2
T21	14.249	4.562	-0.311	0.140	1.000	1	24.000	2
T22	26.239	9.197	0.409	-0.188	7.000	2	50.000	5
T6	9.183	3.492	0.270	0.122	0.000	1	19.000	1
T7	17.362	5.162	-0.353	-0.520	4.000	2	28.000	1

```
CANLISRL.SPS  HOLZINGER & SWINEFORD (1939) DATA **;
       ESTIMATED CORRELATION MATRIX
```

	T2	T4	T20	T21	T22	T6	T7
T2	1.000						
T4	0.340	1.000					
T20	0.281	0.324	1.000				
T21	0.243	0.331	0.390	1.000			
T22	0.281	0.306	0.395	0.377	1.000		
T6	0.153	0.159	0.344	0.321	0.448	1.000	
T7	0.139	0.077	0.337	0.302	0.470	0.733	1.000

```
         THE PROBLEM USED      94552 BYTES (=  3.1% OF AVAILABLE WORKSPACE)
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:48     Function I   2nd Variate n=301 v=7

Preceding task required .71 seconds CPU time;  1.86 seconds elapsed.

  70  0  LISREL
  71  0    /"1b  First Function   n=301 v=7"
  72  0    /DA NI=7 NO=301 MA=KM
  73  0    /MATRIX=IN(CR1)
  74  0    /MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR
  75  0     GA=FU,FI PH=SY,FR NX=2 NY=5 NK=2 NE=1
  76  0    /VA 1.0 PH(1,1) PH(2,2)
  77  0    /VA 1.0 LY(1,1)
  78  0    /FR LY(2,1) LY(3,1) LY(4,1) LY(5,1)
  79  0    /FR GA(1,1) GA(1,2)
  80  0    /OU SS FS SL=1 TM=1200 ND=5
There are 3,036,568 bytes of memory available.
The largest contiguous area has 3,030,440 bytes.


                    LISREL 7:  ESTIMATION OF LINEAR STRUCTURAL EQUATION SYSTEMS
                            PROGRAM VERSION 7.16       DISTRIBUTED BY

                            SCIENTIFIC SOFTWARE, INC.
                            1369 NEITZEL ROAD
                            MOORESVILLE, INDIANA 46158
                            (317) 831-6336


                  THIS COPY AUTHORIZED FOR USE IN SPSS-X
              PROGRAM COPYRIGHT 1977-89 BY SCIENTIFIC SOFTWARE, INC.,
                            (A MICHIGAN CORPORATION).
  DISTRIBUTION OR USE UNAUTHORIZED BY SCIENTIFIC SOFTWARE, INC. IS PROHIBITED.
                             MVS - L I S R E L  7.16
                                       BY
                         KARL G JORESKOG AND DAG SORBOM

THE FOLLOWING LISREL CONTROL LINES HAVE BEEN READ :

1b  First Function    n=301 v=7
DA NI=7 NO=301 MA=KM
KM FI=LSDDDTA FO
(5E14.6)
LA
 T2       T4       T20      T21      T22      T6       T7
MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR   C
  GA=FU,FI PH=SY,FR NX=2 NY=5 NK=2 NE=1
VA 1.0 PH(1,1) PH(2,2)
VA 1.0 LY(1,1)
FR LY(2,1) LY(3,1) LY(4,1) LY(5,1)
FR GA(1,1) GA(1,2)
OU SS FS SL=1 TM=1200 ND=5
1b  First Function    n=301 v=7
                           NUMBER OF INPUT VARIABLES  7
                           NUMBER OF Y - VARIABLES    5
                           NUMBER OF X - VARIABLES    2
                           NUMBER OF ETA - VARIABLES  1
                           NUMBER OF KSI - VARIABLES  2
                           NUMBER OF OBSERVATIONS    301
    rst Function    n=301 v=7
```

CORRELATION MATRIX TO BE ANALYZED

	T2	T4	T20	T21	T22	T6	T7
T2	1.00000						
T4	0.33986	1.00000					
T20	0.28121	0.32427	1.00000				
T21	0.24334	0.33099	0.38990	1.00000			
T22	0.28116	0.30619	0.39474	0.37672	1.00000		
T6	0.15293	0.15864	0.34405	0.32058	0.44758	1.00000	
T7	0.13939	0.07720	0.33672	0.30204	0.46980	0.73319	1.00000

1b First Function n=301 v=7

PARAMETER SPECIFICATIONS

LAMBDA Y

	ETA 1
T2	0
T4	1
T20	2
T21	3
T22	4

GAMMA

	T6	T7
ETA 1	5	6

PHI

	T6	T7
T6	7	
T7	8	9

THETA EPS

	T2	T4	T20	T21	T22
T2	10				
T4	11	12			
T20	13	14	15		
T21	16	17	18	19	
T22	20	21	22	23	24

1b First Function n=301 v=7

INITIAL ESTIMATES (TSLS)

LAMBDA Y

	ETA 1
T2	1.00000
T4	1.17397
T20	1.18343
T21	1.16531
T22	1.14421

GAMMA

	T6	T7
ETA 1	0.00000	0.00000

COVARIANCE MATRIX OF ETA AND KSI

	ETA 1	T6	T7
ETA 1	0.00000		
T6	0.00000	1.00000	
T7	0.00000	0.73319	1.00000

THETA EPS

	T2	T4	T20	T21	T22
T2	1.00000				
T4	0.33986	1.00000			
T20	0.28121	0.32427	1.00000		
T21	0.24334	0.33099	0.38990	1.00000	
T22	0.28116	0.30619	0.39474	0.37672	1.00000

SQUARED MULTIPLE CORRELATIONS FOR Y - VARIABLES

T2	T4	T20	T21	T22
0.00000	0.00000	0.00000	0.00000	0.00000

TOTAL COEFFICIENT OF DETERMINATION FOR Y - VARIABLES IS 0.000

1b First Function n=301 v=7

```
LISREL ESTIMATES (MAXIMUM LIKELIHOOD)
        LAMBDA Y
              ETA 1
            --------
      T2    1.00000
      T4    0.76757
     T20    2.34225
     T21    2.13559
     T22    3.17417
        GAMMA
                 T6          T7
            --------    --------
   ETA 1    0.06992     0.09682

        COVARIANCE MATRIX OF ETA AND KSI
             ETA 1         T6          T7
          --------    --------    --------
   ETA 1   0.02419
      T6   0.14091     1.00000
      T7   0.14808     0.73319     1.00000
        THETA EPS
                T2          T4         T20         T21         T22
          --------    --------    --------    --------    --------
      T2   0.97581
      T4   0.32129     0.98575
     T20   0.22455     0.28079     0.86730
     T21   0.19169     0.29134     0.26891     0.88968
     T22   0.20438     0.24726     0.21490     0.21275     0.75629
        SQUARED MULTIPLE CORRELATIONS FOR Y - VARIABLES
                T2          T4         T20         T21         T22
          --------    --------    --------    --------    --------
           0.02419     0.01425     0.13270     0.11032     0.24371
        TOTAL COEFFICIENT OF DETERMINATION FOR Y - VARIABLES IS  0.300


         CHI-SQUARE WITH   4 DEGREES OF FREEDOM =     4.87 (P = .301)
                     GOODNESS OF FIT INDEX =0.995
            ADJUSTED GOODNESS OF FIT INDEX =0.968
                  ROOT MEAN SQUARE RESIDUAL =     0.013
1b  First Function    n=301 v=7
SUMMARY STATISTICS FOR FITTED RESIDUALS
SMALLEST FITTED RESIDUAL =   -0.036
  MEDIAN FITTED RESIDUAL =    0.000
 LARGEST FITTED RESIDUAL =    0.050
STEMLEAF PLOT
- 3|6
- 2|
- 1|40
- 0|90000000000000000000
  0|
  1|24
  2|0
  3|
  4|
  5|0
SUMMARY STATISTICS FOR STANDARDIZED RESIDUALS
SMALLEST STANDARDIZED RESIDUAL =   -2.117
  MEDIAN STANDARDIZED RESIDUAL =    0.000
 LARGEST STANDARDIZED RESIDUAL =    2.117
STEMLEAF PLOT
- 2|1
- 1|
- 1|0
- 0|85
- 0|00000000000000000000
  0|
  0|58
  1|0
```

```
  2¦1
1b  First Function    n=301 v=7
FACTOR SCORES REGRESSIONS
        ETA
                 T2          T4         T20         T21         T22          T6          T7
             --------    --------    --------    --------    --------    --------    --------
   ETA 1     0.00000     0.00000     0.00000     0.00000     0.00000     0.06992     0.09682
        X
                 T2          T4         T20         T21         T22          T6          T7
             --------    --------    --------    --------    --------    --------    --------
      T6     0.00000     0.00000     0.00000     0.00000     0.00000     1.00000     0.00000
      T7     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     1.00000
1b  First Function    n=301 v=7
STANDARDIZED SOLUTION
        LAMBDA Y
              ETA 1
             --------
      T2     0.15553
      T4     0.11938
     T20     0.36428
     T21     0.33214
     T22     0.49367

        GAMMA
                 T6          T7
             --------    --------
   ETA 1     0.44957     0.62250

        CORRELATION MATRIX OF ETA AND KSI
              ETA 1          T6          T7
             --------    --------    --------
   ETA 1     1.00000
      T6     0.90598     1.00000
      T7     0.95212     0.73319     1.00000
        REGRESSION MATRIX ETA ON X (STANDARDIZED)
                 T6          T7
             --------    --------
   ETA 1     0.44957     0.62250
        THE PROBLEM USED      7704 BYTES (=    0.3% OF AVAILABLE WORKSPACE)
                          TIME USED :     0.00 SECONDS
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:50     Function I   2nd Variate n=301 v=7

Preceding task required .44 seconds CPU time;  1.41 seconds elapsed.

  81  0  SUBTITLE 'Function I   1st Variate n=301 v=7'.
  82  0  execute .
Preceding task required .01 seconds CPU time;  .03 seconds elapsed.

  83  0  PRELIS
  84  0    /VARIABLES
  85  0    t6 (CO) t7 (CO)
  86  0    t2 (CO) t4 (CO) t20 (CO) t21 (CO) t22 (CO)
  87  0    /TYPE=CORRELATION
  88  0    /MATRIX=OUT(CR2)
Time stamp on saved file:  07-DEC-97 07:52:50
File contains 9 variables, 72 bytes per case before compression
There are 3,041,056 bytes of memory available.
The largest contiguous area has 3,030,872 bytes.


                     P R E L I S    A PREPROCESSOR FOR LISREL

                     PROGRAM VERSION 1.12       DISTRIBUTED BY

                             SCIENTIFIC SOFTWARE, INC.
                             1369 NEITZEL ROAD
                             MOORESVILLE, INDIANA 46158
                             (317) 831-6336
```

MVS - P R E L I S 1.12
BY
KARL G JORESKOG AND DAG SORBOM

THE FOLLOWING PRELIS CONTROL LINES HAVE BEEN READ :

```
CANLISRL.SPS  HOLZINGER & SWINEFORD (1939) DATA **;
DA NI=7 NO=0 MI= -0.989898D+37 MC=1 TR=LI
LA
   T6         T7         T2         T4         T20        T21        T22
RA FI=PLDDRAW
CO T6
CO T7
CO T2
CO T4
CO T20
CO T21
CO T22
OU MA=KM SM=PLDDMAT WP
```

TOTAL SAMPLE SIZE = 301
UNIVARIATE SUMMARY STATISTICS FOR CONTINUOUS VARIABLES

VARIABLE	MEAN	ST. DEV.	SKEWNESS	KURTOSIS	MINIMUM	FREQ.	MAXIMUM	FREQ.
T6	9.183	3.492	0.270	0.122	0.000	1	19.000	1
T7	17.362	5.162	-0.353	-0.520	4.000	2	28.000	1
T2	24.352	4.710	0.475	0.377	9.000	1	37.000	5
T4	18.003	9.048	0.387	-0.879	2.000	1	36.000	6
T20	26.890	19.334	0.493	0.199	-18.000	1	87.000	2
T21	14.249	4.562	-0.311	0.140	1.000	1	24.000	2
T22	26.239	9.197	0.409	-0.188	7.000	2	50.000	5

CANLISRL.SPS HOLZINGER & SWINEFORD (1939) DATA **;
ESTIMATED CORRELATION MATRIX

	T6	T7	T2	T4	T20	T21	T22
T6	1.000						
T7	0.733	1.000					
T2	0.153	0.139	1.000				
T4	0.159	0.077	0.340	1.000			
T20	0.344	0.337	0.281	0.324	1.000		
T21	0.321	0.302	0.243	0.331	0.390	1.000	
T22	0.448	0.470	0.281	0.306	0.395	0.377	1.000

THE PROBLEM USED 94344 BYTES (= 3.1% OF AVAILABLE WORKSPACE)

```
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:52     Function I   1st Variate n=301 v=7

Preceding task required .72 seconds CPU time;  1.86 seconds elapsed.

  89  0  LISREL
  90  0    /"1a  First Function   n=301 v=7"
  91  0    /DA NI=7 NO=301 MA=KM
  92  0    /MATRIX=IN(CR2)
  93  0    /MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR
  94  0     GA=FU,FI PH=SY,FR NX=5 NY=2 NK=5 NE=1
  95  0    /VA 1.0 PH(1,1) PH(2,2) PH(3,3) PH(4,4) PH(5,5)
  96  0    /VA 1.0 LY(1,1)
  97  0    /FR LY(2,1)
  98  0    /FR GA(1,1) GA(1,2) GA(1,3) GA(1,4) GA(1,5)
  99  0    /OU SS FS SL=1 TM=1200 ND=5
 100  0
There are 3,032,512 bytes of memory available.
The largest contiguous area has 3,026,376 bytes.
```

LISREL 7: ESTIMATION OF LINEAR STRUCTURAL EQUATION SYSTEMS
PROGRAM VERSION 7.16 DISTRIBUTED BY

```
                              SCIENTIFIC SOFTWARE, INC.
                              1369 NEITZEL ROAD
                              MOORESVILLE, INDIANA 46158
                              (317) 831-6336


                    THIS COPY AUTHORIZED FOR USE IN SPSS-X
                PROGRAM COPYRIGHT 1977-89 BY SCIENTIFIC SOFTWARE, INC.,
                              (A MICHIGAN CORPORATION).
   DISTRIBUTION OR USE UNAUTHORIZED BY SCIENTIFIC SOFTWARE, INC. IS PROHIBITED.
                               MVS - L I S R E L  7.16
                                          BY
                           KARL G JORESKOG AND DAG SORBOM


THE FOLLOWING LISREL CONTROL LINES HAVE BEEN READ :


1a  First Function    n=301 v=7
DA NI=7 NO=301 MA=KM
KM FI=LSDDDTA FO
(5E14.6)
LA
 T6        T7        T2        T4        T20       T21       T22
MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR   C
  GA=FU,FI PH=SY,FR NX=5 NY=2 NK=5 NE=1
VA 1.0 PH(1,1) PH(2,2) PH(3,3) PH(4,4) PH(5,5)
VA 1.0 LY(1,1)
FR LY(2,1)
FR GA(1,1) GA(1,2) GA(1,3) GA(1,4) GA(1,5)
OU SS FS SL=1 TM=1200 ND=5
1a  First Function    n=301 v=7
                           NUMBER OF INPUT VARIABLES  7
                           NUMBER OF Y - VARIABLES    2
                           NUMBER OF X - VARIABLES    5
                           NUMBER OF ETA - VARIABLES  1
                           NUMBER OF KSI - VARIABLES  5
                           NUMBER OF OBSERVATIONS   301
1a  First Function    n=301 v=7
        CORRELATION MATRIX TO BE ANALYZED
                   T6          T7          T2          T4         T20         T21         T22
             --------    --------    --------    --------    --------    --------    --------
      T6      1.00000
      T7      0.73319     1.00000
      T2      0.15293     0.13939     1.00000
      T4      0.15864     0.07720     0.33986     1.00000
     T20      0.34405     0.33672     0.28121     0.32427     1.00000
     T21      0.32058     0.30204     0.24334     0.33099     0.38990     1.00000
     T22      0.44758     0.46980     0.28116     0.30619     0.39474     0.37672     1.00000
1a  First Function    n=301 v=7
PARAMETER SPECIFICATIONS
        LAMBDA Y
              ETA 1
             --------
      T6            0
      T7            1
        GAMMA
                   T2          T4         T20         T21         T22
             --------    --------    --------    --------    --------
   ETA 1            2           3           4           5           6
        PHI
                   T2          T4         T20         T21         T22
             --------    --------    --------    --------    --------
      T2            7
      T4            8           9
     T20           10          11          12
     T21           13          14          15          16
     T22           17          18          19          20          21
        THETA EPS
                   T6          T7
             --------    --------
      T6           22
```

```
    T7          23          24
1a  First Function    n=301 v=7

...

LISREL ESTIMATES (MAXIMUM LIKELIHOOD)
        LAMBDA Y
              ETA 1
            --------
      T6    1.00000
      T7    1.05093
        GAMMA
                 T2          T4          T20         T21         T22
            --------    --------    --------    --------    --------
   ETA 1    -0.00729    -0.09934     0.16926     0.13288     0.36285

...

STANDARDIZED SOLUTION
        LAMBDA Y
              ETA 1
            --------
      T6    0.49635
      T7    0.52163

        GAMMA
                 T2          T4          T20         T21         T22
            --------    --------    --------    --------    --------
   ETA 1    -0.01468    -0.20014     0.34100     0.26772     0.73104

        CORRELATION MATRIX OF ETA AND KSI
              ETA 1        T2          T4          T20         T21         T22
            --------    --------    --------    --------    --------    --------
   ETA 1     1.00000
      T2     0.28388     1.00000
      T4     0.21790     0.33986     1.00000
     T20     0.66492     0.28121     0.32427     1.00000
     T21     0.60626     0.24334     0.33099     0.38990     1.00000
     T22     0.90109     0.28116     0.30619     0.39474     0.37672     1.00000
        REGRESSION MATRIX ETA ON X (STANDARDIZED)
                 T2          T4          T20         T21         T22
            --------    --------    --------    --------    --------
   ETA 1    -0.01468    -0.20014     0.34100     0.26772     0.73104
        THE PROBLEM USED      8616 BYTES (=    0.3% OF AVAILABLE WORKSPACE)
                              TIME USED :     0.00 SECONDS
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:53     Function I   1st Variate n=301 v=7

Preceding task required .41 seconds CPU time;  1.40 seconds elapsed.

 101  0  SUBTITLE 'Function II  2nd Variate n=301 v=7'.
 102  0  execute .
Preceding task required .01 seconds CPU time;  .03 seconds elapsed.

 103  0  LISREL
 104  0    /"2b  Second Function  n=301 v=7"
 105  0    /DA NI=7 NO=301 MA=KM
 106  0    /MATRIX=IN(CR1)
 107  0    /MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR
 108  0     GA=FU,FI PH=SY,FR NX=2 NY=5 NK=2 NE=2
 109  0    /VA 1.0 PH(1,1) PH(2,2)
 110  0    /VA 1.0 LY(1,1) LY(1,2)
 111  0    /VA 0.76757 LY(2,1)
 112  0    /VA 2.34225 LY(3,1)
 113  0    /VA 2.13559 LY(4,1)
 114  0    /VA 3.17417 LY(5,1)
      0    /FR LY(2,2) LY(3,2) LY(4,2) LY(5,2)
```

```
 116  0     /VA 0.06992 GA(1,1)
 117  0     /VA 0.09682 GA(1,2)
 118  0    /FR GA(2,1) GA(2,2)
 119  0    /OU SS FS SL=1 TM=1200 ND=5
There are 3,027,680 bytes of memory available.
The largest contiguous area has 3,021,552 bytes.


                    LISREL 7:  ESTIMATION OF LINEAR STRUCTURAL EQUATION SYSTEMS
                            PROGRAM VERSION 7.16       DISTRIBUTED BY

                            SCIENTIFIC SOFTWARE, INC.
                            1369 NEITZEL ROAD
                            MOORESVILLE, INDIANA 46158
                            (317) 831-6336


                  THIS COPY AUTHORIZED FOR USE IN SPSS-X
              PROGRAM COPYRIGHT 1977-89 BY SCIENTIFIC SOFTWARE, INC.,
                            (A MICHIGAN CORPORATION).
  DISTRIBUTION OR USE UNAUTHORIZED BY SCIENTIFIC SOFTWARE, INC. IS PROHIBITED.
                             MVS - L I S R E L  7.16
                                        BY
                          KARL G JORESKOG AND DAG SORBOM


THE FOLLOWING LISREL CONTROL LINES HAVE BEEN READ :


2b  Second Function  n=301 v=7
DA NI=7 NO=301 MA=KM
KM FI=LSDDDTA FO
(5E14.6)
LA
 T2       T4       T20      T21      T22      T6       T7
MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR   C
  GA=FU,FI PH=SY,FR NX=2 NY=5 NK=2 NE=2
VA 1.0 PH(1,1) PH(2,2)
VA 1.0 LY(1,1) LY(1,2)
VA 0.76757 LY(2,1)
VA 2.34225 LY(3,1)
VA 2.13559 LY(4,1)
VA 3.17417 LY(5,1)
FR LY(2,2) LY(3,2) LY(4,2) LY(5,2)
VA 0.06992 GA(1,1)
VA 0.09682 GA(1,2)
FR GA(2,1) GA(2,2)
OU SS FS SL=1 TM=1200 ND=5
2b  Second Function  n=301 v=7
                          NUMBER OF INPUT VARIABLES  7
                          NUMBER OF Y - VARIABLES    5
                          NUMBER OF X - VARIABLES    2
                          NUMBER OF ETA - VARIABLES  2
                          NUMBER OF KSI - VARIABLES  2
                          NUMBER OF OBSERVATIONS   301
2b  Second Function  n=301 v=7
       CORRELATION MATRIX TO BE ANALYZED
```

	T2	T4	T20	T21	T22	T6	T7
T2	1.00000						
T4	0.33986	1.00000					
T20	0.28121	0.32427	1.00000				
T21	0.24334	0.33099	0.38990	1.00000			
T22	0.28116	0.30619	0.39474	0.37672	1.00000		
T6	0.15293	0.15864	0.34405	0.32058	0.44758	1.00000	
T7	0.13939	0.07720	0.33672	0.30204	0.46980	0.73319	1.00000

```
2b  Second Function  n=301 v=7
PARAMETER SPECIFICATIONS
       LAMBDA Y
             ETA 1      ETA 2
```

```
         ________  ________
   T2           0         0
   T4           0         1
  T20           0         2
  T21           0         3
  T22           0         4
    GAMMA
               T6        T7
         ________  ________
ETA 1           0         0
ETA 2           5         6
    PHI
               T6        T7
         ________  ________
   T6           7
   T7           8         9
    THETA EPS
               T2        T4       T20       T21       T22
         ________  ________  ________  ________  ________
   T2          10
   T4          11        12
  T20          13        14        15
  T21          16        17        18        19
  T22          20        21        22        23        24
2b  Second Function  n=301 v=7

...

STANDARDIZED SOLUTION
    LAMBDA Y
            ETA 1     ETA 2
         ________  ________
   T2     0.15553   0.02842
   T4     0.11938   0.11927
  T20     0.36429   0.03311
  T21     0.33215   0.04645
  T22     0.49368   0.00077
```

GAMMA

	T6	T7
ETA 1	**0.44956**	**0.62251**
ETA 2	**1.40013**	**-1.33228**

```
    CORRELATION MATRIX OF ETA AND KSI
            ETA 1     ETA 2        T6        T7
         ________  ________  ________  ________
ETA 1     1.00000
ETA 2    -0.00001   1.00000
   T6     0.90598   0.42332   1.00000
   T7     0.95212  -0.30572   0.73319   1.00000
    REGRESSION MATRIX ETA ON X (STANDARDIZED)
               T6        T7
         ________  ________
ETA 1     0.44956   0.62251
ETA 2     1.40013  -1.33228
    THE PROBLEM USED     8072 BYTES (=   0.3% OF AVAILABLE WORKSPACE)
                        TIME USED :    0.00 SECONDS
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:54     Function II  2nd Variate n=301 v=7

Preceding task required .63 seconds CPU time;  1.45 seconds elapsed.

 120  0  SUBTITLE 'Function II  1st Variate n=301 v=7'.
 121  0  execute .
Preceding task required .01 seconds CPU time;  .03 seconds elapsed.

 122  0  LISREL
 123  0    /"2a  Second Function  n=301 v=7"
      0    /DA NI=7 NO=301 MA=KM
      0    /MATRIX=IN(CR2)
```

```
/MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR
 GA=FU,FI PH=SY,FR NX=5 NY=2 NK=5 NE=2
/VA 1.0 PH(1,1) PH(2,2) PH(3,3) PH(4,4) PH(5,5)
/VA 1.0 LY(1,1) LY(1,2)
  /VA 1.05093 LY(2,1)
/FR LY(2,2)
  /VA -.00729 GA(1,1)
  /VA -.09934 GA(1,2)
  /VA 0.16926 GA(1,3)
  /VA 0.13288 GA(1,4)
  /VA 0.36285 GA(1,5)
/FR GA(2,1) GA(2,2) GA(2,3) GA(2,4) GA(2,5)
/OU SS FS SL=1 TM=1200 ND=5

There are 3,024,192 bytes of memory available.
The largest contiguous area has 3,018,040 bytes.

          LISREL 7:  ESTIMATION OF LINEAR STRUCTURAL EQUATION SYSTEMS
                 PROGRAM VERSION 7.16       DISTRIBUTED BY

                 SCIENTIFIC SOFTWARE, INC.
                 1369 NEITZEL ROAD
                 MOORESVILLE, INDIANA 46158
                 (317) 831-6336

            THIS COPY AUTHORIZED FOR USE IN SPSS-X
        PROGRAM COPYRIGHT 1977-89 BY SCIENTIFIC SOFTWARE, INC.,
                 (A MICHIGAN CORPORATION).
  DISTRIBUTION OR USE UNAUTHORIZED BY SCIENTIFIC SOFTWARE, INC. IS PROHIBITED.
                  MVS - L I S R E L  7.16
                            BY
               KARL G JORESKOG AND DAG SORBOM

THE FOLLOWING LISREL CONTROL LINES HAVE BEEN READ :

2a  Second Function  n=301 v=7
DA NI=7 NO=301 MA=KM
KM FI=LSDDDTA FO
(5E14.6)
LA
 T6       T7       T2       T4       T20      T21      T22
MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR   C
  GA=FU,FI PH=SY,FR NX=5 NY=2 NK=5 NE=2
VA 1.0 PH(1,1) PH(2,2) PH(3,3) PH(4,4) PH(5,5)
VA 1.0 LY(1,1) LY(1,2)
VA 1.05093 LY(2,1)
FR LY(2,2)
VA -.00729 GA(1,1)
VA -.09934 GA(1,2)
VA 0.16926 GA(1,3)
VA 0.13288 GA(1,4)
VA 0.36285 GA(1,5)
FR GA(2,1) GA(2,2) GA(2,3) GA(2,4) GA(2,5)
OU SS FS SL=1 TM=1200 ND=5
2a  Second Function  n=301 v=7
                          NUMBER OF INPUT VARIABLES  7
                          NUMBER OF Y - VARIABLES    2
                          NUMBER OF X - VARIABLES    5
                          NUMBER OF ETA - VARIABLES  2
                          NUMBER OF KSI - VARIABLES  5
                          NUMBER OF OBSERVATIONS    301
2a  Second Function  n=301 v=7
        CORRELATION MATRIX TO BE ANALYZED
                T6        T7        T2        T4        T20       T21       T22
             --------  --------  --------  --------  --------  --------  --------
```

T6	1.00000						
T7	0.73319	1.00000					
T2	0.15293	0.13939	1.00000				
T4	0.15864	0.07720	0.33986	1.00000			
T20	0.34405	0.33672	0.28121	0.32427	1.00000		
T21	0.32058	0.30204	0.24334	0.33099	0.38990	1.00000	
T22	0.44758	0.46980	0.28116	0.30619	0.39474	0.37672	1.00000

2a Second Function n=301 v=7

PARAMETER SPECIFICATIONS

LAMBDA Y

	ETA 1	ETA 2
T6	0	0
T7	0	1

GAMMA

	T2	T4	T20	T21	T22
ETA 1	0	0	0	0	0
ETA 2	2	3	4	5	6

PHI

	T2	T4	T20	T21	T22
T2	7				
T4	8	9			
T20	10	11	12		
T21	13	14	15	16	
T22	17	18	19	20	21

THETA EPS

	T6	T7
T6	22	
T7	23	24

2a Second Function n=301 v=7

...

STANDARDIZED SOLUTION

LAMBDA Y

	ETA 1	ETA 2
T6	0.49635	0.05370
T7	0.52163	-0.03878

GAMMA

	T2	**T4**	**T20**	**T21**	**T22**
ETA 1	**-0.01469**	**-0.20014**	**0.34101**	**0.26771**	**0.73104**
ETA 2	**-0.06706**	**1.00653**	**0.02762**	**0.17402**	**-0.35972**

CORRELATION MATRIX OF ETA AND KSI

	ETA 1	ETA 2	T2	T4	T20	T21	T22
ETA 1	1.00000						
ETA 2	0.00001	1.00000					
T2	0.28387	0.22399	1.00000				
T4	0.21790	0.94015	0.33986	1.00000			
T20	0.66493	0.26101	0.28121	0.32427	1.00000		
T21	0.60625	0.36611	0.24334	0.33099	0.38990	1.00000	
T22	0.90109	0.00607	0.28116	0.30619	0.39474	0.37672	1.00000

REGRESSION MATRIX ETA ON X (STANDARDIZED)

	T2	T4	T20	T21	T22
ETA 1	-0.01469	-0.20014	0.34101	0.26771	0.73104
ETA 2	-0.06706	1.00653	0.02762	0.17402	-0.35972

THE PROBLEM USED 9480 BYTES (= 0.3% OF AVAILABLE WORKSPACE)

TIME USED : 0.00 SECONDS

07-Dec-97 CANLISRL.SPS Holzinger & Swineford (1939) Data **

07:52:56 Function II 1st Variate n=301 v=7

AERA

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE
(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Structural Equation Modeling versus Ordinary Least Squares Canonical Analysis: Some Heuristic Comparisons	
Author(s): Thomas E. Dawson	
Corporate Source:	Publication Date: 4/13/98

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce the identified document, please CHECK ONE of the following options and sign the release below.

[X] ← Sample sticker to be affixed to document

Check here
Permitting microfiche (4"x 6" film), paper copy, electronic, and optical media reproduction

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
THOMAS E. DAWSON
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Level 1

Sample sticker to be affixed to document → [ ]

"PERMISSION TO REPRODUCE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY
Sample
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

or here
Permitting reproduction in other than paper copy.

Level 2

Sign Here, Please

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries."

Signature: Thomas E. Dawson	Position: RES ASSOCIATE
Printed Name: THOMAS E. DAWSON	Organization: TEXAS A&M UNIVERSITY
Address: TAMU DEPT EDUC PSYC COLLEGE STATION, TX 77843-4225	Telephone Number: (409) 845-1831
	Date: 3/18/98