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AUTHOR Thompson, Bruce; Borrello, Gloria M.
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ABSTRACT

The application and utility of confirmatory second-order factor analytic methods are discussed. Factor analysis is central to concerns regarding measurement validity. Confirmatory methods are especially useful because they explicitly consider measurement error influences and because the methods are inherently theory-driven and theory-oriented. Second-order confirmatory methods, which have not been applied with great frequency in the literature, allow the researcher to explore more thoroughly a reality that may be just as complex as are other formulated models. To make the explanation of applying confirmatory second-order methods more concrete, a data set involving responses of 487 undergraduates and graduate students (representing three pooled samples from previous research studies) to the Hendrick-Hendrick love instrument was analyzed for heuristic purposes. Two tables contain data from the study. Two appendices contain seven additional tables related to the analysis. A 31-item list of references is included. (Author/SLD)

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# MEASURING SECOND-ORDER FACTORS USING CONFIRMATORY METHODS: A CASE STUDY EXAMPLE WITH THE HENDRICK-HENDRICK LOVE INSTRUMENT

Bruce Thompson
Texas A&M University 77843-4225

Gloria M. Borrello
University of New Orleans

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ABSTRACT

The present study illustrates the application, and the utility, of confirmatory second-order factor analytic methods. Factor analysis is central to concerns regarding measurement validity. Confirmatory methods are especially useful, because they explicitly consider measurement error influences, and because the methods are inherently theory-driven and theory-oriented. Second-order confirmatory methods, not applied with great frequency in the literature, offer the promise of allowing the researcher to explore more thoroughly a reality which many see as being just as complex as some of the models that we have been led to formulate. To make the explanation of applying confirmatory second-order methods more concrete, a data set involving responses of 487 subjects to the Hendrick-Hendrick love instrument is analyzed for heuristic purposes.

Factor analytic studies of measurement integrity are important, as Nunnally (1978, pp. 111-112) notes:

> construct validity has been spoken of as "trait validity" and "factorial validity".... Factor analysis is intimately involved with questions of validity... Factor analysis is at the heart of the measurement of psychological constructs.

Gorsuch (1983, pp. 350-351, emphasis added) concurs, noting that "A prime use of factor analysis has been in the development of *both* the theoretical constructs for an area and the operational representatives for the theoretical constructs." Similarly, C. Hendrick and S. Hendrick (1986, p. 393) note that "theory building and construct measurement are joint bootstrap operations." Factor analysis at once both tests measurement integrity and sheds light on underlying theory. Confirmatory factor analytic methods are particularly important, because these methods overcome the tendency of exploratory methods to capitalize on error. However, confirmatory factor analytic methods do tend to require fairly large sample sizes (Baldwin, 1989).

Second-order factor analytic methods can yield especially useful insights for some problems, but are little understood and are somewhat infrequently applied by researchers (Thompson, Webber & Berenson, 1990). Many researchers are familiar with the extraction of principal components principal factors from either a variance-covariance matrix or a correlation matrix. However, the factors extracted from such matrices, called first-order factors, can be rotated obliquely such that the rotated factors themselves are correlated. This interfactor matrix can then, in turn, also be subject to factor analysis. These "higher order" factors would be termed second-order factors. As Kerlinger (1984, p. xiv) noted, "while ordinary factor analysis is probably well understood, second-order factor analysis, a vitally important part of the analysis, seems not to be widely known and understood." Example applications of second-order factor analysis are reported by Kerlinger (1984), Thompson and Borrello (1986), and by Thompson and Miller (1981). Thompson (1990) offers a program that automates exploratory second-order analysis.

Logically, if confirmatory factor analytic methods are useful, and if second-order methods are useful, the combination of these methods might also prove useful. The combination was very briefly alluded to by Joreskog and Sorbom (1986, p. I.11). Marsh and his colleagues (Marsh, 1985; Marsh & Hocevar, 1985, 1988; Marsh & Richards, 1987) has elaborated this application. The purpose of the present paper was to illustrate the potential utility of combining confirmatory and second-order methods, and to illustrate the mechanics of the analysis. To make the discussion concrete, the application is illustrated using real data not previously analyzed using confirmatory second-order methods.

## Heuristic Example

Behavioral scientists have traditionally eschewed scholarly inquiry regarding love phenomena. As Wrightsman and Deaux (1981, p. 170) observe, researchers have historically "believed that love is too mysterious and too intangible for scientific study." Initial investigations of love phenomena conducted during the 1940s were "followed by nearly a 20-year period in which there is almost no published evidence of efforts to investigate love phenomena using inventories or paper-and-pencil testing" (Elkins & Smith, 1979, p. 10). For example, Curtin (1973) found that love was not mentioned in the 23 volumes of the Annual Review of Psychology that he surveyed. However, as C. Hendrick and S. Hendrick (1986, p. 392) note, "During the past decade, love has become respectable as an area for study by psychologists." Work by Rubin (1984), by Sternberg and Grajek (1984), and by Tennov (1979) illustrates efforts to develop science in the area of love phenomena.

One series of studies of love has been inductive (Thompson & Borrello, 1990). Another series of studies has been deductively grounded (Borrello & Thompson, 1990, in press; C. Hendrick & S. Hendrick, 1986, in press; S. Hendrick & C. Hendrick, 1987; C. Hendrick, S. Hendrick, Foote & Slapion-Foote, 1984) in Lee's (1973/1976) typology of three primary love styles: (a) **eros**, which is romantic or passionate love, (b) **ludus**, which is game playing love, and (c) **storge**, which is friendship love. Lee suggests that three secondary styles are formed as compounds of the primary styles, but still have their own unique properties and characters: (d) **mania**, which is a compound of ludus and eros, (e) **pragma**, which is a compound of storge and ludus, and (f) **agape**, which is a compound of eros and storge.

In at least three major studies with discrete and large cohorts of subjects Hendrick and Hendrick have consistently found that their measure yields a six-dimensional orthogonal structure corresponding to the elements of Lee's (1973/1976) typology. However, Lee's model might be interpreted as being hierarchical, and one appropriate test of the model would employ hierarchical factor analysis, as against the conventional nonhierarchical factor analytic methods used in most of the previous studies, and to implement the analysis using confirmatory methods.

## Method

### Subjects

Subjects in the study were 487 undergraduate and graduate students who have participated in previous studies (Borrello & Thompson, 1987, 1989a, 1989b; Thompson & Borrello, 1987) focusing on a measure other than C. Hendrick and S. Hendrick's (1986, in press). However, as part of one study (Thompson & Borrello, 1987) 260 subjects completed the 18 items, three per factor for each of the six factors, that were most highly correlated with the structure isolated by C. Hendrick and S. Hendrick (1986). In other studies 227 (176 + 51) subjects completed the same 18 items from the Hendrick-Hendrick measure and two additional items from the measure. These two items measure the Agape and Mania constructs in the Lee typology. For the purposes of the present study these three samples were pooled. Table 1 presents the demographic characteristics of the samples.

INSERT TABLE 1 ABOUT HERE.

## Analysis

The analysis in the present study was implemented using LISREL (Joreskog & Sorbom, 1986) to fit a second-order model to the data (n=487) based on the interitem correlation matrix. The variance-covariance matrix is certainly another sensible candidate for analysis, and the same basic logic is applied in such an analysis. Four matrices are estimated in a second-order analysis.

The first matrix is the first-order factor matrix, called "LAMBDA X" in LISREL. This matrix has v rows, corresponding to the number of variables. In the present example, v was 18. The number of columns in the matrix equals the number of first-order factors posited plus the number of second-order factors posited. The illustrative model posited the existence of the six dimensions named by Lee (1973/1976). Each first-order factor was "marked" by three variables. One second-order (potentially "G") factor was presumed in the model tested, i.e., it was posited that all six first-order factors might be associated with a single higher-order factor, as suggested by findings in some previous research (e.g., Sternberg & Grajek, 1984) isolating "G" or general factor dynamics.

Usually it is wise to isolate factor positions with several variables, so that factor positions are more fully constrained. So that the model will be mathematically "identified", one coefficient per first-order factor is fixed with a value of 1.0. Typically, in every v by f+s "LAMBDA Y" matrix, f entries are constrained to be ones, v-f entries are free to be estimated based on the data in hand, and (v times f+s)-v entries are constrained to be zeroes.

Thus, in the present example, $f$=6 entries were fixed to be ones, 12 ($y$=18 minus $f$=6) entries were free to be estimated, and 108 ($y$=18 times $f$=6+$s$=1 minus $y$=18) entries were fixed to be zeroes.

The second matrix is the second-order factor matrix, called "BETA" in LISREL. This matrix has $f$+$s$ rows and columns. Typically, $s$ entries are constrained to be ones so that the model is mathematically "identified", $f$-$s$ entries are free to be estimated based on the data in hand, and ($f$+$s$ times $f$+$s$)-$f$ entries are constrained to be zeroes. Thus, in the present example, $s$=1 entry was fixed to be a one, 5 ($f$=6 minus $s$=1) entries were free to be estimated, and 43 ($f$+$s$=7 times $f$+$s$=7 minus $f$=6) entries were fixed to be zeroes.

The third matrix is the factor variance matrix, called "PSI" in LISREL. This is a triangular matrix with $f$+$s$ diagonal entries and ($f$+$s$ times $f$+$s$-1)/2 unique off-diagonal entries. Typically, the off-diagonal entries will be fixed to be zeroes and the diagonal entries are estimated. Thus, in the present study $f$+$s$=7 entries in the "PSI" matrix were estimated.

The fourth matrix is a one-dimensional array of length $y$. This matrix estimates the combination of both the measurement error and the unique variances associated with each variable. These entries are akin to ones minus the communality coefficients in exploratory factor analysis. If this matrix is constrained to consist of zeroes, a model analogous to a principal components model is being evaluated. Typically, the entries in this matrix are set free to vary, as they were here.

Table 2 presents the model fit to the data for the 487 subjects. With 129 degrees of freedom, the chi-square goodness of fit statistic was 390.14. The fit index was .912, while the adjusted fit index was .884. These results suggest that the model is plausible, though reasonable fit never rules out that possibility that alternative models may also fit the data.

INSERT TABLE 2 ABOUT HERE.

## Discussion

The Table 2 data can be consulted to illustrate both the mechanics of the interpretation process, and the potential utility of confirmatory second-order methods. There have been some indications in previous research with other measures (cf. Sternberg & Grajek, 1984; Borrello & Thompson, 1989a) that a "G" or general factor dominates the factor space underlying love, and that other factors exist as thematic variation about this overriding dimension. Given that the model was a reasonable fit to the data, the second-order analysis can be consulted to explore this issue.

The standard errors of the estimates can be consulted to facilitate interpretation of the maximum-likelihood estimates presented in Table 2. Most of the standard errors for the "LAMBDA Y" estimates were about .08; the largest standard error (.161) was for item 14, a Ludus item, which had a "LAMBDA" estimate of .940. Most of the standard errors of the "BETA" estimates were about .09; the largest standard error (.130) was for the Agape factor, which involved an estimate of .785. The standard errors associated with the "PSI" matrix ranged from .053 (Agape) to .180 (Storge). Since the estimates were uniformly several times their standard errors, all the estimates presented in Table 2 warrant attention during interpretation.

The "BETA" coefficients for Mania and Agape (and to some extent for Pragma) for the second-order factor suggest that a fairly dominant Mania-Agape combination underlies the structure. The entries in the "PSI" matrix confirm this impression. As Marsh and Hocevar (1985, p. 570) explain, "When a lower order factor is incorporated into a higher order factor, the diagonal of psi is a factor residual; otherwise, the diagonal value of psi is a factor variance."

A residual first-order factor variance of .922 suggests that Storge does not play much of a role in the second-order factor. The relatively small residual factor variances for Mania (.104) and Agape (.246) suggest that the second-order factor contains a goodly portion of these two first-order factors. The variance of the second-order factor (.420) is also itself commensurate with the residual variances for first-order factors Ludus (.423), Pragma (.439), and Eros (.530).

Taken together, these results appear supportive of a model of love positing the existence of a Mania-Agape factor somewhat dominating the factor space in the presence of several more thematic factors. This view is consistent with some findings in studies employing different measures and different analytic methods (e.g., Sternberg & Grajek, 1984).

In summary, the present study has illustrated the application, and hopefully the utility, of confirmatory second-order factor analytic methods. Confirmatory methods are useful, because they explicitly consider measurement error influences, and because the methods are inherently theory-driven and theory-oriented. Second-order confirmatory methods offer the promise of allowing the researcher to explore more thoroughly a reality which many see as being just as complex as some of the models that we have been led to formulate.

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Table 1
Sample Demographic Characteristics

| Study | Mean Age[a] | *n* Female | *n* |
|---|---|---|---|
| Borrello & Thompson (1987) | 32.9 (5.5) | 135(76.7%) | 176 |
| Thompson & Borrello (1987) | 35.4 (7.1) | 207(79.6%) | 260 |
| New subjects added by Borrello & Thompson (1989a) | 36.1(11.0) | 34(66.7%) | 51 |
| Total | 35.0 (7.5) | 376(77.2%) | 487 |

[a]Standard deviations are presented in parentheses next to means.

Table 2
Confirmatory Second-Order Solution
($\underline{n}$=487, $\underline{v}$=18)

| LAMBDA Y Item | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE | LOVE G |
|---|---|---|---|---|---|---|---|
| Eros 2 | .000 | .838 | .000 | .000 | .000 | .000 | .000 |
| Ludus 8 | 1.000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Storge18 | .000 | .000 | 1.000 | .000 | .000 | .000 | .000 |
| Pragma25 | .000 | .000 | .000 | .000 | 1.000 | .000 | .000 |
| Mania 33 | .000 | .000 | .000 | .887 | .000 | .000 | .000 |
| Agape 38 | .000 | .000 | .000 | .000 | .000 | 1.000 | .000 |
| Pragma27 | .000 | .000 | .000 | .000 | .636 | .000 | .000 |
| Eros 4 | .000 | 1.000 | .000 | .000 | .000 | .000 | .000 |
| Storge21 | .000 | .000 | .602 | .000 | .000 | .000 | .000 |
| Agape 39 | .000 | .000 | .000 | .000 | .000 | .985 | .000 |
| Mania 32 | .000 | .000 | .000 | 1.000 | .000 | .000 | .000 |
| Ludus 14 | .940 | .000 | .000 | .000 | .000 | .000 | .000 |
| Agape 42 | .000 | .000 | .000 | .000 | .000 | .979 | .000 |
| Mania 31 | .000 | .000 | .000 | .881 | .000 | .000 | .000 |
| Pragma26 | .000 | .000 | .000 | .000 | .548 | .000 | .000 |
| Storge20 | .000 | .000 | .336 | .000 | .000 | .000 | .000 |
| Ludus 9 | .609 | .000 | .000 | .000 | .000 | .000 | .000 |
| Eros 7 | .000 | .670 | .000 | .000 | .000 | .000 | .000 |

| BETA | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE | LOVE G |
|---|---|---|---|---|---|---|---|
| LUDUS | .000 | .000 | .000 | .000 | .000 | .000 | .246 |
| EROS | .000 | .000 | .000 | .000 | .000 | .000 | .327 |
| STORGE | .000 | .000 | .000 | .000 | .000 | .000 | .175 |
| MANIA | .000 | .000 | .000 | .000 | .000 | .000 | 1.000 |
| PRAGMA | .000 | .000 | .000 | .000 | .000 | .000 | .524 |
| AGAPE | .000 | .000 | .000 | .000 | .000 | .000 | .785 |
| LOVE G | .000 | .000 | .000 | .000 | .000 | .000 | .000 |

| PSI | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE | LOVE G |
|---|---|---|---|---|---|---|---|
| LUDUS | .423 | | | | | | |
| EROS | .000 | .530 | | | | | |
| STORGE | .000 | .000 | .922 | | | | |
| MANIA | .000 | .000 | .000 | .104 | | | |
| PRAGMA | .000 | .000 | .000 | .000 | .439 | | |
| AGAPE | .000 | .000 | .000 | .000 | .000 | .246 | |
| LOVE G | .000 | .000 | .000 | .000 | .000 | .000 | .420 |

Note. Entries of ".000" were all constrained or fixed to be zeroes; entries of "1.000" were all fixed to be ones; all other results were maximum-likelihood estimates that were considered "free" in the model fit to the data.

## Appendix A:

## R Matrices for 18 Items Administered to 487 Subjects (Below Diagonal) and for 20 Items for a Subsample of 227 Subjects (Above Diagonal)

| Item | 2E | 8L | 18S | 25P | 33M | 38A | 27P | 4E | 21S | 39A | 32M | 14L | 42A | 31M | 26P | 20S | 9L | 7E | 37A | 34M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2E | | -127 | 117 | 007 | -063 | 062 | -055 | 486 | 131 | 131 | 042 | -133 | 111 | -024 | 132 | 006 | -047 | 348 | 155 | 087 |
| 8L | -140 | | 061 | 141 | 244 | -049 | 205 | -212 | 054 | -146 | 133 | 414 | -172 | 169 | 060 | 026 | 340 | 030 | -129 | 012 |
| 18S | 056 | 079 | | 043 | 012 | -068 | 110 | 065 | 584 | 117 | 073 | -094 | -044 | -015 | 184 | 248 | 038 | 027 | 040 | -056 |
| 25P | -002 | 156 | 122 | | 205 | 098 | 302 | -016 | -001 | 101 | 135 | 148 | 066 | 151 | 234 | 109 | 061 | 141 | 017 | -041 |
| 33M | 028 | 236 | 033 | 210 | | 261 | 121 | -015 | -051 | 253 | 470 | 140 | 219 | 410 | 128 | -039 | 221 | 052 | 240 | 128 |
| 38A | 069 | -044 | 000 | 194 | 306 | | 072 | 099 | 007 | 471 | 288 | 020 | 499 | 124 | 018 | -025 | 009 | 071 | 427 | 068 |
| 27P | -094 | 206 | 090 | 365 | 130 | 089 | | -049 | 098 | 064 | 194 | 208 | -013 | 114 | 122 | 064 | 137 | 012 | -061 | 036 |
| 4E | 491 | -152 | 022 | 049 | 061 | 128 | -076 | | 056 | 228 | 060 | -199 | 193 | 024 | 222 | 054 | -033 | 423 | 250 | 144 |
| 21S | 120 | 032 | 563 | 066 | 040 | 067 | 015 | 097 | | 177 | -054 | -056 | -005 | -044 | 159 | 118 | -045 | -056 | 026 | -063 |
| 39A | 225 | -088 | 126 | 130 | 263 | 502 | 085 | 254 | 200 | | 391 | 012 | 527 | 119 | 138 | -045 | 046 | 146 | 457 | 119 |
| 32M | 087 | 153 | 081 | 172 | 446 | 348 | 196 | 061 | 020 | 381 | | 056 | 340 | 448 | 117 | -027 | 126 | 103 | 247 | 225 |
| 14L | -116 | 420 | -011 | 098 | 147 | 004 | 199 | -176 | -048 | 015 | 121 | | 004 | 136 | -094 | -038 | 258 | 020 | -092 | 022 |
| 42A | 180 | -146 | 029 | 160 | 230 | 496 | -004 | 254 | 110 | 481 | 365 | 030 | | 247 | 039 | -050 | -073 | 122 | 548 | -025 |
| 31M | 046 | 165 | 005 | 163 | 443 | 244 | 112 | 080 | 028 | 217 | 457 | 173 | 331 | | 045 | -100 | 121 | 017 | 140 | 004 |
| 26P | 132 | 081 | 160 | 305 | 095 | 124 | 150 | 240 | 177 | 193 | 109 | -040 | 151 | 141 | | 269 | 126 | 177 | 155 | 085 |
| 20S | -001 | -022 | 315 | 118 | -080 | 024 | 083 | 009 | 184 | -016 | -028 | -082 | 004 | -144 | 103 | | 069 | 133 | 025 | -036 |
| 9L | -069 | 277 | 064 | 040 | 174 | -026 | 179 | -074 | -016 | 000 | 041 | 257 | -094 | 040 | 065 | 084 | | 064 | -066 | 185 |
| 7E | 310 | 067 | 018 | 132 | 176 | 165 | 055 | 378 | 022 | 164 | 159 | 018 | 102 | 112 | 143 | 056 | 022 | | 179 | 135 |
| 37A | | | | | | | | | | | | | | | | | | | | 072 |

Note. The item names indicate the number of each item in the Hendrick-Hendrick measure, and subscale membership is reported as the alphabetic code following each item number. The abbreviations are: "A" = Agape; "E" = Eros; "L" = Ludus; "M" = Mania; "P" = Pragma; and "S" = Storge. Thus, item "2E" was the second item from the Hendrick-Hendrick measure and was associated with the Eros subscale in their studies.

## Appendix B.1

Confirmatory First-Order Solution Positing Uncorrelated Factors
($n$=487, $v$=18)

| LAMBDA X Item | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE |
|---|---|---|---|---|---|---|
| Eros 2 | .000 | .635 | .000 | .000 | .000 | .000 |
| Ludus 8 | .673 | .000 | .000 | .000 | .000 | .000 |
| Storge18 | .000 | .000 | .982 | .000 | .000 | .000 |
| Pragma25 | .000 | .000 | .000 | .000 | .859 | .000 |
| Mania 33 | .000 | .000 | .000 | .658 | .000 | .000 |
| Agape 38 | .000 | .000 | .000 | .000 | .000 | .720 |
| Pragma27 | .000 | .000 | .000 | .000 | .424 | .000 |
| Eros 4 | .000 | .774 | .000 | .000 | .000 | .000 |
| Storge21 | .000 | .000 | .573 | .000 | .000 | .000 |
| Agape 39 | .000 | .000 | .000 | .000 | .000 | .697 |
| Mania 32 | .000 | .000 | .000 | .678 | .000 | .000 |
| Ludus 14 | .625 | .000 | .000 | .000 | .000 | .000 |
| Agape 42 | .000 | .000 | .000 | .000 | .000 | .609 |
| Mania 31 | .000 | .000 | .000 | .674 | .000 | .000 |
| Pragma26 | .000 | .000 | .000 | .000 | .354 | .000 |
| Storge20 | .000 | .000 | .321 | .000 | .000 | .000 |
| Ludus 9 | .411 | .000 | .000 | .000 | .000 | .000 |
| Eros 7 | .000 | .488 | .000 | .000 | .000 | .000 |

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL:
CHI-SQUARE WITH 135 DEGREES OF FREEDOM IS 585.40 (PROB. LEVEL = .000)
GOODNESS OF FIT INDEX IS .881
ADJUSTED GOODNESS OF FIT INDEX IS .849
ROOT MEAN SQUARE RESIDUAL IS .122

## Appendix B.2
## Confirmatory First-Order Solution Positing Correlated Factors
## ($n$=487, $v$=18)

LAMBDA X

| Item | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE |
|---|---|---|---|---|---|---|
| Eros 2 | .000 | .622 | .000 | .000 | .000 | .000 |
| Ludus 8 | .769 | .000 | .000 | .000 | .000 | .000 |
| Storge18 | .000 | .000 | .906 | .000 | .000 | .000 |
| Pragma25 | .000 | .000 | .000 | .000 | .689 | .000 |
| Mania 33 | .000 | .000 | .000 | .654 | .000 | .000 |
| Agape 38 | .000 | .000 | .000 | .000 | .000 | .687 |
| Pragma27 | .000 | .000 | .000 | .000 | .500 | .000 |
| Eros 4 | .000 | .796 | .000 | .000 | .000 | .000 |
| Storge21 | .000 | .000 | .620 | .000 | .000 | .000 |
| Agape 39 | .000 | .000 | .000 | .000 | .000 | .705 |
| Mania 32 | .000 | .000 | .000 | .713 | .000 | .000 |
| Ludus 14 | .547 | .000 | .000 | .000 | .000 | .000 |
| Agape 42 | .000 | .000 | .000 | .000 | .000 | .713 |
| Mania 31 | .000 | .000 | .000 | .640 | .000 | .000 |
| Pragma26 | .000 | .000 | .000 | .000 | .431 | .000 |
| Storge20 | .000 | .000 | .344 | .000 | .000 | .000 |
| Ludus 9 | .384 | .000 | .000 | .000 | .000 | .000 |
| Eros 7 | .000 | .474 | .000 | .000 | .000 | .000 |

PHI

| | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE |
|---|---|---|---|---|---|---|
| LUDUS | 1.000 | | | | | |
| EROS | -.238 | 1.000 | | | | |
| STORGE | .077 | .067 | 1.000 | | | |
| MANIA | .358 | .165 | .061 | 1.000 | | |
| PRAGMA | .335 | .125 | .234 | .404 | 1.000 | |
| AGAPE | -.128 | .385 | .105 | .645 | .321 | 1.000 |

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL:
CHI-SQUARE WITH 120 DEGREES OF FREEDOM IS 285.92 (PROB. LEVEL = .000)
GOODNESS OF FIT INDEX IS .938
ADJUSTED GOODNESS OF FIT INDEX IS .912
ROOT MEAN SQUARE RESIDUAL IS .056

Appendix B.3

Confirmatory First-Order Solution Positing Uncorrelated Factors (n=260 from Thompson & Borrello, 1987, v=18)

| LAMBDA X Item | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE |
|---|---|---|---|---|---|---|
| Eros 2 | .000 | .638 | .000 | .000 | .000 | .000 |
| Ludus 8 | .600 | .000 | .000 | .000 | .000 | .000 |
| Storge18 | .000 | .000 | .925 | .000 | .000 | .000 |
| Pragma25 | .000 | .000 | .000 | .000 | .945 | .000 |
| Mania 33 | .000 | .000 | .000 | .657 | .000 | .000 |
| Agape 38 | .000 | .000 | .000 | .000 | .000 | .768 |
| Pragma27 | .000 | .000 | .000 | .000 | .445 | .000 |
| Eros 4 | .000 | .778 | .000 | .000 | .000 | .000 |
| Storge21 | .000 | .000 | .587 | .000 | .000 | .000 |
| Agape 39 | .000 | .000 | .000 | .000 | .000 | .686 |
| Mania 32 | .000 | .000 | .000 | .649 | .000 | .000 |
| Ludus 14 | .718 | .000 | .000 | .000 | .000 | .000 |
| Agape 42 | .000 | .000 | .000 | .000 | .000 | .644 |
| Mania 31 | .000 | .000 | .000 | .733 | .000 | .000 |
| Pragma26 | .000 | .000 | .000 | .000 | .385 | .000 |
| Storge20 | .000 | .000 | .411 | .000 | .000 | .000 |
| Ludus 9 | .358 | .000 | .000 | .000 | .000 | .000 |
| Eros 7 | .000 | .438 | .000 | .000 | .000 | .000 |

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL:
CHI-SQUARE WITH 135 DEGREES OF FREEDOM IS 446.60 (PROB. LEVEL = .000)
GOODNESS OF FIT INDEX IS .837
ADJUSTED GOODNESS OF FIT INDEX IS .793

## Appendix B.4
### Confirmatory First-Order Solution Positing Correlated Factors
### (n=260 from Thompson & Borrello, 1987, v=18)

LAMBDA X

| Item | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE |
|---|---|---|---|---|---|---|
| Eros 2 | .000 | .647 | .000 | .000 | .000 | .000 |
| Ludus 8 | .734 | .000 | .000 | .000 | .000 | .000 |
| Storge18 | .000 | .000 | .903 | .000 | .000 | .000 |
| Pragma25 | .000 | .000 | .000 | .000 | .801 | .000 |
| Mania 33 | .000 | .000 | .000 | .643 | .000 | .000 |
| Agape 38 | .000 | .000 | .000 | .000 | .000 | .720 |
| Pragma27 | .000 | .000 | .000 | .000 | .500 | .000 |
| Eros 4 | .000 | .765 | .000 | .000 | .000 | .000 |
| Storge21 | .000 | .000 | .600 | .000 | .000 | .000 |
| Agape 39 | .000 | .000 | .000 | .000 | .000 | .681 |
| Mania 32 | .000 | .000 | .000 | .690 | .000 | .000 |
| Ludus 14 | .590 | .000 | .000 | .000 | .000 | .000 |
| Agape 42 | .000 | .000 | .000 | .000 | .000 | .697 |
| Mania 31 | .000 | .000 | .000 | .705 | .000 | .000 |
| Pragma26 | .000 | .000 | .000 | .000 | .462 | .000 |
| Storge20 | .000 | .000 | .420 | .000 | .000 | .000 |
| Ludus 9 | .332 | .000 | .000 | .000 | .000 | .000 |
| Eros 7 | .000 | .443 | .000 | .000 | .000 | .000 |

PHI

| | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE |
|---|---|---|---|---|---|---|
| LUDUS | 1.000 | | | | | |
| EROS | -.210 | 1.000 | | | | |
| STORGE | .121 | .013 | 1.000 | | | |
| MANIA | .379 | .270 | .080 | 1.000 | | |
| PRAGMA | .278 | .142 | .267 | .381 | 1.000 | |
| AGAPE | -.089 | .460 | .179 | .718 | .408 | 1.000 |

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL:
CHI-SQUARE WITH 120 DEGREES OF FREEDOM IS 246.79 (PROB. LEVEL = .000)
GOODNESS OF FIT INDEX IS .905
ADJUSTED GOODNESS OF FIT INDEX IS .864
ROOT MEAN SQUARE RESIDUAL IS .068

## Appendix B.5
## Confirmatory Second-Order Solution
## ($n$=260 from Thompson & Borrello, 1987, $v$=18)

LAMBDA Y

| Item | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE | LOVE G |
|---|---|---|---|---|---|---|---|
| Eros 2 | .000 | .850 | .000 | .000 | .000 | .000 | .000 |
| Ludus 8 | .800 | .000 | .000 | .000 | .000 | .000 | .000 |
| Storge18 | .000 | .000 | 1.000 | .000 | .000 | .000 | .000 |
| Pragma25 | .000 | .000 | .000 | .000 | 1.000 | .000 | .000 |
| Mania 33 | .000 | .000 | .000 | .902 | .000 | .000 | .000 |
| Agape 38 | .000 | .000 | .000 | .000 | .000 | 1.000 | .000 |
| Pragma27 | .000 | .000 | .000 | .000 | .568 | .000 | .000 |
| Eros 4 | .000 | 1.000 | .000 | .000 | .000 | .000 | .000 |
| Storge21 | .000 | .000 | .727 | .000 | .000 | .000 | .000 |
| Agape 39 | .000 | .000 | .000 | .000 | .000 | .940 | .000 |
| Mania 32 | .000 | .000 | .000 | .988 | .000 | .000 | .000 |
| Ludus 14 | 1.000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Agape 42 | .000 | .000 | .000 | .000 | .000 | .935 | .000 |
| Mania 31 | .000 | .000 | .000 | 1.000 | .000 | .000 | .000 |
| Pragma26 | .000 | .000 | .000 | .000 | .528 | .000 | .000 |
| Storge20 | .000 | .000 | .492 | .000 | .000 | .000 | .000 |
| Ludus 9 | .477 | .000 | .000 | .000 | .000 | .000 | .000 |
| Eros 7 | .000 | .616 | .000 | .000 | .000 | .000 | .000 |

BETA

| | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE | LOVE G |
|---|---|---|---|---|---|---|---|
| LUDUS | .000 | .000 | .000 | .000 | .000 | .000 | .087 |
| EROS | .000 | .000 | .000 | .000 | .000 | .000 | .474 |
| STORGE | .000 | .000 | .000 | .000 | .000 | .000 | .250 |
| MANIA | .000 | .000 | .000 | .000 | .000 | .000 | .762 |
| PRAGMA | .000 | .000 | .000 | .000 | .000 | .000 | .530 |
| AGAPE | .000 | .000 | .000 | .000 | .000 | .000 | 1.000 |
| LOVE G | .000 | .000 | .000 | .000 | .000 | .000 | .000 |

PSI

| | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE | LOVE G |
|---|---|---|---|---|---|---|---|
| LUDUS | .537 | | | | | | |
| EROS | .000 | .461 | | | | | |
| STORGE | .000 | .000 | .719 | | | | |
| MANIA | .000 | .000 | .000 | .215 | | | |
| PRAGMA | .000 | .000 | .000 | .000 | .574 | | |
| AGAPE | .000 | .000 | .000 | .000 | .000 | .049 | |
| LOVE G | .000 | .000 | .000 | .000 | .000 | .000 | .484 |

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL:
CHI-SQUARE WITH 129 DEGREES OF FREEDOM IS 303.03 (PROB. LEVEL = .000)
GOODNESS OF FIT INDEX IS .880
ADJUSTED GOODNESS OF FIT INDEX IS .841
ROOT MEAN SQUARE RESIDUAL IS .083

Appendix B.6
Confirmatory First-Order Solution Positing Correlated Factors
($n$=227 from Borrello & Thompson, 1987, [$n$=176]
and Borrello & Thompson, 1989a, [$n$=51] $v$=20)

LAMBDA X

| Item | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE |
|---|---|---|---|---|---|---|
| Eros 2 | .000 | .607 | .000 | .000 | .000 | .000 |
| Ludus 8 | .793 | .000 | .000 | .000 | .000 | .000 |
| Storge18 | .000 | .000 | .965 | .000 | .000 | .000 |
| Pragma25 | .000 | .000 | .000 | .000 | .546 | .000 |
| Mania 33 | .000 | .000 | .000 | .674 | .000 | .000 |
| Agape 38 | .000 | .000 | .000 | .000 | .000 | .636 |
| Pragma27 | .000 | .000 | .000 | .000 | .511 | .000 |
| Eros 4 | .000 | .813 | .000 | .000 | .000 | .000 |
| Storge21 | .000 | .000 | .605 | .000 | .000 | .000 |
| Agape 39 | .000 | .000 | .000 | .000 | .000 | .702 |
| Mania 32 | .000 | .000 | .000 | .742 | .000 | .000 |
| Ludus 14 | .518 | .000 | .000 | .000 | .000 | .000 |
| Agape 42 | .000 | .000 | .000 | .000 | .000 | .775 |
| Mania 31 | .000 | .000 | .000 | .575 | .000 | .000 |
| Pragma26 | .000 | .000 | .000 | .000 | .378 | .000 |
| Storge20 | .000 | .000 | .257 | .000 | .000 | .000 |
| Ludus 9 | .445 | .000 | .000 | .000 | .000 | .000 |
| Eros 7 | .000 | .522 | .000 | .000 | .000 | .000 |
| Agape 37 | .000 | .000 | .000 | .000 | .000 | .684 |
| Mania 34 | .000 | .000 | .000 | .192 | .000 | .000 |

PHI

| | LUDUS | EROS | STORGE | MANIA | PRAGMA | AGAPE |
|---|---|---|---|---|---|---|
| LUDUS | 1.000 | | | | | |
| EROS | -.263 | 1.000 | | | | |
| STORGE | .038 | .104 | 1.000 | | | |
| MANIA | .342 | .066 | .036 | 1.000 | | |
| PRAGMA | .394 | .105 | .215 | .425 | 1.000 | |
| AGAPE | -.188 | .328 | .018 | .534 | .148 | 1.000 |

MEASURES OF GOODNESS OF FIT FOR THE WHOLE MODEL:
CHI-SQUARE WITH 155 DEGREFS OF FREEDOM IS 217.92 (PROB. LEVEL = .001)
GOODNESS OF FIT INDEX IS .913
ADJUSTED GOODNESS OF FIT INDEX IS .882
ROOT MEAN SQUARE RESIDUAL IS .063