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ABSTRACT

Confirmatory Factor Analysis was used to test first- and second-order factor models on cognitive abilities and their invariance across male and female samples. Subjects were a stratified random sample of 234 male and 225 female 15-year-old students in Singapore attending Secondary 3 (the equivalent of grade 9). Four first-order factors were found underlying the 23 subtest scores of 2 group intelligence tests, the AH(sub 4) Test of Intelligence and the Advanced Progressive Matrices, and 2 group Piagetian tests, Science Reasoning Tasks and the Arlin Test of Formal Reasoning. Slight differences found in the formal operations, spatial, numerical, and verbal factors of the male and female groups suggest some gender-related differences in these factors. There were two alternative second-order general factor models for the male group, one with three first-order factors and the other with four first-order factors. Only a general factor model with three first-order factors could fit the data of the female sample. This female group model contains some differences in the loading of the formal operations and spatial factors, when compared with that of the male group. Eight tables present study findings. (Author/SLD)

GENDER-RELATED DIFFERENCES IN INTELLIGENCE: APPLICATION OF CONFIRMATORY FACTOR ANALYSIS[1]

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ABSTRACT

Confirmatory Factor Analysis was used to test first- and second-order factor models on cognitive abilities and their invariance across male and female samples. Four first-order factors were found underlying the 23 subtest scores of two group intelligence tests, the AH_4 Test of Intelligence and the Advanced Progressive Matrices, and two group Piagetian tests, Science Reasoning Tasks and Arlin Test of Formal Reasoning. Slight differences found in the formal operations, spatial, numerical and verbal factors of the male and female groups suggested some gender-related differences in these factors. There were two alternative second-order general factor models for the male group, one with three first-order factors and the other with four first-order factors. Only a general factor model with three first-order factors could fit the data of the female sample; this female group model contains some differences in the loadings of the formal operations and spatial factors, when compared with that of the male group.

INTRODUCTION

Most empirical studies on cognitive differences between males and female students generally showed that males performed better on certain tests of visual-spatial and quantitative ability while females performed better on measures of verbal ability (Harris, 1979; Jensen, 1980; Maccoby &

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Jacklin, 1974). Hyde (1981) conducted a meta-analysis of the studies reviewed in Maccoby and Jacklin and found small gender-related differences in performance in intelligence tests. Another meta-analytic review by Hyde and Linn (1988) found, through trend analyses, that such differences among adolescents have decreased markedly over the past generation. While these studies explored mean differences in the performances of males and females, other studies in Feingold (1992) examined gender differences in variability; males were found to be consistently more variable than females in quantitative reasoning and spatial visualization.

A few studies tackled gender-related differences in the factor structure of abilities underlying intelligence tests. Hertzog and Carter (1982) established two factors, spatial and verbal, underlying 10 different cognitive tests, e.g., WAIS and Ravens Progressive Matrices. They were able to establish evidence of substantial invariance in the factor pattern and factor covariance matrices in males and females, but were unable to reject the hypothesis of complete invariance. They concluded that males and females had somewhat similar cognitive structures. In a similar investigation, Hyde, Geiringer and Yen (1975) found fairly similar factor structures between males and females, but there were differences in the loadings of the spatial factor. Both studies used confirmatory factor analysis to fit a hypothesized factor structure simultaneously across the male and female group and found this to be more useful than comparing factor analytic results from two independent analyses.

In the past, studies on the factor structure of intelligence tended to focus on first-order factors rather than higher-order factors or the general factor. Humphreys (1971) attributed the neglect of the general factor to the popularity of the group factor model and the almost universal restriction of that model to factors in the first-order only. Recently, studies by Undheim and Gustafsson (1987), Rindskopf and Rose (1988), and Keith (1990) used higher-order factor analysis. Keith carried out the hierarchical confirmatory factor analysis of Elliot's (1990) Differential Ability Scales (DAS) and found that the DAS provided a robust measure of the general factor. Rindskopf and Rose as well as Undheim and Gustafsson also tested higher-order factor models in the structure of ability, using different intelligence tests. Both Keith and Undheim and Gustafsson tested the invariance of the structure of intelligence across different age groups.

In studies on Piagetian tests, Meehan (1984) carried out a meta-analysis of 53 studies on formal reasoning and showed differences in favour of the males, but with no more than 1% to 5% of the variance explained by gender. Males performed better on Piagetian tasks such as pendulum, equilibrium balance, inclined plane and floating bodies. The structure underlying Piagetian tests have not been studied extensively.

The above studies indicate a need to do further research in gender-related differences in factor structures of cognitive abilities underlying both intelligence and Piagetian tests. Such studies would, as Halpern (1986) pointed out, help us to determine whether males and females used similar abilities in how they solve cognitive problems. The focus of this study was on the factor structure underlying two group intelligence tests, the AH_4 Test of Intelligence and the Advanced Progressive matrices, and two group Piagetian tests, Science Reasoning Tasks and the Arlin Test of Formal Reasoning. It used confirmatory factor analysis to test first- and second-order factor models on cognitive abilities and their invariance across male and female adolescent groups.

METHOD

Sample

The data for the study were collected in Singapore for a dissertation that considered the relationships between intelligence and Piagetian tests (Lim, 1988). The study was conducted on a stratified random sample of 459 fifteen-year-old students in Singapore. This sample consisted of 234 males and 225 females attending Secondary 3 (the equivalent of Grade 9) in Singapore schools. The instruments administered were two group intelligence tests and two group Piagetian tests.

Instrument

The AH_4 Test of Intelligence (Heim, 1970) stresses deductive reasoning and has verbal/numerical and nonverbal items on items on directions, opposites, analogies, series and simple computations. There are eleven subscales in this test. Raven's (1962) Advanced Progressive

Matrices (APM) assesses mental ability by means of abstract analogical reasoning tasks. The APM consists of designs which requires completion; the examinee selects from multiple-choice options, the segment which completes the design most appropriately. A correct answer may complete a pattern or analogy, systematically alter a pattern, introduce systematic permutations or systematically resolves figures into parts.

The Science Reasoning Tasks (SRT) are designed by Shayer (1979) to measure the ability of children and adults to use concrete and formal reasoning strategies. The seven SRT correspond closely to the original Piagetian tasks (Inhelder & Piaget, 1958), three of the SRT, volume, pendulum and balance are administered to the present sample. The Arlin (1984) Test of Formal Reasoning (ATFR) is designed as a group test to assess abilities associated with the formal operations stage. The items are applications of Piaget's principles and not a direct translation of the Piagetian tasks. The test is organized into eight subtests, each measuring one formal "schema" or specific ability: volume, probability, correlation, combinations, proportions, momentum, mechanical equilibrium and frames of reference.

ANALYSES AND RESULTS

Data

The 23 variables used in the study were the subtest scores of the four tests listed in Table 1: **APM**, **B1** to **B11** (the subtests of the AH_4), **C1** to **C8** (the subtests of the ATFR) and **T1** to **T3** (the SRT). Summary statistics computed for the variables, in Table 1, indicated that female students had significantly lower mean scores and greater variability in the APM, all the nonverbal subtests of the AH_4, the SRT and 3 subtests of the ATFR. Surprisingly, the female students did not score significantly higher in the verbal scores.

Insert Table 1 here

Initially, a first-order factor model was developed to fit the data of the male group. It was then fitted simultaneously across the two groups. From this initial analysis, models were developed to explore the differences in the factor structure of both males and females. The process was then repeated with second-order factor models.

First-Order Confirmatory Factor Analysis

The analyses were performed within the LISREL framework developed by Joreskog and Sorbom (Joreskog, 1969; Joreskog & Sorbom, 1979, 1984). In the basic model developed for the male group, Model 1 (M1), the unspecified parameters were estimated by the maximum likelihood method. The hypothesized structure of M1, based on previous exploratory and confirmatory factor analysis on the combined sample of male and female students (Lim, 1988), was fitted to the data of the male group. The LX matrix of M1 contained the hypothesized structure of the loadings of the 23 variables on the four first-order factors. It had 22 of the parameters set free to be estimated by LISREL.

All the parameters in the PH matrix were set free for estimation, since the four factors were correlated with each other. All the uniqueness components of the 23 variables (the diagonal elements of the TD matrix) were also set free to be estimated by the model. As presented in Table 2, M1 had a good fit, as shown by the χ^2 of 244.03 with 226 degrees of freedom and a probability value of .196. Thus four factors adequately reproduced the intercorrelation matrix of the male sample. A description of this factor structure is given below.

Insert Table 2 here

To determine whether the factor structure of M1 would fit the female sample, i.e., whether M1 was invariant over both the male and female groups, the factor structure of M1 was simultaneously fitted to the data of both groups, producing Model 2 (M2). M2, as shown in Table

2, did not fit the two groups as the χ^2 for testing the goodness of fit of the model was 643.44 with 502 degrees of freedom and a probability value of less than .001. The hypothesis that there were no quantitative differences between the male and female groups was rejected.

Model 3 (M3) had the same pattern of free fixed and starting values for the data of both the male and female groups, but without the cross-group constraints of equal quantitative values for the parameters. M3 did not fit the data with a χ^2 of 569.59, based on 452 degrees of freedom and a probability value of less than .001. Since M3 was nested within M2, one could compare the two models; the difference in the χ^2 of 73.85 with 50 degrees of freedom turned out to be statistically significant at a probability value of less than .05 (see Table 2). There appeared to be differences between the factor structure of the male and female samples.

To explore the differences between the factor structure of the two samples, Model 4 (M4) hypothesized equal number of factors in the two groups, but that the factor pattern in the LX matrices might be different. The TD and PH matrices had the same pattern of fixed and free values and same starting values for the two groups. As established in Table 2, the fit of M4 is good, with a χ^2 value of 488.44, 499 degrees of freedom and a probability value of .097. There was a highly significant difference between M3 and M4; the χ^2 difference between the two models was 81.85 with 3 degrees of freedom. Essentially, the LX matrix of the female group had the pattern of the male group but with the relaxation of 3 additional paths.

Insert Table 3 here

Table 3 depicts the standardized path patterns of the LX matrices of both the male and female groups. The 4 first-order factors of the two groups were identified as Factor A (formal operations factor), Factor B (spatial factor), Factor C (numerical factor) and Factor D (verbal factor). In both groups, Factor A had loadings of the SRT, Volume , Pendulum and Balance tasks (T1 to T3), 5 of the eight subtests of the ATFR (C1, C2, C4, C5, and C8), the APM and nonverbal superimpositions of the AH_4 (**B11**). An additional variable, nonverbal analogies (**B7**), loaded on Factor A of the female group.

In the male and female samples, all the nonverbal tests of the AH_4, (**B7** to **B11**) loaded on Factor B, the spatial factor. In the female group, the APM also loaded on this factor. Factor C had loadings of the numerical subtests of the AH_4, (**B1**, **B3**, and **B5**), as well as verbal analogies (**B4**). As in the other 2 factors for the female group, there is an additional variable, Momentum (**C6**), loading on Factor C. Factor D, the verbal factor, had the same structure for both groups, with loadings of verbal opposites and synonyms (**B2**, **B6**) and numerical series (**B3**).

Second-Order Confirmatory Factor Analysis

The study on the relationships between intelligence and Piagetian tests, from which this data base was taken, demonstrated a second-order factor underlying the structure of the sample of 459 males and females (Lim, 1988). To explore gender-related differences across the second-order factor structure, the invariance of the second-order factor model across the male and female groups were tested.

Within the LISREL framework, the second-order confirmatory factor analysis requires the specification of 5 matrices: LY, GA PH, TE and PS (Rindskopf and Rose, 1988). In Model 5 (M5), the LY matrix (structure similar to LX matrix of M4 of the male group) contained the hypothesized structure of the loadings of the 23 variables on the four first-order factors while the GA matrix showed the hypothesized structure of these factors on the second-order factor. The PH matrix with the single second-order factor was set at 1.0. All the uniqueness components of the 23 variables (the diagonal elements of the TE matrix) and the uniqueness components of the first-order factors (the diagonal elements of the PS matrix) were also set free to be estimated by the model.

Insert Table 4 here

The hypothesized structure of M5 was fitted to the intercorrelation matrix of the male sample. Table 4 showed that M5 had a good fit to the data of the male sample, with a χ^2 value of 254.72, 227 degrees of freedom and a probability value of .10. As in the analysis of the first-order factor model, M5 was simultaneously fitted across the male and female samples with the 5 invariant matrices, giving rise to Model 6 (M6). M6 did not fit the data since the χ^2 value of 601.50 and 480 degrees of freedom had a probability value of less than .001 (see Table 4).

As M6 was not invariant across the male and female groups, M5 was then fitted across the two groups, with the 5 matrices specified as having the same pattern of fixed and free values and the same starting values. This relaxation of the invariance specifications in Model 7 (M7), as shown in Table 4, did not produce a good fit of the model (χ^2 of 576.64 with 454 degrees of freedom and a probability value of less than .001). However the significant difference in the χ^2 between M6 and M7 (χ^2_{diff} of 73.07, df_{diff} of 49 and a probability value of less than .05) indicated differences between the second-order factor structures of the 2 groups.

It was decided in the next model (M8) to relax three paths in the LY matrix of the female group (similar to the three paths in the LX matrix of the female group of M4). The other matrices (GA, PH, PS and TE) had the same patterns of fixed and free values and same starting values for both the groups. M8 fitted the data across the two groups with a χ^2 of 491.40, 451 degrees of freedom and a probability value of .092 (see Table 4). However there were problems with M8 despite the "acceptable" fit according to the χ^2 goodness of fit test: the PS matrix of the female group was not positive definite, factor 3 had negative residuals and a standardized coefficient of greater than one for the path of variable 3 on Factor 4 and the path of Factor 3 on the general factor.

An examination of the correlation matrix of the 23 variables (3 clusters of variables shown) and the correlation matrix of the four first-order factors indicated the possibility of more first-order factors being modelled in M8, particularly for the female group, than are well defined in the data. The correlation matrix of the first-order factors of the female group showed high correlation coefficients between factors 1 and 3 and between factors 3 and 4 ($r > .80$), suggesting a lack of clear definition of these as separate factors. Alternative models with 3 first-order factors were explored, in the first instance, for the data of the female group.

Insert Table 5 here

A hypothesized structure with 3 first-order factors (numerical and verbal factors combined to form Factor 3) was fitted to the data of the female group. There were problems with verbal opposites (B1); a Heywood case was encountered with it and setting the unique variance of the variable to zero did not help. It was only when variable 3 was deleted, that there was an acceptable fit of the model, M9, in Table 6 (χ^2 of 230.10 with 206 degrees of freedom and a probability value of .120). Deletion of a variable to get an acceptable fit was in line with the LISREL analyses on the hierarchical organization of cognitive abilities carried out by Undheim and Gustafsson (1987).

Insert Table 6 here

An alternative model of three factors was then explored for the male group. Model 10 (M10) had the same number of variables and factors as M9, but with a slightly different pattern for LY matrix. The other matrices (GA, PH, PS and TE) had the same patterns of fixed and free values and same starting values as for M9. As reported in Table 6, the fit of M10 was good, with a χ^2 value of 214.16, 208 degrees of freedom and a probability value of .370. M10 was then fitted simultaneously across the data of the male and female groups, with 2 additional paths released in the LY matrix of the female group, giving rise to Model 11 (M11). GA, PH, PS and TE matrices had the same patterns of fixed and free values and same starting values in both groups. M11, as indicated in Table 6, fitted the data across the two groups with a χ^2 of 435.37, 414 degrees of freedom, and a probability value of .226.

The LY matrices (Table 7) and the GA matrices (Table 8) of M11 illustrate the structure of the first- and second-order factor structures of the male and female groups. Factor A is the formal operations factor, Factor B is the spatial factor and Factor C is the verbal/numerical factor; all 3 factors load on the general factor. There is a slight difference in Factor A in the two groups; the female group has an additional loading of non-verbal analogies (**B7**) in the formal operations factor. Similarly, the female group has an additional loading of the **APM** in Factor B. Factor C has loadings of the verbal and numerical variables in both groups.

Insert Table 7 here

Insert Table 8 here

DISCUSSION

In this study, there are alternative models that are able to fit the data of the male group: M5 (Table 4) has a hierarchical structure of one general factor and four first-order factors while M10 (Table 6) has one general factor with three first-order factors. Loehlin (1992) pointed out that it would be prudent to look at alternative models; the fact that one model fits the data reasonably well does not mean that there could not be other, different models that can also fit the data. At best, a given model represents a tentative explanation of the data. In comparing the fit of Models 5 and 10, it would appear that M10 has a better fit, more parsimonious and a lower χ^2/df ratio. The first-order matrix of the male group in Models 4 and 5 (shown in Table 3) are similar; Factor C, the numerical factor, has a loading of a verbal subtest, while Factor D, the verbal factor, has a loading of a numerical test. The first-order matrix of the male group in M10, similar to that of M11 (Table 7), has a simpler structure in that all the numerical and verbal tests load on one factor.

In the first-order structures of the male and female groups in M11 (Table 7), Factor A, the formal operations factor, is loaded by all the Piagetian tasks of the SRT, 6 subtests of the ATFR and the APM. In the validity study of ATFR, Arlin (1982) did not discuss the validity of the two variables that did not load on Factor A, Correlations and Equilibrium; they may not be measuring formal operations skills. The female group has an additional loading of non-verbal analogies (**B7**) in Factor A, suggesting that females may be using formal reasoning to solve spatial analogies.

Factor B, the spatial factor, as expected, is loaded by all the nonverbal tests of the AH_4. However, the female group has an additional loading of the **APM** in this factor. This reinforced the observation of possible differences in the way males and females handle spatial analogies. The findings of slightly different loadings of variables on the spatial factor for males and females is somewhat consistent with the findings of Hyde et al. (1975), which suggested that females could be using different approaches to solve spatial problems. In addition, Herzog and Carter (1982) found Raven's Progressive Matrices to be factorially complex, further suggesting that analogical matrices could be solved by either verbal or spatial strategies.

Factor C is loaded by the numerical and verbal subtests of AH_4 in both groups. The lack of a distinctive numerical or quantitative factor is also found in Kline (1989). Kline could not fit a four factor model (verbal reasoning, quantitative reasoning, abstract/visual reasoning and short-term memory) to the data on the standardization of the fourth edition Stanford Binet test (5013 subjects from 5 to 23 years of age). He was only able to fit a three factor model (Verbal, non-verbal and memory) to the data. In this study however, a four first-order factor model, with separate numerical and verbal factors could also be fitted to the data of the male group. This leads to the interesting possibility that males and females could be using different strategies to solve numerical problems. Could the females be using verbal approaches to solve numerical problems, leading to less efficient strategies and lower scores. Generally, this study has shown that males and females appear to use different slightly different approaches to solving spatial analogies, matrices and numerical problems. Further research may be needed to identify the approaches and strategies used.

REFERENCES

Arlin, P. K. (1982) A multitrait-multimethod validity study of a test of formal reasoning, Educational and Psychological Measurement , 42, 1077 - 1088.

Arlin, P. K. (1984) Arlin Test of Formal Reasoning East Aurora, NY: Slosson.

Feingold, A. (1992) Sex differences in variability in intellectual abilities: A new look at an old controversy, Review of Educational Research, 62, 1, 61 - 84.

Harris, L. J. (1979) Sex-related differences in spatial ability: A developmental psychological view. In C. Kopp (Ed.) Becoming female: Perspectives on Development, New York: Plenum.

Heim, A. W. (1970) Manual for the AH, group test of General Intelligence, Windsor: NFER.

Hertzog, C. & Carter, L. (1982) Sex differences in the structure of intelligence: A confirmatory factor analysis, Intelligence, 6, 287 - 303.

Humphreys, L. G. (1979) The construct of general intelligence, Intelligence, 3, 105 - 120.

Hyde, J. S. (1981) How large are cognitive gender sex differences? A meta-analysis using ω^2 and *d*, American Psychologist, 36, 892 - 901.

Hyde, J. S., Geiringer, E. R. & Yen, W. M. (1975) On the empirical relation between spatial ability and sex differences in other aspects of cognitive performance, Multivariate Behavioral Research, 10, 289 - 309.

Hyde, J. S. & Linn, M. C. (1988) Gender differences in verbal ability: A meta-analysis. 3, Psychological Bulletin, 107, 139 - 153.

Inhelder, B. & Piaget, J. (1958) The growth of Logical Thinking from Childhood to Adolescence, New York: Basic Books.

Jensen, A. R. (1980) Bias in Mental Testing New York: Free Press.

Joreskog, K. G. (1969) A general approach to confirmatory maximum likelihood factor analysis, Psychometrica, 32, 443 - 482.

Keith, T. Z. (1990) Confirmatory and hierarchical confirmatory maximum analysis of the differential ability scales, Journal of Psychoeducational Assessment, 8, 391 - 405.

Kline, R. B. (1989) Is the fourth edition Stanford-Binet a four-factor test: Confirmatory analysis of alternative models for ages 2 through 23, Journal of Psychoeducational Assessment, 7, 4 - 13.

Lim, T. K. (1988) Relationships between standardized psychometric and Piagetian measures of intelligence at the formal operational level, Intelligence, 12, 167 - 182.

Loehlin, J. C. (1992) Latent Variable Models: An introduction to factor, path and structural analysis, Hillsdale, N.J.: Erlbaum.

Maccoby, E. E. & Jacklin, C. N. (1974) The Psychology of Sex Differences, Stanford: Stanford University Press.

Meehan, A. M. (1984) A meta-analysis of sex differences in formal operational thought, Child Development, 55, 1110 - 1124.

Raven, J. C. (1962) Advanced Progressive Matrices London: Lewis.

Rindskopf, D. & Rose, T. (1988) Some theory and applications of confirmatory second-order factor analysis, Multivariate Behavioral Research, 23, 51 -67.

Shayer, M. (1979) Has Piaget's construct of operational thinking any utility, British Journal of Educational Psychology, 492, 266 - 276.

Undheim, J. O. & Gustafsson, J. -E. (1987) The hierarchical organization of cognitive abilities: Restoring general intelligence through the use of linear structural relations (LISREL), Multivariate Behavioral Research, 22, 149 - 171.

TABLE 1. Summary Statistics of the Variables for the Male and Female Groups.

Variables		Male group (N=234)		Female Group (N=225)		t test
		Mean	S.D.	Mean	S.D.	
APM	Advanced Progressive Matrices	24.67	4.36	23.72	4.37	5.41*
B1	Numerical Directions	6.00	1.81	5.68	1.95	3.31
B2	Verbal Opposites	7.48	1.80	7.53	1.78	0.09
B3	Numerical Series	6.93	1.49	6.67	1.72	2.99
B4	Verbal Analogies	5.30	1.77	4.86	1.98	6.28*
B5	Arith. Computations	5.94	1.95	5.89	2.20	0.06
B6	Verbal Synonyms	6.23	1.64	6.19	1.55	0.07
B7	Nonverbal Analogies	10.51	1.67	9.80	1.89	18.15**
B8	Nonverbal Similarities	11.76	1.24	11.27	1.53	14.20**
B9	Nonverbal Subtractions	11.22	1.72	10.60	2.00	12.66**
B10	Nonverbal Series	12.02	1.18	11.52	1.56	15.00**
B11	Nonverbal Superimpos	10.89	1.69	10.14	2.07	118.06**
C1	Volume	3.16	1.04	2.69	1.23	19.51**
C2	Probability	2.47	1.12	1.96	1.33	19.72**
C3	Correlations	3.20	1.07	3.21	1.14	0.01
C4	Combinations	1.64	1.10	1.51	1.13	1.55
C5	Proportions	3.28	1.06	2.57	1.31	40.71**
C6	Momentum	1.47	1.21	1.41	1.19	0.29
C7	Mechanical Equilibrium	1.85	1.19	1.70	1.11	1.94
C8	Frames of Reference	2.24	1.35	1.64	1.18	25.51**
T1	Volume Task	3.30	0.68	2.86	0.85	37.48**
T2	Pendulum Task	3.58	0.78	3.26	1.01	14.43**
T3	Balance Task	3.76	0.70	3.12	0.96	66.68**

TABLE 2. Measures of Goodness of Fit of the First-Order Models.

Model	χ^2	df	χ^2/df	p	Model	χ^2	df	p
M1	244.03	226	0.991	.196				
M2	643.44	502	1.282	< .001				
M3	569.59	452	1.260	< .001	M2-M3	73.85	50	.016
M4	488.44	449	1.088	.097	M3-M4	81.85	3	< .001

TABLE 3. Standardized Solution of the LX Matrices of Model 4.

Variable	Factors							
	Male Group				Female Group			
	A	B	C	D	A	B	C	D
APM	.59				.43	.31		
B1			.69				.74	
B2				.84				.85
B3			.37	.45			.59	.25
B4			.76				.79	
B5			.65				.78	
B6				.88				.93
B7		.74			.26	.66		
B8		.68				.80		
B9		.69				.70		
B10		.79				.84		
B11	.13	.66			.15	.73		
C1	.37				.51			
C2	.36				.56			
C3								
C4	.46				.54			
C5	.53				.59			
C6						.44		
C7								
C8	.46				.44			
T1	.63				.70			
T2	.50				.67			
T3	.59				.73			

TABLE 4. Measures of Goodness of Fit of the Second-Order Models.

Model	χ^2	df	χ^2/df	p	Model	χ^2	df	p
M5	254.72	227	1.122	.106				
M6	649.71	503	1.437	<.001				
M7	576.64	454	1.270	<.001	M6-M7	73.07	49	.016
M8	493.99	451	1.090	.092	M7-M8	85.24	3	<.001

TABLE 5. Standardized Solution: GA Matrices of Model 8

	Male Group	Female Group
Factor A	.73	.78
Factor B	.59	.59
Factor C	.94	1.07
Factor D	.80	.80

TABLE 6. Measures of Goodness of Fit of Alternative Second-Order Models.

Model	χ^2	df	χ^2/df	p
M9	230.10	206	1.117	.120
M10	214.16	208	1.030	.370
M11	435.37	414	1.052	.226

TABLE 7. Standardized Solution: LY Matrices of Model 11.

Variable	Factors					
	Male Group			Female Group		
	A	B	C	A	B	C
APM	.58			.40	.33	
B1			.69			.74
B3			.76			.82
B4			.75			.79
B5			.63			.78
B6			.76			.78
B7		.74		.23	.68	
B8		.67			.79	
B9		.69			.79	
B10		.78			.84	
B11		.76			.83	
C1	.37			.52		
C2	.36			.55		
C3						
C4	.45			.54		
C5	.54			.60		
C6	.18			.44		
C7						
C8	.45			.43		
T1	.64			.70		
T2	.50			.66		
T3	.59			.73		

TABLE 8. Standardized Solution: GA Matrix of Model 11

	Male Group	Female Group
Factor A	.90	.82
Factor B	.72	.65
Factor C	.73	.97