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ABSTRACT

A series of confirmatory factor analyses using both LISREL VI (maximum likelihood method) and LISCOMP (weighted least squares method using covariance matrix based on polychoric correlations) and including cross-validation on independent samples were applied to items from the High School and Beyond data set to explore the measurement characteristics of a proposed set of academic self-concept measures. Results most strongly supported a first-order model with English Self Concept (ESC) and Math Self-Concept (MSC) as uncorrelated factors and General School Self-Concept as a factor correlating with ESC and MSC. Tests for invariance suggested that the model holds up across gender, but not across socioeconomic status. The results provide further confirmation of the independence of ESC and MSC and for the invariance of the structure of self-concept across gender, at least for adolescents. The possibility that the structure may differ across socioeconomic status deserves further consideration. (Author/NB)

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The High School & Beyond Data Set: Academic Self-Concept Measures

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The High School & Beyond Data Set: Academic Self-Concept Measures

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Summary. A series of confirmatory factor analyses using both LISREL VI (maximum liklihood method) and LISCOMP (weighted least squares method using covariance matrix based on polychoric correlations) and including cross-validation on independent samples were applied to items from the High School and Beyond data set to explore the measurement characteristics of a proposed set of academic self-concept measures. Results most strongly supported a first-order model with English Self-Concept (ESC) and Math Self-Concept (MSC) as uncorrelated factors and General School Self-Concept as a factor correlating with ESC and MSC. Tests for invariance suggested that the model holds up across gender, but not across SES.

Academic self-concept (ASC) is a topic that is currently receiving considerable attention in the research press (e.g., Byrne & Shavelson, 1986; Licht, Stader, & Swenson, 1989; Mboya, 1989). While there are undoubtedly a variety of reasons for this resurgence of interest, pioneering theoretical work by Shavelson and his colleagues (e.g., Shavelson, & Bolus, 1982; Shavelson, Hubner, & Stanton, 1976;) and voluminous empirical work by Marsh and others (e.g., Marsh, 1984, 1987, 1988a, 1988b; Marsh & Parker, 1984; Marsh, Parker, & Barnes, 1985; Marsh, Parker, & Smith, 1983; Marsh & Shavelson, 1985) have contributed significantly to this thrust. One of the drawbacks in researching this area is that large samples are usually needed in order to identify the relatively small effect sizes connected with ASC. This is particularly troublesome because ASC is one of those "sensitive" variables that are often pragmatically hard to collect. Accordingly, the use of large archival data sets would seem to be particularly useful in this area. The High School and Beyond (HS&B) data set is one such source. Although it does not contain an ASC scale, per se, HS&B does contain several items that have face validity as measures of this construct. This paper reports the results of a series of confirmatory factor analyses testing whether a set of items from the HS&B data set can be validated as an ASC measure. These analyses are very similar, but not identical, to those reported by Marsh (1988a, b) (Please see Note 1.)

Measurement Models for Academic Self-Concept. Several different models of the structure of self-concept exist (Byrne, 1984) with varying degrees of support. The model that formed the conceptual basis for this study is the Shavelson (e.g. see Shavelson & Bolus, 1982) hierarchichal model with general self-concept at the apex, subject area-specific self-concepts on the lowest level, and academic self-concept(s) occupying the intermediate level. There is some conflicting evidence over whether this model contains a global ASC that subsumes English self-concept (ESC) and Math self-concept (MSC) or whether ESC and MSC are independent. Recent evidence tends to support the latter (Byrne & Shavelson, 1986, Marsh & Shavelson. 1985). Some models also include a "general school" self-concept (GSSC) that is subsumed by both ESC and MSC. Various levels of nonacademic self-concept are also included. This paper explores only the ASC side of the model.

Methodology

Pre-planned Analyses. The analytic tool used for this project was confirmatory factor analysis (CFA) using the LISREL VI program (Joreskog & Sorbom, 1985). Since some of the analyses were "exploratory" in nature, a set of analyses that included cross-validation were pre-planned. This procedure reduces post-hoc capitalization on chance findings. Specifically, the plan included: (a) CFA of a first-order correlated factors model including ESC, MSC and GSSC (Model 1) (b) possible adjustments based on this analysis and resulting in Model(s) 1a, 1b, etc., (c) cross-validation of the "best" first-order factors model on a separate sample, (d) construction of a hierarchical model (Model 2) on a separate sample and testing it against the first-order model to determine which model is most supportable, (e) cross-validation of Model 2, (f) testing of the resulting model for invariance across gender and a 3-level categorization of SES. Step (d) is only justified if a correlated first-order factor model is confirmed.

Because the data are not of the interval variety usually associated with Pearson correlations and the resulting covariance matricies that were used in the analyses reported above, additional CFA analyses were performed using the LISCOMP program (Muthen, 1988) that uses polyseric and polychoric correlations as its basic data.

Procedures. A scan of the HS&B codebook produced 12 items as candidates for measurement variables corresponding to the GSSC, MSC and ESC latent variables. Four observed variables were tentatively matched to each of the three constructs. (See Figures 1 and 2). Using SPSSX utility procedures, five independent samples, four with N = 250 and one with N = 500, evenly balanced by gender,. were randomly drawn from the 1980 cohort of the HS&B base-year survey of 30,030 high school sophomores.

Since LISREL requires listwise deletion of missing data, exact N's for each analysis varied.

Figure 1:

Observed Variables Corresponding to Latent Self-Concept Variables

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English Self-Concept

E1 I am usually at ease in English class. (T/F)

E2 Doing English assignments makes me feel tense. (T/F)

E3 English class does not scare me at all. (T/F)

E4 I dread English class. (T/F)

Mathematics Self-Concept

M1 I am usually at ease in Mathematics class. (T/F)

M2 Doing Mathematics assignments makes me feel tense. (T/F)

M3 Mathematics class does not scare me at all. (T/F)

M4 I dread Mathematics class. (T/F)

General School Self-Concept

S1 Others see you as a good student? (Very, somehwat, not at all)

S2 I am interested in school. (T/F)

S3 I like to work hard in school (T/F)

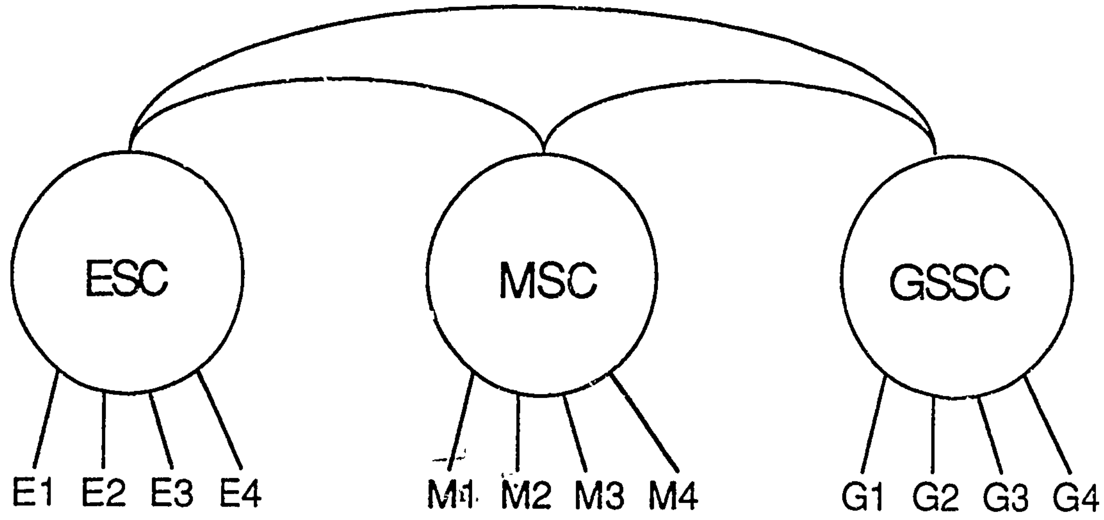
S4 Regardless of plans, ability to complete college? (5-point Likert)

Results

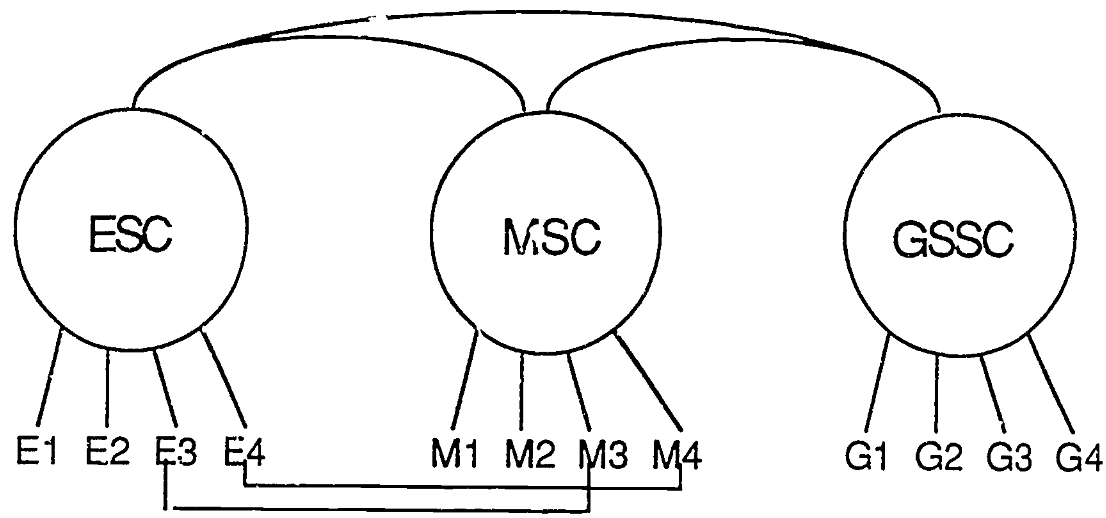
Model 1: Initial Analysis. Model 1 was a first-order correlated factors model with ESC, MSC and GSSC as latent variables. Each was uniquely represented by four observed variables (items) as per Figure 2. All possible correlations between the factors were allowed, but errors (i.e. uniquenesses) for the individual items were not allowed to correlate. Model testing using the LISREL VI program produced a highly significant

Figure 2: Models of Self-Concept Structure

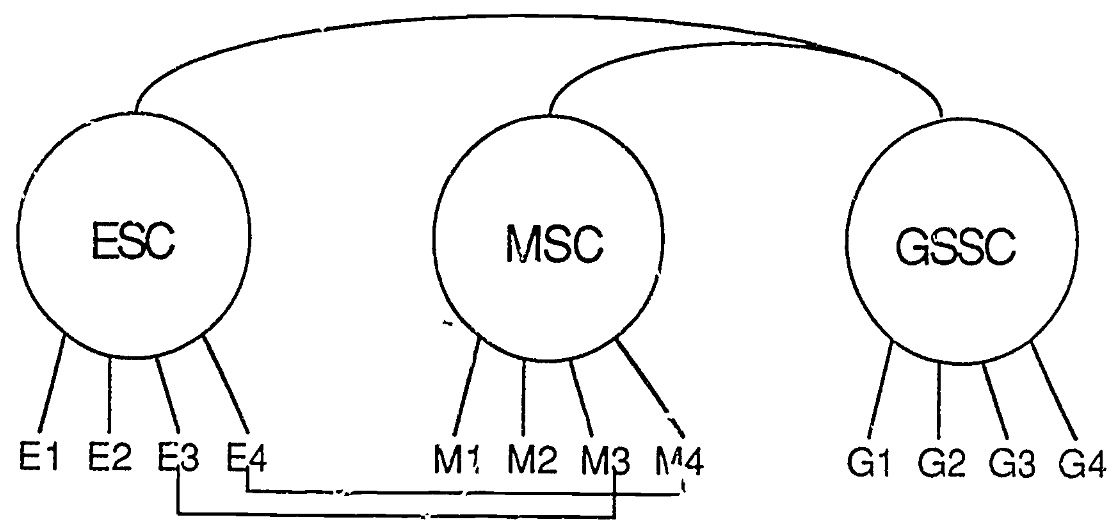
Model 1



Model 1a



Model 2



X^2 (see Table 1). Although this would seem to suggest a very poor fitting model, two factors must be considered: (a) all of the analyses in this project use relatively large samples (215 is the smallest) which produce large X^2 values and thus tend to over-identify cases with trivially small lack of fit, and (b) the X^2 statistic is sensitive to departures from normality, especially in conjunction with noninterval data, such as the dichotomously-scored and Likert items in this study (Joreskog & Sorbom, 1988). Accordingly, the Goodness-of-Fit Index (GFI) (Joreskog & Sorbom, 1988), which is less influenced by nonnormality, the Root Mean Square Residual (RMR), the X^2/df ratio - a flawed, but commonly used index -, and the number of normalized residuals > |2.0| will be emphasized in this paper, except when directly comparing a series of nested models. To compare nested models, Sobel and Bohrnstedt's (1985) "baseline model" approach will be used. In this procedure, a baseline model is identified based on the current state of research knowledge regarding the relationships of interest. Alternative models are then tested for improvements over the current state of knowledge. Sobel and Bohrnstedt argue convincingly for the use of this approach over the "null model" approach advocated by Bentler and Bonett (1980) whenever prior knowledge provides clear support for some structuring of the data. In the present case, model 1 was chosen as the baseline model based on the substantial amount of previous research referred to in the previous section.

Table 1

Fit Indicies for Validation and Cross-validation of Models (LISREL VI ML Method)

Model	Sample	X^2 (df)	p	X^2/df	GFI	RMR	No. of Normalized Resid. > |2.0|
1	1	139.62(51)	.0001	2.74	.907	.018	6/78
1 a	1	112.16(49)	.0001	2.29	.925	.017	4/78
2	1	112.84(50)	.0001	2.26	.925	.017	8/78
2	2	89.35(50)	.001	1.79	.934	.016	5/78
2 (tau-eq)	2	150.86(56)	.0001	2.69	.904	.037	8/78

Data for the fit indicies for Model 1 are displayed in Table 1. Taken collectively, the fit indicies suggested a model that approached an acceptable fit, but that clearly needed improvement. Analysis of normalized residuals (6 of 78 were > |2.0|) and modification indicies suggested that the model could be improved by allowing the uniqueness terms for two of the ESC and MSC item pairs (E3, M3 / E4, M4) to correlate. Correlated errors should only be allowed when there is good reason to believe that the items share specific variance (often method variance) rather than indicating an unidentified factor (Wheaton, 1987). In the present case, the ESC and MSC items are identical, except for the "English" or "math" term. It therefore seems quite reasonable that each respective pair shares considerable specific variance. There is a particularly strong case for this assertion in regard to the item pairs in question, because they contain extreme wording ("English [math] doesn't scare me."; "I dread English [math]"). The analysis also indicated a nonsignificant correlation between MSC and ESC.

Model 1a: Selected Correlated Uniquenesses. Based on the initial results with Model 1, the model was retested on the same sample allowing correlated uniqueness terms for the two ESC and MSC item pairs. (See Table 1 for fit indicies). Comparison of the X^2 values for models 1 and 1a showed a significant ($p < .01$) decrease in the X^2 value, thus indicating significantly better fit. Using Model 1 as the "baseline" model, the incremental change index Δ =.197 (Sobel and Bohrnstedt,1985), indicating that Model 1a represents only a modest improvement over Model 1, albeit a statistically significant improvement. This finding is also supported by constant, but modest, improvements in the other fit indicies. This model clearly deserves further consideration. Analysis of the remaining four significant residuals did not suggest any conceptually justifiable modifications in factor loadings or correlated errors, but once again the MSC/ESC correlation was nonsignificant. Constraining MSC and ESC to be independent is justifiable in light of previous research (Marsh, Byrne, & Shavelson, 1988) supporting the independence of these constructs. A model (Model 2) with MSC and ESC uncorrelated was thus chosen for further validation. As shown in Table 1, the fit indicies for Model 2 were virtually identical to those for Model 1a, except for an increase in the number of normalized residuals > |2.0|. However, inspection of the normalized residuals in both models 1a and 2 shows a nearly identical pattern. In both cases the S3 variable accounts for a majority of the significant normalized residuals.

Given the nearly identical fit indicies for Models 1a and 2, other research supporting the independence of ESC and MSC (Marsh, Byrne, & Shavelson, 1988), and that Model 2 is slightly more parsimonious that Model 1a, Model 2 was chosen for cross-validation. In view of the apparent

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orthogonal relationship between two of the three constructs, a higher order model was not investigated.

Cross-validation of Model 2. To cross-validate Model 2, a second sample (N = 219) was used in the LISREL analysis. The model held up well, producing better fit indicies (see Table 1) than in the previous sample. This congeneric model was further tested to see if it was tau-equivalent (i.e. equal factor loadings among each respective set of observed variables). With an increase of 6 degrees of freedom, the X^2 jumped by 61.51 points to 150.86, a clearly significant difference. A tau-equivalent model can not be supported. Taken collectively at this step, the analyses supported a congeneric 3-factor model, with no correlation between ESC and MSC, a moderate correlation between ESC and GSSC ($r \approx .40$) and a low correlation between MSC and GSSC ($r \approx .25$) . These results are consistent with Marsh's (1988a) finding of the independence of the ESC and MSC latent constructs using the same items as measurement variables.

Comparison Across Gender. Since the model was explored and confirmed on samples that included both males and females, and since gender differences on such scales are plausible (Licht, Stader, & Swenson, 1989), model 1a was tested for invariance across groups. Althou 'ı Model 2 was best-supported at this point, the less-restricted, less-informed model was used in the event that the factor correlations were different in the different groups. A separate sample of 215 males and 227 females was used for this series of analyses which which imposed increasingly more stringent equality constraints [see Joreskog & Sorbom(1988), and Benson & Tippets (1988) for documented examples of this analytic strategy]. As a review of Table 2 will show there is consistent evidence that the model holds up across gender; in no case did addition of an equality constraint significantly increase the X^2 value. Other fit indicies suggest adequate fit for both males and females. Consistent with previous results, MSC and ESC were not significantly correlated for either gender. Additionally, for females MSC did not appear to correlate significantly with GSSC, but this is unclear given that the overall analysis supported equal factor correlations across groups.

Comparison of Model Across SES. Some literature (Marsh, Parker, & Smith, 1983) has suggested that ASC behaves differently in different SES groups. To investigate this issue, Model 1a was simultaneously tested across three levels of SES using a sample of 117 low, 203 middle, and 105 high SES subjects. The definition of SES levels comes from a trichotomized variable in the HS&B data set. Inspection of Table 3 reveals that, by contrast to the analogous gender analyses, impositions of additional equality constraints significantly increased the X^2 value. The hypothesis of equal number of factors is tentatively retained, but factor loadings and correlations among factors may be different. The model tended to fit best

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Table 2

Simultaneous Confirmatory Factor Analyses across Gender for Model 1a

	Model	X^2	df	X^2/df	GFI M/F	RMR M/F
1	Equal number of factors	176.09	98	1.80	.93/.95	.02/.01
2	Eq. # of factors Equal loadings	185.26	107	1.73	.92/.95	.02/.01
3	Eq. # of factors Equal loadings Eq. Uniquenesses	197.37	121	1.63	.92/.95	.02/.01
4	Eq. # of factors Equal loadings Eq. Uniquenesses Eq. factor correl.	206.44	127	1.62	.92/.94	.03/.02

Model Comparisons	X^2	df	Critical X^2 ($p \leq .05$)
Model 1 vs. Model 2	9.17	9	16.9
Model 2 vs. Model 3	12.11	14	23.7
Model 3 vs. Model 4	9.07	6	12.6

with the low and middle groups, but worse with the high group. ESC and MSC remained uncorrelated in all three groups. By contrast, GSC correlated significantly with ESC in only the low and middle groups, but correlated significantly with MSC only in the high group. However, these findings should be interpreted cautiously because they have not been cross-validated and the subsample sizes of the low and high groups are moderate, at best.

Nonnormality Issues. Of the 12 observed variables in this study, 10 are dichotomous (true/false or yes/no), 1 is a 3-point Likert scale and 1 is a 5-point Likert scale. Clearly, the data are not of the interval variety usually associated with Pearson correlations and the resulting covariance matricies that were used as input data for all LISREL analyses in this

Table 3

Simultaneous Confirmatory Factor Analyses across SES for Model 1a

	Model	X^2	df	X^2/df	GFI Lo/Mid/Hi	RMR Lo/Mid/Hi
1	Equal number of factors	209.14	147	1.42	.92/.94/.90	.02/.01/.02
2	Eq. # of factors Equal loadings	249.83	165	1.51	.91/.94/.87	.03/.02/.03
3	Eq. # of factors Equal loadings Eq. Uniquenesses	299.40	193	1.55	.90/.94/.84	.04/.02/.03
4	Eq. # of factors Equal loadings Eq. Uniquenesses Eq. factor correl.	319.05	205	1.56	.89/.93/.84	.06/.02/.04

Model Comparisons	X^2	df	Significance Level
Model 1 vs. Model 2	40.69	18	$p > .01$
Model 2 vs. Model 3	49.57	28	$p > .01$
Model 3 vs. Model 4	19.65	12	$p < .05$

study. Joreskog and Sorbom (1988) strongly warn against using Pearson r's with such data. Accordingly, all of the results of this study, especially the X^2 values, must be viewed with caution.

The recommended alternative procedure in the case of noninterval observed variables is to use polychoric coefficients and the weighted least squares (WLS) method of estimation rather than the maximum liklihood (ML) method incorporated in the standard LISREL procedure (Joreskog & Sorbom, 1988). Accordingly, Models 1, 1a and 2 were reanalyzed using the LISCOMP (Muthen, 1988) program based on polychoric correlations between the measurement variables and the weighted least squares estimation procedure. In general, the LISCOMP results paralleled those from the more commonly-used LISREL procedure, but some differences emerged (see Table 4). On data set 1, Models 1a and 2 both represented significant (.01) improvements in fit over Model 1 using the X^2 difference test, and decreases in the root mean square residuals. However, the incremental fit Δ's (.085 and .067, respectively) were considerably smaller than for the LISREL procedure. Cross-validation on sample 2 suggested acceptable fit, especially in view of the lowest RMR, but produced a higher X^2 value than that produced by the LISREL analysis on the same sample. This was unexpected, given the finding (Joreskog, & Sorbom, 1988) that the X^2 value is inflated for this kind of data.

Table 4

Fit Indicies for Validation and Cross-validation (LISCOMP WLS Method)

Model	Sample	X^2 (df)	p	X^2/df	RMR
1	1	126.44(51)	.0001	2.48	.191
1 a	1	115.72(49)	.0001	2.36	.178
2	1	118.03(50)	.0001	2.36	.182
2	2	121.30(50)	.0001	2.43	.168

Discussion

Comparison to Marsh (1988a, b) Studies. In a study focusing on the relationships between school average ability and academic outcomes and aspirations, Marsh (1988b) used the eight ESC and MSC items and three of the GSSC (S1, S2, S4) items as measures of a composite academic self-concept (ASC) variable. Subjects for the study were the 14,000+ respondents to the second follow-up of the HS&B sophomore cohort. As such, Marsh's (1988b) subjects are from a potentially different universe than that from which the subjects in the present study were drawn, in that the present study drew samples from the entire base year cohort of 30,030 subjects. Although Marsh (1988b) does not include analysis of the measurement model used in this study, the relationships between the ASC composite variable and other variables in the larger structural model were consistent with those previously reported in the ASC literature, thus lending support to the use of these nine items as measures of ASC.

The Marsh (1988a) study, which used the same data set as the (1988b) study but focused on influences on the formation of ESC and MSC, used the same eight measurement variables as did the present study. Marsh did not include a GSSC construct in this study. By contrast to the present study, Marsh allowed the uniquenesses of each respective set of ESC and MSC items to correlate. Consistent with the results of the present study, Marsh (1988a) found support for using the eight variables as measures of ESC and MSC and also found ESC and MSC to be uncorrelated. Addressing the "naming" problem, Marsh concluded that these variables can be thought of as ESC and MSC measures, as contrasted to something like academic anxiety, given the relationships that he found between the hypothesized scales and other variables in the structural model. Based on the observed nonsignificant correlation between ESC and MSC, additional model-testing on the data set [unreported in Marsh (1988a)] and previous research, Marsh (1988a) concluded that the results "... provide further support for the inappropriateness of a single global measure of academic self-concept." (p. 17).

Based on this set of analyses using several independent samples for cross-validation and invariance tests, it would seem that Model 2 is supportable, except perhaps for high SES students. This study did not provide data to address the "naming problem" (Wheaton, 1987; that is, the comfirmatory factor analyses showed that the variables legitimately may be considered to form three respective latent variables but the these analyses do not prove that each latent variable is that construct and not something else. However, the data provided in the Marsh (1988a) study that showed theoretically predictable relationships between the ESC and MSC measures and other variables, such as academic achievement, lend support to the present interpretation of the ESC and MSC variables. Given the congruence of results between this study and Marsh (1988a), researchers may use these variables in the HS&B data set with some confidence. The status of the GSSC variable is less clear. Analysis of the residuals suggests that item S3 may be a poor candidate as a measure of this construct. Marsh (1988b) did not include this item in his composite measure of ASC. An additional study, excluding S3, but including the other variables would help to clarify this issue.

The results of this study provide further confirmation of the independence of ESC and MSC (Marsh, Byrne & Shavelson, 1988) and for the invariance of the structure of self-concept across gender (Byrne, 1988), at least for adolescents. The possibility that the structure may differ across SES deserves further consideration. Marsh, Parker and Smith (1983) found higher correlations between ASC and academic achievement for high SES students than for lower SES students. Less work has been done on the possibility of structural differences in self-concept for these varying groups.

Parallel analysis of the data by both the maximum liklihood (i.e., LISREL) and weighted least squares (i.e., LISCOMP) methods is an unusual feature of this study. Discussion of the methodological issues surrounding the use of these contrasting methods with noninterval data is beyond the scope of this paper, but two interesting findings emerge. First, the results are largely in agreement with one another regardless of the methodology used. Secondly, the X^2 for cross-validation on sample 2 was higher than for the same analysis using the maximum liklihood procedure. A lower value would be expected for such data (Joreskog & Sorbom, 1988).

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Author Notes

1. The author planned the project, conducted the LISREL VI analyses, and submitted the poster session proposal to APA before discovering the Marsh (1988a, b) works in their manuscript forms in the ERIC document system. Nevertheless, the author acknowledges that Marsh's very similar analyses on nearly the same dataset (universe of data) carry an earlier publication date assigned by ERIC. The author believes that the two studies complement one another, and freely acknowledges the pioneering work done by Marsh on both measurement and substantive issues in the self-concept area.

2. The author wishes to express his gratitude to Dr. Jeri Benson, University of Maryland at College Park for her guidance, patience and willingness to give of her time in regard to this project.

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