Confirmatory Factor Analysis vs. the Generalized Graded Unfolding Model for Analyzing Responses to the Academic Motivation Scale

B.J. Miller

Eastern Mennonite University

Abstract

The current study examined theoretical and measurement issues regarding the construct of academic motivation. Specifically, responses to the Academic Motivation Scale (AMS; Vallerand et al., 1992) were analyzed using both CFA and an IRT unidimensional unfolding model. Results indicated that both models provided plausible fit to the data. Theoretical, scale development, and measurement implications of the findings are discussed. Ultimately, the unfolding model was endorsed as the appropriate choice of model because of its closer alignment with the theory, its role in scale development, and its parsimony.

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The purpose of the current study is to compare the utility and implications of two different measurement techniques in the analysis of responses to the Academic Motivation Scale (AMS; Vallerand et al., 1992). The scale has traditionally been analyzed using Confirmatory Factor Analysis (CFA; Cokley, Bernard, Cunningham, & Motoike, 2001; Fairchild, Horst, Finney, & Barron, 2005; Vallerand et al., 1992). However, CFA has produced mixed results in terms of the internal structure of the data as well as the relationships among factors. Unfolding theory (Coombs, 1964) offers an alternative approach to analyzing responses to the AMS.

Theoretical Framework

Self-Determination Theory. The AMS was created to measure college students' motivation for attending college within the framework of Self-Determination Theory (SDT; Deci & Ryan, 1985). Broad categories along the motivation continuum specified by SDT include amotivation, extrinsic motivation, and intrinsic motivation. Extrinsic motivation is further delineated according to its degree of self-regulation in the following order: external, introjected, identified, and integrated. Figure 1 depicts the SDT continuum in terms of self-regulation, motivation, and associated behavior (i.e., self-determined vs. non-self-determined). The AMS departs somewhat from SDT in that no items were included to measure integrated extrinsic motivation, and intrinsic motivation was operationalized as three separate (but unordered) subtypes: intrinsic motivation to know, intrinsic motivation to accomplish, and intrinsic motivation to experience stimulation.

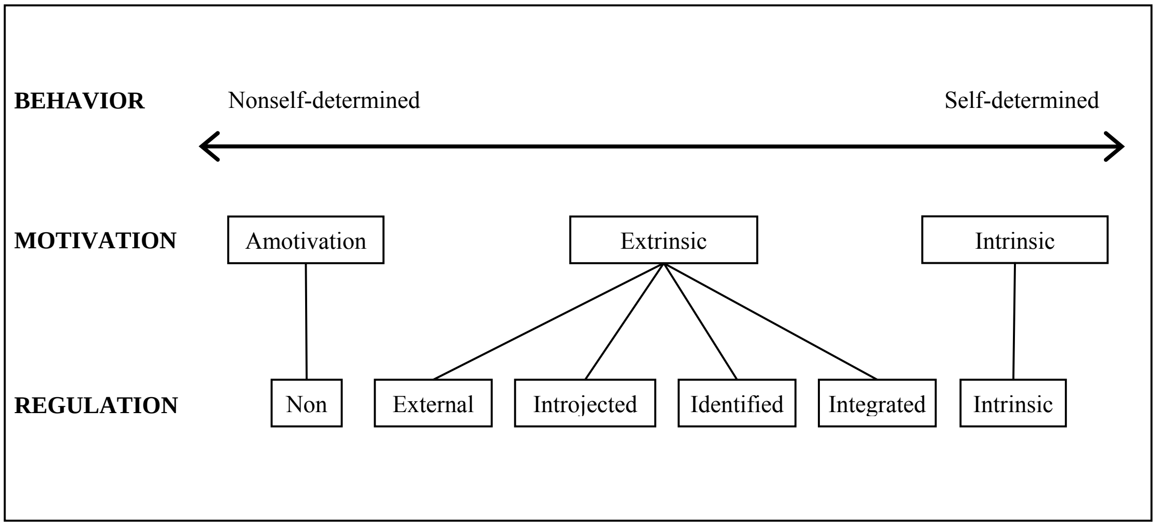

Figure 1. The self-determination continuum.

Unfolding Theory. Three basic assumptions underlie unfolding theory (Coombs, 1964). First, it is assumed that persons and stimuli (e.g., statements, items) can be located along the same single dimension. Second, it is assumed that there is universal agreement regarding the order of the stimuli along this dimension. Note that this assumption holds even though individuals are expected to differ in their locations along the continuum. Finally, it is assumed that a person's location is determined by an ideal-point process. That is, a person will be located closest to his or her most preferred stimulus. An implication of this response process is that a person has one of two reasons for *not* endorsing a given item, and that reason depends upon the person's location. If the person is located *higher* on the continuum than the item, then the person is said to *disagree from above*. If the person is located at a *lower* level, then the person is said to *disagree from below*.

The Generalized Graded Unfolding Model (GGUM; Roberts, Donoghue, & Laughlin, 2000) is an IRT approach to analyzing polytomous responses to graded-agreement attitude measures. In addition to the stated assumptions of unfolding theory, GGUM further assumes that the latent responses of *disagree from above* and *disagree from below* can be modeled. Unfolding data yield a single-peaked, inverted U-shaped probability function under the model, and the peak corresponds to the ideal point. Parameters estimated by GGUM include the locations of persons (θ) and items (δ) along the continuum.

The unfolding approach can be contrasted with the cumulative approach of CFA. CFA specifies multiple latent constructs, or factors. The items serve as the observed indicators of the factors, and are typically crafted to maximally represent their latent constructs (Kyngdon, 2006). In other words, all of the items representing a single factor are assumed to be located at the highest level of that construct, and respondents are located along the construct's continuum according to their factor score. The analysis thus produces a profile of factor scores for each respondent. In the context of measuring academic motivation according to SDT, the conceptual differences between the unfolding approach and the CFA approach have important implications.

The unfolding approach implies that a unidimensional motivational scale exists, whereas the CFA approach implies that separate, ordered subscales comprise the motivational continuum. In the unfolding approach, a person is described by a single score along the motivational continuum, whereas in the CFA approach, a person is described by a profile of factor scores. In short, the unfolding approach seems congruent with SDT, whereas the CFA approach is more congruent with motivation theorists who argue that individuals can be both extrinsically and intrinsically motivated toward the same activity (e.g., Lepper, Corpus, & Iyengar, 2005).

Method

Participants. Sophomores at James Madison University (JMU) participated in a required campus-wide assessment day during the spring semester of 2006. A total of 851 students completed the instrument used in the current study.

Measure. The Academic Motivation Scale (AMS; Vallerand et al., 1992) was used to measure academic motivation according to SDT. The scale is composed of 28 items representing possible answers to the question, "Why are you going to college?" Four items address each of the following four types of motivation ordered along the self-determination continuum as follows: amotivation (AMOT), externally regulated extrinsic motivation (EMEX), introjected extrinsic motivation (EMIJ), and identified extrinsic motivation (EMID). In addition, four items address each of three types of intrinsic motivation defined by Vallerand et al. (1989): motivation to know (IMTK), to accomplish (IMTA), and to experience stimulation (IMES). As previously noted, no particular order was specified for the intrinsic motivation types. The AMS employs a seven-point response scale where a 1 indicates that the item "Does not correspond at all" and a 7 indicates that the item "Corresponds exactly" to the student's reason for attending college.

Analyses. The GGUM was fit to the data using GGUM2004 (Roberts & Cui, 2004). A seven-factor CFA model was also fit to the data using LISREL 8.72 (Jöreskog & Sörbom, 1996). Relationships between estimated θs and AMS subscale scores were examined using scatterplots.

Results

GGUM. The global fit statistic indicated poor model fit ($G^2(186) = 1020.00$, $p < .001$); however, this fit statistic is based on the chi-square distribution, which is sensitive to large sample sizes. Therefore, a supplemental graphical method of evaluating global model fit was also employed. Specifically, average observed responses were plotted as a function of θ – δ for each of 100 fit groups (see Figure 2). Average observed values showed only slight deviations from the probability function predicted by the model. The plot also shows a function consistent with an ideal point process – that is, a single-peaked, inverted U shape with its peak at the point where there was no difference between persons and items (i.e., where θ – δ = 0). The marginal reliability of θ scores was estimated to be .93 using the following formula (Zimowski, Muraki, Mislevy, & Bock, 1996): $\bar{\rho}_\theta = \frac{1}{1+\bar{\sigma}_e^2}$.

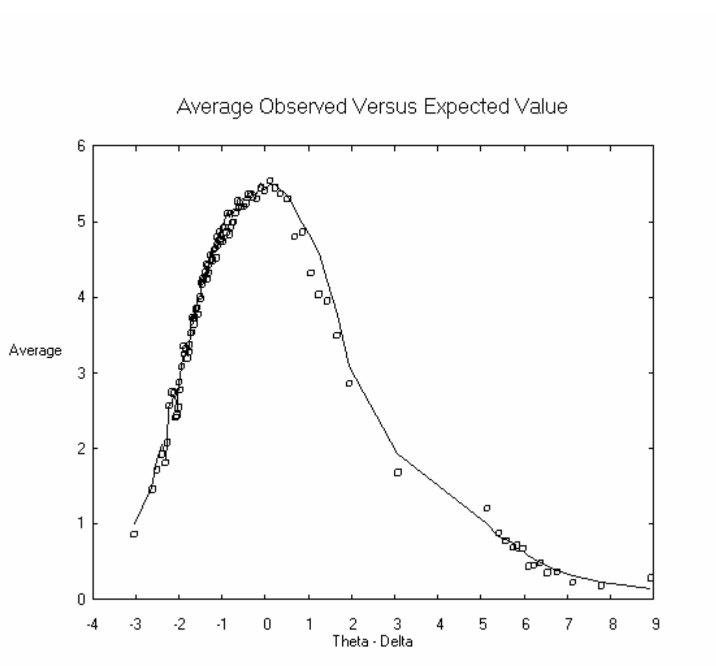

Figure 2. Average observed versus expected values.

Table 1 presents all GGUM estimated item parameters, and Figure 3 depicts the item locations with respect to the distribution of θ. With the exception of the items labeled EMIJ and EMID, the estimated item locations conformed to SDT.

Table 1

Estimated Item Parameters for the AMS

Item #	SDT Type	δ_i	α_i	τ_{i1}	τ_{i2}	τ_{i3}	τ_{i4}	τ_{i5}	τ_{i6}
26	AMOT	-6.63	0.30	-0.60	-2.53	-5.74	-3.92	-6.07	-2.33
19	AMOT	-6.22	0.31	0.29	-0.48	-7.60	-2.88	-5.66	-4.00
12	AMOT	-6.19	0.21	-0.41	-0.69	-7.00	-1.76	-5.89	0.16
5	AMOT	-5.83	0.27	-1.18	-0.70	-5.21	-3.23	-3.20	-2.94
1	EMEX	0.34	0.18	-3.10	5.55	--	-1.89	-3.06	2.24
22	EMEX	0.63	0.82	-1.83	-2.32	-2.34	-2.02	-1.65	-0.48
15	EMEX	0.68	0.81	-1.65	-2.15	-2.11	-2.02	-1.85	-0.75
8	EMEX	0.75	1.02	-2.29	-1.96	-2.49	-2.19	-1.95	-0.94
10	EMID	0.92	0.96	-2.44	-2.23	-2.70	-2.74	-2.38	-1.28
21	EMIJ	0.97	1.46	-1.76	-1.93	-2.10	-1.43	-1.38	-0.45
17	EMID	1.00	1.23	-2.40	-1.94	-2.75	-2.28	-1.80	-0.84
7	EMIJ	1.00	1.14	-1.98	-1.70	-2.26	-1.61	-1.55	-0.42
24	EMID	1.02	1.36	-2.41	-2.07	-2.48	-1.95	-1.77	-0.72
3	EMID	1.05	0.89	-2.29	-1.97	-3.03	-2.37	-3.11	-1.35
28	EMIJ	1.06	2.44	-2.26	-1.91	-2.05	-1.67	-1.39	-0.61
14	EMIJ	1.08	2.18	-1.97	-1.92	-2.02	-1.70	-1.30	-0.64
27	IMTA	1.29	2.36	-2.48	-1.95	-2.15	-1.69	-1.43	-0.71
20	IMTA	1.31	2.56	-2.42	-2.03	-1.98	-1.75	-1.26	-0.53
13	IMTA	1.34	2.78	-2.36	-2.15	-2.06	-1.68	-1.35	-0.61
6	IMTA	1.36	1.76	-2.37	-2.04	-2.04	-1.51	-1.13	-0.30
4	IMES	1.46	1.15	-2.76	-2.03	-2.26	-1.47	-1.06	-0.28
23	IMTK	1.54	2.12	-2.73	-2.89	-2.68	-2.27	-2.02	-1.07
16	IMTK	1.56	1.68	-2.72	-2.80	-2.52	-2.40	-1.86	-1.06
18	IMES	1.57	1.06	-2.23	-1.94	-1.94	-1.37	-0.92	-0.46
9	IMTK	1.61	2.00	-2.86	-2.54	-2.57	-2.13	-1.65	-0.90
25	IMES	1.62	1.06	-2.33	-1.86	-2.03	-1.59	-0.94	-0.48
11	IMES	1.62	0.99	-2.45	-1.69	-2.21	-1.36	-1.10	-0.66
2	IMTK	1.71	1.35	-3.65	-2.62	-3.28	-2.39	-2.05	-0.68

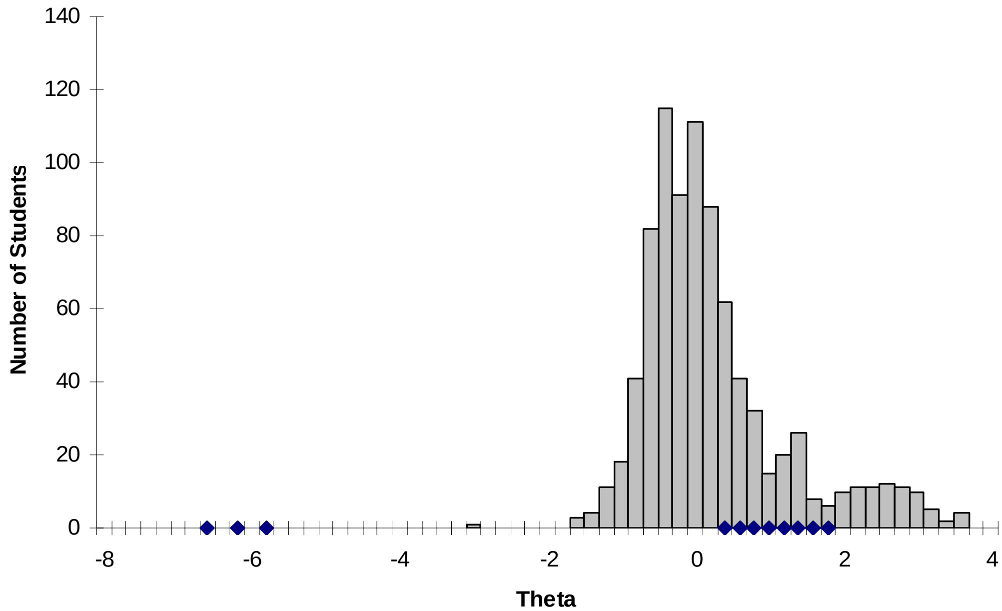

Figure 3. Estimated AMS item locations and distribution of θ.

CFA. Fit statistics for the seven-factor model indicated adequate fit according to commonly accepted criteria (SRMR = .05; RMSEA = .10; CFI = .95). Table 2 presents pattern coefficients and factor correlations for the seven-factor solution. All unstandardized pattern coefficients were significant at $p < .01$ and at least 64% of the variance for each item was explained by its assigned factor. The factor correlations were expected to exhibit a simplex pattern in which the opposite ends of the motivational continuum (AMOT and the intrinsic motivation types) would be strongly and negatively correlated. In addition, neighbors along the continuum should be more strongly correlated than non-neighbors. As found in previous studies (Cokley, 2000; Fairchild et al., 2005; Vallerand et al., 1993), the estimated correlations deviate somewhat from this pattern. Specifically, AMOT was as strongly related to EMID as it was to the intrinsic motivation types. Also, EMIJ is generally more strongly correlated to the intrinsic motivation types than is EMID, which reverses their positions along the theoretical continuum.

Table 2

Unstandardized (Standardized) Pattern Coefficients and Factor Correlations for the Seven AMS Subscales

Item	AMOT	EMEX	EMIJ	EMID	IMTK	IMTA	IMES
5	1.42 (0.82)						
12	1.57 (0.80)						
19	2.54 (0.95)						
26	2.36 (0.95)						
1		3.58 (0.89)					
8		6.64 (0.98)					
15		6.92 (0.96)					
22		7.24 (0.98)					
7			4.35 (0.94)				
14			5.19 (0.95)				
21			5.33 (0.95)				
28			4.40 (0.97)				
3				7.91 (0.96)			
10				7.79 (0.97)			
17				6.15 (0.96)			
24				5.42 (0.96)			
2					3.89 (0.96)		
9					4.25 (0.96)		
16					5.81 (0.96)		
23					7.39 (0.97)		
6						3.17 (0.94)	
13						4.04 (0.96)	
20						3.41 (0.96)	
27						3.39 (0.96)	
4							2.63 (0.91)
11							2.31 (0.94)
18							2.54 (0.94)
25							2.43 (0.92)
AMOT	1						
EMEX	-0.62	1					
EMIJ	-0.65	0.91	1				
EMID	-0.71	0.97	0.94	1			
IMTK	-0.70	0.89	0.94	0.95	1		
IMTA	-0.69	0.88	0.97	0.93	0.98	1	
IMES	-0.58	0.77	0.88	0.83	0.93	0.94	1

Note: All unstandardized coefficients significant at the $p < .01$ level.

AMS subscale means, standard deviations and reliabilities are presented in Table 3. All subscales demonstrated good reliability as measured by Cronbach's coefficient alpha.

Table 3

AMS Subscale	Mean	SD	α
AMOT	6.3	3.96	.85
EMEX	22.3	4.85	.81
EMIJ	20.1	5.78	.88
EMID	23.7	3.90	.78
IMTK	21.2	4.65	.84
IMTA	18.5	5.73	.87
IMES	15.7	6.16	.87

Relationships between θ and subscale scores. Scatterplots of the relationships between θ and the AMS subscale scores are shown in Figure 3. With the exception of AMOT, the relationships were not linear but rather "folded" at the approximate location of the item. In other words, students with moderate AMS subscale scores were observed in two different regions of the θ scale. Essentially, these scatterplots illustrate the response process of disagreeing from above and disagreeing from below.

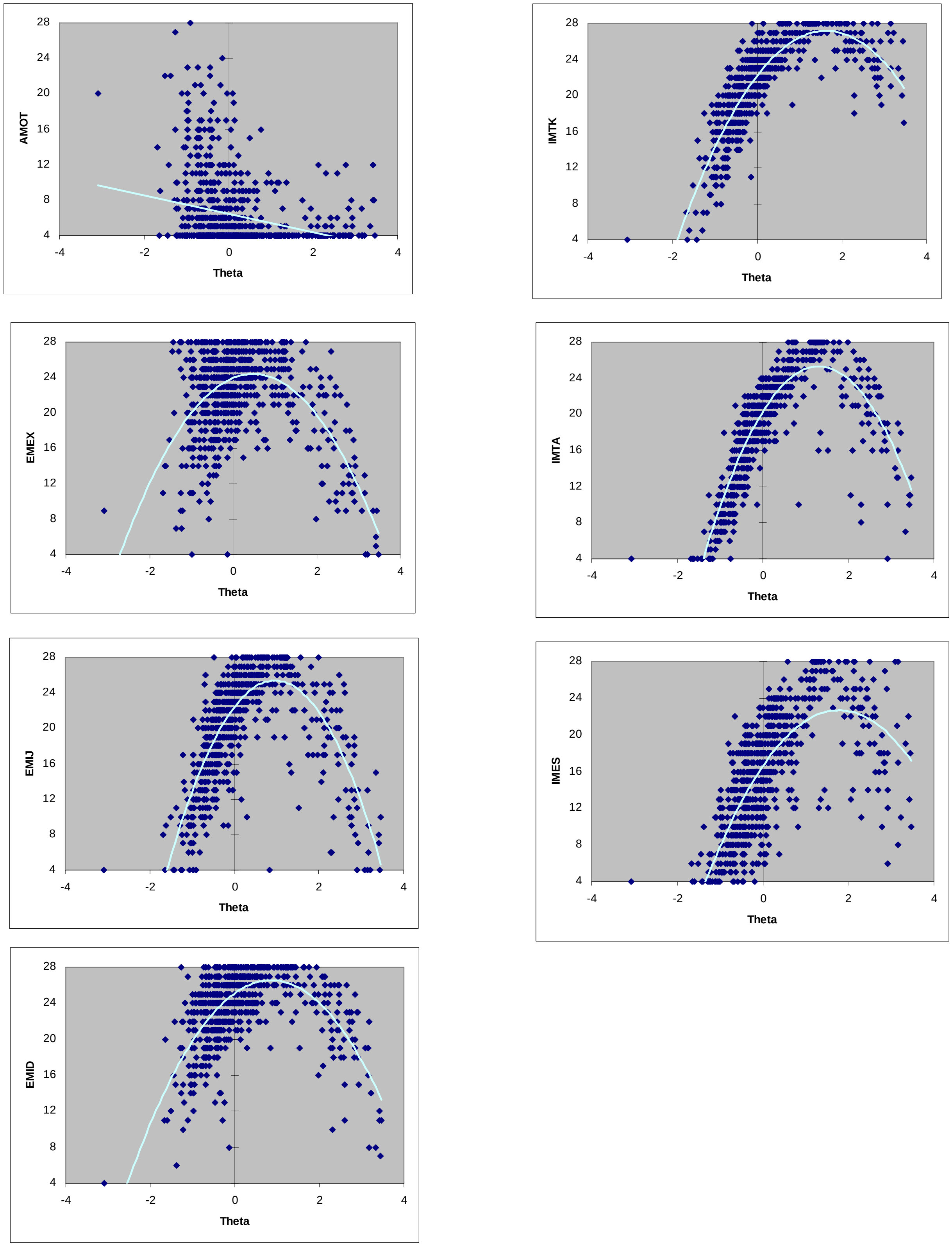

Figure 3. Relationships between θ and AMS subscale scores.

Conclusions and Implications

Given plausible fit for two conceptually different measurement models, how are we to choose one over the other? Theory should be the driving force for this decision. We must ask ourselves whether SDT describes a single construct or several separate constructs. Assuming that we want to measure academic motivation using a graded-agreement, self-report instrument, the answer to the question of dimensionality has implications for scale development as well as the choice of an appropriate measurement model and data analysis technique.

In a multidimensional, cumulative model, several observed indicators are required for each construct in order to estimate parameters and to achieve satisfactory reliability. Typically, these items are created to maximally represent the construct, often resulting in a final product composed of several sets of semantically similar items representing the separate constructs. Contrastively, for the unidimensional unfolding model, items are created to represent different degrees of the single construct along a continuum. Ideally, items are empirically located across the entire continuum with relatively equal spacing between them.

The AMS was clearly designed according to the multidimensional, cumulative model. Psychometrically, the seven-factor linear model fits quite well, the factor relationships are somewhat consistent with the theory, and the subscale scores are sufficiently reliable. Theoretically, however, the unidimensional unfolding approach seems to be more consistent with SDT than the multidimensional approach of CFA. The unfolding approach has the added advantage of parsimony. That is, a single score is estimated, simplifying the investigation of relationships with other variables and locating persons along the continuum. In addition, items are explicitly ordered along the same continuum, providing a simple way to compare item ordering results with the theory and to depict the distances between the different types of motivation.

Unfolding also offers the opportunity to create a more parsimonious scale in terms of the number of items representing each SDT motivation type. Unlike the cumulative CFA approach, the unfolding model does not require multiple items to describe any one type of motivation. Rather, the entire continuum is represented by the set of items. This approach to scale development is appealing because it produces a shorter scale with more semantic variety, qualities which arguably make the test-taking experience more enjoyable.

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