Alexander M. Schoemann & V. Ryan Hudson
East Carolina University
schoemanna@ecu.edu

Factor Models for Ordinal Data: Comparing Categorical and Continuous Approaches
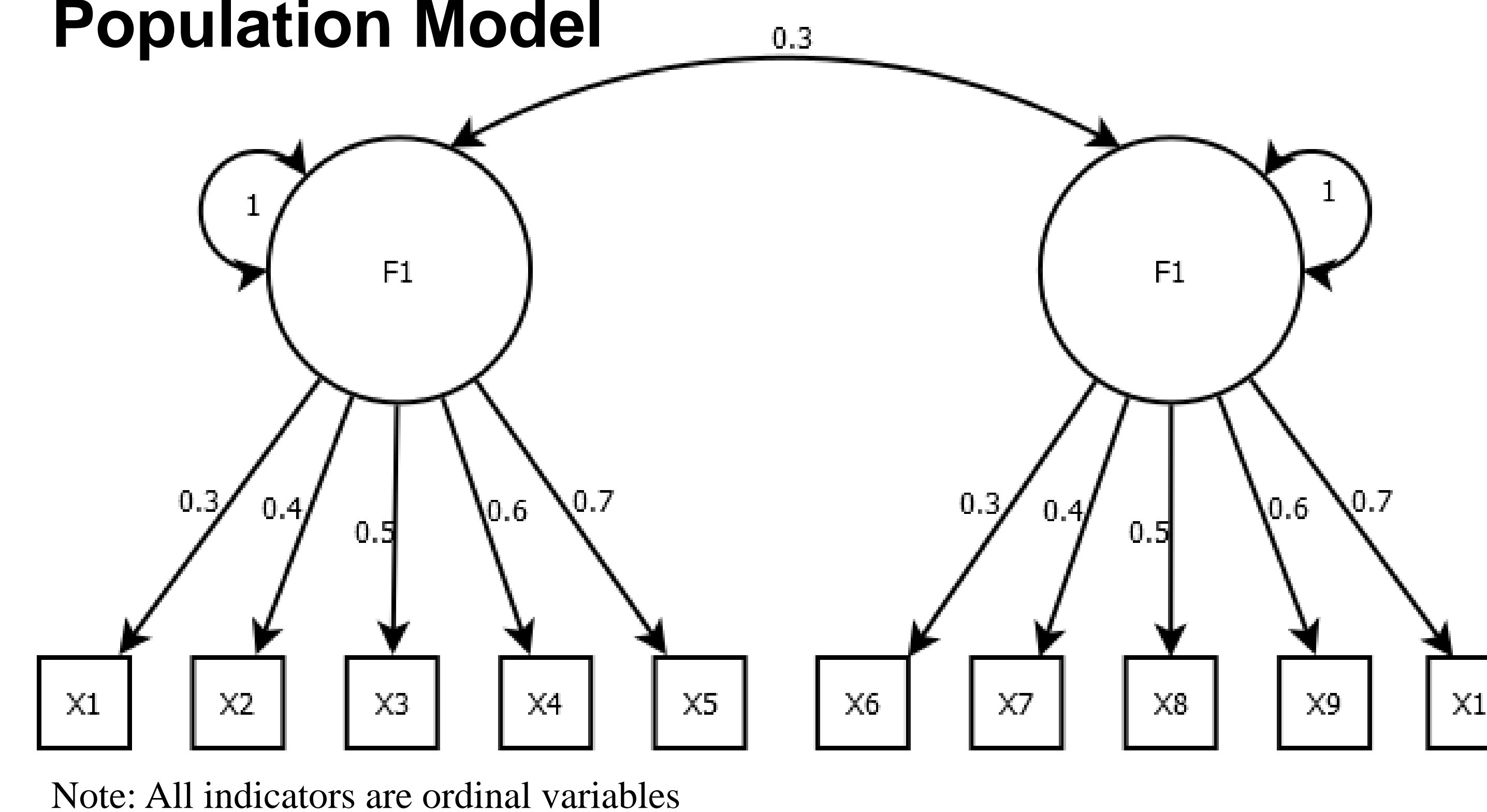
Introduction

Constructs in social and personality psychology are frequently measured on ordinal scales such as Likert scales. Determining proper methods for analyzing data from ordinal scales is important when using these measures. Issues for ordinal scales are particularly relevant for techniques using item level analysis, e.g. Confirmatory Factor Analysis (CFA). Previous research (Rhemtulla, Brosseau-Liard, & Savalei, 2012) has provided general guidelines for when ordinal measures should be treated as categorical or continuous in CFA models. However, these recommendations are general and may not apply to all situations. We discuss methods of fitting CFA models with ordinal indicators and methods for comparing models treating indicators as continuous or categorical.

Methods for fitting a CFA with ordinal indicators

- Continuous indicators − Robust Maximum Likelihood (MLR)
  - Model fit/comparison indices: χ^2, RMSEA, TLI, CFI, AIC, & BIC
- Categorical indicators − Weighted Least Squares (WLS)
  - Model fit /comparison indices: χ^2, RMSEA, TLI, & CFI
- Categorical indicators −Maximum Likelihood (ML)
  - Model fit /comparison indices: χ^2, RMSEA, & TLI,
- Continuous indicators − Bayesian CFA
  - Model fit /comparison indices: ppp, DIC, & BIC
- Categorical indicators −Bayesian CFA
  - Model fit /comparison indices: ppp

Comparing CFAs with ordinal and continuous indicators

CFA models treating indicators as ordinal or continuous are not nested models and cannot use traditional likelihood ratio tests to compare models. Instead comparisons need to be made using information criteria or model fit indices

- When both models are fit with Maximum Likelihood (MLR and categorical ML) models can be compared with AIC or BIC
  - A Vuong (1989) test is possible, but is not implemented in popular software
- When the continuous model is fit with MLR and the categorical model is fit with WLS models can be compared with RMSEA, TLI, or CFI
- Current software implementations of Bayesian CFA (e.g. Mplus or blavaan) do not provide information criteria to compare models (e.g. DIC or BIC)

Method

We used a Monte Carlo simulation in Mplus v. 8 (Muthén, & Muthén, 2017) with 1000 replications to evaluate our method. Data were generated (N =200, 500) using an categorical CFA model with 4 or 7 categories per variable and asymmetric thresholds. Data were analyzed using categorical CFA models with ML and WLSMV estimation and a continuous CFA model using robust ML estimation.

For each replication categorical CFA models fit with ML were compared to the continuous model using AIC and BIC and categorical CFA models fit with WLSMV were compared to the continuous model using RMSEA, TLI, and CFI.

Results

Patterns of results did not differ between N = 200 and N = 500 and 4 or 7 categories. All results presented are from the N = 500, 4 category model. Differences in AIC and BIC were highly correlated (r = .99), only AIC difference are reported. Differences in CFI, TLI, and RMSEA were highly correlated (rs > |.7|) only CFI is reported.

- AIC always indicated better fit for the categorical model
- CFI indicated better fit for the categorical model (difference in CFI > 0) for 19% of replications, and equivalent fit (difference in CFI = 0) between the models for 43% of replications

Poster available at: http://marlab.org/Supplemental_Materials/

Population Model

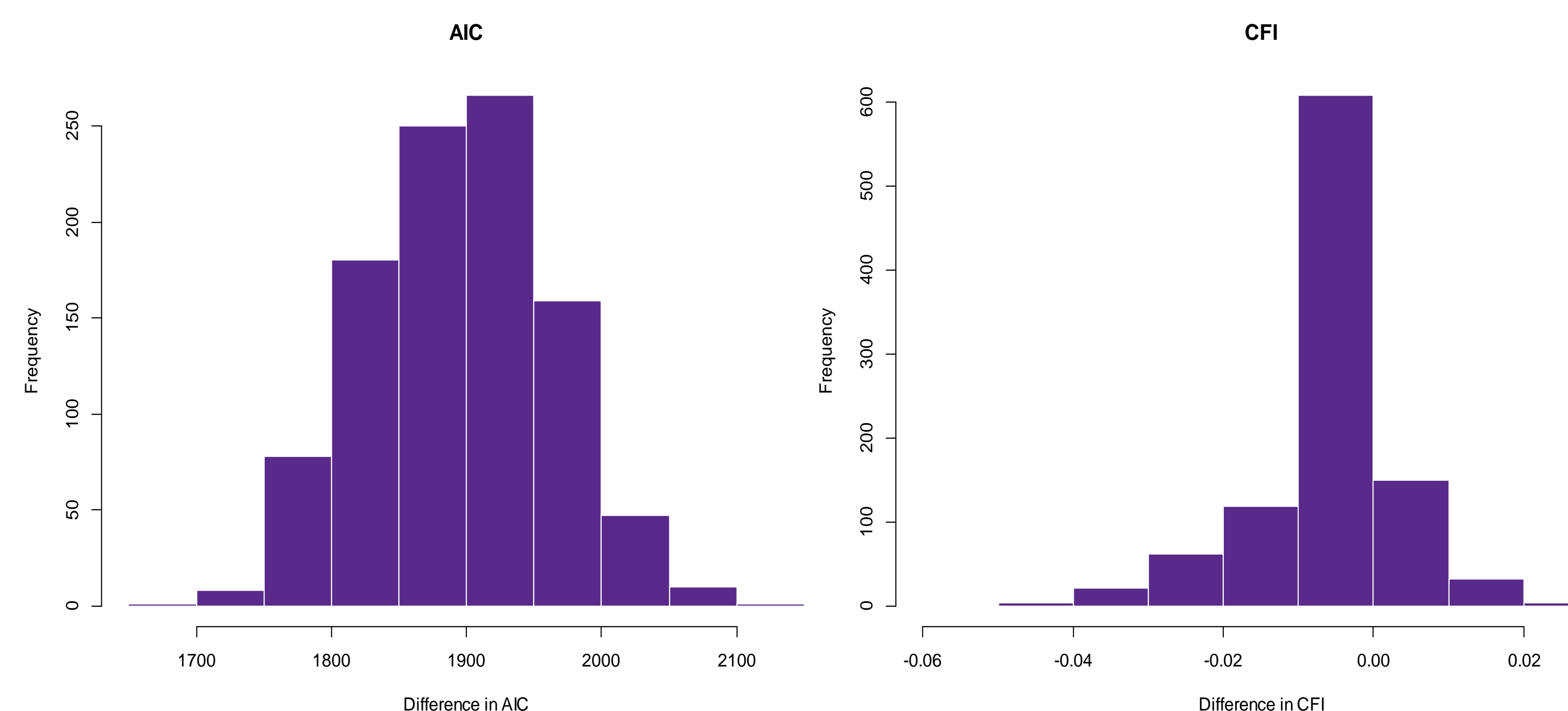Note: All indicators are ordinal variables

Discussion and Future Directions

- The categorical CFA model is the population model and should fit better than the continuous CFA model across all replications.
- AIC and BIC select the categorical CFA model over the continuous CFA model across all replication
  - AIC and BIC may be too sensitive to use to compare categorical and continuous models
- CFI, TLI, and RMSEA show promise for comparing categorical and continuous CFA models
  - More research is needed to investigate which model fit indices are best for distinguishing between continuous and categorical CFAs and to determine cutoff values for these indices
- Future directions should examine the Vuong (1989) test for non-nested models and Bayesian CFA approaches
  - Current software implementations of categorical CFA using ML or Bayesian methods do not provide sufficient information to compare models with the Vuong test or Bayesian methods.

References

Muthén, L.K. and Muthén, B.O. (1998-2017). *Mplus User's Guide.* Eighth Edition. Los Angeles, CA: Muthén & Muthén

Rhemtulla, M., Brosseau-Liard, P. É., & Savalei, V. (2012). When can categorical variables be treated as continuous? A comparison of robust continuous and categorical SEM estimation methods under suboptimal conditions. *Psychological Methods, 17,* 354 – 373.

Vuong, Q. H. (1989). Likelihood Ratio Tests for Model Selection and non-nested Hypotheses. *Econometrica. 57,* 307–333.