Writing about SEM/Best Practices

- Presenting results
- Best Practices
  - » specification
  - » data
  - » analysis
  - » interpretation

Writing about SEM

- Summary of recommendation from Hoyle & Panter, McDonald & Ho, Kline
  - » the model
  - » the data
  - » estimation and fit
  - » parameter estimates
  - » alternative models

Presenting the Model

- H&P suggest presenting a more abstract version of the model first ("conceptual model") followed by a concrete model specified in enough detail to allow the reader to reconstruct the analysis ("statistical model")
  - » reader should be able to compute observations and degrees of freedom from statistical model
  - » indicate clearly any parameters that were fixed
- M&H want to see more discussion of identifiability
- Both want readers to do more theoretical justification for presence and absence of paths

Data

- Check for violations of assumptions and present diagnostic information
  - » esp., provide information about kurtosis
  - » Mardia's coefficient gives information on multivariate normality
- Give information on missing data (how much?), and how this was handled (e.g., listwise deletion)
- Provide data
  - » covariance matrix that includes all observed variables OR
  - » correlation matrix and standard deviations
  - » M&H: if > 30 variables, put on web or state that the data are available from the author

Estimation and Fit

- State what method of estimation you used
  - » Maximum Likelihood best in most cases
- Present strategy for testing fit (H&P)
  - » state which indices will be presented and give justifications for choosing them
  - » give conceptual definition of each index used
  - » state the cutoff values you will be using
- Give $\chi 2$, df, sample size and p value
  - » can do this succinctly:

  $\approx \chi 2(48, N = 500) = 303.80, p < .001, TLI = .86, CFI = .90$

Global Fit Indices

- H&P recommend
  - » GFI because it's in the same metric as R
  - » NNFI or IFI
  - » CFI
- M&H recommend
  - » RMSEA, RMR, CFI, GFI
- Kline recommends
  - » RMSEA, CFI

More on Fit

- M&H and Kline suggest that discrepancy information should be presented
  - » M&H say to present it in the other half of the variance/ covariance matrix of the observed variables
- M&H and Kline also both recommend a two-step testing strategy to insure that structural part of model fits well
  - » See M&H Table 2 (p. 74) for examples in which structural portion did not fit well but this was masked by the overall good fit of the model

Parameter Estimates

- Report all parameter estimates
  - » including variances
  - » report standard errors as well
  - » clearly indicate any paths that were fixed (e.g., to 1.0 to set the scale for a latent variable)
- M&H suggest presenting measurement model parameters in tabular form and leaving the observed variables out of the diagram, for clarity

Alternative Models

- Present and test alternative models
- If respecification is done, present this information clearly
  - » H&P recommend that results for the hypothesized model be presented first
  - » In a separate section, present the modified model
- Test equivalent models, if possible

Cross-Validation

- If you have a holdout sample, test your final model on them and present the results
- If you can't do this, provide estimates of the likelihood that your model will replicate
  - » Browne & Cudeck cross-validation statistic

Keeping Up

- Recommendations are changing, so look for people to continue writing on this topic in:
  - » Psychological Methods
  - » Specialty journals
    - Structural Equation Models
    - Multivariate Behavioral Research
    - Applied Psychological Measurement
    - Psychometrika

Best Practices: Specification

- Lay out your model before you collect data
  - » if it is not identified, you can add more measured variables
- Try to include all important causes that are already known
- When modeling latent variables, have enough indicators
  - » Kenny (1979): "Two *might be* fine, three is better, four is best and anything more is gravy."
  - » Number of indicators necessary for identification depends on the model

Best Practices: Specification

- Think hard about directionality
  - » does the logic of the study design and protocol rule out some causal orders?
  - » have some causal orders been confirmed or disconfirmed in other studies (especially longitudinal or experimental)?
  - » if not, you may want to consider (and test) other causal orders
- Don't use feedback loops (causal arrows going both ways) as a way to get around thinking hard about directionality

Best Practices: Specification

- Add correlations between error or disturbance terms only when conceptually justified
  - » try to work out ahead of time which error terms may need to be correlated
  - » avoid correlating error terms solely to improve fit
- Try for indicators that load on one factor (latent variable) only
  - » allow cross-loadings only if clearly justified theoretically

Best Practices: Data

- Implement quality control practices for examining data
- Minimize missing data
  - » If much data is missing, imputation may be the best method, if data are not missing at random
  - » watch for new developments
- Check for violations of assumptions
  - » normal distributions for endogenous variables
  - » linearity
  - » independence
- Screen for outliers
  - » As in regression and ANOVA, SEM is sensitive to outliers

Best Practices: Analysis

- Use theory and previous findings to guide respecification
  - » modification indices (e.g., Lagrange) can be useful, but do not rely on them blindly (unless you like making Type I errors)
- Double check your syntax
  - » make sure you are running the model you think you are
- Look carefully at your output for signs of problems
  - » error messages (or not "all is ok" message)
  - » negative variances (and other impossible things)
  - » huge standard errors (and other unlikely things)

Best Practices: Analysis

- Report unstandardized as well as standardized estimates
- Check for multicollinearity
  - » Kline says correlations >.85 may be problematic
- Check your sample size
  - » At least 100 cases AND
  - » 10:1 ratio for cases to parameters estimated (or, at an absolute minimum, 5:1)

Best Practices: Analysis

- Provide SEM program with start values, if it is having trouble
  - » If program doesn't converge or there are other signs of problems, but estimates are printed, use those as start values
  - » Kline has several appendices that give advice about providing start values
- Be aware of the possibility of empirical underidentification
- Evaluate the measurement and structural portions of the model separately

Best Practices: Interpretation

- Look at all of your output
  - » fit indices are important but they are only part of the picture
  - » be sure to look at matrix of residuals -- this lets you know if all of the model is fitting well or if there are some areas of misfit
- Do not assume, believe, or state that your model *must* be correct, because fit is good
  - » we can disprove models (state that they must be incorrect) but we can't prove that a model is correct

Best Practices: Interpretation

- Remember that good fit does not imply anything about how much variance in the endogenous variables is explained
  - » good fit means the variance in the variance-covariance matrix is well represented by the model
  - » if you care about being able to predict large amounts in the variance in some or all endogenous variables, you have to look at that separately
- Consider and test alternative models
- If possible, consider mathematically equivalent models
  - » nice if you can rule some out using theory or logic

Best Practices: Interpretation

- Remember that SEM is not a cure for poor theory or design
- Don't reify your factors
  - » you tried to choose indicators so as to create a latent factor that represents the construct of interest
  - » but you may not have succeeded
  - » when reading other people's work, don't rely just on their name for the latent variable -- look critically at the indicators
- Report enough information so that readers can reproduce your analysis and try alternative models