Questions and Sample Answers for Chapter 7

Section 1 – Questions

Question 1

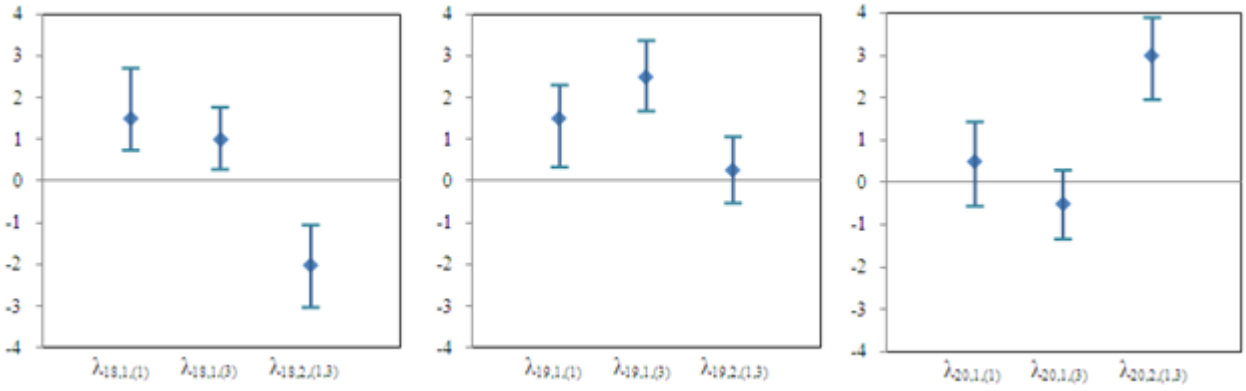
An item involving two attributes is estimated using the NIDA model. The parameter estimates are $g_1 = 0.20$, $g_2 = 0.05$, $s_1 = 0.05$, and $s_2 = 0.10$. Write out the equation for the response probability π_{ic} in both the traditional NIDA and LCDM formulations.

Question 2

When representing core DCMs in the LCDM framework, one of the distinctive features of the DINO model is that this model contains (a) main and interaction effect parameters that are identical in value and (b) negative interaction effect parameters. Explain why these two features are necessary for this model in the LCDM parameterization.

Question 3

Suppose we have three items (Item 18, 19 and 20) and each of them measures two attributes, Attribute 1 and 3. We further estimate the item parameters using different DCMs in the LCDM framework, whose values are shown in the following three graphs along with a band of plus or minus two standard errors. Please identify the appropriate DCM that is suggested for each item based on the likely values of the population parameter values.



(1) (2) (3)

a. (1) DINO, (2) C-RUM, (3) DINA
b. (1) NIDA, (2) DINA, (3) DINO
c. (1) C-RUM, (2) DINO, (3) NIDA
d. (1) DINO, (2) NC-RUM, (3) NIDO

Question 4

Specifying DCMs using a log-linear cognitive diagnosis model (LCDM)(framework for the analysis of diagnostic assessment data has a number of advantages over using exploratory latent class models (LCMs). Which of the following statement(s) capture(s) such advantages?

a. Although specialized software exists for estimating exploratory LCMs, practical estimation problems often limit the complexity of models that can be fit to items within a particular assessment. Specifying DCMs allows for increasingly complex models to be fit to different items with computational ease.

b. Using the LCDM framework offers researchers greater flexibility over exploratory LCMs in that it facilitates exploratory as well as confirmatory research, as different Q-matrices and structural model specifications can be used to investigate the number of latent classes that would best represent the underlying structure of data.

c. Using an LCDM framework is most powerful in that the parameters of core DCMs are readily interpretable and facilitate an effective communication of results about learners. Thus, using the LCDM parameterization of DCMs makes these models accessible to a wider assessment audience.

d. Using the LCDM framework offers researchers greater flexibility in that it facilitates the identification and direct comparison of models that posit very different relationships between mastery states of required attributes and the likelihood of an item endorsement or correct response.

Section 2 – Sample Answers

Question 1

The traditional NIDA formulation is

Question 2

The DINO model is a compensatory model which assumes that as long as any one of the required attributes is mastered by the respondent, he or she is able to provide a correct response. In other words, mastering additional attributes does not contribute to an increase in response probability when one attribute has already been mastered. In the LCDM framework, the exponent consist of one intercept term, all main effects for required attributes, and all possible interactions between these attributes. Since no increase in response probability should be induced by mastering additional attributes, all main effect parameters and the interaction effect parameters need to be identical in value so their joint inclusion in the model cancels out any potential additional effects while preserving the underlying meaning of the condensation rule for the DINO model.

Question 3

Correct answer: a

The LCDM is a very flexible framework which can be utilized to represent various DCMs. Since the values of the parameters are differently restricted in those DCMs, we can identify the candidate model according to the values of parameter estimates.

Figure (1) shows parameter estimates for a model that has positive main effects and a negative interaction effect, which points to a DINO model or an LCDM that does not have any specific name. Since the confidence bands for the two main effects overlap and the value of the interaction effect is likely to be the negative of the value of the main effects, it is possible that a DINO model fits.

Figure (2) shows parameter estimates for a model that has positive main effects and no interaction effects, which points to the NIDO model or the C-RUM. Since the estimation of different parameter values for different items implies that no parameter restrictions have been placed across items or attributes, the C-RUM model is the appropriate choice here. Figure (3) shows parameter estimates for a model that has no main effects and a positive interaction effect, which points to the DINA model. Thus, option (a) is the correct choice.

Question 2

Correct answers: b & d

a. Using the LCDM framework permits different models to be fit across items, but it does not support increasing their complexity. While it is true that LCDMs can be estimated using software that is readily available (including M-Plus), using this framework does not relieve the practical limitations of reliably estimating or the theoretical limitations of specifying complex models. The goal of any modeling endeavor is to identify a parsimonious model of a minimally needed complexity that nonetheless captures the core patterns present in the data. So this statement is not supportable in its current form.

b. It is true that DCMs are confirmatory models that allow for an operationalization and testing of specific substantive hypotheses via Q-matrices and structural model specifications. However, parameter restrictions can also be placed on general LCMs even though one would probably not classify them as "exploratory" in that case. So, given the language used in the statement, this statement is overall supportable.

c. Although slipping and guessing probabilities may be derived from LCDM parameters, this does not mean that parameter interpretations are "straightforward" or "readily interpretable" for many practitioners. Translating the relationship between model parameters, predicted response probabilities, observed response probabilities, and model fit is a complex endeavor that the use of a DCM does not simplify per se. If anything, the use of multidimensional measurement models like DCMs makes this endeavor more challenging relative to exploratory LCMs and simpler models such as unidimensional IRT model. So this statement is not supportable in its current form.

d. The use of unified estimation frameworks like the LCDM, the G-DINA framework, and the GDM framework have significantly enhanced the flexibility of fitting different model structure to different items. This development mirrors the current state-of-the-art in IRT research, although not necessarily always practice, where item-specific models can be fit as well. So this statement is supportable.