Model for Polytomous Items

$$P_{ik}^{*}(\theta) = \frac{e^{1.7\,a_i\,(\theta - b_{ik})}}{1 + e^{1.7\,a_i\,(\theta - b_{ik})}}$$

For an item *i*, $P_{ik}^{*}(\theta)$ is the probability of a response in or above a particular category *k* (except in the first category) given the value of θ and the parameters a_i (slope or discrimination) and b_{ik} (thresholds). The * refers to probability of a response or *higher*.

Understanding Thresholds

- Let us consider the example of subjects' responses to a 5-point Likert scale item. This is an example of a polytomous item (an item with more than two ordered categories).

- IRT (in this case the Graded-Response Model) uses item characteristics curves (ICCs) that depict the probability of each response as a function of a person's trait level.

- The parameter estimates in our example include one slope (discrimination parameter) and four thresholds.

- The number of thresholds equals the number of response categories minus one.

- An item characteristic curve (ICC) can be produced for each response category as shown below in Figure 1. In this case, each curve is a category response curve.
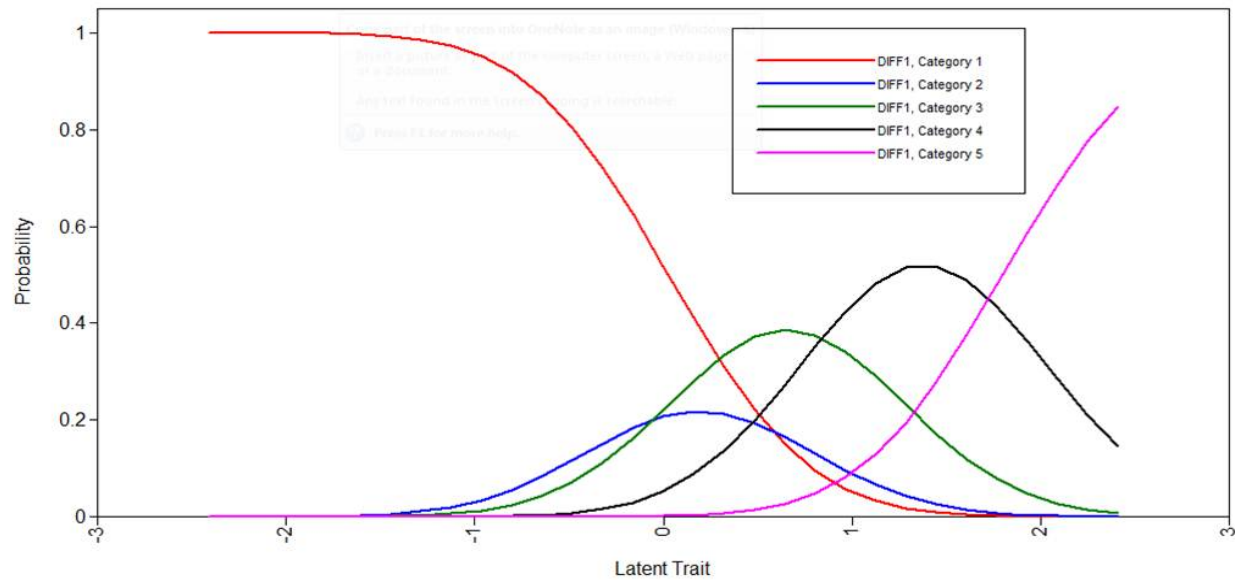
Understanding Thresholds

Figure 1. Category response curves for a five-point Likert scale item.

Understanding Thresholds

- A threshold is the value of the trait level θ on the "threshold" (.50 probability) of crossing over into the next highest response category. More specifically the four thresholds in our example distinguish:

- Categories 1 (very unlikely) **vs**. 2 (unlikely), 3 (neutral), 4 (likely), 5 (very likely)
- Categories 1 (very unlikely), 2 (unlikely) **vs**. 3 (neutral), 4 (likely), 5 (very likely)
- Categories 1 (very unlikely), 2 (unlikely), 3 (neutral) **vs**. 4 (likely), 5 (very likely)
- Categories 1 (very unlikely), 2 (unlikely), 3 (neutral), 4 (likely) **vs**. 5 very likely)

- Thus the first threshold which in our example has a value of 0.028 is the trait level at which there is a .50 probability of endorsing "unlikely" or higher. This is shown in Figure 2.
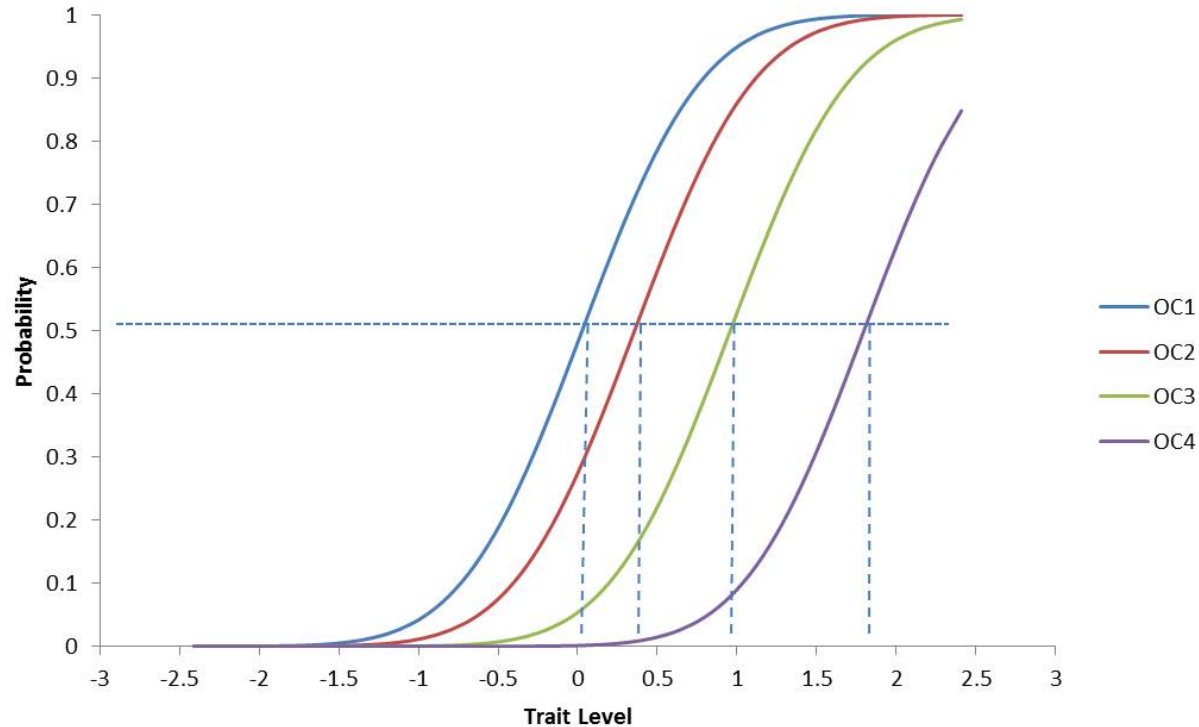
Understanding Thresholds

Figure 2. Operating characteristic curves for a five-point Likert scale item. Note that the threshold values (0.028, 0.357, 0.958, and 1.799) correspond to the intersection points between the vertical dotted lines and the X-axis referring to the latent trait value.

Understanding Thresholds

- Note that IRT methodologists have differed in the way they label item characteristic curves (or category characteristic curves for polytomous items) and operating characteristic curves. I have used the terminology by Embreston and Reise (2000); others have used opposite labels to define these two types of curves (e.g., DeMars, 2010).

DeMars, C. (2010). *Item response theory*. New York: Oxford University Press.

Embreston, S. E., & Reise, S. P. (2000). *Item response theory for psychologists*. Mahwah, NJ: Erlbaum.

Thresholds in Mplus

- Mplus reports thresholds (instead of means) for outcome variables specified as CATEGORICAL

- CATEGORICAL in Mplus specifies that the outcome variables are ordered-categorical or dichotomous

- This approach is ideal when your outcome variables are test or questionnaire items such as Likert-scale responses or any other types of responses with 10 or less ordered categories