

ASSESSING THE INFORMATIVENESS OF TOTAL TEST SCORE ON THE BASIS OF AN ITEM RESPONSE THEORY MODEL

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Objectives

Explore the informativeness of multiple item measures based on graded response model of individual scores [1] and total score approaches.

Define a mathematical condition to identify, which items increase the informativeness of the total score.

Methods

- The contribution of different items to total score information in COMFORT pain scale was determined based on a previously published item response theory model for pain[2].
- In a simulation study, the impact of graded response model parameters on the total score informativeness was explored.

Calculating the total score information

In the graded response model, the probability P_{jk} for item j getting a grade k can be expressed as

$$p(y_j > k|D) = \frac{e^{a_j(D-b_{jk})}}{1 + e^{a_j(D-b_{jk})}}$$
$$P_{jk}(D) = p(y_j > k-1|D) - p(y_j > k|D)$$

The test information I for n items with K grades can be calculated as

$$I(D) = \sum_{j=1}^n \sum_{k=1}^K I_{jk}(D) = \sum_{j=1}^n I_j(D)$$

Where

$$I_{jk}(D) = -P_{jk} \frac{\partial^2 \ln[P_{jk}(D)]}{\partial D^2}$$

The total score information I_{TS} can be calculated, using solutions for the information of a continuous variable [3]

$$I_{TS}(D) = \left(\frac{\partial E_{TS}(D)}{\partial D} \right)^2 / V_{TS}(D)$$

Where

$$E_{TS}(D) = \sum_{j=1}^n \sum_{k=1}^K k \cdot P_{jk}(D) = \sum_{j=1}^n E_j(D)$$

$$V_{TS}(D) = \sum_{j=1}^n \sum_{k=1}^K (k - E_j(D))^2 P_{jk}(D)$$

To summarize the information scores objectively throughout the latent variable range, the following equations were used for weighting the information at different latent variable values.

$$I_{IRT} = \int_{-\infty}^{\infty} I(D) \cdot p(D) dD$$

$$I_{TS} = \int_{-\infty}^{\infty} I_{TS}(D) \cdot p(D) dD$$

Where $p(D)$ denotes the probability density of the latent variable, in this case the standard normal distribution.

Conclusions

The informativeness of the total score from an item response theory model can be approximated analytically by treating the responses as continuous data. This approximation works well in the case of individual items (Figure 1A).

Total score information decreases as variance of discrimination parameters increases (Figure 2), which is in line with earlier work based on Monte-Carlo mapped power calculations [4].

Results

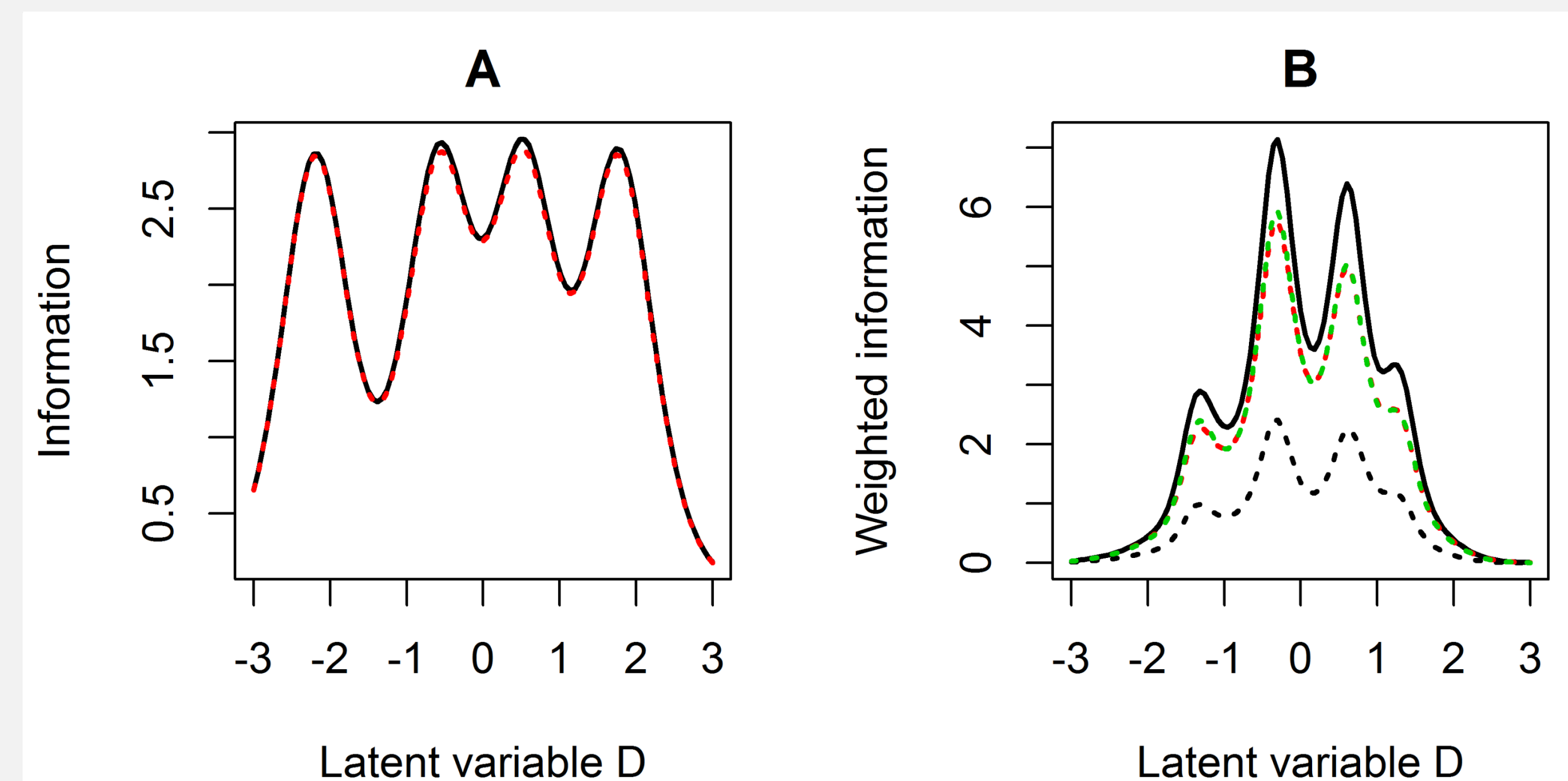


Figure 1. A) Agreement between the item information, calculated by treating the data as categorical (black solid line) or continuous (red dashed line) B) Weighted test information for COMFORT items as a function of the latent variable. Black, solid line is the test information with IRT, for all available COMFORT items. Dotted lines are the total scores information functions for all seven available COMFORT items (black), all five behavioural COMFORT items (red) and for the four most informative COMFORT items Calmness, Alertness, Facial Tension and Body Movement (green). The total scores information increases by leaving out some items.

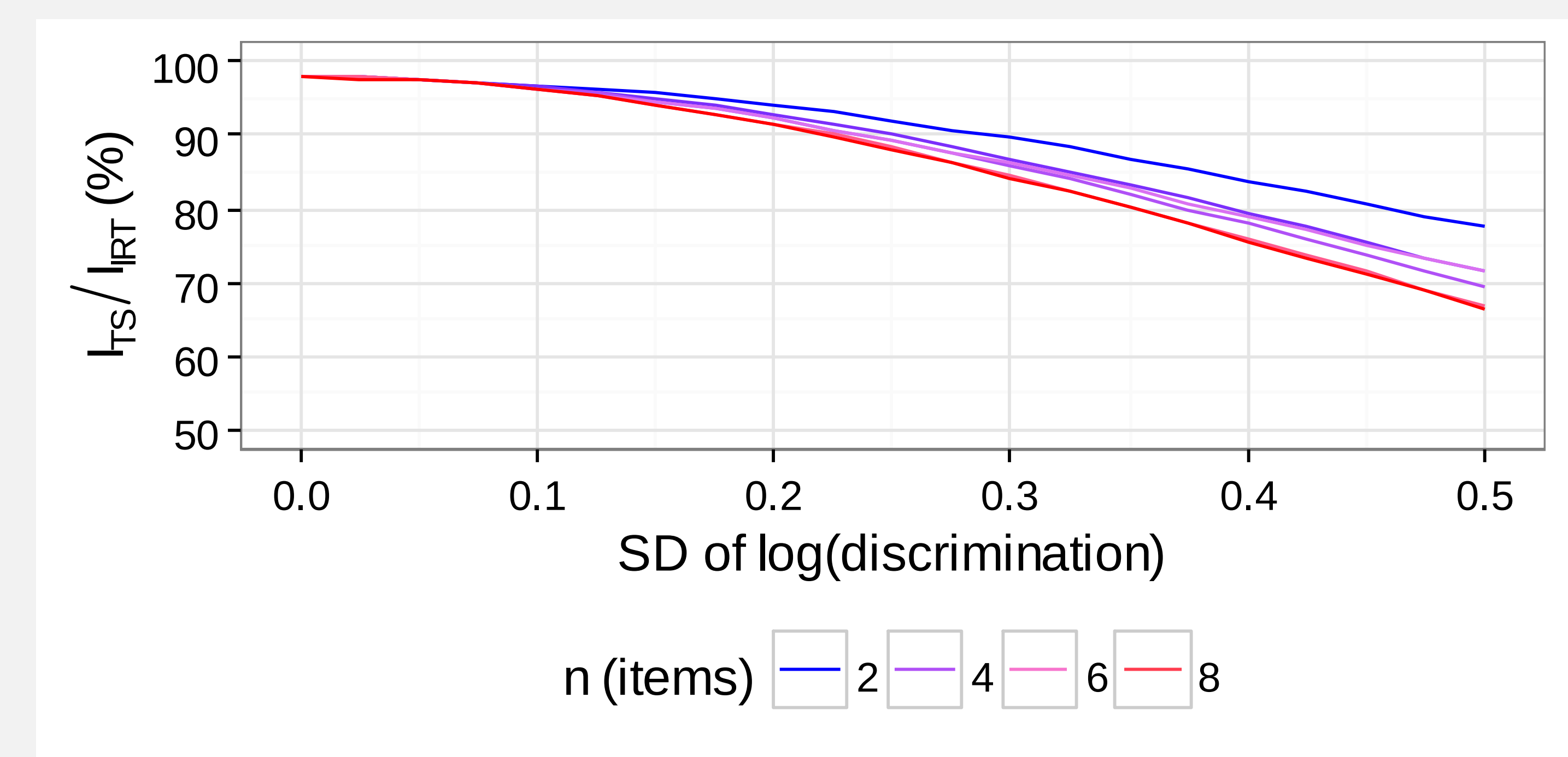


Figure 2. Ratio of total score information over IRT information, as a function of discrimination parameter variability. The total score was always less informative than an IRT analysis. As the variance of discrimination parameters increases, the total score information decreases relative to the IRT test information.

References

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