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Statistical foundations of person parameter estimation in the Thurstonian IRT model for forced-choice and pairwise comparison designs

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The statistical foundations of person parameter estimation for the multivariate Thurstonian item response theory (TIRT) model of pairwise comparison and forced-choice (FC) ranking data are elaborated, and several misconceptions in IRT and TIRT are addressed. It is shown that directional information (i.e. multivariate information as defined by Reckase & Kinley, 1991; Applied Psychological Measurement, 15, 361) is not suited to quantify the precision of the estimates unless the Fisher information matrix is diagonal. The asymptotic covariance can be quantified by the inverse Fisher information matrix if the genuine likelihood is used and by the inverse Godambe information for independence likelihood estimation that results from ignoring within-block dependencies of pairwise comparisons. Analytical expressions are provided for the genuine likelihood and the Fisher information matrix for a generalized TIRT model that comprises binary pairwise comparison and ranking designs, which enables maximum likelihood estimation (MLE) and Bayesian estimation (maximum a posteriori probability with normal and Jeffreys prior) of person parameters. The bias of the MLE is quantified, and methods of bias prevention and bias correction are introduced. The correct marginal likelihood of graded pairwise comparisons is provided that might be used for person parameter estimation based on the independence likelihood.

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