

A nonlinear mixed framework for explanatory item response models

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1. Abstract

It is beneficial to see item response models as extensions of linear regression models in the case where the data are repeated categorical observations. While the link function and the random component of the regression model remain the same, the most interesting part of the extension concerns the structural part of the model: (1) the kind of predictive function (linear or *nonlinear*, e.g. bilinear), (2) the effects (weights) of the predictors (fixed effects or *mixed* effects – the combination of fixed and random). This framework can be easily linked with multilevel modeling and structural equation modeling (SEM) for categorical data. The explanatory nature of the model depends on the predictors that are used and on the predictive function and the kinds of effects. Based on a volume recently published by Springer: “Explanatory Item Response Models: A generalized linear and nonlinear mixed approach” (De Boeck & Wilson, 2004), we will illustrate how one can specify models for binary and multicategorical data, multilevel models, multidimensional models and SEMs, and how the framework can be used for extensions, such as SEMs with latent person variables and latent item variables, models with gradual change from a random turning point, and copula models for local item dependency. For the estimation, the SAS procedure MIXED and WinBUGS are used.

2. Intended audience of the session

The intended audience is composed of measurement specialists, psychometricians, and applied statisticians with knowledge of the basic item response models who are interested in framing these models into a broader approach that is flexible enough to formulate and estimate models that go beyond the classical ones such as: 1PL, 2PL, 3PL, PCM and GRM.

3. Objective of the training session

The objectives are:

- (1) to provide a flexible and general framework for modeling test data and other categorical repeated observations data
- (2) to show how this framework is related to similar frameworks (multilevel, SEM)
- (3) to learn how one can formulate and estimate well-known and less well-known models, making use of the framework and both SAS NLMIXED and WinBUGS
- (4) to show how new models can be formulated and estimated within the same framework

The underlying philosophy for using these models is explanatory measurement, the combination of measurement and explanation (understanding the data).

4. Organization and length of the session

The session will be organized on Saturday July 9, 2005, from 9.00 to 16.30.

09.00 – 10.30 A nonlinear mixed framework for explanatory measurement

10.30 – 10.50 Coffee

10.50 – 12.20 Explanatory modeling of multicategorical data

12.20 – 13.40 Lunch

13.40 – 15.10 Multidimensional models and SEM

15.10 – 15.30 Coffee

15.30 – 16.30 Software

Session 1: A nonlinear mixed framework for explanatory measurement

An introduction will be given to item response models as nonlinear mixed models, and a general framework will be presented for how to include explanatory variables, so that the measurement becomes explanatory. Some new models will be presented to show the flexibility of the approach.

Session 2: Explanatory modeling of multicategorical data

Multicategorical data require an extension to a multivariate modeling of the data. The implications of this extension will be discussed for the various kinds of logits (adjacent, cumulative, baseline-category). It will be illustrated how one can build explanatory models for multicategorical data.

Session 3: Multidimensional models and SEM

Starting from the simple linear logistic test model, it will be explained how item response models can be extended to multidimensional models and SEMs.

Session 4: Software

The basic principles of writing SAS NLMIXED code and WinBUGS code for the models will be explained. The will be illustrated with examples and exercises.

5. Documentation

Participants will receive slides of the presentations.

Further documentetation:

De Boeck, P., & Wilson, M. (Eds.) (2004). *Explanatory Item Response Models. A Generalized Linear and Nonlinear Approach*. New York: Springer.

Rijmen, F., Tuerlinckx, F., De Boeck, P., & Kuppens, P. (2003). A nonlinear mixed model framework for item response theory. *Psychological Methods*, 8, 185-205.

6. Qualifications of the organizer and presenters

The edited volume “Explanatory Item Response Models. A Generalized Linear and Nonlinear Approach” is an initiative of the organizers, and except for one chapter, all chapters are co-authored by members of the groups in Leuven and Berkeley. Both Frank Rijmen and Francis Tuerlinckx are the first authors of chapters in this volume.

Paul De Boeck is a professor of psychological assessment at the K.U.Leuven (Belgium). He is the section editor of ARCS, a new section within *Psychometrika*, and co-editor of *Measurement: Interdisciplinary Research and Perspectives*. He is also co-author of the article in *Psychological Methods* on the topic of the training session.

Mark Wilson is a professor of education specializing in measurement and educational statistics at the University of California, Berkeley. He has published some 40 papers in refereed journals on topics in those areas, and has recently published two other books on measurement topics: *Constructing Measures: An Item Response Modeling Approach* (Erlbaum, 2004); and *Towards coherence between classroom assessment and accountability* (103rd Yearbook of the National Society for the Study of Education, Part II. University of Chicago Press, 2004). He is editor of *Measurement: Interdisciplinary Research and Perspectives*, and also chair of the National Research Council Committee on K-12 Science Assessment.

Frank Rijmen is a postdoctoral researcher in the field of psychometrics at the K.U.Leuven (Belgium). He is the winner of the dissertation award of the Psychometric Society in 2003, and also the first author of the article in *Psychological Methods* on the topic of the training session.

Francis Tuerlinckx is an associate professor of data analysis and modeling at the K.U.Leuven (Belgium), and a previous postdoctoral researcher of the statistics department at Columbia University in NY. He is a co-author of the article in *Psychological Methods* on the topic of the training session, and a first author of various psychometric articles based on the same approach (e.g. *Journal of Personality and Social Psychology*, 2002, 448-461; *Psychological Methods*, 2001, 181-195).