PLmixed: An R Package for Generalized Linear Mixed Models With Factor Structures

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Minjeong Jeon¹ and Nicholas Rockwood²

Keywords

Item response theory, factor analysis, latent variable models, MIRT, multilevel models, hierarchical models

Description

The R (R Core Team, 2017) package PLmixed (Jeon & Rockwood, 2017) has been developed to extend the capabilities of the existing R package lme4 (Bates, Machler, Bolker, & Walker, 2015) to allow for profile-likelihood estimation of generalized linear mixed models (GLMMs) with factor structures (i.e., factor loadings, weights, item discrimination parameters), as outlined in Jeon and Rabe-Hesketh (2012). The modeling framework is a subset of the generalized linear latent and mixed model framework (GLLAMM; Skrondal & Rabe-Hesketh, 2004), which subsumes common models used within social and behavioral science research, such as factor analysis models, item response theory (IRT) models, and multilevel models. PLmixed is especially useful for estimating complex measurement models involving multilevel and crossed random effects/latent variables, which are often encountered in large-scale educational testing, multitrait–multimethod designs, and longitudinal studies.

Background

Several researchers have used lme4 to estimate one-parameter logistic (1PL) IRT models (De Boeck et al., 2011). A strength of lme4 is the ability to estimate complex models with an arbitrary number of nested or crossed random effects, making it useful for fitting, for example, 1PL multilevel IRT (Doran, Bates, Bliese, & Dowling, 2007) and random item IRT models (Baayen, Davidson, & Bates, 2008; De Boeck, 2008). However, the major limitation of lme4 in the context of item response and measurement modeling is that, within the GLMM framework, the factor structure of such models must be known a priori.

PLmixed uses a profile-likelihood approach to relax this constraint to allow the factor loadings and discrimination parameters to be freely estimated while still allowing for models with

¹University of California, Los Angeles, USA

²The Ohio State University, Columbus, USA

Corresponding Author:

Nicholas Rockwood, The Ohio State University, 1827 Neil Avenue, Columbus, OH 43210, USA.

Email: rockwood.19@osu.edu

arbitrarily complex random effect structures. This approach was recognized by Jeon and Rabe-Hesketh (2012), who demonstrated that these models could be estimated with nested maximizations using lme4 and the R function optim (Byrd, Lu, Nocedal, & Zhu, 1995). However, until the release of PLmixed, implementation of such methods required specialized programming by the user.

As many existing R users will appreciate, the syntax structure of PLmixed follows directly from lme4, with the addition that common factors can be included within the model formula, and a factor loading matrix, which specifies which loading parameters are freely estimated, can be provided as an additional argument. Further details of the program syntax can be found in the package vignette (see below for link), which walks through two example analyses. These examples included a longitudinal study where students are cross-classified in middle schools and high schools and a multilevel 2PL IRT model.

Availability

PLmixed (Version 0.1.2), which can be implemented on Mac, Windows, and Linux in R versions 3.2.2+, can be downloaded for free from the CRAN (Comprehensive R Archive Network) repository at <https://CRAN.R-project.org/package=PLmixed>. The package documentation, as well as the vignette, is also available on the same web page.

Declaration of Conflicting Interests

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