



## Deviance statistic in HGLM models

A deviance statistic, such as routinely printed for linear analyses in HLM, is not provided in the output for all the HGLM models. The absence is due to the use of the Penalized Quasi-Likelihood (PQL) estimation procedure. Although the actual estimates will usually be adequate, any test of random intercepts and slopes in multilevel models for discrete outcomes based on the likelihood may be unreliable.

This is also pointed out Snijders & Bosker (p 220): "Testing a random slope in multilevel logistic regression models can be based on the deviance, provided that the deviance statistic is based on numerical integration rather than on an approximation method".

With PQL, a first or second order Taylor expansion of the link function is used, and the approximation is around an estimate for the fixed part plus the random part. Deviance statistics for model comparison is not available for the PQL models, but only when Laplace or AGQ is used as method of estimation. When these methods are used, the deviance statistic printed in the output for the unit-specific model may be used to compare nested models.

Alternatively:

- the sample proportion  $P$  may be used to approximate the individual level-1 variance components, using the formulae given in the HLM manual, or
- bootstrapping may be used to test hypotheses or estimate confidence intervals for the random parameters in such a model.

If the model is true, it is assumed that the level-1 error variance is equal to  $\pi^2 / 3 = 3.29895$  for the logistic link function (see, *e.g.*, Hedeker & Gibbons (2006), p. 157), where  $\pi$  represents the constant 3.141592654.