Paper 64-2018

A Latent Variable Location Scale Model for Intensive Longitudinal Data

Shelley A. Blozis, University of California, Davis

ABSTRACT

Mixed-effects models give a flexible means to the analysis of longitudinal data. A location scale model, a special case of these models, is useful for intensive longitudinal data in which data are collected for many time points. The model characterizes between-subject variation in response levels over time, as well as within-subject variation in each person's responses. One part of the model allows for the inclusion of person-level predictors of the between-subject variation in mean response levels to understand individual differences, such as individual differences in daily stress averaged across multiple days. A second part of the model allows for the inclusion of both time-specific and person-specific predictors of the within-subject variation. This provides a way to study why the responses of some individuals may fluctuate more widely relative to those of others. Current applications of the model assume that the responses are measured without error. This assumption is not tenable for some measures, including psychological variables for which the observed measures serve only as indicators of an underlying construct. This paper presents a location scale model based on a latent variable model to address measurement error in measured responses. PROC NLMIXED syntax is developed to estimate the model. An example illustrates how model interpretation can be improved by addressing the measurement error that is common to many measured variables in the social and behavioral sciences.

INTRODUCTION

A location scale model is a mixed-effects model that provides a means for describing within-person variation in repeated measures, in addition to between-person differences in the characteristics used to define the model at the first level. In its most basic form, a location scale model is simply a random-intercept model that includes a submodel for the within-person variance and a submodel for the between-person variance of the random intercept. These two submodels are based on a loglinear model of a variance, each of which can easily be extended to include predictors of the variances. For instance, person-level predictors, characteristics of individuals that do not change during the study period, can be included in the loglinear model of the random intercept variance. In this case, the person-level variable can be used to address individual differences in the average response taken across time. Similarly, person-level predictors can be included in the loglinear model of the variance that represents within-person variation in the response across measurement occasions. Unlike the loglinear model for the random intercept variance, the loglinear model for the within-person residual variance can also include occasion-specific predictors, variables whose values can change from one occasion to the next.

Benefits of a location scale model include the ability to relax the assumption that the random intercept is normally distributed. Instead, the random intercept is assumed to be normally distributed conditional on the predictors included in the loglinear model of the random intercept variance. For instance, if a grouping variable such as a treatment condition is included as a predictor of the random intercept variance, then the random intercept is assumed to be normally distributed within each treatment population. With regard to the within-person variance, inclusion of within-person and between-person predictors in the corresponding loglinear model relaxes the assumption of homogeneity of variance in the level 1 residuals. For instance, the within-person variance may be a function of the treatment condition, such that one group has greater within-person variation relative to another group. A popular application of the location scale model is to intensive longitudinal data in which a large number of assessments of the same variable are taken over time, including applications to ecological momentary assessment data (e.g., Hedeker, Mermelstein, & Demirtas, 2008).

DAILY MEASURES OF POSITIVE AFFECT

Prior to describing a location scale model, positive affect measures from the Daily Project are introduced.

The data come from the Midlife in the United States (MIDUS 2): Daily Stress Project (Ryff & Almeida, 2004-2009), a

study designed to evaluate daily stressors and activities in adults. Participants were interviewed by telephone to obtain daily self-reports for up to 8 consecutive days. Included in the daily survey was a scale baesd on 13 items designed to measure positive affect.

LOCATION SCALE MODEL

A location scale model based on a mixed-effects model is a subject-specific model that characterizes the subject-level response, as well as that of the population. In a two-level model, the response variable y_{ti} is assumed to be a function of fixed and random effects, plus error. The random effects are subject specific, whereas the fixed effects are common to all individuals. The model may include time-varying and time-invariant predictors. Here, a total positive affect score, created by averaging responses to the 13 scale items, is studied as a function of participant sex (0 = male; 1 = female):

$$\text{Level 1: } y_{ti} = \gamma_{0i} + \gamma_1 \text{Sex}_i + e_{ti}$$

$$\text{Level 2: } \gamma_{0i} = \gamma_0 + s_i$$

where γ_0 is the average total positive affect score for males, and γ_1 is the mean difference in scores between males and females. The residual at level 1, e_{ti}, varies by measurement occasion and individual and represents the discrepancy between the observed total score and the individual's average total score, statistically adjusting for the effect of Sex. The residuals are assumed to be i.i.d. normal with mean equal to 0 and variance φ_e. At the second level, the random intercept from the first level of the model, γ_{0i}, is expressed as the sum of the fixed intercept γ_0 and random subject effect s_i, with the latter assumed to be i.i.d. normal with mean equal to 0 and variance φ_s. The variance φ_s is the between-person variation in mean daily total positive affect scores.

SAS PROC NLMIXED syntax for fitting the location scale model for the positive affect total score is given here:

Output from estimating the model is given here:

A SECOND ORDER LOCATION SCALE MODEL

CONCLUSION

The location scale model provides a means for describing both within-person and between-person variation in a measured response. Typical applications of the model assume that the observed scores are measured with error. In social and behavioral investigations that assess latent variables, such as affect, this assumption that the observed scores is not tenable. To address the measurement error in such scores, a latent variable model is developed to address the measurement error and the location scale model is applied to the latent scores. The benefit of this advanced model is that the within-person variation in the latent measure is separated from the variation in scores due to measurement error.

REFERENCES

Hedeker, D., Mermelstein, R. J., & Demirtas, H. (2008). "An Application of a Mixed-Effects Location Scale Model for Analysis of Ecological Momentary Assessment (EMA) Data." *Biometrics*, 64: 627–634.

Ryff, C. D., & Almeida, D A. (2004-2009). Midlife in the United States (MIDUS 2): Daily Stress Project. ICPSR26841-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2010-02-26.

CONTACT INFORMATION

Your comments and questions are valued and encouraged. Contact the author at:

Shelley A. Blozis
Psychology Department
UC Davis
sablozis@ucdavis.edu