Models for Replicated Discrimination Tests: A Synthesis of Latent Class Mixture Models and Generalized Linear Mixed Models

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Discrimination tests are often used to evaluate if individuals can distinguish between two items. The tests are much used in sensory and consumer science to test food and beverage products, and in psychophysics to investigate the cognitive strategies of the mind. Signal detection theory, experimental psychology and medical decision making are other areas, where the tests are applied. The basic idea is to use humans as instruments to measure attributes or differences between products (eg. Lawless and Heymann, 1998). In sensory and consumer science a panel of judges or a sample of consumers are employed, but humans are difficult to calibrate and much variation remains between individuals.

Often respondents perform the test several times and because subjects tend to have different discriminal abilities, this leads to overdispersion in the data. Traditionally this is handled by marginal models where the amount of overdispersion is estimated in order to adjust standard errors.

Commonly used discrimination tests can be identified as generalized linear models (GLMs) with the so called psychometric functions (Frijters, 1979) as inverse link functions (Brockhoff and Christensen, 2008). This makes generalized linear mixed models (GLMMs) available to model the variation between subjects.

The inverse psychometric functions maps the probability of a correct answer in the discrimination test to a measure of discriminal ability, which becomes an intercept parameter in a GLM or GLMM. Since the discriminal ability is a non-negative quantity, the random effect distribution in a GLMM consists of a point mass at zero and a continuous positive part. The resulting model can be seen as a synthesis of a latent class mixture model and a generalized linear mixed effect model. We have implemented functions that will fit the proposed model in R.

Interest is often in characterizing the variation between subjects and in obtaining estimates of individual discriminal abilities. Both sets of quantities are available from the proposed model as a variance component and posterior modes respectively. Also available is an estimate of the proportion of discriminators in the population as well as an estimate of the probability that each individual is a discriminator.

This presentation will introduce models for replicated discrimination tests, show how to fit them in R and consider important properties of the models. We end with an example from sensory science showing how to interpret the results.

References

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