

Advanced modeling of comparative judgment data: Applications to speech quality

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Abstract

Comparative judgment (CJ) data is often analyzed using the Bradley-Terry-Luce (BTL) model, which offers a straightforward method for measuring traits and conducting statistical inference. However, despite its usefulness, research has indicated that several core assumptions of the BTL model are rarely satisfied in modern CJ applications. As a result, the model may struggle to capture the complexity of some traits or stimuli, compromising the reliability and accuracy of trait estimates. Additionally, its requirement to separate trait measurement from hypothesis testing can further undermine the accuracy of statistical inferences drawn from such data.

To address these limitations, [Rivera et al.](#) proposed an approach that extends Thurstone's general form using causal and Bayesian inference methods. This approach allows for the construction of a model specifically tailored to the assumptions of the CJ data under study. Furthermore, it integrates measurement and hypothesis testing within a single analytical framework, facilitating precise and accurate inferences from the data.

This tutorial illustrates the application of the proposed approach to a simulated dataset on speech quality. It provides detailed guidance on data simulation, model specification, estimation, and interpretation using the software **R** and **Stan**. The tutorial assumes that researchers are familiar with causal and Bayesian inference methods, as well as latent variable models, but may not have prior experience with CJ data or the software. By following the procedures outlined here, researchers can reproduce the analysis and adapt the approach to other CJ studies.

Keywords: causal inference, directed acyclic graphs, structural causal models, bayesian statistical methods, thurstonian model, comparative judgement, probability, statistical modeling

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