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Bayesian Hierarchical Methods in Psychology: Two Case-Studies in Cognitive Modeling

Bayesian inference provides a principled and flexible approach for relating cognitive models to observed data. A particularly useful application of Bayesian inference is hierarchical modeling. Bayesian hierarchical modeling explicitly accounts for individual differences in model parameters, but at the same time recognizes that participants share some similarities. Rather than estimating parameters separately for each individual, hierarchical modeling assumes that the individual parameters are drawn from group-level distributions. The group-level distributions specify the between-subject variability in the model parameters. The goal is to obtain inference on both the individual and group levels.

I will discuss the Bayesian hierarchical implementation of two prominent cognitive models and describe the results of applying these models to experimental data. First, I will focus on the horse-race model of response inhibition, a model that allows the estimation of the unobservable latency of stopping an ongoing response (Logan & Cowan, 1984). In particular, I will outline a hierarchical mixture model that provides estimates of the entire distribution of stopping latencies and quantifies the probability that participants fail to trigger their stop response (Matzke, Love, & Heathcote, 2015). Second, I will focus on a multinomial processing tree model (Batchelder & Riefer, 1986) that allows the estimation of the encoding and retrieval processes in the free recall of semantically related word pairs. In particular, I will outline a hierarchical crossed-random effects extension that accounts for heterogeneity in items as well as participants and allows the estimation of the correlation between the model parameters (Matzke, Dolan, Batchelder, & Wagenmakers, 2015).