Hierarchical Hidden Markov Models for Response Time Data

Mario Peruggia[1], Zhifei Yan[1], Peter Craigmile[1], Trisha Van Zandt[1]

[1] *The Ohio State University, USA*

Abstract

Psychological data, particularly those measurements obtained sequentially in experiments designed to test theories and models of human cognition, are often treated as independent and identically distributed samples from a single distribution that describes the random behavior of the cognitive process of interest. This assumption is made for mathematical and analytic convenience; it is widely appreciated that such data are in fact mixtures from two or more processes, a subset of which are associated with the cognitive process of interest. There is a long history of trying to determine the components of psychological data mixtures and estimate the relative contributions of each (see, e.g., Luce, 1986 for a review), and the mixture construct has been an important tool in investigating memory phenomena such as spreading activation and response preparation (e.g., Meyer et al., 1985; Yantis & Meyer, 1988). Our own work (Kim et al., 2017) has demonstrated the importance of including components to describe fast (subcognitive) and slow (supracognitive) processes that contribute to the measurements derived from the cognitive process of interest. In this project, we build on classic studies that attempt to distinguish the separate components of a psychological mixture process (Falmagne, 1965, 1968; Ollman, 1966; Yellott, 1971). Our modeling framework for response time data makes use of a hierarchical hidden Markov structure. The hidden states of the model are intended to capture the three putative processes (subcognitive, cognitive, and supracognitive) and to describe possibly varying levels of attention within a process. Appropriate parameter specifications allow the processes to evolve over time. The fit of the model is demonstrated on experimental data.