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# Introduction to the Special Issue

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All cognitive modelers sooner or later (usually sooner) run headlong into fundamental issues associated with comparing and selecting alternative models and with evaluating the validity of the models that have been developed. We developed this special issue around the theme of *model comparison* to highlight the critical importance of these topics for ongoing progress in cognitive science. What are the different methods by which one can compare two or more models in terms of their capacity to explain a set of experimental findings? Can these models be empirically distinguished in terms of their qualitative or quantitative predictions? What are the prospects for making direct comparisons across statistical, mathematical, and computational modeling approaches? How does the focus of comparisons differ across modeling approaches, and what value might the best practices of one of these modeling communities have for the others? How should we deal with the complex interplay of issues such as the breadth and depth of explanatory mechanisms, parsimony, plausibility, precision, and accuracy within and across modeling approaches? Without clear answers to these questions, how can our science measure its progress? We have assembled a collection of articles that address some of these and other important questions.

The structure and content of this special issue is strongly influenced by a workshop we organized in September 2006 on the topic of comparing complex models of cognition. At the time, all three of us were employed by the Air Force Research Laboratory, and the workshop was sponsored by the Air Force Office of Scientific Research, where Busemeyer was serving as manager of the Cognition and Decision basic research program. Academic, government, and industry scientists from cognitive psychology, mathematical psychology, computer science, cognitive neuroscience, and statistics participated in two days of discussion and debate of the issues and challenges involved in comparing and evaluating complex cognitive models. The workshop provided a venue not only for identifying core issues and challenges within specific model comparison methodologies, but also for facilitating the productive exchange and cross-fertilization of ideas, methods, approaches, and solutions across multiple research disciplines. Shortly after the completion of the workshop, the call for proposals went out for a future special issue of the journal *Cognitive Science*. There has been no prior special issue on model

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comparison methodologies in *Cognitive Science* and precious little explicit treatment of the topic in individual articles within the journal. We felt it was time for an informed exposition and discussion of this important topic. Naturally, there was more workshop content than could possibly fit in a single journal issue, so we right-sized to a representative sample of the major approaches and themes, with a bias toward multidisciplinary methodological integration. The articles in this special issue are those that survived the journal's rigorous peer review process and whose authors persisted and accommodated the requirements for multiple revisions to the original submissions. We would like to thank the *Cognitive Science* editorial board and a long list of anonymous reviewers for their thoughtful suggestions and constructive criticisms. The contributions of the individual articles and of the special issue in its entirety are stronger thanks to their hard work.

Although each of the following seven articles stands solidly on its own merits, we have made an effort to impose a rough thematic structure and logical flow in their ordering, motivated by an interest in emphasizing some of the methodological similarities and differences. The issue begins with Shiffrin, Lee, Kim, and Wagenmakers's article, which provides a general overview of quantitative model comparison and selection metrics and methods. The second half of their article focuses on hierarchical Bayesian analyses, with example use cases in the context of memory models. The second article, written by Pitt, Myung, Montenegro, and Pooley, emphasizes the importance of considering model flexibility when interpreting the impressiveness and implications of model fits to empirical data. The beginning of the article reviews methods for measuring and comparing flexibility. Then, the authors focus on parameter space partitioning (PSP) as a powerful and informative means of comparing cognitive models, with an example demonstration in the context of connectionist models of speech perception. Almost as if in response to Pitt et al. (although not actually so), Cassimatis, Bello, and Langley propose that a bias toward evaluating models on the basis of fit to empirical data has come to dominate current practice in cognitive science, and that the field would be well-advised to consider factors such as ability, breadth, and parsimony to be important complements, or perhaps even preferred alternatives, to empirical fit measures. The sub-point in the Cassimatis et al. article regarding the important role for cognitive science of architecture-based models makes a nice segue to the next two articles. Anderson et al. describe their recent methodological developments at the intersection of computational cognitive process modeling and brain imaging, using fMRI data to evaluate the BOLD response predictions of models developed in ACT–R. They emphasize the generality of their method and its use in comparing and selecting among specific models and also in iteratively improving on the underlying architectural theory used to generate the models. In the next article, Weaver brings a statistician's perspective to model validation in suggesting the reinterpretation of stochastic information processing models in terms of the mathematical form of the likelihood function for those models. Her examples are derived from ACT–R, but the approach is fundamentally more general. A sub-theme in the Weaver article is an argument in favor of taking architected information processing models seriously as simulations of individual subjects, which provides a convenient transition to the Ahn, Busemeyer, Wagenmakers, and Stout article. They compare the generalizability of eight decision learning models, with an emphasis on estimating parameters at an individual subject level of analysis for purposes of predicting performance on other tasks. Finally, the

Lee and Vanpaemel article returns us to the use of hierarchical Bayesian analysis, this time as a method for identifying theoretically based priors for parameter estimates in alternative category learning models.

We hope the cognitive science community will find this special issue to be an informative and useful collection of articles.