Relevance to the symposium. This presentation addresses the current and anticipated future state-of-the-art in human behavior modeling, focusing on models that integrate cognition and decision-making, motivation, and real-time interaction. A theoretical framework is advanced—based on boundedly optimal control—that builds on recent advances in cognitive modeling while addressing some of its current major limitations. The approach is illustrated with applications to domains of multi-tasking, human-computer interaction, and rapid decision-making. (This is joint work with Professor Andrew Howes (Manchester) and Dr. Alonso Vera (NASA Ames)).

Rationale. Cognitive science and cognitive neuroscience have made significant strides in developing empirically motivated theories of the human cognitive architecture and its associated constraints (e.g. limited attention, noise, memory). The most powerful of these theories accounts for the flexible nature of human behavior by admitting of an unlimited range of possible behavioral strategies. But both predictive and explanatory power are seriously compromised when the application of such theories to any specific task requires the selection and programming of detailed behavioral strategies by a modeler. In such cases, it is often unclear who or what is doing the predictive heaving lifting: the theory of cognitive architecture, or the modeler in choosing the strategy.

We argue that further progress in both application and science requires principled methods for deriving—rather than stipulating—behavioral strategies that are adapted to both the external contingencies of the task environment, and the internal constraints on the human processing architecture. We propose that the emerging theoretical and methodological framework of cognitively bounded rational analysis provides one promising avenue for accomplishing this goal. This framework construes cognition and action as boundedly optimal control problems—as rational processes constrained by both the structure of the environment and the structure and limitations of the cognitive architecture.

Methods and results. Underlying the approach are computational methods (from machine learning) for evaluating large spaces of possible behavioral strategies in terms of their expected utility given the architectural constraints, rather than their fit to observed data. We demonstrate the generality of the approach by summarizing its application to several domains, including: (1) rapid multi-tasking (where it provides novel quantitative accounts of individually varying dual-task performance); (2) decision-making (where it provides novel derivations of “fast-and-frugal” decision making strategies); and (3) human-device interaction (where it provides novel derivations of the coordination of hands, eyes and cognition in service of specific tasks).
Conclusions. These initial results illustrate several features of the approach that make it attractive as a general framework for behavior modeling with applied aims: (1) its formulation of the strategy selection problem as boundedly optimal adaptive control confers significant generality, permitting its application to domains ranging from interaction to decision making to communication; (2) its combination of normative rational analysis with detailed accounts of the constraining cognitive machinery permit the derivation of behavior with both greater predictive and prescriptive value; (3) its explicit role for quantitative objective functions provides a natural point of contact with applied domains where formal evaluation metrics are available or developing; and (4) its derivation of behavior adapted to individually varying cognitive architectures opens up a new path for principled accounts of individual differences.