A Coherent Computational Framework for Modeling Component Decision Processes

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This talk summarizes recent advances in developing a coherent approach to the study of human decision making. Our approach is a clear departure from—and possesses marked advantages over—the traditional method that has dominated the field for decades. We rely instead on a dynamic framework that has been successfully applied to many other cognitive domains, such as memory and categorization. Specifically, we apply sequential sampling principles across several distinct but interconnected levels to model a variety of processes that serve decision making.

Descriptive theories of human decision making have roots in normative analyses of rational decisions. The primitive element of these theories is a holistic value, or expected utility, for any given option. This utility integrates the subjective values of the different dimensions of an option, or the different outcomes of a probabilistic event. Early utility theories supposed this integration was a simple weighted (by outcome probability) sum of outcome values. However, decades of empirical research have refuted this model as a descriptive account of human behavior. Most decision researchers have responded with amendments to the basic model such as by adding parameters, relaxing assumptions, or requiring specific functional forms in allowing for subjective assessment of probability and value. Despite the complexity arising from incessant modification of the utility framework, contemporary versions are still unable to account for many robust phenomena.

Rather than attempting to retain the ailing utility model, we adopt a completely different approach. Here, we show how a computational perspective can elucidate the nature of information processing that underlies overt decision behavior. We do not suppose that complex algebraic utility calculations drive decision making. Instead, we directly model the components of the decision-making process, including subjective weighting of event probabilities, subjective valuation of possible outcomes, deliberation as information integration, and response selection.

We utilize dynamic systems that describe the state of a system at any given moment. These systems can be summarized by the distribution over initial states of the system, the transition probabilities among states, and the exit probabilities of terminating when in each state. By adopting the appropriate interpretation of system states, we then formalize these three elements to derive predictions for various decision behaviors. We model deliberation and choice as transitions among relative preference states for the considered options. This model receives input from two other dynamic systems. First, a system defined by transitions in attention to different attributes produces the equivalent of decision weights (subjective probability). Second, a system defined by motivational need states determines how outcomes are evaluated (subjective value). Outputs from the choice model determine an overt response, such as a discrete choice among options or the pricing of a single option; the latter is modeled by transitions among candidate prices in another dynamic system.

In sum, we use a single mathematical process in several different ways to generate predictions for the components that produce decisions. This method details the dynamic, stochastic processes that produce measurable responses. This approach is in stark contrast to the theoretical tradition of static, deterministic utility as a determinant of behavior. This framework thus predicts measures that utility theories cannot, such as deliberation time and response distributions. Furthermore, we show how this approach easily explains an abundance of behavioral trends that collectively serve as a benchmark for descriptive adequacy not met by even complex versions of the traditional model.

References

Busemeyer, J. R. & Johnson, J. G. (2004). Computational models of decision making. In D. Koehler & N. Harvey (Eds.) *Handbook of Judgment and Decision Making*. Malden, MA: Blackwell Publishing Co.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision Field Theory: A dynamic cognitive approach to decision making. *Psychological Review, 100,* 432-459.

Busemeyer, J. R., Townsend, J. T., & Stout, J. C. (2002). Motivational underpinnings of utility in decision making: Decision field theory analysis of deprivation and satiation. In S. Moore (Ed.) *Emotional Cognition*. Amsterdam: John Benjamins.

Johnson, J. G. & Busemeyer, J. R. (2005). A dynamic, stochastic, computational model of preference reversal phenomena. *Psychological Review, 112*, 841-861.

Johnson, J. G. & Busemeyer, J. R. (2006). A computational model of the decision weighting process.

Roe, R. M., Busemeyer, J. R., & Townsend, J. T. (2001) Multi-alternative decision field theory: A dynamic connectionist model of decision making. *Psychological Review, 108*, 370-392.