Rational Explanations

Symposium

Organiser:
Andrew Howes[1]

Panelists:
John Anderson[2], *Nick Chater*[3], *Lael Schooler*[4], *Richard L. Lewis*[5], *Henry Brighton*[4]

University of Manchester[1]

Carnegie Mellon University[2]

University College London[3]

Max Planck Institute for Human Development[4]

University of Michigan[5]

Human behaviour is the product of two adaptive systems that generate and select actions beneficial to the organism. Through one of these systems, genetic selection, the species has acquired relatively stable psychological mechanisms. Through the other, learning, individuals acquire the knowledge that determines behaviour on a moment to moment basis. Together these systems generate the complex behaviours that cognitive science seeks to explain.

Focusing on behaviour as the product of adaptation opens up possibilities for deep explanations that answer questions not only about how people behave but also why they behave as they do. These *rational explanations* are grounded in theories of the constraints on adaptation, including constraints derived from the observable structure of the task environment (either evolutionary or local). They are also grounded in one, or other, assumption of rationality, which is sometimes defined in terms of optimality criteria. The assumption of rationality is the point of departure for a range of approaches to understanding cognition and perception, including rational analysis and related Bayesian approaches (Anderson, 1990; Anderson & Schooler, 1991; Oaksford & Chater, 2007), optimal motor control approaches (e.g. Maloney, Trommershäuser, & Landy, 2007), as well as signal detection theory and ideal observer analysis (Giesler, 2003). Others, notably Simon (1955) and Gigerenzer, ABC Research Group and Todd (2000), focus on the adaptive benefit of heuristics given that rationality is limited by psychological bounds.

The symposium will encourage discussion of relevant contributions made over the past 20 or so years and, further, will seek to expose the key unanswered questions. The remainder of this abstract provides brief descriptions of current contributors of the symposium speakers.

Anderson began to pursue the issue of how cognition might be adapted to the statistical structure of the environment in the late 1980s and soon published "The Adaptive Character of Thought" (Anderson, 1990). The fundamental idea was that to understand human cognition we do not need to develop a theory of its mechanisms but only need to understand the statistical structure of the problems it faces. This effort has had successes in developing theories of human memory and categorization. In the memory domain, Anderson and Schooler (1991) collected statistics on the information-retrieval demands made on human memory and showed that behavioral functions mirrored these. In the case of categorization this lead to a program which accounted for a wide range of human data and which did well on a number of machine-learning data sets. The rational analysis work played a major role in defining a better version of the ACT-R subsymbolic activation processes. Anderson realized that while these subsymbolic processes were tuned to the statistical structure of the environment, one needed an overall computational structure like ACT to understand how they interacted.

Furthering his earlier work with Anderson, Schooler is now pursuing a modeling and empirical effort that, in the context of David Marr's functional approach to understanding cognition, bridges two research programs grounded in an appreciation of the adaptive value of human cognition: The program on fast and frugal heuristics explores cognitive processes that use limited information to make effective decisions; and the ACT-R research program that strives for a unified theory of cognition. This work illustrates how a memory system that is tuned to automatically retrieve information can be exploited for a different purpose, namely making inferences about real objects in the world, based on meta-cognitive judgments about how the memory system responds to stimuli (Schooler & Hertwig, 2005). This work provides a good point of departure to discuss the kinds of cognition that yield to a rational analysis and those that might not.

Chater has argued that rationality is defined by the ability to reason about uncertainty. Although people are typically poor at numerical reasoning about probability, human thought, shaped through evolution, is sensitive to subtle patterns of qualitative Bayesian, probabilistic reasoning. In Bayesian Rationality (Oaksford & Chater

2007), the case is made that cognition in general, and human everyday reasoning in particular, is best viewed as solving probabilistic, rather than logical, inference problems. The psychology of "deductive" reasoning is addressed directly: It is argued that purportedly "logical" reasoning problems, revealing apparently irrational behaviour, are better understood from a probabilistic point of view. Data from conditional reasoning tasks, for example, are explained by recasting these problems probabilistically. The probabilistic approach makes a variety of novel predictions which have been experimentally confirmed.

Brighton's research, e.g. Brighton and Todd (2008), focuses on modeling the computational processes that underlie adaptive behaviour. With Gigerenzer, Brighton views heuristics as cognitive processes that gain efficiency by ignoring information. In contrast to the widely held view that less processing reduces accuracy, the study of heuristics shows that less information, computation, and time can in fact improve accuracy. Heuristics are ecologically rational when deployed in the right environment. The "adaptive toolbox" provides a systematic theory of heuristics that identifies their building blocks and the evolved capacities they exploit. According to this program, while people have biased minds and ignore part of the available information, they can handle uncertainty more efficiently and robustly than an unbiased mind relying on more resource-intensive and general-purpose processing strategies.

Lewis and Howes assume that individuals adapt rationally to a utility function given constraints imposed by their cognitive architecture and the *local* task environment (Howes, Lewis, Vera, accepted). This assumption underlies a new approach to modelling and understanding cognition —cognitively bounded rational analysis—that sharpens the predictive acuity of general, integrated, theories of cognition and action. Such theories provide the necessary computational means to explain the flexible nature of human behaviour, but in so doing introduce extreme degrees of freedom in accounting for data. The new approach narrows the space of predicted behaviours through analysis of the payoff achieved by alternative strategies, rather than through fitting strategies and theoretical parameters to data. Analyses of dual-task performance, and the development and analysis of a new theory of ordered responses, yield several novel results, including a new understanding of the role of strategic variation in existing accounts of dual-task performance, and the first predictive, quantitative, account showing how the details of ordered dual-task phenomena emerge from the rational control of a cognitive system.

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