The bounds of rationality and cognitive building blocks

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In 1956, Herbert Simon scolded researchers using economic theory to characterize rational choice, admonishing that "organisms … do not, in general, 'optimize'" (p. 129). Simon rejected the notion that decision makers met the god-like qualifications required of rational agents. Instead, he proposed that, to fully understand decision making, one must study two critical components: the cognitive capacities of the organism and the structure of the environment in which an organism operates (Simon 1956).

Despite the clear relevance of Simon's ideas to the study of animal behavior, few have appreciated his contribution (but see Callebaut 2007). The role of the environment has been appropriately credited as an important force shaping animal behavior via the concept of adaptive specialization. For instance, comparative analysis indicates that a species' foraging ecology likely molds how it deals with risk and temporal delays in decision making (Rosati et al. 2007; Heilbronner et al. 2008). The cognitive capacities of organisms, however, have not been properly considered by models of animal behavior, and this is where Fawcett et al.'s notion of the behavioral gambit is useful.

Unlike many economists studying human behavior, optimization modelers studying animal behavior accepted early on that animals were not optimizing. For instance, in the field of foraging theory, modelers began searching for simple rules of thumb (such as giving-up time rules) that animals could be using to approach optimal outcomes (Stephens and Krebs 1986). But beyond developing simpler rules that avoid the need for sophisticated computations, little work in animal behavior has actively integrated psychological mechanisms into evolutionary accounts of behavior.

Fawcett et al. nicely highlight the behavioral flexibility that learning offers animals. Expressly modeling the mechanisms of learning and how they influence behavior is underappreciated and critical for understanding the evolution of behavior. However, learning is not the only means to achieve flexibility. Conditional decision rules also produce behavioral flexibility, and they also require an understanding of the *cognitive building blocks* that must be in place for an organisms to implement the rule.

The cognitive building blocks approach suggests that decision rules are composed of multiple cognitive capacities needed to process information. As an example, consider the cooperative strategy tit-for-tat. This relatively straightforward strategy simply copies its opponent's single last behavior in a cooperative interaction. Though tit-for-tat and its variants have been used extensively to model reciprocal cooperation (e.g., Nowak 2006), rarely do researchers consider the cognitive building blocks needed to implement it. Yet, tit-for-tat requires that individual wait for future rewards, remember past encounters, and perhaps quantify costs and benefits and imitate partner actions (Stevens, Cushman, and Hauser 2005). Unfortunately, animals (including humans) have a difficult time waiting for future rewards and remembering specific past events, potentially limiting the use of tit-for-tat and its variants.

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Experiments on blue jays indicate that they only cooperate in an iterated prisoner's dilemma when they play against a tit-for-tat strategist and the experimenter reduces the jay's impulsivity (Stephens, McLinn, and Stevens 2002). Further, an experimental test of human memory in an iterated prisoner's dilemma situation demonstrates that even humans have a difficult time tracking the past behavior of partners (Stevens et al. 2011). Thus, psychological data force us to rethink the kinds of strategies that organisms actually use in cooperative situations.

The thrust of the behavioral gambit and cognitive building blocks approaches is that we need to fundamentally change how we model behavior. Optimality and game theory have generated an enormous amount of interesting research. But we cannot stop there. To better understand how humans and other animals behave, we must take Simon's concept of bounded rationality seriously and integrate cognitive capacities with the structure of the environment when constructing models of behavior. The behavioral gambit has proven too risky.

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