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Evolutionary Game Theory

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Game theory is the study of strategic interactions. As choice problems for rational agents, these are linear optimization problems. However, when interpreted as matrices of propagation factors for types within a population, the resulting non-linear evolutionary dynamics often yield results quite different from the rational optima. It seems that mindless natural selection can solve problems that ideally rational agents cannot.

Evolutionary game theory (EGT) has proved to be a remarkably productive research framework, spanning disciplines as diverse as biology, economics, psychology, and philosophy. Its primary impact has been in the study of cooperation and altruism, demonstrating that the human moral behaviors which have been so puzzling to rational choice theory as well as to simplistic characterizations of evolution are actually the sorts of things one should expect in complex social animals. Of possibly greater philosophical significance is the application of evolutionary game theory to epistemology and semantics. The reliability as well as the design parameters of perceptual and cognitive mechanisms must be explained by evolutionary history, and these adaptive challenges are being productively analyzed with the tools of EGT. Due to its indifference to ontologies, EGT can be used to model biological and cultural evolution with equal facility, and raises the prospect of rigorous modeling of causal interaction and information flow in evolved learning and communication systems.

The past thirty years of EGT have taught us several things. First and foremost, informal intuitions and related linear methods of analysis are inadequate for understanding and predicting the behavior of even simple strategic interactions, much less complex culture/genetic coevolution. Everybody needs to learn to do the math, or at least respect it. Gradually, fundamental concepts of dynamic equilibria, stability and instability, and basins of attraction are becoming common parlance even for non-modelers. Multi-level models like Boyd and Richerson's have shown us that cultural evolution can cease to serve biological ends in a variety of situations. (Whether these cases are viewed as pathologies or as liberation from the dictates of "mere" biology is open to debate.) The concept of selection hierarchies allows the accumulation of different kinds of information at multiple levels, forcing us toward new precision in our epistemological questions.

The vector models which form the conceptual basis for EGT are not a panacea, however. Vector modeled selection hierarchies are ultimately not the best tool for looking at information flow in evolved learning systems, indicating that agent-based modeling is necessary for evolutionary epistemology. Similarly, spatially explicit evolutionary models yield results beyond vector dynamics methods. Meanwhile, the power and flexibility of EGT is bought at a price. Vector models simply quantify causes of frequency change without characterizing them. Agent-based models do not possess the physical constraints of real world systems, and so do not model emergence in physical systems. So while they do help us study the way environments can create order out of randomness, they are unhelpful in understanding the constraints on emerging forms -- the stuff selection works on. One might say that our understanding of selection is proceeding apace in EGT, genetics and ecology. The theory of variation will be more difficult.