

# Rule Learning in Symmetric Normal-Form Games: Theory and Evidence<sup>1</sup>

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An experiment, consisting of two 15-period runs with  $5 \times 5$  games, was designed to test Stahl's [*International Journal of Game Theory* 28, 111–130 (1999)] model of boundedly rational behavioral rules and rule learning for symmetric normal-form games with unique symmetric Nash equilibria. A player begins with initial propensities on a class of evidence-based behavioral rules and, given experience over time, adjusts her propensities in proportion to the past performance of the rules. The experimental data provide significant support for rule learning and heterogeneity characterized by three modes. We also strongly reject “Nash learning” and “Cournot dynamics” in favor of rule learning. *Journal of Economic Literature* Classification Numbers: C72, C90, C51, C52. © 2000 Academic Press

*Key Words:* learning; rules; games; evidence

## 1. INTRODUCTION

Current research in game theory addresses the question of how players learn to play. At one end of the spectrum, we have the super-rational theories of Jordan (1991) and Kalai and Lehrer (1993), and at the other extreme, we have reinforcement learning models of Mookherjee and Sopher (1994, 1997), Roth and Erev (1995), and Erev and Roth (1998), in which players have only minimal intellect. The objectives of these inquiries are mixed, and include (i) a foundation for an improved equilibrium theory, and (ii) a realistic description of human behavior (especially in experimental games) whether or not that behavior is consistent with Nash

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equilibria. While the super-rational theories require unrealistically strong assumptions, the naive reinforcement models suffer from the opposite sin of assuming players are too limited in their reasoning powers.

The middle ground, in which players potentially have access to decision-making rules of varying sophistication and can learn which rules are appropriate in given situations, is probably much closer to the truth and, hence, would provide a far better descriptive and predictive model of human strategic behavior. If all that humans could learn about a game was which action to choose eventually, then nothing would be learned that could be reliably transferred to a different game. There is a clear advantage for humans to learn general rules which could be applied across a variety of games. The highest payoffs will go to those who choose actions that are optional with respect to the true probability distribution of play in the population for the next encounter, which entails being one step ahead of everyone else and, hence, requires flexibility in forecasting/decision rules. As teachers of economics and game theory, perhaps our greatest contribution is to introduce students to new ways to analyze problems and make decisions (such as Bayes rule). For our theories to continue to exclude such learning would be shortsighted.

Some steps in this direction have already been taken (Camerer and Ho, 1997, 1999; Cooper and Feltovich, 1996; Erev and Roth, 1998; Rapaport et al., 1997; Sonsino et al., 1998). The purpose of this paper is to take another step towards articulating and empirically testing such middle-ground theories.

Stahl (1999) put forth a theory of boundedly rational behavior characterized by “behavioral rules” and a theory of rule learning based on the performance of these rules. The general model is illustrated in Fig. 1. A *behavioral rule* is a function that maps from the available information (the game and any history of play) to the set of probability distributions on the actions available in the game. We also define a probability distribution ( $\varphi$ ) over the space of behavioral rules. A random draw (from  $\varphi$ ) selects a rule, which (given the available information) generates a probability distribution on the actions. A second random draw from this latter distribution consti-

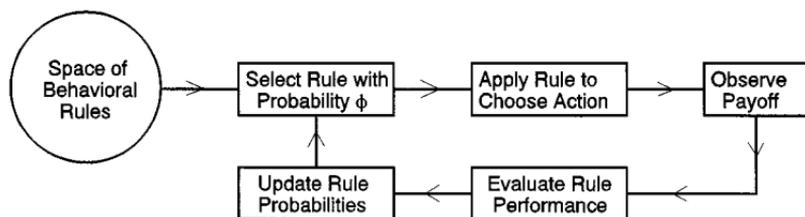


FIG. 1. Rule learning scheme.

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