Chapter 3.18
Social Simulation with Both Human Agents and Software Agents:
An Investigation into the Impact of Cognitive Capacity on Their Learning Behavior

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ABSTRACT

In this chapter, we will present agent-based simulations as well as human experiments in double auction markets. Our idea is to investigate the learning capabilities of human traders by studying learning agents constructed by Genetic Programming (GP), and the latter can further serve as a design platform in conducting human experiments. By manipulating the population size of GP traders, we attempt to characterize the innate heterogeneity in human being's intellectual abilities. We find that GP traders are efficient in the sense that they can beat other trading strategies even with very limited learning capacity. A series of human experiments and multi-agent simulations are conducted and compared for an examination at the end of this chapter.

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INTRODUCTION

The double auction is the core trading mechanism for many commodities, and therefore a series of

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human experiments and agent-based simulation studies have been devoted to studying the price formation processes or to looking for effective trading strategies in such markets. Among these studies, experiments on human-agent interactions such as Das, Hanson, Kephart, & Tesauro (2001), Taniguchi, Nakajima, & Hashimoto (2004), and Grossklags & Schmidt (2006), as well as computerized trading tournaments such as Rust, Miller, & Palmer (1993, 1994) have exhibited a general superiority of computerized trading strategies over learning agents, where the learning agents may stand for learning algorithms or human traders.

In Rust, Miller, & Palmer (1993, 1994)'s trading program tournaments, adaptive trading strategies did not exhibit human-like "intuitive leaps" that human traders seem to make in conjecturing good strategies based on limited trading experiences, although Rust, Miller, & Palmer (1993, 1994) also expected that most human traders will not be able to outperform software trading strategies because of their limited computational capability.

Rust, Miller, & Palmer (1993, 1994)'s conjecture can be evident when a series of human-agent interaction experiments is conducted. In Das, Hanson, Kephart, & Tesauro (2001), Taniguchi, Nakajima, & Hashimoto (2004), and Grossklags & Schmidt (2006)'s studies, in most of the situations, human traders cannot compete with their software counterparts. It seems that human traders could learn. However, due to some uncertain limitations, they just cannot win.

The ineffectiveness of learning behavior in double auction markets raises an interesting question: If learning is ineffective, then it implies that all human trading activities in double auction markets should have been replaced by trading programs since programs can perform better and more quickly. However, this is not the case in real markets. So, what is the unique property of human learning behavior in double auction markets?

For the above question, Rust, Miller, & Palmer (1994) speculated that human traders do not outperform software strategies because they are constrained by their computational capacity, but they do have the advantage of being adaptive to a wide range of circumstances:

"The key distinction is adaptivity. Most of the programs are 'hardwired' to expect a certain range of trading environments: if we start to move out of this range, we would expect to see a serious degradation in their performance relative to humans. ... Anyone who has actually traded in one of these DA markets realizes that the flow of events is too fast to keep close track of individual opponents and do the detailed Bayesian updating suggested by game theory." (Rust, Miller, & Palmer, 1994, p.95)

Thus, learning ability constrained by computational capacity could be not only an explanation of how human traders are different from software strategies, but also the source of heterogeneity observed among human decision makers.

Obviously, unless the innate property of human learning behavior is captured and well characterized in software agents, we cannot build a sufficiently adequate model to describe what happens in real auction markets, let alone move on to evaluate alternative market institutions with agent-based systems populated by autonomous agents. As a result, agent-based computational economists have contributed much in discovering or inventing proper algorithms based on human experiments to describe human learning processes. However, besides Casari (2004), not much has been done to consider the impact of cognitive capacity on human traders' learning ability.

Therefore, in this chapter we initiate a series of experiments to test the possibility of constructing learning agents constrained by their cognitive capacity. We achieve this by modeling learning agents with Genetic Programming (GP) and then we manipulate their "cognitive capacity" or "computational capacity" by assigning GP traders with populations of different sizes.

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