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Learning to make better strategic decisions☆

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ABSTRACT

Strategic settings are often complex and agents who lack deep reasoning ability may initially fail to make optimal decisions. This paper experimentally investigates how the decision making quality of an agent's opponent impacts learning-by-doing (LBD) and learning-by-observing (LBO) in a 2-player strategic game. Specifically, does LBD become more effective when agents face an opponent who exhibits optimal decision making? Similarly, does LBO become more effective when agents observe an opponent who exhibits optimal decision making? I consider an experimental design that enables me to measure strategic decision making quality, and control the decision making quality of an agent's opponent. The results suggest that LBD is more effective when facing an optimal decision making opponent. Whereas, LBO is, at most, marginally more effective when observing an optimal decision making opponent. The results also suggest that LBD is at least as effective as LBO at improving decision making in the 2-player game considered.

1. Introduction

Economic settings are often complex and optimal decision making can require deep reasoning ability. Oligopolies, negotiations, contracting, and auctions represent a few of the many complex economic settings where agents are called upon to make important strategic decisions. Agents who lack high levels of strategic sophistication and/or deep reasoning ability are likely to initially make sub-optimal decisions, which can often lead to inefficient outcomes. As a result, investigating how agents learn to make better decisions remains an important and largely open research question. The motivation of this paper is to investigate learning in strategic settings and provide insights regarding how agents can possibly become better strategic decision makers.

In relation to single agent decision tasks, one learning mechanism that can facilitate improved decision making is learning-by-doing (LBD). By repeatedly *doing* a decision task, an agent can acquire knowledge and skills that can subsequently lead to better decision making. In a seminal paper, Arrow (1962) argues that "learning is the product of experience. Learning can only take place through the attempt to solve a problem and therefore only takes place during activity" (p. 155). I refer the reader to Thompson (2010) for a comprehensive review of the extensive literature on LBD, including theoretical applications and empirical investigations supporting LBD. An alternative, yet related, learning mechanism that can facilitate improved decision making in single agent decision tasks is learning-by-observing (LBO). By repeatedly *observing* the decision making

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of another, an agent can acquire knowledge and skills that can subsequently lead to better decision making. For example, Jovanovic and Nyarko (1995) present a model of LBO where an "apprentice" learns from the skillful "foreman" he observes. Merlo and Schotter (2003) and Nadler et al. (2003) provide experimental evidence that supports LBO.[1]

In relation to strategic games, I contend that LBD corresponds to the acquisition of knowledge and skill by repeatedly playing the game. I, henceforth, refer to this analog of LBD in a game as *strategic* LBD. Similarly, LBO in a strategic game corresponds to the acquisition of knowledge and skill by repeatedly observing another agent play the game. I, henceforth, refer to this analog of LBO in a game as *strategic* LBO. Games, unlike single agent decision tasks, involve decision making of multiple agents. Therefore, it is possible that the effectiveness of strategic LBD and strategic LBO will be influenced by the decision making of the other agents in the game. The first motivation of this study is to experimentally investigate how strategic LBD and strategic LBO are influenced by the decision making quality of an agent's opponent. Specifically, I investigate whether strategic LBD becomes more effective when an agent repeatedly plays against an opponent who makes optimal decisions, compared to sub-optimal decisions. Similarly, I investigate whether strategic LBO becomes more effective when an agent repeatedly observes an agent who plays an opponent who makes optimal decisions, compared to sub-optimal decisions.

To shed light on these questions, I propose a stylized experimental design, described in detail in the following section, that uses a 2-player, sequential-move game which features a dominant strategy. The dominant strategy of the chosen game serves as an identifiable and measurable proxy for optimal strategic decision making. The design also features the implementation of pre-programmed computer opponents, which enables me to explicitly control the decision making quality of each subject's opponent.[2] In particular, I consider two *types* of computer opponents: The first, which I refer to as the *optimizing opponent*, is pre-programmed to play a dominant strategy, i.e., make optimal decisions. The second, which I refer to as the *naïve opponent*, is pre-programmed *not* to play a dominant strategy, i.e., make sub-optimal decisions. In the experiment, some subjects exclusively play the game, while other subjects initially observe a subject playing the game and then play the game themselves. This variation in whether subjects initially play the game or observe play of the game, in combination with the variation of the decision making quality of the computer opponent, allows me to identify how strategic LBD and strategic LBO are impacted by the decision making quality of one's opponent.

I find that subjects who initially played against the *optimizing opponent* make better decisions than subjects who initially played against the *naïve opponent*. However, I find that subjects who initially observed another subject playing the *optimizing opponent* make only marginally better decisions than those subjects who initially observed another subject playing the *naïve opponent*. These results suggest that strategic LBD can be more effective when playing against an opponent who makes an optimal decisions, while strategic LBO may be, at most, marginally more effective when observing an opponent who makes an optimal decisions.

As a second motivation of this study, I experimentally compare the effectiveness of strategic LBD and strategic LBO. That is, I compare the decision making quality of subjects who initially play the game to subjects who initially observe another subject play the game, for both the *optimizing opponent* and *naïve opponent*. This is similar in spirt to Merlo and Schotter (2003) who experimentally compare LBD and LBO in a single-agent profit maximization problem.[3] In their setting, Merlo and Schotter find that subjects who initially observe learn better than subjects who initially do. In the strategic game that I consider, I find very little difference between the decision making quality of the subjects who initially observe and the subjects who initially play. The results suggest that strategic LBD and strategic LBO appear to be comparably effective mechanisms for making better decisions. Because this study compares LBD and LBO in a strategic setting, the results should be viewed as complementary to those of Merlo and Schotter.

It is important to note that in a game with multiple decision makers, agents who play the game are going to also observe the decisions made by the other agents playing the game, i.e., observation of one's opponent is naturally embedded into playing a multi-decision maker game. In this regard, strategic LBD includes the effect of simultaneously observing the decision making of one's opponent while playing. Therefore, when I investigate strategic LBD, I am actually investigating the compound effect of playing the game *and* observing the opponent.[4] Because subjects are playing a game, it impossible to isolate the effect of playing the opponent, from observing the opponent. At the same time, because subjects who play necessarily observe the opponent, I contend that this compound effect is the appropriate and meaningful effect when investigating strategic LBD. However, to minimize the saliency of observing the opponent, with respect to strategic LBD, I consider two auxiliary treatments as part of the experimental design where subjects play an asymmetric version of G21. That is, a version of G21 where the subject and the computer opponent have different optimal strategies. In this asymmetric version of G21, I find

[1] LBO has also been well documented in several animal experiments including John et al. (1969), Tomasello et al. (1987), and Terkel (1996).

[2] The use of pre-programmed computer opponents is certainly not novel to this study. For example, Johnson et al. (2002) who use pre-programmed computer opponents in an alternating bargaining game. Merlo and Schotter (2003) use pre-programmed computer opponents in a tournament game. Shachat and Swarthout (2004) use pre-programmed computer opponents in a matching pennies game. Dürsch et al. (2010) use pre-programmed computer opponents in a repeated Cournot game.

[3] Technically, the authors consider a 2-player simultaneous move tournament game. However, the authors effectively transform the 2-player game into a single agent profit maximization problem by informing subjects that they will face a computer opponent that is pre-programmed to always make the same pre-specified decision.

[4] I thank an anonymous referee for calling to my attention this important point.