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Expert or Victim? How the Way in Which Game Theory Is Taught Affects Payoffs in an Iterated Cournot Game

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Abstract. This paper shares exploratory findings from a classroom study that investigated whether the sequence in which international students learnt about game theory influenced their performance while playing an iterated Cournot game. We found that gender has no major impact on cooperative behaviour, but prior familiarity with the concept of the prisoner's dilemma coincided with slightly greater instances of sustained cooperation. The most common outcome across all students was an inability to identify either the highest mutual payoff (sustained cooperation) or the unilaterally optimal strategy (defection). The sequence of instruction had a significant impact on student's results, and the group that was least likely to find the Nash equilibrium was in fact the group that was provided the most learning opportunities to identify it. Finally, we found that an exposure to game theoretic concepts was positively associated with cooperative (i.e. non-selfish) outcomes.

Keywords: Cournot, game theory, Nash equilibrium.

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1. Introduction

In our experience game theory can be one of the most fun topics to teach in an economics course. Students typically arrive in class wanting to think more strategically, and the prevalence of examples and real-life applications make the content engaging. And yet game theory exemplifies the fact that knowledge accumulation can be a double-edged sword.

Consider the classic centipede game. Player 1 and player 2 make a sequential decision to either cash in a pot of money, or pass the pot to the other player. The pot starts in the possession of player 1, and contains £5. If player 1 stops the game,

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they receive £4 and player 2 receives £1. If they pass the pot to player 2, the value of the contents doubles, to £10. Now player 2 has a decision to make – cash it in (in which case they will receive £8 and player 1 receives £2), or pass it back. Each time the pot is passed between players the total value doubles, but whoever cashes it in receives 4 times the amount of their opponent. If the pot is passed between players 6 times, such that the value reaches £320, the game ends and player 1 receives £256 and player 2 receives £64.

Students typically recognise that it is in both players interests to cooperate with each other – if they reach the end they are both better off than if they fail to cooperate (player 1 would prefer £256 to £4 and player 2 would prefer £64 to £1). However, at each stage of the game whoever is in possession has an incentive to renege on this commitment. Usually the pot moves back and forth for a few rounds, but once they approach the endgame the penny drops. Player 2 realises that if they defect on their final turn, and cash in the pot instead of passing it back to player 1, they can obtain a bigger reward (£128 on the penultimate round would beat the £64 received in the endgame). If player 1 is thinking strategically, they should anticipate this, and therefore defect on the round prior. Which means player 2 should have defected earlier. This is a great example of backwards induction (i.e. look at the endgame, and work your way back), and demonstrates that the "solution" to the game – which occurs if both players are acting strategically – is mutually suboptimal.[2] If the students achieve any cooperation at all they will receive bigger pay-outs then if they immediately defect. It therefore seems odd to describe their behaviour as irrational. Indeed, a key insight from game theory is that sometimes being an expert can also make you a victim. A mutually naïve strategy is superior to a mutually strategic one.[3]

This article presents the findings from a two-year study involving a diverse group of 341 masters students. All students played an iterated Cournot game but we alternated the sequence of learning so that some students received a theoretical lecture first. It is commonly accepted that learning economics can induce selfish behaviour (Kahneman 2011, pp. 55-56), but does the way in which concepts are taught affect that? Our findings investigate the relevance of gender and prior knowledge of students to their proclivity to cooperate, as well as the relevance of the instruction sequence for observed outcomes and average payoffs.

The rest of this paper will proceed as follows. Section 1 surveys the relevant literature, and finds an existing lack of attention to the sequence of instruction. Section 2 explains the design of our study, to demonstrate how we are filling the gap. Section 3 presents key charts to help summarise findings relating to student characteristics, observed outcomes, and average payoffs, Section 4 concludes.

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2. The "solution" is for Player 1 to stop the game at the first opportunity.
3. This doesn't mean that it's good to be naïve, it just means that having a naïve opponent can outweigh the handicap of being naïve yourself. It is always better to be strategic, but mutually strategic players receive lower payoffs than mutually naïve ones.

2. Using Game Theory in the Classroom

There is an extensive history of utilising experiments to learn about important economic phenomena, and strategic issues that relate to industrial organisation are particularly suitable topics. For a literature review of papers published since 2000 that use experimental economics to understand oligopoly markets, see Potters and Suetens (2013), while Brandts and Potters (2018) provide a more recent survey of experimental studies relating to game theory concepts. In this paper, we are particularly interested in the pedagogical insights from student based experiments. It seems obvious that game theory should be a focal point for interactive teaching – the concepts lend themselves to enjoyable activities and student engagement, and as Brokaw and Merz (2004) point out, "active learning arouses audience interest while introducing important concepts" (p.259). O'Roark and Grant (2018) employ comic books to demonstrate practical examples that simplify the key concepts, and the utilisation of games have become significant parts of economics courses. Becker (2000) and Bergstrom and Miller (2000) provide good examples of resources that advocate and advise instructors on how to use class room games, and Jacobson and Luedtke (2023) introduce articles with instructions for engaging, interactive games that vary from serving simple economic applications to targeting complex interdisciplinary learning objectives.

Although Dixit and Skeath (1999) suggest that simple bargaining games should be played on the first day of class, there's also a potential downside of exposing students to game theory – it may affect their behaviour and proclivity to cooperate with each other. Indeed, it is widely acknowledged that economics courses may make students more selfish, and less socialist in inclination. According to Landsburg (2018, p.19) it is commonly reported that students who take economics courses are less willing to contribute to left-of-center political organisations. Some studies attempt to understand the impact of monetary incentives on student outcomes, for example Rouso *et al.* (2015) find that students who play a prisoner's dilemma game with real money achieve higher test scores. Kahneman (2011 p.55-56) meanwhile, argues that using money in experiments primes respondents to be more independent and more selfish. That said, and more recently, Girardi et al (2024), find no clear link between studying economics and students self-interest, or indeed on their views on other people's self-interest. Indeed, classroom settings are well known for developing student's social capital, and encouraging team work and group allegiance. We therefore wonder whether fun activities do more to promote collective betterment than the specific learning objective (which in this case is to identify a prisoner's dilemma) does to prompt selfish behaviour.

Liberman *et al.* (2004) created a study where students were told to play a standard prisoner's dilemma.[4] Some of the participants were introduced to the game as "the Wall Street game" and others played "the community game".

Despite the payoffs being identical they found that students defected more than twice as often in "the Wall Street game". Seemingly the framing of the game induces an expectation of the other players behaviour which in turn becomes a self-fulfilling prophecy. In their discussion on the study, Fisman and Sullivan (2016) conclude that "we may not even realise it, but "the market" makes us selfish in such a way that undermines the common good" (p. 179). Holt (1999) even argues that although it is routine protocol to use real money in research experiments, such incentives are often unnecessary in classroom activities. This is because a competitive setting is often sufficient grounds to observe aggressive, or even selfish behaviour.[5]

Our study utilises the Cournot game found in Beckman (2003).[6] Students are split into pairs and given instructions, a payoff table, and a record sheet.[7] They make a simultaneous choice about how much output to produce, and their profit reflects the two choices made. Students gradually learn that restricting output leads to higher profits, but only if both do so. The game involves 10 rounds after which they calculate their individual profit. A really nice element of this game is that it combines a number of important game theory topics. Although it ostensibly focuses on oligopoly behaviour (it is a "Cournot" game due to the simultaneous output decision), it is perfectly suited to a game theory class since each round contains a potential prisoner's dilemma, and the 10 successive rounds has some features of a centipede game.[8]

Critically, the game is presented as a strategic situation but it is not obvious that it is a prisoner's dilemma. The purpose of the exercise is for students to recognise that there's a "cooperative" solution, where both players produce 3 units of output, and receive a payoff of 18. But in this situation, there is an incentive for each to defect – your best response to your partner producing 3 units is to produce 4, and increase your payoff to 20.[9] If both players play their best

4. Given that two players are taking part, one might think it is a "prisoners' dilemma". However, we elect to use the conventional punctuation of a "prisoner's dilemma".
5. That said, in the original experiment Beckman (2003) reports that around one third of students arrived at the joint monopoly and another third on the Nash equilibrium. The fact that two thirds of students in the present study do so admittedly questions either their incentives or capabilities.
6. The version used is available here: https://www.dropbox.com/s/o3vqbwa8orhqa9c/Cournot%201812.pdf?dl=1.
7. Pairs were assigned by the instructor based on seating positions, so there was an element of selection by the students themselves.
8. The prisoner's dilemma (i.e. whether to cooperate or defect) can be considered a reduced game within the Cournot game. The Cournot game has close similarities with a centipede game because in round 10 it is unilaterally advantageous to defect and therefore the principal of backwards induction implies that rational players should not cooperate from the start. After the Cournot game has been played instructors can utilise a separate profit table where players make simultaneous choices about price, i.e. Bertrand competition. An additional aspect is switching the Cournot game from a simultaneous decision to a sequential one. Not only does this teach the concept of Stackelberg competition (aka "first mover advantage") but in doing so creates an ultimatum game. The coverage of so many concepts within such a short exercise demonstrates just how powerful Beckman (2003) is!