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Using or hiding private information? An experimental study of zero-sum repeated games with incomplete information

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ABSTRACT

This paper studies the value of private information in strictly competitive interactions in which there is a trade-off between (i) the short-run gain of using information, and (ii) the long-run gain of concealing it. We implement simple examples from the class of zero-sum repeated games with incomplete information. While the empirical value of information does not always coincide with the theoretical prediction, the qualitative properties of the value of information are satisfied in the laboratory: (i) it is never negative, (ii) it decreases with the number of repetitions, (iii) it is bounded below by the value of the infinitely repeated game, and (iv) it is bounded above by the value of the one-shot game. In line with the theory, the empirical use of private information is almost complete when it should be, and decreases in longer interactions.

1. Introduction

It is well known that private information may not always be valuable in strategic contexts. In other situations, although it may be valuable, information should not be used, or should only be partially used. A typical example is the use of balanced strategies in poker: a good poker player should sometimes resist the temptation to bet or raise the best hand in the current round of betting to hide his information from his opponents, even though naive reasoning would suggest that he raise his hand in order to increase the pot. This is best illustrated by the following advice from the famous professional poker player Dan Harrington:

> "*No matter what style you finally adopt as your own, you'll have to learn to play what I call a balanced strategy. Simply put, this means that you have to learn to vary both your raises and calls, as well as the actual size of your bets, to avoid giving your opponents a read on your style. You'll have to do this even when you believe that a certain bet is clearly correct. What you sacrifice in terms of making a slightly incorrect bet on a given occasion will be recovered later, when your opponents have to guess at what you're really doing, and they guess wrong.*"[1]
>
> Harrington and Robertie (2007, p. 52)

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[1] He further explains: "*Here's a simple example. Suppose you believe that when you hold aces in first or second position, the "right" play is to open with a raise* [...] *If you always make this play with aces* [...] *they will know that when you call, you don't have aces. This is dangerous information to be giving away, so you need to take some countermeasures. The simplest countermeasure is to vary your play at random, giving a higher probability to the play you think is correct, but mixing in other plays frequently enough so that your opponents can't put you on a hand easily.*"

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	Left	Right
Top	10, 0	0, 10
Bottom	0, 10	0, 10

A^1

	Left	Right
Top	0, 10	0, 10
Bottom	0, 10	10, 0

A^2

Fig. 1. Payoff matrices in the NR games.

Choosing payoff dominated actions today in order to get greater benefit from information in the future is also a feature of well-known deceptive military strategies. This includes the WWII example of British military intelligence. When they were able to secretly read radio communications of the Axis powers enciphered using Enigma machines, they sent spotter submarines and aircraft to search for Axis ships just to disguise the source of the intelligence behind the Allied attacks (Hinsley, 1993). The Axis forces who observed these spotters and their radio transmissions then concluded that their ships were being located by conventional reconnaissance. Similar strategies were used to disguise the intelligence source from Allied crews themselves, by sending them on useless search missions.

This trade-off between (i) using information to get higher information rents today, but at the cost of losing an informational advantage tomorrow and (ii) choosing non-informed, and therefore more costly decisions today, in order to keep an informational advantage in the future, can also be found in strategic economic interactions. Consider for example a repeated common value auction in which identical objects are successively put up for sale and bidders receive private and independent signals about the true value. If bids are observed after each period, a well-informed bidder faces the same trade-off: "*if a bidder's proprietary information indicates that the units are all of high quality, he would like to increase his chance of winning the object by bidding more aggressively, but doing so may prove costly later on as other bidders may compete away the value of the information released through the bid*" (Hörner and Jamison, 2008, p. 476). As in the previous examples, this leads the informed bidder to delay information revelation by acting as an uninformed bidder, so as to make the other bidders more cautious and thus win with a lower bid.

This paper studies experimentally how subjects react to the above-mentioned trade-off between the short-run cost and long-run benefit of concealment. We raise the following general questions. When it is optimal to do so in the long-run, is there empirical evidence in a controlled environment that subjects only partially use their information, or delay information revelation, even though it is costly in the short-run? That is, do informed subjects refrain from using a naive, fully-revealing strategy, in order to benefit from an informational advantage in subsequent periods? Do these same subjects fully use their information when there is no value for information concealment, for example in late periods or in one-shot interactions? Do they suffer from a curse of knowledge, i.e., could the empirical value of information be negative in some instances? Do uninformed subjects extract information from informed subjects' behavior?

We address these questions by studying three examples from the class of zero-sum repeated games with incomplete information on one side and perfect monitoring, drawn from Aumann and Maschler (1966, 1967) and Stearns (1967). In this class of games, repetition is the channel through which information is transmitted from one stage to another. Because of perfect monitoring, information is (at least partially) revealed by the informed player's action whenever he decides to use it. Exactly as in the strategic applications mentioned above, the basic problem for the informed player is to find the optimal balance between using information as much as possible and revealing as little as possible to his opponent. On the other side, the uninformed player tries to find out the actual information of his opponent and to minimize its value. In the three examples under study, the stage games are trivial, i.e., the informed player has a different dominant strategy in either state. However, if he simply plays this naive strategy, the uninformed player will learn the state and subsequently choose actions that result in a very low payoff for the informed player.

As an illustration, Fig. 1 presents the payoff matrices of the leading repeated games we implement in the laboratory.[2] At the beginning of a repeated game, one of the two payoff matrices, A^1 or A^2, is drawn at random with the same probability. Player 1 (the row player) is privately informed about the state of nature (matrix A^1 or A^2), and has a dominant action in each state: Top in A^1, Bottom in A^2. This is clearly the best strategy for him in the one-shot game: he should completely use his private information. Player 2 (the column player) would like to play Right in A^1 and Left in A^2 but, being uninformed, he has to choose the same action in both states, yielding an expected payoff equal to 5 for both players. When the game is repeated, the past decisions of the informed player become a signal about his information: if this private information is fully used, then player 2 becomes aware of the actual state after the first stage, and plays his perfectly informed decision forever: Right following Top (i.e., in A^1) and Left following Bottom (i.e., in A^2). In this case, the payoff of the informed player is 0 in each subsequent stage, yielding an average payoff of $5/n$ in the n-stage game. Alternatively, the informed player can keep his information private by using a pooling strategy which is independent of the actual payoff matrix, for example mixing his play uniformly between Top and Bottom – just as if he was uninformed. The cost of this non-revealing strategy is the loss of the rent derived from information in the first stage. The benefit is that it provides an expected payoff equal to $5/2$ in each stage, whatever the length of the game. So, whenever the game is not one-shot, not using information at all is better

[2] In the game presented in Fig. 1, as in all instances we implement in the laboratory, the sum of players' utilities is constant across actions profiles. They are thus strategically equivalent to zero-sum games.