



HAL
open science

Some Strategic Aspects of Private Information: An Experimental Study

Andrés Salamanca, Olga Manrique Chaparro

► **To cite this version:**

Andrés Salamanca, Olga Manrique Chaparro. Some Strategic Aspects of Private Information: An Experimental Study. 2016. hal-01305213

HAL Id: hal-01305213

<https://hal.science/hal-01305213>

Preprint submitted on 20 Apr 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Some Strategic Aspects of Private Information: An Experimental Study[☆]

Andrés Salamanca Lugo¹

Toulouse School of Economics

Olga Manrique Chaparro

Department of Economics, Universidad Nacional de Colombia

Abstract

In this paper we experimentally analyze the use of private information in a class of zero-sum repeated games with incomplete information on one side and perfect monitoring. We analyze whether the information disclosure by the informed players, and its use by the uninformed players, matches the theoretical predictions. We consider two games that differ according to the amount of information that the informed player should optimally disclose: in the first game, the informed player should entirely conceal his information. In contrast, in the second game the informed player should fully disclose his information. We find that the flow of information is higher than predicted in the first game and lower than predicted in the second game. However, the use of information is strictly higher in the second game than in the first one. Uninformed subjects tend not to use the revealed information in the first game, and seem to misinterpret the revealed information in the second game.

Keywords: Repeated games, incomplete information, experiments.

JEL Classification: C73, D83, C91.

1. Introduction

In this paper we experimentally analyze the use of private information in two examples from the class of undiscounted zero-sum repeated games with incomplete information on one side

[☆]A preliminary version of this paper was written as part of Olga's doctoral dissertation at the Universitat Autònoma de Barcelona. The two authors carried out the experiment in 2011 and completed the present version of the paper in 2016. Financial support in the form of a Research Grant from the *Fondo de Investigación Jesús Antonio Bejarano* of the Faculty of Economics at the Universidad Nacional de Colombia (Bogotá) is gratefully acknowledged. We thank Nikos Georgantzís, Jordi Brandts, Rosemarie Nagel, Jonathan Schulz, Astrid Hopfensitz and Françoise Forges for extremely useful comments. We also benefited from numerous comments from participants at the International Meeting on Experimental and Behavioral Economics (2012) and the Second International Meeting on Experimental and Behavioral Social Sciences (2015).

Email addresses: asalamanca1.tse@gmail.com (Andrés Salamanca Lugo), olmanriquec@unal.edu.co (Olga Manrique Chaparro)

and perfect monitoring studied by Aumann and Maschler [1]. In the first example, the informed player cannot benefit in the long-run from his private information: behaving as if he were uninformed is optimal. In contrast, in the second example the informed player should optimally disclose his information by consistently playing the stage-dominant action.

Figure 1 presents the payoff matrices of the first repeated game we implement in the laboratory.

| | | G_A | | G_B | | |
|-----|-------|-------|------|-------|------|-------|
| | | W | E | W | E | |
| N | 1, -1 | 0, 0 | 0, 0 | N | 0, 0 | 0, 0 |
| S | 0, 0 | 0, 0 | 0, 0 | S | 0, 0 | 1, -1 |

Figure 1: Non-revealing game

Before the game starts, one of the two payoff matrices, G_A or G_B , is randomly chosen from an equiprobable distribution and only player 1 is informed about the matrix to be played. After that, both players repeatedly choose an action simultaneously: player 1 chooses a row, player 2 chooses a column. The game consists of a “long” number of finitely many repetition, but no player is certain about how many¹. At the end of every stage each player is informed about the choice made by his opponent (full monitoring), however, payoffs received by each one are credited (in the case of player 1) or debited (in the case of player 2) from their accounts without any of them to be able to see the amounts recorded.

By ignoring his private information, and playing both actions with equal probability, player 1 can guarantee an (undiscounted) expected payoff equal to 1/4. A strategy like that is called a *non-revealing (NR) strategy*, since the actions do not reveal in any way the choice of the chance. Aumann and Maschler [1] showed that the minmax value of this repeated game is 1/4, thus the NR strategy is optimal for player 1. If player 1 slightly alters his strategy to take some advantage of his knowledge, player 2 will eventually notice this and he will switch to his best response. In accordance with this, we shall refer to this game as the *non-revealing game*.

The following repeated game has the same description as the NR game except that the two possible matrices are now:

| | | G_A | | G_B | | |
|-----|-------|-------|------|-------|------|-------|
| | | W | E | W | E | |
| N | -1, 1 | 0, 0 | 0, 0 | N | 0, 0 | 0, 0 |
| S | 0, 0 | 0, 0 | 0, 0 | S | 0, 0 | -1, 1 |

Figure 2: Fully revealing game

¹This interpretation of a infinitely repeated game is consistent with the idea that players can approximately optimally play in any long finite game of duration n without making any essential use of n (see Aumann and Maschler [1, pp. 131]).

By using the *fully revealing (FR) strategy* “always choose S if the matrix is G_A and always choose N if the matrix is G_B ” player 1 guarantees a payoff of 0 at each stage of the game. Because the highest payoff that player 1 can get in both matrices is 0, it is clear that the minmax value of this game is 0 and the FR strategy is optimal for player 1. We refer to this game as the *fully revealing game*.

Each one of these repeated games was implemented as a separate experiment. In total, 130 subjects participated. The NR (resp. FR) game was played by 33 (resp. 32) pairs of players, of which 16 (resp. 10) played the game A and 17 (resp. 22) the game B. Subjects were instructed on the rules of the game with written instructions² and they played the repeated game for 17 rounds. No individual was informed about the number of repetitions. Subjects were only told that the game will be repeated for a “long” number of rounds, without any clear idea of *how* long. In each period, uninformed players were asked the following question: *Which do you think is the matrix you are playing?*. Further details on the experimental design are given in the appendix.

The experimental analysis shows that the flow of information is higher than predicted in the NR game and lower than predicted in the FR game. However, the use of information is strictly higher in the FR game than in the NR game. Uninformed subjects tend not to use the revealed information in the NR game, and seem to misinterpret the revealed information in the FR game (although their actions are consistent with their incorrect beliefs).

Our experiment is closely related to Jacquement and Koessler [2] (JK henceforth), albeit both experiments were conducted independently and without mutual knowledge of each other. Both papers use a similar experimental protocol (although JK consider a partially revealing game in addition to NR and FR games), and measure the use of information (they also study the empirical value of information). The following are the main differences between both experimental designs: first, the payoff matrices employed by JK are constant-sum modified versions of the matrices we use. In particular, they consider a FR game in which the informed player cannot guarantee himself the maximum payoff of the game, so that the uninformed player has more incentives to exploit the information revealed by the informed player³. Second, we focus on long-run games instead of the 1 to 5 periods used by JK. Finally, contrary to JK, we investigate the role of the beliefs guiding the decision making process of the uninformed players. For that, we elicit explicitly the beliefs of the individuals. This allow us to go further in the analysis of the uninformed players’ behavior. While most of our results regarding the informed subjects are similar to those in JK, one result which is markedly different concerns the behavior of uninformed subjects in the FR game, i.e., having consistently wrong beliefs about the actual stage game, despite rather clear information revealed by the behavior of the informed players. We provide a possible explanation for this result, yet it remains puzzling.

²Instructions were written in Spanish. Translated instructions are provided in the appendix.

³This difference may explain the differing results regarding the uninformed players’ behavior in the FR game.

2. Experimental Analysis

2.1. Non-revealing Game

In this section we present the results from our experiment in the NR game. Figure 3 depicts the relative frequency of the stage-dominant action in the actual game⁴. According to the theoretical predictions, the informed subjects should play each action with a probability equal to 50%. However, we observe that the frequencies of the stage-dominant action are consistently larger than 50% at every stage (see panel (a) of figure 3 and table 1 in the appendix). Indeed, every informed player chose in average the stage-dominant action 66% of the times. This means that informed players made use of their information more than they should do. The ability of the experimental subjects to optimally ignore their private information is weak.

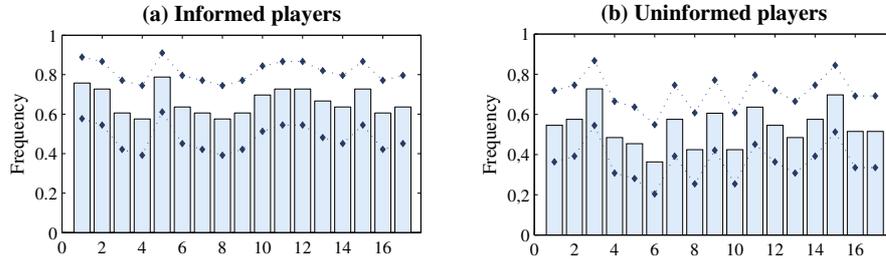


Figure 3: Relative frequency of the stage-dominant action in the NR game

Given the revelation pattern, we expect the uninformed players to optimally respond by playing more often the stage-dominant action of the actual game. However, the observed frequencies for the uninformed subjects suggest that they were unable to account for the information they received (see panel (b) of figure 3). In average, they played both actions equally likely (see table 2 in the appendix). In order to study the extent to which uninformed players reacted to the transmitted information, we estimated conditional fixed-effect⁵ logit regressions on the uninformed players' decisions. We denote $I(E)$ the binary variable associated to decision E , $Belief_n$ a binary variable taking value 1 when the uninformed player thinks he is facing game A, and $PI's\ choice_{n-1}$ a binary variable taking value 1 whenever he observes that player 1 chose action S in the previous stage. We separate regressions according to the actual stage game. Table 1 presents the regression results.

Regarding the players in stage game A, only beliefs were statistically significant. This is not surprising, since current beliefs are a sufficient statistic for all information contained in any history of the game. A positive estimated marginal effect for beliefs is consistent with an optimal response: as long as an uninformed player thought he was facing game A, the probability of playing action E was increased by about 30%. In contrast, for those subjects in stage game B neither the beliefs nor the informed player's choice were significant at any confidence level. Statistical evidence suggests that uninformed players in the stage game B faced difficulties to account for the revealed information.

⁴Dotted lines corresponds to 95% confidence intervals.

⁵Fixed effects controls for non-observable heterogeneity among individuals.

Table 1: Probability of choosing E

| Conditional Fixed-Effects Logit Regression | | | |
|---|---------------------|-------------------|---------------------|
| GAME A | | | |
| $I(E)$ | (1) | (2) | (3) |
| Belief $_n$ | 0.347*** (0.080) | | 0.325*** (0.101) |
| P1's choice $_{n-1}$ | | -0.010 (0.107) | 0.003 (0.090) |
| GAME B | | | |
| $I(E)$ | (1) | (2) | (3) |
| Belief $_n$ | 0.000 (0.226) | | 0.058 (0.231) |
| P1's choice $_{n-1}$ | | -0.017 (0.139) | -0.015 (0.142) |

Marginal effects reported instead of estimated coefficients.

Marginal effects calculated at the multivariate point of means.

P1's choice $_{n-1} = 1$ if S . Belief = 1 if game A.

Significance level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

2.2. Fully Revealing Game

We now turn to the fully revealing game. Theoretically, informed players should play the stage-dominant action at each stage of the game. Figure 4 displays the relative frequency of the dominant action in the actual payoff matrix. The observed frequencies suggest a strong correlation between decisions and private information. In average, the informed subjects played the stage-dominant action 75% of the times. Therefore, they used their information more than in the non-revealing game, but less than they should do. On the other hand, uninformed players accounted for the revealed information, but they reacted in an unexpected way: the most frequent action in every stage was the stage-dominant action. Indeed, the dominant action was only chosen 39% of the times. These frequencies are statistically different from 50% (see tables 3 and 4 in the appendix).

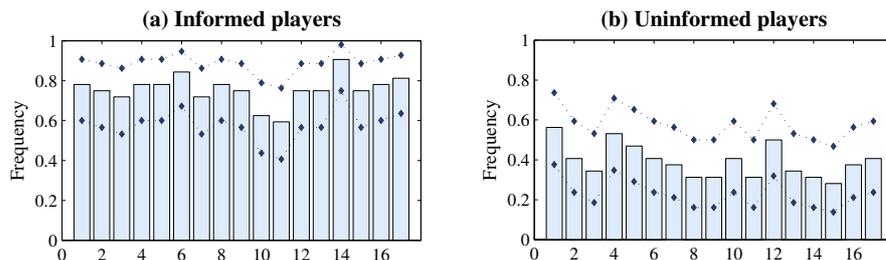


Figure 4: Relative frequency of the stage-dominant action in the FR game

We estimated conditional fixed-effect logit regressions on the uninformed players' decisions as in section 2.1. Regression results are summarized in table 2. Observed actions were consistent with a rational behavior given the elicited beliefs: the probability of choosing action W (resp. E) was increased once the player believed he faced the stage game A (resp. B). However, beliefs were not updated consistently with the revealed information. Whenever the actual stage

game was A (resp. B), the average frequency of uninformed players that believed to be in game B (resp. A) was around 70% (resp. 50%)⁶. This explains why the observed behavior of the uninformed individuals is not consistent with an optimal response given the revealed information.

Table 2: Probability of choosing E

| Conditional Fixed-Effects Logit Regression | | | |
|---|----------------------|------------------|----------------------|
| GAME A | | | |
| $I(E)$ | (1) | (2) | (3) |
| Belief _{n} | -0.457*** (0.035) | | -0.603*** (0.104) |
| P1's choice _{$n-1$} | | 0.212 (0.137) | 0.240 (0.210) |
| GAME B | | | |
| $I(E)$ | (1) | (2) | (3) |
| Belief _{n} | -0.493*** (0.007) | | -0.513*** (0.062) |
| P1's choice _{$n-1$} | | 0.110 (0.092) | 0.023 (0.077) |

Marginal effects reported instead of estimated coefficients.
Marginal effects calculated at the multivariate point of means.
P1's choice _{$n-1$} = 1 if S . Belief = 1 if game A.
Significance level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The question is why the uninformed subjects did not update their beliefs according to the information revealed on the actual stage game. We think that the uninformed individuals mainly focused on their own payoff matrices disregarding the payoff motivations of the informed individuals. This resulted in a lack of incentive compatibility: despite the fact that the informed individuals found profitable to release their private information, uninformed subjects could not believe in such a disclosure. Our hypothesis is that external motivations other than the strategic aspects led the uninformed players to believe that any revelation could only be for the purpose of misleading. Then, in anticipation of a deceiving behavior, uninformed players modified their beliefs in the opposite direction. In sharp contrast with the strategic motivations, social motivations like “mistrust” can be a leading factor guiding human decisions.

References

- [1] Aumann, R. and Maschler, B. (1995). *Repeated Games with Incomplete Information*. Cambridge, MIT Press.
- [2] Jacquement, N. and Koessler, F. (2013). Using or hiding private information? An experimental study of zero-sum repeated games with incomplete information, *Games and Economic Behavior*, 78, p. 103-120.

⁶Reported frequencies for stage game A are statistically different from 50% (see table 5 in the appendix). Figure 1 in the appendix provides a summary of the evolution of average beliefs on each actual stage game.