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Can there be a Market for Cheap-Talk Information? An Experimental Investigation

Abstract

This paper reports on experiments testing the viability of markets for cheap talk information. We find that the poor quality of the information transmitted leads to a collapse of information markets. The reasons for this are surprising given the previous experimental results on cheap-talk games. Our subjects provide low-quality information even when doing so does not increase their monetary payoff.

JEL-Codes: D830, C720, G140.

Keywords: experiment, cheap talk, auction, information acquisition, information sale.

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1. Introduction

Information transmission is a common occurrence in economic life. Transmission occurs even when only soft/unverifiable information can be transmitted and the incentives of senders and receivers are not well aligned. Potential competitors sometimes share information, such as when business or academic recruiters discuss the characteristics and ability of individuals they would both be interested in hiring or when corporate raiders discuss potential takeover targets. The drawback of sharing information in this way is that conflicts of interest may make the source unreliable. However, when acquiring information is costly, market participants can benefit by sharing this information - even though the information shared may be noisy - possibly in return for some payment, thereby creating a market for information. Clearly, the lower the rivalry of information or the higher its cost, the more likely soft information is sold and transmitted. The literature on cheap-talk games initiated by Crawford and Sobel (1982) establishes the conditions under which soft information can be transmitted in strategic settings.

This paper reports on a series of experiments testing the viability of a market for information. There are several reasons why such an experimental analysis of these issues is interesting. On the one hand, previous experimental (and empirical) evidence shows that real subjects often tell the truth even when this goes against their self-interest, suggesting that they derive utility from not breaching a truth-telling norm. This could strengthen the case for a market for information. On the other hand, any game with a cheap-talk element features multiple equilibria, and hence, it is conceivable that real players have some difficulty in coordinating their play. In our experiments, we find that markets for information are fragile. The reasons for this outcome are rather different from those we could have anticipated on the basis of earlier work. Our experimental subjects provide low-quality information even in situations where doing so does not increase their monetary payoff. The poor quality of the information transmitted leads then to a collapse of information markets.

In particular, we run experiments based on a stylized game in which agents can acquire information by paying a fixed cost and can then sell information to others via non-verifiable reports. That is, a seller of information has no commitment to sending reports with correct information. What makes the model relevant for our purpose is that there is a potential conflict of interest: the seller of information may be able to profit directly from the information he acquired, for instance by carrying out some advantageous trades in the market, in which case he has an interest to mislead the buyers of information. It is important (and we argue also realistic) that this conflict of interest does not always exist, that is that these profitable opportunities do not always arise, in which case there is no motive to mislead buyers. Cabrales and Gottardi (2014), henceforth *CG*, characterize the equilibria of such a game (assuming that all agents are strictly self-interested and do not have an intrinsic motive to tell the truth) where sellers of information always send truthful reports when they have no profitable opportunities to use directly the information they have, and otherwise send an uninformative message. In this environment markets for information are active in equilibrium, provided the cost of acquiring information is not too high. The game has another equilibrium where the seller of information is expected to send uninformative messages, i.e. babbles, and then information is not transmitted.

It is of interest to contrast the findings for the above game with those for an alternative game specification, where the sellers of information can only send truthful messages, while the rest of the game remains unchanged. In this case, when the seller faces a conflict of interest and prefers buyers to remain informed, he can only achieve this outcome by not selling a report. The equilibrium for this game is payoff equivalent to the informative equilibrium of the game where messages are cheap-talk (while there is no equilibrium with outcomes analogous to the babbling equilibrium). We call the game where reports are given by cheap talk messages, and can then be false, the game with soft information, or *Soft game* for short, and the game where reports must be truthful the game with hard information or *Hard game*.

We performed experiments both for the Hard and the Soft games. Since the only possible difference between them is in the quality of information at the message stage, and there is random assignment to the treatment, one can causally attribute any difference in observed outcomes to this feature.

Our experimental findings are quite conclusive, in that the market for information in the Soft game does not appear to work well because the low quality of information (with respect to the one predicted by the above theoretical analysis) renders this market too small and fragile. We find there are far fewer purchases of reports from informed players in the Soft-Game and, in the last repetitions of the game, these purchases decline further and practically disappear. This is in clear contrast with what we get for the Hard game, where we observe the size of the market for information is considerably larger and, more importantly, does not decrease as the game is repeated.

We should point out that the games briefly described above are static, thus reputational concerns do not affect the choice of sellers regarding the informational content of the reports they send. In the experiment, the games are repeated a few times, so in principle the sellers of information may benefit from creating a reputation for honesty in the Soft game. This makes the non-viability of information markets in the laboratory even more striking. The experimental results are thus clear and provide a negative reply to our motivating question: in spite of being "theoretically" possible, markets for information do not develop in our laboratory setting when information is Soft.

Having provided an answer to our main question, we also investigate the mechanism leading to this finding. The reasons for the failure of markets for information turn out to be rather surprising. As expected from the previous experimental literature on cheap-talk games, we observe numerous truthful messages from sellers of information when they could profit by directly using their information (interested sellers), even though sending a truthful message reduces the gains they can earn from their superior information. This clearly favors the emergence of a well-functioning information market. This effect is, however, counteracted by another one working in the opposite direction: many sellers of information who find that they cannot profit by using directly their information (uninterested sellers) either lie or send uninformative messages.

The fact that some uninterested sellers are not sending informative messages is a novel finding, to the best of our knowledge. To understand this behavior, it is important to note that, when a seller of information has no profitable opportunity to use directly his information and sends truthful reports, a receiver may benefit from the information contained in the report and hence his expected payoff could be higher than that of the sender. A possible explanation for the behavior we observed is that the seller is envious or non-pro-social, in which case he may prefer to lie and thereby lower the payoff gained by the buyer of information. Of course, alternative explanations are possible. For example, a babbling equilibrium could prevail in the message part of the game, with sellers simply randomizing in their reports or sending the same report regardless of the information they have, as this would also clearly lead to the collapse of the market for information.

We have in fact measured the social preferences of subjects playing the games. However, the low number of purchases of information, and thus messages sent, in the

Soft-Game makes it quite hard to test the hypothesis that the low quality of information arises out of envy motives, or lack of pro-sociality. In Cabrales et al. (2016) we analyze a sender-receiver game closely related to the message component of the Soft game and verify that, indeed, social preferences can explain the anomalous, non-truthful behavior of senders. However, we cannot unambiguously conclude from this that the same is true in the situation considered here, since the two games still exhibit some significant differences. We leave then such question for future research.

Given this quite limited availability of observations on the reports that are actually sent, in this paper we have then focused the analysis on the determinants of the decisions to sell a report, once information has been acquired, and to purchase a report, examining the importance of social preferences as well as prior experience as determinants of these decisions. In this respect, the more relevant results are that in the Soft treatment the receipt of untruthful or uninformative report lowers the willingness of subjects to purchase reports in the future. In the Hard treatment - in contrast to the Soft treatment - the decision to post a price seems to be affected by social preferences: subjects with anti-social traits are more likely to post a price when they are interested in the object, perhaps because that is a sure way to guarantee an advantage over the other players, through the receipt of the payment of the price of the report, whereas the extra gain he could get in the auction by not selling information and hence retaining the informational advantage is a gamble.

Notably, the novelty of our findings can arise in part because of a subtle but important difference between the game we consider and the class of standard sender-receiver games examined in the experimental cheap-talk literature, following Crawford and Sobel (1982). In the usual experimental implementation of those games,[1] truth-telling (or, more precisely, separating) equilibria exist when the interests of the sender and the receiver are perfectly aligned so that their monetary payoffs coincide. In this case, both sender and receiver strictly gain from the sender's truth-telling behavior. In fact, the experimental evidence shows that in those situations, truth-telling behavior prevails. When the payoffs of the sender and the receiver conflict, truth-telling behavior is not consistent with equilibrium, although it is sometimes observed.[2] In contrast, in our setup, truth-telling behavior is consistent with equilibrium when the sender's monetary payoff

[1] See, e.g., Dickhaut, McCabe and Mukherji (1995), Blume et al. (1998), or Cai and Wang (2006).
[2] This behavior could simply be due to pure lie aversion which, as reported by López-Pérez and Spiegelman (2013), is a significant force behind honesty.

is lower than the receiver's, and the sender's payoff is not affected by his reporting behavior. In this situation we observe significant deviations from truth-telling.

1.1. Literature

First, we should mention the seminal work of Crawford and Sobel (1982) on strategic information transmission, which studies how the alignment of preferences between sender and receiver affects information transmission (Sobel (2013) reviews the vast theoretical literature following that paper[3]). As noted above, with respect to that paper (and the subsequent literature), we consider a different and richer game structure that yields some novel results. In particular, the amount of information available to agents is endogenously determined, and we allow payments to be required for the receipt of messages. Crucially, the alignment of interests between senders and receivers is not commonly known, as it depends on the preferences of the sender and the realized type of the object.

The experimental literature on information transmission has concentrated primarily on analyzing sender-receiver games à la Crawford and Sobel (1982). A first series of papers (e.g., Dickhaut, McCabe and Mukherji (1995), Blume et al. (1998, 2001), and Kawagoe and Takizawa (1999)) demonstrates that when the interests of the sender and receiver are well aligned (the underlying game is one of common interest), play tends to converge to informative/separating equilibria, although other equilibria (babbling/pooling) exist. A more recent strand of the literature (see Sánchez-Pagés and Vorsatz (2007), Kawagoe and Takizawa (2005), Cai and Wang (2006), and Wang, Spezio and Camerer (2010)) finds more evidence of truth-telling than the most informative equilibrium in Crawford-Sobel would predict in games in which interests do not align well, which can be explained by a truth-telling norm. While in our experiments we also find some evidence of aversion to lying, we also observe a substantial amount of deception/misinformation even when lying does not increase the senders' payoff but reduces that of the receivers.

The paper is organized as follows. The Soft and the Hard games and their equilibria are presented in Section 2, while Section 3 describes the experimental design

[3] There is also a relevant theoretical literature that studies information transmission when agents may have a preference for telling the truth (see Kartik, Ottaviani and Squintani (2007) and Bolton, Freixas and Shapiro (2007)).

and the results. Finally, some robustness checks of our findings are briefly presented in Section 4, together with some concluding remarks.

2. The game and equilibria

The main objective of this paper is to assess, and compare, the viability of information markets in the presence of soft, and of hard information. To this effect, we consider two simple variants of the model proposed in CG.

There is one object for sale. The object can be of one of 2 possible varieties, assumed to be equally likely *ex ante*. Let $v \in \{1,2\}$ be the true variety of the object. There are 3 potential buyers. Each buyer $i \in \{1,2,3\}$ has utility 200 for one variety θ_i and 100 for the other variety. The value of θ_i can be 1 or 2 with the same probability and is drawn independently across types at the beginning of the game; it is buyer i's private information and denotes his *type.* The object is allocated to buyers via a second-price auction.

We assume that, to begin with, no trader knows the variety of the object for sale. But, before the auction takes place, any buyer can learn the true variety of the object by paying a cost *c=20*. Any agent who paid this cost can then sell a report about the information he learned. The utility of buyer *i* is denoted by $\pi_i = 100 + 100I_{vi} - 20I_{ci} - t_i$, where I_{vi} is an indicator variable that takes value 1 if buyer *i* gains the object and its true variety equals *i*' s type and 0 otherwise, I_{ci} is another indicator that takes value 1 if *i* acquires information directly and 0 otherwise. Finally, t_i is the sum of the net monetary payments made by buyer *i* in the auction, to gain the object, and to the other traders, to purchase/sell information from/to them. Clearly, an important feature of this environment is that the preferences of the different agents for the object are not always in conflict but, since types are privately known, it is also not common knowledge whether this is the case.

To be more precise, the timing of the game is as follows:

1. Each buyer decides, in a pre-specified sequence, whether or not to pay *c* to acquire information about the object. This decision to acquire information is observable by all agents.
2. All the buyers who paid the cost *c* learn the true variety of the object and then they simultaneously decide whether to sell a report and, if so, its price *p*, thus becoming *sellers of information*.

3. All the buyers who did not acquire information in stage 1 decide, again in a pre-specified sequence, whether to purchase a report from one or more of the agents selling information. These decisions are also commonly observed.
4. Any *seller of information* sends a (common) report to all the buyers who purchased information from him.
5. A second-price auction takes place among all buyers to allocate the object.

We consider two different specifications of this game which differ by the nature of the information that is sold. In the first specification (Soft game) the report is unverifiable, a cheap talk message; hence the information sold is soft. The set of messages available to a seller of information is given by the set of possible varieties of the object plus one additional message. We will refer to this last message as the empty message, denoted by 0. Thus, the set of messages is as follows: $M = \{0,1,2\}$.

In the second specification (Hard game) the seller must truthfully report the true variety of the object. In this case what is sold is hard information.

We turn next to analyze the equilibria of these two games. Note that they differ only in stage 4, when the seller of information may choose the content of the information in the Soft game, but not in the Hard game. Our aim is precisely to study the impact of this difference, and the choice over the content of information, on the viability of the information markets and the properties of the allocations that are obtained. To this end we will focus on equilibria in which players use undominated strategies in the auction (we refer to them as *truthful bidding strategies* because each buyer makes a bid equal to his expected valuation for the object, conditional on his information).

We start with the Soft game. Since the information sent in stage 4 is a cheap-talk report, and babbling equilibria always exist in cheap-talk games (see Crawford and Sobel (1982)), the Soft game considered has several equilibria. By a straightforward reformulation of the analysis in *CG* we can show that an equilibrium with non-trivial information transmission exists, where sellers of information always tell the truth whenever doing so belongs to the agent's best response to the other players' strategies and beliefs (we refer then to this as the informative equilibrium).

In particular, sellers of information adopt the following message strategy:

$$m_i = \begin{cases} \upsilon \ if \ \upsilon \neq \theta_i \\ 0 \ if \ \upsilon = \theta_i \end{cases} \tag{1}$$

where m_i is the report issued by agent *i*. Therefore, agent *i* is truthful about the variety of the object when this is different from his own type. However, when he likes the object, he sends the empty message 0.

To understand why this strategy could be optimal, it is useful to examine the nature of the possible conflict of interest between the seller and the buyers of information. When agent *i* (the seller) learns that the true variety of the object is not the one he likes, he does not expect to gain from participating in the auction, whatever the information the buyers have. His payoff (as specified in π_i) is then unaffected by the content of his report and he is thus willing to tell the truth. On the other hand, in the event where the seller learns that he likes the object, he would like to gain the object in the auction and prefers then to send a report that lowers the expected valuation of the buyers. In this case there is a conflict of interest and agent *i* would gain by sending a message that deceives buyers and induces them to make the lowest bid. Because message strategy (1) conveys some information and hence the bids of other buyers depend on the message sent, this is achieved by sending the empty message.

In this situation, the reports sent has a positive informational content, and hence we can show that in equilibrium buyers agree to pay a positive price for them.

As we said, there is always another equilibrium, the babbling equilibrium, in which reports are uninformative. That is, the message sent is independent of the true type of the object. For example, the message strategy is given by:

$$m_i = 0 \; for \; every \; v \tag{2}$$

In this case clearly in equilibrium buyers will not agree to pay a positive price for the reports.

Proposition 1.

A) *There exists a perfect Bayesian equilibrium of the Soft game described above in which the sellers of information adopt the reporting strategy in equation (1) while buyers choose a truthful bidding strategy in the auction. Furthermore, one agent acquires information and always posts a price* $p = 12.5$ *for a report, which one other agent accepts. The object goes to the seller of information if he likes it or, if he does not like it, to the buyer of the report when he, in turn, likes it, at a price of 150. If neither of them likes it, the third agent gets the object at a price of 100.*

> ***B)*** *Another perfect Bayesian equilibrium of the Soft game also exists where the sellers of information adopt the reporting strategy in equation (2) while buyers choose a truthful bidding strategy in the auction. Furthermore, one agent acquires information and no reports are sold. The object goes to this agent, if he likes it, at a price of 150. If he does not like it, one of the other agents gets the object for a price of 150.*

Note that in equilibrium A) the buyer of a report gains from it because it allows him to gain the object at a price of 150 when he likes it and the seller of information does not. In this event, he pays 150 for an object with value 200 for him, a surplus of 50. Since the event has probability ¼, a price of 12.5 is indeed the maximum he is willing to pay for such report.

The payoffs in the informative equilibrium, A), where the market for information is active, are as follows. The buyer who acquires information, has an expected payoff of $\frac{1}{2}(200-150)+\ 12.5\ -\ 20=17.5$. The buyer who purchases a report has a payoff $\frac{1}{4}(200-150)\ -\ 12.5=0$. The uninformed buyer has a payoff of $\frac{1}{8}(200-100)=12.5$.

The payoffs in equilibrium B), with inactive market for information, are instead as follows. The informed buyer has an expected payoff of $\frac{1}{2}(200-150)-\ 20=5$. The other buyers have an expected payoff of $\frac{1}{8}(200-150)+\frac{1}{8}(100-150)=\ 0.$

In addition to the two equilibria characterized in Proposition 1, there is a continuum of other equilibria with intermediate levels of information conveyed in the seller's report. For instance, when the seller is not interested in the object he can tell the truth with probability q and any of the other messages with equal probability $\frac{1}{2}(1-q)$ where $q\geq\frac{1}{3}$. The price of information in these equilibria ranges accordingly from 0 when $q=1/3$ to 12.5 when $q=0$. The truthful bids by the agents who buy information also vary with q: when the buyer of information receives a message saying the object is of a type he likes, his expected valuation, and hence his truthful bid, decreases with q, from 200 when $q=0$ to 150 when $q=1/3$. When the buyer of information receives a message saying the object is of a type he does not like, his truthful bid increases with q, from 100 when $q=0$ to 150 when $q=1/3$.

Note that we would obtain very similar behavioral properties to those of the equilibria just described, with regard to information transmitted, prices of reports and auction bids, in the following situation: senders of information adopt a reporting strategy as in (1) but with mistakes, in the spirit of a quantal response equilibrium, QRE. Specifically, sellers follow the strategy specified in (1) with probability $1-\varepsilon$ and with probability $\varepsilon/2$ they send one of the other two reports.

In spite of this multiplicity of equilibria we should point out that the presence of an even very small cost of not telling the truth (as in Kartik (2009)), either from an intrinsic disutility or from fear of being caught and punished, would select the equilibrium in Proposition 1A.

In the Hard game there is no issue regarding the quality of the information in the reports. Hence the different incentives of the seller to transmit information when he likes or does not like the object affect his decision whether or not to sell the information. We can show the following:

Proposition *2.*

There exists a perfect Bayesian equilibrium of the Hard game described above in which buyers choose a truthful bidding strategy in the auction. In this equilibrium one agent acquires information and, when he does not like the object, he posts a price $p = 25$ for a report, which one other agent accepts. If he likes the object, he does not post a price. The object goes to the seller of information when he likes it, and otherwise to the buyer of the report if he, in turn, likes it, at a price of 150. If neither of them likes it, the third agent gets the object at a price of 100.

Note that despite the high price at which information can be sold, still the seller prefers not to sell information in the event in which he likes the object. Furthermore, there is no equilibrium where the seller always sells information, no matter what are the beliefs off the equilibrium path.[4]

It is important to point out that at the equilibrium described in Proposition 2 both the allocation and the expected payoffs are the same as in the informative equilibrium of the Soft game described in Proposition 1A. Thus in the environment considered the soft

[4] On the other hand, an equilibrium where the seller never sells information does exist, supported by the out of equilibrium belief that a sale comes from a seller who likes the object. Such equilibrium though does not survive the intuitive criterion.

or hard nature of the information should have no effect on the market outcome, nor on the performance of the market for information, if the informative equilibrium obtains in the Soft game. Hence, according to the theory, a difference between Hard and Soft information should only arise for some specific equilibria of the Soft game that are however not robust if individuals experience a cost for not telling the truth.

3. The experiment and the results

3.1 Design of the experiment

At the beginning of the experiment, subjects are divided into groups of three individuals. The subjects in any given group interact for 20 iterations of the game, and this feature is common information. Additionally, within each group of three subjects, each individual is randomly assigned a player position (1, 2 or 3) that remains fixed throughout the experiment.

We consider two main treatments (which we label *Soft* and *Hard*), where we implement respectively the Soft and Hard games described in Section 2. Players are informed that, in each round, they will have the opportunity to buy an object by bidding in an auction. The object can be either green or orange (its color is randomly drawn at the beginning of the round with equal probability). Similarly, each player has a randomly assigned color for the round (also green or orange, with equal probability). The object has a value of 200 ECUs (experimental currency units) for a player if it is of his assigned color and of 100 ECUs otherwise. At the beginning of every round, each player is endowed with 250 ECUs and is informed of his assigned color but not of others' colors nor of the color of the object.

In every round, there are five stages. In the first stage, each player decides whether to pay 20 ECUs to learn the color of the object. This decision is made in sequence by the three players in any group, with an order randomly drawn at the beginning and then held fixed through the experiment, and with each player knowing the decisions of his predecessors.

In the second and third stages, we have the market for reports. In the second stage, each player who paid to acquire the information in stage 1, after learning the true color of the object, decides whether to set a price for his report on the color of the object. The price can be any integer number of ECUs less than or equal to 20. Prices are set simultaneously by all sellers of information. Then, in the third stage, those players who are still uninformed decide which of the reports, if any, they want to buy at the indicated price (each one of those players can buy at most one report). These decisions are again made in sequence, with each player knowing the choices of his predecessors.

In the fourth stage, the reports are issued. This is the only point where the two treatments differ. In the treatment Soft, any sender is free to choose between the following reports: “the object is orange”, “the object is green” or “the object is orange or green”. In the treatment Hard, the sender must truthfully report the color of the object.

Finally, in the fifth stage the auction takes place. The three players simultaneously make their bids for the object. A bid can be any number of ECUs less than or equal to 250. The players know that the highest bidder will obtain the object, earning 200 ECUs if it is of his assigned color and 100 ECUs if it is not, and paying a price equal to the second-highest bid.[5] The remaining bidders neither earn nor pay anything. Then, payoffs are realized.

At the end of each round, each player is informed of his payoff, the true color of the object, the bids made by each player, and the player who won the object together with the price he paid. At the end of the experiment, subjects were paid their payoffs from 4 randomly selected rounds at a conversion rate of 100 ECUs = 1 euro.

We ran four sessions for each treatment at the laboratory of experimental economics of the University of Siena (LabSi) in December 2017. A total of 99 subjects (51 in *Soft* and 48 in *Hard*) participated in these sessions, providing a total of 33 groups (17 in *Soft* and 16 in *Hard*). The subjects were recruited from the LabSi pool of human subjects, primarily consisting of undergraduate students from the University of Siena. No subject was allowed to participate in more than one session. After subjects had read the instructions, the instructions were read aloud by an experimental administrator. Throughout the experiment, we ensured anonymity and effective isolation of subjects to minimize any interpersonal influences that could stimulate cooperation. The average duration of sessions was 70 minutes (including the reading of instructions, but excluding payment procedures). The experiment was computerized and conducted using the experimental software z-Tree (Fischbacher (2007)). The experimental instructions, translated into English, are reported in the online Appendix. Table 1 provides a summary of all our experiments and treatments.

[5] In the event of a tie, the acquirer of the object is randomly selected among the highest bidders. Note that in this case, the highest and second-highest bids coincide.

Table 1. Experimental data

Treatment	# sessions	# groups	# subjects
Soft	4	17 (4+4+4+5)	51
Hard	4	16 (4+4+4+4)	48

After the 20 rounds of play, at all sessions we elicited the subjects' attitudes towards risk and social preferences. We used the risk test proposed by Charness and Gneezy (2010).[6] Regarding social preferences, we followed the approach proposed by Bartling et al. (2009) to identify pro-social and envious attitudes. In Table 2 we report the (dictator) games used for the elicitation of social preferences. Each subject had to make four decisions (one of them, randomly chosen, was paid). Each decision consists of a choice between *distribution 1* and *distribution 2*. The choice of a distribution determines a payoff for the player and a payoff for another player.[7]

Table 2. Games for the elicitation of social preferences

Game (All payoffs in euros)	*Distribution 1 self: other*	*Distribution 2 self: other*
(I) Pro-sociality	2: 2	2: 1
(II) Costly pro-sociality	2: 2	3: 1
(III) Envy	2: 2	2: 4
(IV) Costly envy	2: 2	3: 5

There is one design feature that deserves an explanation. We have fixed groups, and even fixed positions within each group, for the iterations of the game considered in a session, unlike in the theoretical benchmark considered in Section 2, where the players interact once. We made these choices because this is a complicated experimental design from a cognitive perspective, and we wanted to maximize the probability that the players learned the best strategies to play the game. This becomes easier against a single group of players in a fixed position than against changing opponents and/or changing roles.

[6] The subjects decide how much of their endowment (5 euros) to invest in a risky asset and how much to keep. They earn 2.5 times the amount invested if the asset is successful (prob. 0.5) and lose the amount invested otherwise.

[7] According to the choices in these games, we can classify the subjects according to their pro-sociality and envy attitudes. Regarding pro-sociality (games I and II), those subjects choosing distribution 1 in game I and distribution 2 in game II are classified as weakly pro-social and those choosing distribution 1 in both games are classified as strongly pro-social. In contrast, those choosing distribution 2 in both games are classified as non-pro-social. Regarding envy (games III and IV), the subjects choosing distribution 1 in game III and distribution 2 in game IV are classified as weakly envious, while those choosing distribution 1 in both games are classified as strongly envious. Those choosing distribution 2 in both games are classified as non-envious.

Obviously, the procedure also has disadvantages. The most important is that the repetition of the game may create new equilibria, and thus the theoretical benchmark is less clear. However, the main new equilibria that may arise are those in which the amount of truth-telling increases because of reputational concerns. As we will see, the amount of truth-telling in our results is smaller even than that in the informative equilibrium described in Proposition 1A. Additionally, the dynamic trends apparent in the data are easy to explain using simple learning heuristics, without resorting to complicated strategies in the repeated game.

3.2 Results

In this section, we present the experimental results for the treatments *Soft* and *Hard* and compare them with the theoretical predictions reported in Section 2. Table 3 presents the results concerning the behavior of subjects in the auction in the two treatments. In the columns, we report the bids made in the first half (rounds 1 to 10) and the second half (rounds 11 to 20) of the experiment. In the rows, subjects are differentiated according to their available information: In the first two rows, we report the behavior of the informed players, i.e., those who acquired information directly, specifically their average bid when the color of the object coincided with their assigned color (Color – Yes) and when it differed (Color – No); the third row displays the average bid of the uninformed players (i.e., those who neither acquired information directly nor purchased a report); The last rows display the average bid of indirectly informed players (buyers of reports) when the report states that the color of the object coincided with their assigned color (Color – Yes), when it did not coincide (Color – No) and when the report said "the object is orange or green" (we refer to this as the 0 report). We also report the bids that would be made by subjects in the equilibrium characterized in Proposition 1A for treatment Soft and Proposition 2 for treatment Hard, referring to these as [Predictions].

Comparing the bids between treatments by periods and type of available information that subjects have, we do not find systematic significant differences (as shown by the reported results of the Mann Whitney test and t-test). Furthermore, in both treatments we observe a fairly clear learning pattern: when we move from the first to the second half of the experiment, bids are increasing and they are getting quite close to the theoretical predictions. This fact holds for all types of available information and both treatments.

RESULT 1. The bidding behavior in the auction does not differ across treatments and, in the second half of the experiment, is very close (on average) to the theoretical predictions.

Table 3. Average bids by treatment, type of player and block of 10 rounds

		Soft		*Hard*	
		Rounds 1-10	*Rounds 11-20*	*Rounds 1-10*	*Rounds 11-20*
Informed players	*Color - Yes* [Prediction: 200]	152.87	203.22	153.48*	200.87
	Color - No [Prediction: 100]	91.75	116.51	93.05	120.12
Uninformed players	[Prediction: 150]	115.81	145.22	112.21	143.58
Buyers of report	Content: *Color - Yes* [Prediction: 200]	135.06	180.14	142.57	206.80^
	Content: *Color - No* [Prediction: 100]	105.53	136.37	74.37	140.00
	Content: 0 [Prediction: 150]	93.94	167.5	N/A	N/A

Mann Whitney test significance at *** p<0.01, ** p<0.05, * p<0.1
t-test significance at ^^^ p<0.01, ^^ p<0.05, ^ p<0.1

In Table 4 we present, for both treatments, the numbers and relative frequencies for the different choices that players could make regarding the acquisition of information: (i) directly acquire information in the first stage (*Informed*), (ii) buy a report in the third stage (*Buy a report*) and (iii) remain uninformed (*Uninformed*). We present again the data separately for the first ten rounds and the second ten rounds of the experiment. According to the informative equilibrium of the Soft game and the equilibrium of the Hard game described in Section 2, regardless of the treatment we should observe the same number for each one of these choices: in each period, one player in the group should directly acquire information, one player should buy a report, and one player should remain uninformed. In contrast, in the two treatments we observe that data follow a rather different pattern.

In the first half of the experiment, in both treatments the modal choice was *to acquire the information directly*, followed by the choice of *remaining uninformed*, with a low frequency of *purchases of reports*. However, the frequency of buying a report is significantly lower in treatment Soft (9.61%) than in treatment Hard (19,79%) at the 1%

level (Mann Whitney test) and the frequency of acquiring the information directly is considerably higher in treatment Soft than in treatment Hard (65.29% and 49.79% respectively), with the difference being significant at the 1% level (Mann Whitney test).

Table 4. Behavior in information markets in Soft and Hard treatment – Absolute number of observations and relative frequencies (% over total row)

	Rounds 1 -10			Rounds 11 – 20		
	Uninformed	Informed	Buy a report	Uninformed	Informed	Buy a report
Soft	128 (25.10)	**333 (65.29)**	49 (9.61)	**256 ^^^ (50.20)**	228 ^^ (44.71)	26 ^^ (5.10)
Hard	146 (30.42)	**239 *** (49.79)**	95 *** (19.79)	177 (36.88)	**212 (44.17)**	91 *** (18.96)

Soft vs Hard: Mann Whitney test significance at *** p<0.01, ** p<0.05, * p<0.1
Periods 1-10 vs 11-20: Signed-Ranks test significance at ^^^ p<0.01, ^^ p<0.05, ^ p<0.1

In the second half of the experiment we find that differences across treatments increase. First, we observe that, whereas the modal choice for treatment Hard is again *to acquire the information directly*, in treatment Soft it becomes *to remain uninformed*. Moreover, we find that in treatment Soft the frequency with which reports are purchased is markedly reduced (from 9.61% in the first half of the experiment to 5.10% in the second half, the difference being significant at the 5% level, Signed-Ranks test), while in the hard treatment it remains quite constant (19.79% and 18.96%, respectively). Hence, the observed difference across treatments of the level of activity in the market of reports increases in the second half of the experiment. Indeed, in treatment Soft we find that the market for reports progressively collapses (the average frequency is 5.10%, with almost no activity in the last rounds). Furthermore, when comparing the first to the second half of the experiment we find systematic and significant differences only for treatment Soft, so the evolution of information acquisition is different across treatments. Overall, these results show that the market for reports in treatment Soft is systematically smaller with respect to treatment Hard and ultimately collapses.

RESULT 2. In contrast to the theoretical prediction, in treatment Hard we observe a larger market for reports than in treatment Soft. Moreover, in treatment Soft the market of information shrinks over time, whereas it remains stable in treatment Hard.

This result is one of the most important take-home messages from our paper. The difference between the two treatments is exclusively the “hardness” of information. According to the theory, this need not make a difference, as in the main equilibrium considered for the two games the level of activity in the market for information transmitted is the same in both. Yet, the data show quite clearly that this market is deeper and more robust in the Hard than in the Soft treatment.

To understand the reasons for this collapse of the market for reports in treatment Soft, one is naturally led to relate it to the informational content of the reports sent. In Table 5, we present the reports sent, distinguishing the case in which the seller is interested in the object (the object is of his assigned color) and the case in which he is not interested. We observe that the (average) frequency of truthful reports is 52.11%, very close to the theoretical prediction reported in Proposition 1A (50%). However, the distribution of truthful reports between the case in which the sender is uninterested in the object and that in which he is interested is quite different from the predicted distribution.

In the equilibrium for the game Soft described in Proposition 1A, sellers of information are always truthful when they cannot benefit by lying. Hence, uninterested sellers send a truthful report (i.e., reveal the color of the object) while interested sellers send a 0 report. The prediction is thus that all the truthful messages occur when the sender is uninterested. In the experimental evidence, we observe a significant departure from such a behavior: while the modal choice of uninterested sellers (43.75%) is indeed to reveal the true color, there is also a significant fraction of 0-reports (25.00%) and even false ones (31.25%). At the same time, interested sellers send truthful reports with a very high frequency (58.97%). This has a significant effect on the value a receiver obtains from the purchase of information (a truthful message received when the sender is interested in the object means that the receiver will face aggressive bidding from the sender in the auction, as confirmed by the evidence reported in Table 3).

Table 5. Content of the sent report by type of seller (interested in the object or uninterested) in the Soft treatment – Absolute number of observations and relative frequencies (% over total row)

Seller	*0 report*	*False report*	*Truthful report*	*Total*
Uninterested	8 (25.00)	10 (31.25)	**14 (43.75)**	32 (100)
Interested	9 (23.08)	7 (17.95)	**23 (58.97)**	39 (100)
Total	17 (23.94)	17 (23.94)	**37 (52.11)**	71 (100)

Importantly, the observed reporting of sellers of information should be assessed in the light of the response by buyers of information in terms of their behavior in the auction, as shown in Table 3, which reveals they do attribute some (though not full) informative value to a report specifying one color of the object, and less value to a 0 report. It may also be claimed that the observed reporting behavior exhibits some features of either the babbling equilibrium or one of the other equilibria with intermediate degrees of information transmitted described in Section 2, especially when the seller of reports is not interested in the object. However, the modal choice of truthful reporting when the seller of reports is interested in the object is not compatible with these equilibria.

RESULT 3. In treatment Soft, the information conveyed in the reports is very noisy, and differs sharply from the main equilibrium predictions. Uninterested sellers send truthful reports in less than half of the cases and there is an (unpredicted) considerable share of false messages.

To gain some understanding of the observed pattern of activity in the market for information, it is useful to investigate the decision of informed agents whether or not to post a price (i.e. whether or not to try to sell information). The observed data are reported in Table 6.

Table 6. Decision to post a price in the market for reports: relative frequency and total values.

	Uninterested	Interested
Soft	0.860 * 193	0.832 *** 185
Hard	0.804 209	0.635 ^^^ 203

Soft vs Hard: Mann Whitney test significance at *** p<0.01, ** p<0.05, * p<0.1
Uninterested vs Interested: Signed-Ranks test significance at ^^^ p<0.01, ^^ p<0.05, ^ p<0.1

We find significant differences both between and within treatments: interested subjects in treatment Hard post a price with a frequency that is considerably lower both with respect to the frequency with which uninterested subjects post a price in the same treatment and with respect to the frequency with which interested subjects post a price in treatment Soft. Note that this evidence is in line with the theoretical predictions and could be explained by the fact that the only way for interested subject to prevent revealing information in treatment Hard is not to post a price. On the other hand, it is interesting to point out that we observe that all subjects (either interested or not) in treatment Soft, as well as uninterested subjects in treatment Hard, post a price at slightly lower rate than predicted (100%). For the Soft treatment one could argue this is not too surprising, given the high level of noise observed in the reports sold and the consequent difficulty in inducing buyers to purchase them, as we will see in what follows. Moreover, in the babbling equilibrium of Proposition 1B there is no sale of information. The presence of a non-trivial fraction of uninterested sellers who choose not to post a price in the Hard treatment is more difficult to explain. The same can be said for the fact that more than half of the interested sellers in this treatment choose to post a price though the sale of information would lead them to face higher competition in the auction (and the theory predicts no sale in such a case). Hence, the observed results are altogether in the direction of what theory predicts, but with substantial (quantitative) deviations in some cases. We explore the determinants of this behavior in more detail in the econometric analysis reported in Table 10 below.

Next, we examine the level of the prices posted for the sale of reports, of the accepted prices and the acceptance rate (the ratio between the number of accepted prices and the number of posted prices) and how they evolved along the experiment. Table 7 presents the average price posted in each round (if more than one price is posted in a round, the minimum price). This is done separately for the first and last ten rounds and according to whether the seller is interested or uninterested in the object. Table 8 presents then the average price accepted by buyers and the acceptance rates (again for the first and second block of ten rounds).

Table 7. Minimum asking price in the market for reports

	Rounds 1 – 10	Rounds 11 – 20
Soft	8.23	6.49^^
Hard	11.29***	11.40***
	Uninterested	Interested
Soft	7.67	7.30
Hard	11.33 ***	11.40 ***

Soft vs Hard: Mann Whitney test significance at *** p<0.01, ** p<0.05, * p<0.1
Rounds 1 -10 vs 11 – 20 and Uninterested vs Interested: Signed-Ranks test significance at ^^^p<0.01, ^^ p<0.05, ^ p<0.1

First of all, we find a strongly significant difference across treatments. Posted prices are higher in treatment Hard, both disaggregating by blocks of periods and by the seller's interest in the object, and the difference is statistically significant. Furthermore, in the second part of the experiment the posted prices are significantly smaller in treatment Soft relative to the first part, while in treatment Hard they remain roughly constant. Finally, we note that posted prices do not depend in a significant way on whether the subject is interested or not on the object.

This pattern is reflected in the accepted prices (Table 8). Treatment Hard displays significantly higher levels of the accepted prices and acceptance rates. Furthermore, in treatment Soft accepted prices and acceptance rates are lower in the second half of the experiment, relative to the first (even though in this case the differences are not statistically significant).

Table 8. Accepted price and Acceptance rate in the market for reports

		Rounds 1 – 10	Rounds 11 – 20
Accepted Price	Soft	8.35	4.96
	Hard	11.19*	11.40***
Acceptance Rate	Soft	0.24	0.19
	Hard	0.55***	0.56***

Soft vs Hard: Mann Whitney test significance at *** p<0.01, ** p<0.05, * p<0.1
Rounds 1 -10 vs 11 – 20: Signed-Ranks test significance at ^^^ p<0.01, ^^ p<0.05, ^ p<0.1

These findings are in line with the much lower level of information contained in the reports in treatment Soft, as observed in Table 5. Furthermore, they reflect the fact that over time buyers of information realize reports are quite noisy and hence are not willing to pay much for them.

It is of interest to relate the observed pattern of prices to the actual information contained in the reports purchased and hence on the actual value for buyers to purchase a report. The higher (average) prices in treatment Hard clearly reflect the higher level of information conveyed in the reports in that case. Furthermore, we can say that the prices offered in treatment Hard, given that messages are truthful, are in line with the value of the information contained, and hence worth paying (they are actually lower than the equilibrium price reported in Proposition 2). On the contrary, although the prices in treatment Soft are below the equilibrium prediction reported in Proposition 1A, they are still too high relative to the value of the reports, given the much larger level of noise present in the content of the reports with respect to the equilibrium prediction (as reported in Table 5). We shall further explore the effect of the level of prices posted on the subjects' decisions to buy reports in the econometric analysis (reported in Table 10 below).

Let us summarize the findings so far.

1. The market for reports is considerably smaller in treatment Soft than in treatment Hard.

2. The size of this market becomes smaller over time in treatment Soft whereas it remains stable in treatment Hard.
3. Given the experimental design, where the two treatments differ only in the verifiability of the information, the explanation for findings 1 and 2 needs to be found in this feature.
4. Moreover, we find that the quality of the informational content of the reports in treatment Soft is considerably lower than predicted by the informational equilibrium described in Proposition 1A.
5. The reduction in the size of the market of reports that we observe in the Soft treatment goes together with a reduction of the posted and accepted prices and of the acceptance rate. Both prices and acceptance rates are lower than in treatment Hard.
6. The evidence in 4 and 5 suggest that in treatment Soft we observe a behavior that, especially over time, gets closer (though with some qualifications) to the babbling equilibrium or the equilibria with intermediate levels of information transmission described in Section 2.

In Table 9 we analyze the subjects' earnings in the two treatments, distinguishing according to the type of information available to subjects and time (first or second part of the experiment). In both treatments, we find that earnings decline significantly over time for informed players. In addition, we do not find systematic significant differences in payoffs across treatments.

Table 9. Average earnings by treatment, type of available information and rounds

	Soft treatment	
	Rounds 1 – 10	Rounds 11 – 20
Uninformed	256.60	251.63
Informed	246.85*	240.26^^^
Buyers of reports	245.90	250.54
	Hard treatment	
	Rounds 1 – 10	Rounds 11 – 20
Uninformed	259.23	246.69
Informed	259.33	240.35^^^
Buyers of reports	252.61	242.54

Soft vs Hard: Mann Whitney test significance at *** p<0.01, ** p<0.05, * p<0.1
Rounds 1 -10 vs 11 – 20: Signed-Ranks test significance at ^^^ p<0.01, ^^ p<0.05, ^ p<0.1

If we then compare the differences in earnings between types of players (Signed-Rank tests, not reported in Table 9), we do not find any significant difference in the first part of the experiment, neither in treatment Soft nor in treatment Hard. On the other hand, in rounds 11-20 we find that, in treatment Soft, the earnings of Informed players are significantly lower than those of Uninformed players (1% level) and of Buyers of reports (5% level); in treatment Hard, the earnings of Informed players are also significantly lower than those of Uninformed players (5% level). No other differences are significant.

These findings could seem puzzling in light of the theory. In particular, in all the equilibria we characterized of the games Soft and Hard it is the informed player who gets the highest payoff. However, we should point out that the subjects who acquire information in the Soft treatment are very rarely able to sell it. So they bear the cost and are not able to get the benefits from lower competition in the auction and from the sale of reports often enough to defray its cost. This can easily explain the small negative difference of payoff against them. In the Hard treatment, the puzzle can be explained because the informed players sells information too often when they are interested in the object, relative to the equilibrium predictions, and by so doing increase the competition in the auction. Importantly, this also reduces total surplus in the Hard treatment, even though the market for information remains viable in that case, as the surplus is "bid away" in the auction and rather goes to the owner of the object.

To provide some further explanation for our findings regarding the different performance of the market for reports with hard and soft information, we should investigate more in detail the determinants of the key decisions in this market: (i) to buy a report, (ii) to post a price for a report and (iii) the content of the message sent in treatment Soft (that is the quality of the information transmitted). On the latter we should point that the quite limited size of the market for information in treatment Soft prevents a proper statistical analysis of that decision (the total number of reports sold is only 71, and only 26 in the second half of the experiment, considerably lower than the number of times the game was played (340, as there were 20 iterations per group and a total of 17 groups), and much lower than the number predicted by the equilibrium considered where a report is sold every time the game is played). In what follows, we will thus focus on the first two decisions.

(i) Regarding the decision to buy reports notice that, to be able to participate as a buyer in the market for reports a subject must have chosen not to acquire information directly in the first stage. For this reason, we jointly estimate the *Selection equation* (the probability of not acquiring information in the first stage) and the *Buying a report* *equation* (the probability of buying a report in the second stage, given that the player did not acquire information directly).

(ii) Regarding the decisions to post a price, note that to be able to participate as a seller in the market for reports a subject must have chosen to acquire information directly in the first stage. Thus, we jointly estimate the *Selection equation* (the probability of acquiring information in the first stage) and the *Posting a price equation* (the probability of posting a price in the second stage, given that the player did acquire information directly).

Our models (i)-(ii) are quite similar to a Heckman probit estimation (that allows for the possibility of correlation between the selection and the report equations, measured by parameter *Rho* in Table 10). In addition, we need to account for the fact that, to be able to participate in the market for reports, another condition is required. In model (i) at least one player in the group must have acquired the information in the first stage (i.e., there has to be a seller), and in model (ii) at least one player in the group must not have acquired the information in the first stage (i.e., there has to be a buyer).[8] We cluster standard errors at the group level to account for the correlation arising from the fact that a group interacts for 20 periods.[9]

Therefore, we estimate 4 models and the results are reported in Table 10. In models (1) and (2) we estimate for treatment Soft, respectively, the determinants of the decision to buy a report and the determinants of the decision to post a price. In models (3) and (4) we carry out the same analysis for treatment Hard. In the upper (lower) panel of Table 10 we report the estimation results for the corresponding *Selection equation* (respectively, *Buying a report*, *Posting a price*). The variables included in the *Selection equations* are:

- *round*, a variable that represents the number of iteration of the game (from 1 to 20);
- *info_1*, a dummy that takes value 1 if the subject acts as mover 2 and the predecessor (mover 1) has directly acquired the information, and value 0 otherwise;
- *info_12*, a variable that takes value 1 if the subject is mover 3 and at least one predecessor has acquired directly the information, and value 0 otherwise*;*

[8] For this reason, we could not use the standard Stata command for Heckman probit estimation, and needed to program it ourselves. The program is available upon request.
[9] The Stata program to perform these estimations is available from the authors upon request.

- *env|np*, a variable that takes value 1 (0) if the subject is (is not) classified either as envious or non-prosocial according to his/her choices in the dictator games described in Table 2;
- *risk*, a variable that measures how risk loving that player is (represents the amount - from 0 to 5 - invested by the subject in the risky asset in the risk test);
- *mover2*, a dummy that takes value 1 (0) if the subject acts (does not act) as mover 2;
- *mover3*, a dummy that takes value 1 (0) if the subject acts (does not act) as mover 3;
- *true_cum*, a cumulative variable that reports the difference between the number of previous rounds in which the subject bought a report containing a true message and the number of previous rounds in which he bought a report containing a false or uninformative message (it takes value 0 if the subject has not bought any report yet);
- *L_acquire_inf*, a (lagged) variable that takes value 1 if the subject acquired information directly in the previous round, and value 0 otherwise.

Note that *true_cum* is intended to capture the effects of previous experience with purchasing reports on subsequent information acquisitions. For this reason, it is only included in the estimations for the decision to buy a report in treatment Soft (in treatment Hard by design all reports are truthful).

The variables included in the *Buying a report equations* are: *round*, *env|np*, *risk*, *true_cum* and

- *inf_tot*, a variable that measures the number of subjects in the group that acquired directly the information (i.e., the number of potential sellers of reports);
- *askmin*, a variable that measures the lowest price posted in the group.

The variables included in the *Posting a price equations* are: *round*; *inf_tot*, *env|np*, *risk* and

- *noint*, a dummy variable that takes value 1 if the subject is not interested in the object, 0 otherwise;

and the interactions of this last variable with the anti-social preference variable (*noint**env|np*) and with the risk variable (*noint**risk*).

Table 10. Market for reports: decision to post a price and decision to buy a report

	Treatment Soft		Treatment Hard	
	Buying a report (1)	**Posting a price (2)**	**Buying a report (3)**	**Posting a price (4)**
	Selection equation			
cons	0.1028 (0.2397)	-0.1136 (0.2370)	0.7948* (0.4686)	-0.7977** (0.3258)
round	0.0399*** (0.0116)	-0.0399*** (0.0117)	0.0183*** (0.0070)	-0.0180*** (0.0068)
info1	0.1868 (0.2229)	-0.2483 (0.2332)	0.5047 (0.4987)	-0.4734** (0.1992)
info12	-0.2457 (0.2796)	0.2339 (0.2896)	0.9206*** (0.2850)	-0.9054*** (0.2413)
env/np	-0.0829 (0.1476)	0.0923 (0.1337)	-0.1004 (0.1413)	0.1000 (0.1378)
risk	-0.0377 (0.0406)	0.0378 (0.0404)	-0.1821** (0.0773)	0.1803** (0.0733)
mover2	-0.2907 (0.1890)	0.3383* (0.1870)	-0.3657* (0.2057)	0.3451* (0.1849)
mover3	-0.0518 (0.2678)	0.0668 (0.2924)	-0.8249** (0.3465)	0.8169*** (0.2670)
true_cum	0.0073 (0.0731)			
L_acquire_inf	-0.6075*** (0.1727)	0.5991*** (.1740)	-0.5952*** (0.1634)	0.6077*** (0.1175)
	Buying a report/Posting a price equation			
cons	-1.1201*** (0.4187)	1.5592 (.9677)	0.6963 (1.0740)	-0.8929** (0.3513)
round	-0.0443* (0.0240)	-0.0815*** (0.0272)	-0.0204 (0.0260)	-0.0039 (0.0117)
inf_tot	0.2596* (0.1527)	-0.1670 (.2438)	0.6469** (0.3039)	0.2137 (0.2673)
env/np	0.5528 (0.3968)	0.0634 (0.4436)	-0.6505** (0.3142)	0.5802*** (0.2102)
Risk	0.0106 (0.0492)	0.1712 (0.1246	-0.0164 (0.2439)	0.1391** (0.0603)
Askmin	-0.0702*** (0.0269)		-0.0632*** (0.0245)	
true_cum	0.2250** (0.1029)			
noint		-0.1883 (0.4737)		1.4870*** (0.4612)
*noint*env/np*		0.4786 (0.4285)		-0.6594** (0.3299)
*noint*risk*		-0.0216 (0.0900)		-0.2086 (0.1316)
Rho	0.8241*** (0.2479)	0.1859 (0.7809)	-0.0918 (1.7796)	0.2788 (0.4410)
N. Obs.	969	969	912	912

***, **, * significant at the 1%, 5%, and 10% level, respectively

The selection equation of model (1) of Table 10 shows that the probability of not acquiring the information directly in treatment Soft (and therefore of being selected to participate as buyers in the market for reports) is increasing in *round* (significant at 1%). Moreover, it shows that the fact that a player acquired the information directly in the previous round increases the likelihood that he/she does the same in the current round (and therefore is not selected to act as buyer in the market for reports), as shown by the negative and significant coefficient of *L_acquire_inf*. This confirms what we have mentioned earlier. The participants in the experiment realize that quality in the market for reports is too low, given its price and simply drop out from the market.

Regarding the *buying of report* equation, the main determinants of buying a report turn out to be the variables *true_cum* and *askmin*. The fact that *true_cum* is positive and significant suggests that previous experiences in the market of reports are important to decide: subjects who have accumulated bad experiences in the past are less likely to buy a report. We also note that the fact that *askmin* is negative and significant shows that higher prices results in less activity in the market for reports (as argued earlier, the prices posted in the Soft treatment turn out to be higher, on average, than the value of the information contained in them). Finally, the coefficient of *round* is negative and significant (at the 10% level), showing the decline across rounds of purchases of reports in treatment Soft. Also, *inf_tot* is (marginally) significant, suggesting that having two rather that one potential seller of information may increase the probability to buy reports.

If we turn our attention to the decision to post a price in treatment Soft (model (2)), we observe that the Selection equation is almost the 'inverse mirror image' of the one reported in model (1), reflecting the fact that, basically, those variables that increase the probability of being selected to participate as buyers in the market of reports decrease the probability of being selected to participate as sellers. In the *Posting a price* equation, only variable *round* is significant, showing that the number of subjects that post a price decrease over time in treatment Soft. One may argue they feel discouraged by the observed decrease in the acceptance rates in the market for reports (see Table 8). No other variable is significant, potentially due to the fact that in treatment Soft the decision whether or not to post a price is not crucial, since the 'seller' has always the possibility to undo the information transmission by sending an uninformative (or even false) message.

Next, we study the behavior in treatment Hard, starting with the decision to buy a report. The results for model (3) of Table 10 show that the probability of not acquiring the information directly is increasing in *round* and decreasing in *L_acquire_inf*, as happened in treatment Soft. But now the variables *info_1* and *info_12* are positive, with the latter one being significant. This shows that the fact that the subjects moving before me acquired directly information reduces the probability that I acquire information. This is quite reasonable in treatment Hard, since players may be able to purchase in the later stages truthful information in the market of reports, potentially at a lower price. Also, in this case the variable *risk* is negative and significant, indicating that the more risk lover a player is, the higher the probability to acquire directly information (note that this decision entails the risk of not being able to sell reports in subsequent stages). Finally, variables *mover2* and *mover3* are negative and significant, suggesting that players that act later in the sequence are more likely to acquire directly information (therefore being less likely to act as buyers in the market of reports).

Regarding the *Buying a report* equation of model (3), variable *inf_tot* is positive and significant, showing that the presence of more sellers of information induces more reports to be bought. Though the result is similar to that for treatment Soft, we should point out a difference of treatment Hard which may be relevant here: having two sellers of information, although this is an out-of-equilibrium event, may now mean that none of them is interested in the object, making the information very valuable. Furthermore, *env|np* is now negative and significant, suggesting that subjects with anti-social traits are less likely to buy reports in treatment Hard. As in treatment Soft, *ask_min* is negative and significant, implying that higher prices reduce the purchases of reports.

Finally, we move to analyze the decisions to post prices in treatment Hard, corresponding to model (4). As in the previous treatment, we observe that the *Selection equation* is almost the 'inverse mirror image' of that one reported in model (3). Regarding the *Posting a price* equation, recall that the behavior of subjects in this decision is one of the most puzzling features observed in the experiment, in the light of the theory based on the standard preferences we postulated: namely, more than half of the interested players sell (hard) information, though this will lead to a significant decline in their payoff in the auction. We see first that the coefficient of the variable *noint* is positive and significant, so that individuals not interested in the object are more likely to post a price. It is then particularly of interest to remark that both *env|np* and the interaction of this variable with *noint* are significant. Adding these two coefficients we obtain that *env|np* only has a significant effect if the subject is interested. Thus, having anti-social traits increases the likelihood of posting a price when the seller of information is interested in the object. Social preferences appear therefore to play a role in explaining the puzzling behavior recalled above. It is not immediate to explain the mechanism via which social preferences may operate, and more work would be needed to understand it. Here we can just point out that by selling a report the maximum achievable material gain over the other players increases, and subjects with anti-social traits may be attracted by this choice.

Note that the coefficient of *risk* is positive and significant, though – again looking at the opposite sign of the interaction term of this variable with *noint* – only when the seller of information is interested in the object. Hence, risk aversion also affects the decision of interested subjects to post a price, in the sense that more risk averse subjects post a price less frequently. A possible explanation is that by selling a report, an interested subject faces a "riskier lottery" in the auction stage, and hence the more risk averse the agent is, the less willing to post a price.

Overall, the conclusion is that pro-social preferences appear to be a driver of the departures observed from equilibrium behavior in terms of price posting in the Hard treatment, while the experience of too noisy information in the reports received in treatment Soft contributed to drive buyers out of the market in that treatment.

4. Discussion and Conclusion

To test the robustness of the observed results (focusing primarily on the market for reports), we ran an additional treatment, denoted treatment *Base*.[10] Treatment Base is very similar to treatment Soft, but with two main differences: the first one is that the subjects that acquire the information post prices for reports prior to knowing whether they are interested in the object or not (that is, they learn the color of the object only before deciding the content of the report). Furthermore, these subjects must always post a price in the market for reports (in case that at least one subject in the group did not acquire the information).[11] We considered this specification because (i) it directly implements the theoretical model proposed in Cabrales and Gottardi (2014) and (ii) it allows us to see whether the collapse in the market of reports observed in treatment Soft depends on the possible presence of a signaling component in the sellers' decision to sell information (muted in treatment Base by the two differences described above).

We show in Appendix A (Tables A1-A3) that the main features of the market for reports in treatment Base are quite similar to those of treatment Soft. We basically find that the market for reports also collapses in this case, with a negative trend in the number

[10] We run 4 sessions, for a total of 48 subjects (16 groups) that played 20 rounds of the game.
[11] We also used a strategy method for the final auction.

of reports sold over time again with almost no activity in the market of reports in the last rounds. Furthermore, the informational content of messages in treatment Base is very poor, as in treatment Soft, suggesting that this is again the key factor driving the failure of the market for reports. The evolution of asked and accepted prices along the experiment is also very similar to that observed for treatment Soft.

We also run another treatment, labelled *Uninterested*, to further investigate the role played by the presence of a conflict of interest between buyers and sellers of reports in the collapse of the market for information. To this aim, as compared to treatment *Base*, in this treatment we add a fourth player (player 0), who cannot participate in the auction (he is uninterested in the object) and is the only one allowed to sell reports. In this case the sellers of information can still lie and send noisy information in their reports but, unlike treatments Soft and Base, have no direct benefit in doing so. Interestingly we find that, as in both these treatments, the market for reports is never very large and ultimately collapses. In a sense, the collapse is even more significant in this case because of the absence of conflicts of interest and the fact that the theoretical prediction now is that two-thirds of the potential buyers should have bought the report (it was only one-third in the two other treatments with soft information). We find that the number of purchases of reports is far lower (approximately one-fourth) of what would be necessary for sellers to recoup the cost paid to acquire information and hence for the market to be viable.

To sum up, in this paper we study experimentally the viability of markets for information where information is transmitted via soft-information, or cheap-talk reports. This type of game has equilibria with and without information transmission, and hence an empirical assessment of the viability of information transmission seems necessary. Furthermore, previous results in the experimental literature on cheap-talk games suggests that agents in the lab may tell the truth even when theory predicts that reports should be uninformative. We do this experimentally by comparing results in a game where messages can be false or uninformative, with one where hard information can be transmitted, that is messages need to be true.

In the laboratory we find that, in the game with soft information, much fewer reports are sold than in the game with hard information. We observe that some agents indeed tell the truth when their monetary payoffs could be increased by sending deceptive reports. However, a novel finding in our experiment is that some agents lie when doing so does not increase their monetary payoff. This deceptive behavior is the main reason for the collapse of the market for information.

We believe that our paper provides important insights for real-life settings. Even though markets for information are pervasive in reality, the fragility of this market in our experiments suggests that we should not take their existence for granted. We have established in a well identified manner that the fact that a conflict of interest between senders and receivers is not always present, or a natural tendency for people to tell the truth, are not enough for these markets to survive. In our setting, senders of information can even construct reputation but that is also not enough. Thus, our results suggest we need further research to find out the reasons for the survival of information markets in reality. For example, there is a lot of third party certification (Lizzeri (1999)), or even government intervention to enforce accuracy in information transmission (Arrow (1963), Haas-Wilson (2001)).

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APPENDIX

A) ANALYSIS OF TREATMENT BASE

In this appendix, we present the main experimental results of treatment *Base* regarding the market of reports.

In Table A1, analogously to Table 4, we present for the frequencies of the choices with which participants in the experiment (i) acquire information in the first stage (*Inform*), (ii) buy a report in the second stage (*Buy rep*) and (iii) remain uninformed (*Uninf*), distinguishing by mover and by block of 10 rounds.

Table A1. Behavior in information markets – Absolute number of observations and relative frequencies (% over total row)

	Rounds 1-10			*Rounds 11-20*		
	Uninf.	*Inform.*	*Buy rep.*	*Uninf.*	*Inform.*	*Buy rep.*
Total	208 (43.33)	**218** **(45.42)**	54 (11.25)	**255** **(53.13)**	192 (40.00)	33 (6.88)

The distribution of available information is very similar to that in the Soft treatment, with the same modal choices. In particular we highlight that the frequency with which reports are purchased is also reduced in the second half of the experiment, where we find that the market for reports progressively collapses (the average frequency is 6.88%, with almost no activity in the last rounds). These results show that as in the Soft treatment, the market for reports is never very large and ultimately collapses.

In Table A2, analogous to Table 5 we present the content of the reports, distinguishing the case in which the seller is interested in the object and the case in which he is not interested.

Table A2. Content of the report by type of seller (interested in the object or uninterested) – Absolute number of observations and relative frequencies (% over total row)

Seller	*0 report*	*False report*	*Truthful report*	*Total*
Uninterested	10 (20.83)	10 (20.83)	**28** **(58.33)**	48 (100)
Interested	12 (36.36)	7 (21.21)	**14** **(40.42)**	33 (100)
Total	22 (27.16)	17 (20.99)	**42** **(51.85)**	81 (100)

As in the Soft treatment we observe a high frequency of empty and false reports even in situation were a true report is expected.

In table A3 we report the averages of the minimum asking price and accepted price observed in the market for report. Again these values are consistent with those observed in treatment Soft (see tables 6 and 7).

Table A3. Minimum asking price and accepted price in the market for reports

	Periods 1 - 10	Periods 11 – 20
Minimum asked price	8.83	6.97
Accepted price	7.78	6.24

B) EXPERIMENTAL INSTRUCTIONS

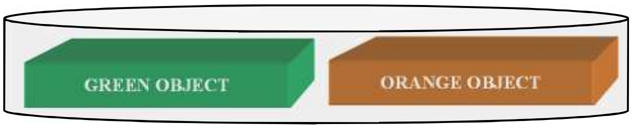
B.1 Experimental instructions of treatment Soft[12]

The aim of this experiment is to study how individuals make decisions in certain contexts. The instructions are simple. If you follow them carefully you will earn a non-negligible amount of money in cash (euros) at the end of the experiment. During the experiment, your earnings will be in ECUs (experimental currency units). Individual payments will remain private, as nobody will know the other participants' payments. Any communication among you is strictly forbidden and will result in immediate exclusion from the experiment.

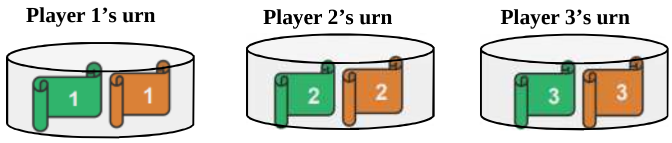
1. The experiment consists of 20 rounds. You will be randomly assigned to a group of 4 participants. This group is determined randomly at the beginning of the experiment and remains the same for all rounds. Moreover, you will be randomly assigned a player number within your group: you will be either player 1, player 2 or player 3. Your player number will remain the same throughout the experiment.

2. At the beginning of each round
   a. You will be endowed with 250 ECUs that you can use to make the decisions within the round, as explained below.
   b. You will be assigned a color (that will be immediately revealed to you) whose value for you is explained below.
3. At each round, you and the other players in your group will have the possibility to buy one object, by bidding in an auction (the auction rules will be detailed below). There will be one auctioned object, which can be either orange or green. The earnings of a player in case of getting the auctioned object depend on the color of the object:
   - If the object is equal to the player's assigned color, then the player will earn 200 ECUs.
   - If the object is different from the player's assigned color, then the player will earn 100 ECUs.
4. At the beginning of each round, the object to be auctioned is randomly drawn by the computer from an (virtual) urn containing two objects: one orange object and one green object. Each object is picked with equal probability (50%).

[12] We omit the experimental instructions of treatments *Base and Uninterested*, which are variations of the instructions of treatment *Soft* (as explained in Sections 3 and 5). These instructions are available from the authors upon request.

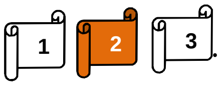


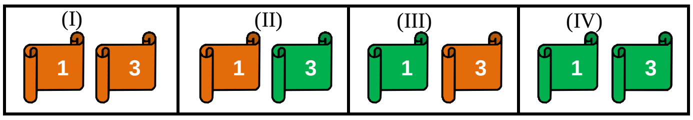
The assigned colors of players 1, 2 and 3 for the round are determined in a similar way. There is one (virtual) urn for each of these three players, containing <u>two pieces of paper</u>: one **orange** and one **green**. The computer randomly (and independently) draws one piece of paper from each urn. Each piece of paper is picked with equal probability (50%). The piece of paper selected for each player determines that player's assigned color for the round.



5. At each round, each player will take his/her decisions knowing his/her preferred color but not others' preferred colors.

FOR EXAMPLE,
if in a round the selected colors for players 1, 2 and 3 are: 

- Then, Player 2 will know: . In such a case, what player 2 will know about the colors of players 1 and 3 is that one of the next four combinations has been drawn, each of them with equal probability (25%):



- An analogous reasoning holds for players 1 and 3 (they only know their own assigned color).

6. Initially, no player knows which object (orange or green) has been selected by the computer for the round. However, prior to the auction, in sequence, you and the other players in the group will have the possibility to become informed of the color of the object to be auctioned by paying 20 ECUs. These decisions take place according to the following sequence: first player 1, then player 2 (knowing player 1's choice), and finally player 3 (knowing players 1 and 2's choices).

7. The color of the object is revealed to all those players that have decided to become informed (See the previous point). Then, if at least one player has decided to acquire the information and at least one player has decided not to acquire it, there is a market

for reports. In such a case, prior to the auction, the players that have acquired the information can sell a report about the color of the object to the uninformed players. In all other cases all the players directly participate in the auction.

These are the rules of the market for reports:

i. First, those players who have acquired the information, and that now know the color of the object, choose whether to sell a report or not. In case they decide to sell a report, these players set a price (for their report) and all the other players observe this price.
ii. The price of the report cannot exceed 20 ECUs.
iii. Then, according to the sequence (player 1 – player 2 – player 3), the uninformed players decide whether to buy one of the reports. When a player makes his/her choice, he/she will know the decisions of those players who acted before him/her in the sequence.
iv. The players who have sold a report decide the content of the report. The content can be: "*The object is orange*", "*The object is green*" or "*The object is orange or green*". Thus, the report can contain the true color, contain the false one, or be uninformative.
v. The buyers of the report receive it.

When the market for reports finishes, all the players participate in the auction, making a bid for the object.

8. Auction rules: The player that makes the highest bid gets the object. However, this player will not pay his bid, but the second-highest bid. The other players neither get the object nor pay anything.

For example: If player 1 bids 8 ECUs, player 2 bids 55 ECUs, and player 3 bids 18 ECUs, then player 2 (the highest bidder) receives the object and pays 18 ECUs for it (the second-highest bid). Players 0, 1 and 3 neither receive the object nor pay anything.

In case of ties in the highest bids, the computer randomly picks (with equal probability) the player who receives the object among those players who have made the highest bid. In such a case, the player who receives the object pays his/her own bid and the remaining players neither receive the object nor pay anything.

For example: If player 1 bids 55 ECUs, player 2 bids 55 ECUs, and player 3 bids 18 ECUs, then either player 1 or player 2 gets the object, with equal probability. The player who gets the object pays 55 ECUs.

9. Summary of round payoffs. The round payoff of a player has three parts:
    a. The endowment (250 ECUs) minus the payments (if any) incurred by the player either to be informed or to buy a report.
    b. In the event of having sold reports, the player gets the agreed price from each buyer.
    c. In the event of getting the auctioned object, the player gets either 200 ECUs (if the object is of his/her assigned color) or 100 ECUs (if it is not) minus his/her payment in the auction.
10. After the auction, and before proceeding to the next round, each player will receive the following ex post information:
    a. The bids made by each player in the auction.
    b. The player who obtained the auctioned object and the price paid for it.
    c. The color of the auctioned object.
    d. His/her round payoff (disaggregated).
11. Payments. At the end of the experiment, you will be paid your payoffs from 4 of the 20 rounds. These rounds will be randomly selected by the computer. The payoffs that you obtained in the selected 4 rounds will be converted into euros at the rate 100 ECUs = 1 euro and will be paid to you in private.

B.2 Experimental instructions of treatment Hard

The instructions of treatment Hard only differ from the instructions of treatment Soft in point 7. In particular, item *iv* (dealing with the decision on the content of the report) is removed. Instead, we add the sentence "*The report reveals the true color of the object*" as a new item just after the sentence "*These are the rules of the market for reports*".