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Summary

We perform a controlled experiment to study the welfare effects of competition in a strategic communication environment. Two equally informed senders with conflicting interests can misreport information at a cost. We compare a treatment where only one sender communicates to a treatment where both senders privately communicate with a decision-maker. Data show that competition between senders does not increase the amount of information decision-makers obtain. We find evidence of under-communication, as the information transmitted is lower than what theory predicts in the most informative equilibrium. Senders are worse off under competition because their relative gains from persuasion are more than offset by their expenditures in misreporting costs. As a result, competition between senders reduces the total welfare.

Keywords: Experiment, Welfare, Multiple senders, Competition, Sender-receiver games

JEL Classification: C72, C92, D60

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Abstract

We perform a controlled experiment to study the welfare effects of competition in a strategic communication environment. Two equally informed senders with conflicting interests can misreport information at a cost. We compare a treatment where only one sender communicates to a treatment where both senders privately communicate with a decision-maker. Data show that competition between senders does not increase the amount of information decision-makers obtain. We find evidence of under-communication, as the information transmitted is lower than what theory predicts in the most informative equilibrium. Senders are worse off under competition because their relative gains from persuasion are more than offset by their expenditures in misreporting costs. As a result, competition between senders reduces the total welfare.

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1 Introduction

Economic theory and intuition suggest that an effective way to obtain reliable information is to consult several well-informed experts with conflicting interests. Competition between experts may spur information transmission and allows for comparing their recommendations. However, competitive pressures may drive experts to dissipate a considerable amount of resources to influence decision-makers. The trade-off between decision-makers' accuracy and the wasteful use of resources for persuasion is central in, e.g., lobbying, legal systems (Posner, 1999; Tullock, 1975), and the efficient design of organizations (Milgrom, 1988). This paper uses a controlled experiment to study how competition between experts affects this trade-off.

We present a novel experimental design that builds upon canonical sender-receiver environments. There are three players: two senders with conflicting interests and one decision-maker. The two senders observe the realization of a random variable, which we will call from now on the *drawn value*. The drawn value can be either a positive or a negative integer. Depending on the treatment, one or both senders privately deliver a report to the decision-maker. The decision-maker is fully aware of the senders' preferences and cares about learning the sign of the drawn value.[1]

A key feature of our setup is that senders can misreport the drawn value at a cost proportional to the size of the lie: reports claiming that the drawn value is further away from its actual realization are more expensive.[2] The explicit inclusion of misreporting costs makes our environment one of "costly talk" rather than cheap talk. This feature allows us to measure the resources senders use to influence decision-makers, a critical component of players' welfare currently unexplored in related experimental work. The presence of multiple senders and misreporting costs generates a framework that combines an all-pay contest with a communication game. This combination produces an interesting trade-off because competition is typically beneficial in the former and detrimental in the latter.[3]

In this experiment, we perform a treatment manipulation by varying the number of

[1]The drawn value can therefore be naturally interpreted as a quality dimension, valence score, or vertical differentiation parameter. For example, in a courtroom the state can represent the quality of a test, strength of evidence, or competence of a witness expert. To adjudicate, the judge needs to believe that the supporting evidence is strong enough, "beyond a reasonable doubt."

[2]These "misreporting costs" have a broad interpretation. They can encapsulate direct costs for tampering with evidence, the time and effort required to credibly "cook the numbers," bribe witnesses, manipulate earnings, etc. Alternatively, they can incorporate more indirect and non-pecuniary costs such as reputation damages, perjury convictions, or moral concerns. Our underlying assumption is that misreporting more is—in expectation—more costly, as doing so requires the use of more resources or it increases the probability of being caught in a lie (see e.g., Abeler, Nosenzo, & Raymond, 2019; Gneezy, Kajackaite, & Sobel, 2018; Kartik, Ottaviani, & Squintani, 2007)

[3]More specifically, our setup can be thought as an all-pay contest where the success function is endogenous. In communication games, competition between senders makes decision-makers better informed (Battaglini, 2002; Krishna & Morgan, 2001b). By contrast, competition is thought to be detrimental to contestants (Baye, Kovenock, & De Vries, 1999; Tullock, 1975).

senders allowed to make a report. In our baseline condition, we consider a monopolistic news market where only one of the two senders communicates with the decision-maker. Instead, the treatment variation mimics a competitive news market where both senders privately communicate with the decision-maker. Because senders are equally and perfectly informed, they compete in the provision of the same piece of information. The absence of information aggregation problems allows us to isolate the effects of competition on the players' welfare. We say that a sender allowed to communicate is *active*. In contrast, a spectating sender is *inactive*. The only difference between the two experimental conditions is the number of active senders. This number determines the underlying strategic environment: the competitive treatment has an adversarial component absent in the monopolistic baseline. The decision-maker can compare and cross-validate the reports of two active senders, whereas she cannot make such comparisons when one sender spectates.

The main findings can be summarized as follows. The introduction of competition between senders significantly decreases the total welfare. The sum of individual payoffs is lower in competition than in the baseline condition. There are two determinants to this result. First, on average, competition does not make decision-makers better informed. Second, the total amount of resources devoted to misreporting information is about two times higher in the competitive condition than in the monopolistic one. The average cost incurred per active sender is similar across treatments. However, the rate at which each active sender achieves persuasion is substantially lower in the competitive treatment. As a result, senders are worse off under competition, and the duplication of their misreporting costs drives the total welfare down.

Even though both treatments' most informative equilibrium is fully revealing, we find that some information is consistently lost. There is evidence of an *under-communication* effect: decision-makers make less informed choices than predicted in the most informative equilibrium. In the monopolistic treatment, decision-makers obtain a payoff that is not significantly different from what is predicted in the least informative equilibrium. These results contrast with the over-communication phenomenon observed in related cheap talk experiments. As argued in Minozzi and Woon (2019), over-communication in the monopolistic treatment may explain why competition has a negligible effect on the amount of information transmitted. However, this cannot be the case in our costly talk setup.

Our results contribute to the debate concerning the effects of competition in communication environments. Conventional wisdom asserts that competition in news markets promotes truth and informs decision-makers better (Gentzkow & Shapiro, 2008). Informational theories support this view (Battaglini, 2002; Krishna & Morgan, 2001b). In contrast, Tullock's criticism of the common law (Tullock, 1975) suggests that adversary dispute resolution systems are informationally inefficient and socially wasteful. A central point of this criticism is that contending parties in adversary systems dissipate a substantial amount of resources to influence decision-makers.[4] As a result, "decentralized self-interested behavior by litigants depresses overall social welfare" (Zywicki, 2008).

The rest of the paper is organized as follows. Section 2 discusses the related literature. Section 3 introduces the experimental design, and Section 4 discusses the theoretical background. Results are in Section 5. Finally, Section 6 concludes. Other material is in the Online Appendix.

2 Related Literature

This paper contributes to the experimental literature on strategic communication. Most work in this literature builds on the theoretical framework of Crawford and Sobel (1982) by studying settings with one sender and payoff-irrelevant messages.[5] A recurrent finding is the over-communication effect, that is, more information is revealed in controlled experiments than in the most informative equilibria (Blume, DeJong, Kim, & Sprinkle, 1998, 2001; Cai & Wang, 2006; Dickhaut, McCabe, & Mukherji, 1995; Kawagoe & Takizawa, 2009; Sánchez-Pagés & Vorsatz, 2007; Wang, Spezio, & Camerer, 2010). In our setup with a single sender but payoff-relevant messages, we find evidence of an under-communication effect: less information is revealed than in the most informative equilibrium.

Differently from the above line of work, we consider an experimental condition with two competing senders. Theoretical work on strategic communication with multiple senders suggests that more information can be revealed with two senders than with one (Battaglini, 2002; Gilligan & Krehbiel, 1989; Krishna & Morgan, 2001a, 2001b; Milgrom & Roberts, 1986). However, the empirical evidence is mixed. Lai, Lim, and Wang (2015) use a multidimensional state space to study fully revealing equilibria as in Battaglini (2002) and find that more information is transmitted with two senders than with one.[6] In experiments with a one-dimensional state space, Battaglini, Lai, Lim, and Wang (2019) and Minozzi and Woon (2019) find that decision-makers do not make more informed decisions when consulting an additional expert. In Battaglini et al. (2019) senders communicate simultaneously, while in Minozzi and Woon (2019) senders communicate sequentially. Both studies find over-communication with one sender but do not find full information revelation when the number of senders is two. In contrast, Minozzi and Woon (2016) show that when two senders communicate simultaneously and are privately informed about their own preferences, there is over-communication and the resulting outcome is close to be fully revealing. Bayindir, Gurdal, Ozdogan, and Saglam (2020) find that with two senders there is no statistically significant over-communication effect, independently of whether the timing of communication is simultaneous or sequential.

[4]See, e.g., Zywicki (2008) and references therein.

[5]For a survey of the experimental literature on cheap talk, see Blume, Lai, and Lim (2020).

[6]Vespa and Wilson (2016) show that fully revealing equilibria can be approximated in the laboratory by using a particular setting with a multidimensional state space.

Our experiment differs from all the papers mentioned above as we introduce misreporting costs that are proportional to the size of the lie.[7] Messages impact directly on the senders' payoffs, and therefore "talk is not cheap." Instead, communication takes the form of costly signaling.[8] For this reason, our setting is more closely related to the theoretical work on communication with exogenous lying costs (Kartik, 2009; Kartik et al., 2007; Vaccari, 2021a, 2021b) than to that of cheap talk and verifiable disclosure.

A few experiments include communication costs in settings with multiple senders. As we consider senders that compete to persuade a decision-maker, our setting is related to experiments that study information in adversarial procedures. Block, Parker, Vyborna, and Dusek (2000) and Block and Parker (2004) compare the adversarial and the inquisitorial judicial systems in an experiment where auditors enforce an anti-perjury rule.[9] Boudreau and McCubbins (2008, 2009) analyze competition between senders that incur penalties for lying.[10] Differently from this body of work, our experiment focuses on the comparison between monopoly and competition in information provision, and studies the welfare of all market participants.

Agranov, Dasgupta, and Schotter (2020) analyze the impact of competition on the welfare of all players in a setting where senders suffer from induced lying costs.[11] Senders are sellers that are privately informed about the quality of their product and their preferences, lying cost included. In their experiment, the welfare of all players is lower with competition than without it. This result is due to a twofold empirical effect of competition on players' behavior: it drives senders to lie more frequently and makes receivers more credulous. In Agranov et al. (2020) sellers use messages to compete in a product market, but they do not compete in the provision of information. By contrast, our experiment considers senders that are equally informed and whose preferences are common knowledge. In our environment, senders compete for the decision-maker's beliefs over the same state of nature.

[7] A prominent explanation for the over-communication effect is the presence of pro-social preferences, and in particular of subjects' lying aversion (Hurkens & Kartik, 2009; Sánchez-Pagés & Vorsatz, 2007, 2009). In a setting with two senders, preference uncertainty, and a one-dimensional state space, Minozzi and Woon (2013) use priming and labeling to affect subjects' lying aversion indirectly.

[8] Experiments on signalling games (see, e.g., Kübler, Müller, and Normann (2008) and references therein) study settings with a different signalling structure than our paper, have a different scope, and feature a single sender only. An exception to the latter is Müller, Spiegel, and Yehezkel (2009), which studies oligopoly limit pricing with two informed senders.

[9] They define perjury as "embellishment as well as falsification" of information, which is punishable by the forfeiture of the offending party's full potential payoff. Differently than in our setting, in Block et al. (2000) and in Block and Parker (2004) the two contending parties are not equally and fully informed.

[10] The penalty consists in the deduction of a fixed sum of money from a sender's earnings for each time such a sender makes a false statement. In Boudreau and McCubbins (2008, 2009) the receivers have unobserved, uncontrolled, and potentially heterogeneous beliefs about the realized state.

[11] Agranov et al. (2020) also induce other belief-dependent psychological costs such as guilt and disappointment. Conversely, our misreporting costs are common knowledge, belief-independent, and map from larger state and message spaces, thus allowing senders to deliver lies of different magnitudes.

3 Experimental Design

Game. In all sessions of our experiment, groups of three participants make decisions for 30 rounds of play. At the beginning of each session, subjects are randomly assigned to a fixed role: either Sender$_i$, with $i \in \{1, 2\}$, or Decision Maker (from now on DM).[12] At the start of each round, and for each group, an integer number labeled as *drawn value* is randomly drawn from the interval [-100, +100] using a truncated discrete normal distribution with $\mu = 0$ and $\sigma = 25$.[13] This number determines the state of the world: if negative, the state of the world is said to be RED, BLACK otherwise. The state can be either RED or BLACK with equal probability if the number is zero. The drawn value is revealed to Sender$_1$ and Sender$_2$ only. Upon receiving this information, both senders must report an integer from the interval [-100, +100] to DM. Having observed the two reports, DM has to guess the state of the world by choosing either action *Red* or action *Black*. While the decision-maker is always better off if the guess is correct, Sender$_1$ and Sender$_2$ have misaligned incentives. Sender$_1$ always prefers action *Black* while Sender$_2$ always prefers action *Red*. Therefore, Sender$_1$ (Sender$_2$) might gain by overreporting (under-) the random number and persuade DM to choose action *Black* (*Red*). However, misreporting is only possible by bearing a cost c_i. Both senders incur a cost that depends on the difference between the random number and their report. Hence, the larger the lie, the larger the cost.[14] The expected payoffs and the cost are automatically displayed and updated on participants' screens to avoid cognitive strain and allow subjects to focus on the experimental game. Once the decision-maker selects an action, the payoffs of all group members are assigned accordingly. To promote learning, at the end of each round participants are provided with a summary of the current and the previous rounds of their group. Hence, they acquire information about the drawn value, the state, the two reports, the DM's action, and all individual payoffs. Table 1 summarises the experimental payoffs.

Treatments. In our experiment, we exogenously vary the market configuration. Our baseline treatment *MONO* is the game described above, with the only exception being that we allow Sender$_1$ to act as a monopolist in the market. Hence, we bar Sender$_2$ from reporting information to DM. For this reason, in this treatment Sender$_2$ bears no misreporting costs. As Sender$_2$ acts as a spectator, we elicit their beliefs about the choices of the other group members. First, we elicit the belief that Sender$_1$ reports the drawn value truthfully. Second, we ask for the probability of DM choosing *Black* conditional on

[12] In the experiment we used neutral labels so as to not frame participants.

[13] We carefully chose this distribution in order to increase the number of rounds where misreporting is more likely, i.e., around zero. Using an uniform distribution would instead lead to more extreme random numbers, where persuasion is too expensive. Although a uniform distribution is easier to understand, we wrote our instructions carefully, making sure that the salient characteristics of the normal distribution were clear enough (see Appendix A). A similar approach has been used in Enke and Zimmermann (2019).

[14] In the experiment we used the following cost function: $c_i = \frac{25 \times |\text{Drawn Number - Report}_i|}{3}$. We calibrated the cost function to allow for the presence of fully revealing equilibria in both our treatments. Thus, failures of perfect information transmission cannot be attributed to an absence of fully revealing equilibria.

		Payoff	Choice
Sender_1		$1200 - c_1$	*Black*
		$400 - c_1$	*Red*
Sender_2		$400 - c_2$	*Black*
		$1200 - c_2$	*Red*
DM		600	if = state
		200	otherwise

Table 1 Experimental payoffs.

Sender_1's report. These beliefs were elicited through an incentive-compatible mechanism. To keep incentives constant across treatments, we do not inform the other two players that Sender_2 can earn extra money from these two questions.[15] This treatment is essential to isolate the effect of competition, and shuts down any difference in behavior between treatments that might be due to other-regarding preferences. In treatment *COMP*, instead, we allow for competition between the two senders as described previously: both senders privately report a number to the decision-maker. In all treatments, the payoffs of the three group members depend on the action chosen by DM. Hence, we can compare their welfare among the different market configurations.

Additional variables. At the end of each session, we elicit a self-reported questionnaire. The answers allow us to check whether treatments were balanced with respect to individual characteristics and to control for personal traits in regression analysis. First, we elicit the gender and the age of the respondent. We then obtain a few individual attitudes toward risk, trust, and honesty. These three questions were answered using a Likert scale. The propensity to take risks was captured by the answer to the question "*Do you see yourself as a person ready to take risk or you try to avoid it?*". We allow for 11 possible levels going from "0: absolutely unwilling to take risks" to "10: absolutely willing to take risks". Trust was elicited by the following question: "*In general, do you think people can be trusted?*". Answers could span from "0: No, you must always be cautious" to "2: Yes, you can almost always trust". Finally, answers to "*In general, do you think people try to take advantage of others if they get the chance?*" ranged from "0: No, people always behave correctly" to "3: Yes, they always try to take advantage of it". We use this question as a proxy for honesty of others. See Appendix A for more details.

Procedures. The experiments took place between March 2021 and October 2021. The experiment was programmed and conducted using the oTree open-source platform (Chen, Schonger, & Wickens, 2016) and supervised online: participants' identities and

[15] As the possibility of receiving money from the two beliefs is Sender_2's private information, this extra payment is not included in the analysis where we compare welfare across treatments.

compliance with the rules were verified through a Zoom meeting. In total, 192 students recruited from the subject pool of the Cognitive and Experimental Economics Laboratory (CEEL) at the University of Trento participated in our experiment. We implemented a between-subject design, where students were allocated to one session as well as one treatment only. Table B.1 in Appendix B provides basic randomization checks, showing treatments were balanced with respect to most of the key variables. Instructions were presented on computer screens and read out loud. Subjects then answered control questions and participated in a trial round to familiarize themselves with the task and the graphic interface. Groups were randomly and anonymously formed at the beginning of each round. Hence, we shut down the channel of reputation. Final payments in the experiment were based on the average earnings of two randomly selected rounds. In the event a participant made a loss (resulting from paying a very high cost of misreporting in the rounds selected for payments), the participation fee covered this loss. In case the fee was insufficient, we asked subjects to complete an additional task whose duration was proportional to their loss.[16] Eventually, no subject had to complete the additional task. Payoffs in each round were given in points and converted into cash at the end of the session using the following conversion rate: 100 points for 1 Euro. A typical session lasted about 80 minutes, and the average payment was 11.93 Euros, including a 4 Euros participation fee. The experiment was preregistered at OSF Registries (https://doi.org/10.17605/OSF.IO/DXWT7). Data and replication files can be found at: https://osf.io/9svpf.

4 Theoretical Background

This section studies the equilibria of the continuous approximation of our experimental conditions. The analysis performed here informs us of the expected payoffs the decision-maker can attain in equilibrium. In Section 5.4, we compare our theoretical predictions with the empirical payoffs. This comparison allows us to test for an over-communication effect present in related work and potentially important in interpreting our results. The equilibrium analysis performed in this section draws from results obtained in Vaccari (2021a, 2021b). We conclude by studying the decision-maker's payoff in several benchmark cases.

There are two equally informed senders (Sender$_1$ and Sender$_2$), and an uninformed decision-maker (DM). There is a random variable with realization $\theta \in \Theta = [-\phi, \phi]$, with $\phi > 0$. We refer to θ as the *drawn value*. This score is distributed according to the pdf f, which has full support in Θ and is symmetric around zero. Senders perfectly observe θ. Depending on the treatment, either one or both senders deliver a report $r_j \in \Theta$, $j \in \{1, 2\}$.

[16] Subjects had to count the number of zeroes in a series of 7x10 matrices, whose number was proportional to the participant's loss. We chose this task for two reasons: (i) it does not distort incentives of misreporting, (ii) and allows us to provide a low participation fee preventing the risk of decreasing the salience of the main experimental task.

In *COMP*, both senders deliver a report privately or simultaneously; in *MONO*, only sender 1 delivers a report, whereas sender 2 cannot. After observing senders' reports, both not the drawn value, the decision-maker takes an action $a \in \{Red, Black\}$.

Player $i \in \{1, 2, DM\}$ gets utility $u_i(\theta, a)$ when the decision-maker selects action a and the state is θ. In addition, Sender$_j$ gets a total payoff of $w_j(r_j, \theta, a) = u_j(\theta, a) - C(r_j, \theta)$ from delivering report r_j when the drawn value is θ and the decision-maker selects action a. $C(\cdot)$ is a misreporting cost function.[17] Apart from senders having private information about the drawn value, every other aspect of the model is common knowledge. The solution concept we use is perfect Bayesian Equilibrium (PBE).

Parameters. The space Θ has $\phi = 100$, and therefore $\Theta = [-100, 100]$. The continuous probability distribution f has full support in Θ and is symmetric around zero.[18] The decision-maker's payoff is $u_R(Black, \theta) = 600$ when $\theta > 0$ and $u_R(Black, \theta) = 200$ when $\theta < 0$; it is $u_R(Red, \theta) = 600$ when $\theta < 0$ and $u_R(Red, \theta) = 200$ when $\theta > 0$. When $\theta = 0$, the decision-maker is equally likely to obtain a payoff of 600 and 200 independently of her chosen action. Senders' payoffs are, for every $\theta \in \Theta$, $u_1(Black, \theta) = u_2(Red, \theta) = 1200$ and $u_1(Red, \theta) = u_2(Black, \theta) = 400$. Finally, misreporting costs are $C(r, \theta) = \frac{25}{3}|r - \theta|$.

Reach. We define Sender$_1$'s reach when the drawn value is θ as the report $\bar{r}_1(\theta) > \theta$ such that $u_1(Red, \theta) = u_1(Black, \theta) - C(\bar{r}_1(\theta), \theta)$. We obtain that $\bar{r}_1(\theta) = \theta + 96$. Similarly, we define Sender$_2$'s reach when the drawn value is θ as the report $\bar{r}_2(\theta) < \theta$ such that $u_2(Black, \theta) = u_2(Red, \theta) - C(\bar{r}_2(\theta), \theta)$. We obtain that $\bar{r}_2(\theta) = \theta - 96$.

4.1 Monopolistic Equilibria

We begin our analysis by studying the perfect Bayesian equilibria (PBE) of the monopolistic condition *MONO*. We focus on those PBE that survive the Intuitive Criterion (Cho & Kreps, 1987). Define,

$$\bar{\lambda} = \mathbb{E}_f[\theta | \theta \in (0, \bar{r}_1(0))],$$

$$\hat{r}(\lambda) = \{r \in \Theta | \mathbb{E}_f[\theta | \theta \in (\bar{r}_1^{-1}(r), r)] = \lambda\},$$

where $\bar{r}_1^{-1}(r) = r - 96$ is the inverse function of Sender$_1$'s reach. Equilibria of the monopolistic condition have the following structure: given a $\lambda \in [0, \bar{\lambda}]$, the monopolistic Sender$_1$'s reporting rule $\rho_1(\theta, \lambda)$ is,

$$\rho_1(\theta, \lambda) = \begin{cases} \hat{r}(\lambda) & \text{if } \theta \in \left(\bar{r}_1^{-1}\left(\hat{r}(\lambda)\right), \hat{r}(\lambda)\right) \\ \theta & \text{otherwise.} \end{cases} \quad (1)$$

[17] We will focus on the cases where, as in the experimental conditions, players have step utility functions and misreporting costs are linear. However, the equilibria's structure remains similar under general preferences, such as non-linear misreporting costs and utilities.

[18] The monopolistic and competitive equilibria discussed in this section are not affected by the distribution, provided f is an atomless pdf with full support in Θ and symmetric around zero. The actual experimental distribution is a truncated Normal distribution with support in [-100,100], zero mean, and a standard deviation of 25.

The decision-maker sequentially rationally selects action *Black* when $r_1 \geq \hat{r}(\lambda)$, and selects *Red* otherwise.

Persuasion takes place when $\theta \in (\bar{r}_1^{-1}(\hat{r}(\lambda)), 0)$. We obtain an equilibrium that fully reveals the sign of the drawn value by setting $\lambda = \bar{\lambda}$. In this case, we have that $\hat{r}(\bar{\lambda}) = \bar{r}_1(0) = 96$ and $\bar{r}_1^{-1}(\hat{r}(\bar{\lambda})) = 0$. By contrast, the least informative equilibrium has $\lambda = 0$. In this case, we have that $\hat{r}(0) = 48$, misreporting occurs when $\theta \in (-48, 48)$, and persuasion takes place when $\theta \in (-48, 0)$.

Denote with F the CDF of f. In a fully revealing equilibrium, the decision-maker always selects the optimal action and thus gets a payoff of 600. By contrast, in the least informative equilibrium the decision-maker obtains an expected payoff of

$$F(-48 < \theta < 0) \cdot 400 + (1 - F(-48 < \theta < 0)) \cdot 600 \approx 505.48.$$

4.2 Competitive Equilibria

We now turn our attention to perfect Bayesian equilibria of our competitive condition *COMP*.[19] There are equilibria that fully reveal the drawn value. These equilibria are similar to the revealing equilibrium of the monopolistic condition. The following is an example: Sender$_1$'s reporting rule is the same as in the fully revealing equilibrium of the monopolistic condition (see $\rho_1(\theta, \lambda)$ in (1) with $\lambda = \bar{\lambda}$), whereas Sender$_2$ always reports truthfully the state. The decision-maker selects action *Black* if and only if the report delivered by Sender$_1$ is equal to or higher than $\bar{r}_1(0)$, and selects action *Red* otherwise. In this fully revealing equilibrium, the decision-maker always learns the drawn value and obtains an expected payoff of 600.

Equilibria of this condition are formally studied in Vaccari (2021a). There, it is shown that there are also other equilibria that satisfy natural conditions and have appealing properties, including uniqueness and robustness to refinement criteria. In these *adversarial* equilibria, the decision-maker does not always learn the sign of the drawn value, and thus obtains a payoff that is lower than 600. Senders always report truthfully when $\theta \notin [-48, 48]$, and play mixed strategies otherwise. The set $[-48, 48]$ is obtained by finding the drawn values that satisfy $\bar{r}_j(\theta) = -\theta$ for $j \in \{1, 2\}$. Consider a $\theta \in (-48, 48)$, and recall that $\bar{r}_1(\theta) = \theta + 96$ and $\bar{r}_2(\theta) = \theta - 96$. The support of Sender$_1$'s reporting strategy is $S_1(\theta) = [\theta, -\bar{r}_2(\theta)]$ when $\theta \in [0, 48)$, and it is $S_1(\theta) = \{\theta\} \cup [-\theta, \bar{r}_1(\theta)]$ when $\theta \in (-48, 0]$. The support of Sender$_2$'s reporting strategy is $S_2(\theta) = [\bar{r}_2(\theta), -\theta] \cup \{\theta\}$ when $\theta \in [0, 48)$, and it is $S_2(\theta) = [-\bar{r}_1(\theta), \theta]$ when $\theta \in (-48, 0]$. Sender 1 reports truthfully with probability $\alpha_1(\theta) = 2\theta \cdot \frac{25/3}{800}$ when $\theta \in [0, 48)$, and with probability $\alpha_1(\theta) = \frac{25/3}{800} \cdot (96 - 2\theta) - 1$ when $\theta \in (-48, 0]$. Sender$_2$ reports truthfully with probability $\alpha_2(\theta) = 1 - \frac{25/3}{800} \cdot (96 - 2\theta)$ when $\theta \in [0, 48)$, and with probability $\alpha_2(\theta) = -2\theta \cdot \frac{25/3}{800}$ when $\theta \in (-48, 0]$. When misreporting,

[19] The Intuitive Criterion does not readily apply to games with more than one informed sender, and therefore we do not use it in our solution concept for this case.

Sender$_j$ delivers a report $r_j \in S_j(\theta) \setminus \{\theta\}$ with a state- and report-independent probability density $\psi_j(r_j, \theta) = \frac{25/3}{800}$.

We define a lower bound for the decision-maker's payoff. Suppose that, given the senders' strategies in an adversarial equilibrium, the decision-maker selects *Black* if and only if $r_1 \geq 0$, and selects *Red* otherwise. Their expected payoff from following this non-sequentially rational rule is

$$\underline{W} = 600(.5 + F(-48)) + 600 \int_{-48}^{0} f(\theta)\alpha_1(\theta)d\theta + 400 \int_{-48}^{0} f(\theta)(1 - \alpha_1(\theta))d\theta \approx 518.10.$$

4.3 Benchmarks

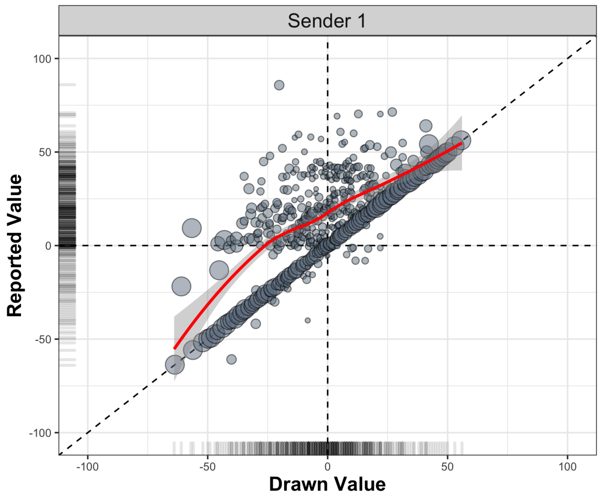
Finally, we analyze a series of benchmark cases. Consider a cheap talk variant of the model discussed above, where $C(\cdot) = 0$ always. Given that we study a situation of pure conflict between players, only babbling equilibria can exist. Therefore, in both treatments, the decision-maker obtains an expected payoff of 400, whereas senders get an expected payoff of 800. Players would obtain the same expected payoffs if they were not allowed to communicate. Consider now a model variant where the decision-maker is fully informed about the drawn value. In this case, the decision-maker obtains an expected payoff of 600, whereas senders get an expected payoff of 800. Players would obtain the same expected payoffs if senders were not allowed to misreport information.

5 Results

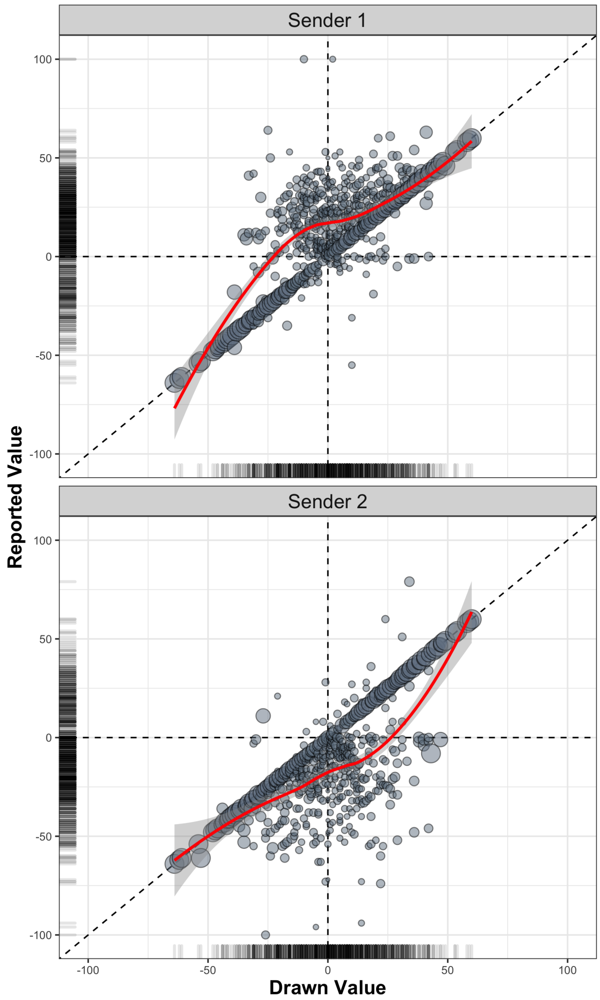
We start this section by first describing the choices of senders (Sender$_1$ and Sender$_2$) and decision-makers (DM). Then, we focus our analysis on welfare measured via individual payoffs (Net Payoffs). Finally, we present some additional results that help understand behavior in the experiment.

5.1 Senders

Figure 1 provides a representation of senders' behavior in terms of reported values conditional on drawn values. The leftward panel portrays behavior in *MONO* and the rightward panel in *COMP*. The size of the circles captures the joint frequency of the reports given the observed drawn value. The continuous line represents a polynomial fitting of the data. The gradient of bars on the side of the graph depicts the marginal distribution of drawn (x-axis) and reported values (y-axis).



(a) *MONO*



(b) *COMP*

Figure 1 Drawn and reported values by treatment.
Panel (a) shows reports of Sender_1 conditional on the drawn value in *MONO*. Panel (b) shows reports from both senders in *COMP*. Each circle captures the joint frequency of the reports given the realized drawn value. The red line represents a polynomial fitting of the data. The x-axis depicts the marginal distribution of the realized random draws. The y-axis shows the marginal distribution of reported values.

Deviations from truthful reporting are widespread: only 49.2% and 56.5% of reports are truthful in *COMP* and *MONO*, respectively. The figure shows that senders react to the monetary incentives in both experimental conditions and tend to misreport to their advantage. Sender_1 overreports the drawn value while Sender_2 tends to send negative reports more frequently (see the marginal distribution of reports on the y-axis). The bubble plot suggests that deviations are more frequent for values closer to zero, as confirmed by the fitting curve. When computing deviations of reported values from drawn values,[20] the overall average deviation is 9.634 in the monopoly and 9.614 in the competition treatment. As the figure suggests, senders misreport to a larger extent when they have a conflict of

[20]The deviation is computed as the difference between the report and the drawn value for Sender_1 and the opposite (drawn value - report) for Sender_2.

interest with DM. In these cases, the average deviation is 13.291 and 13.386 in *MONO* and *COMP*, respectively. Table 2 provides a summary description of misreporting costs sustained by senders in the two treatments.

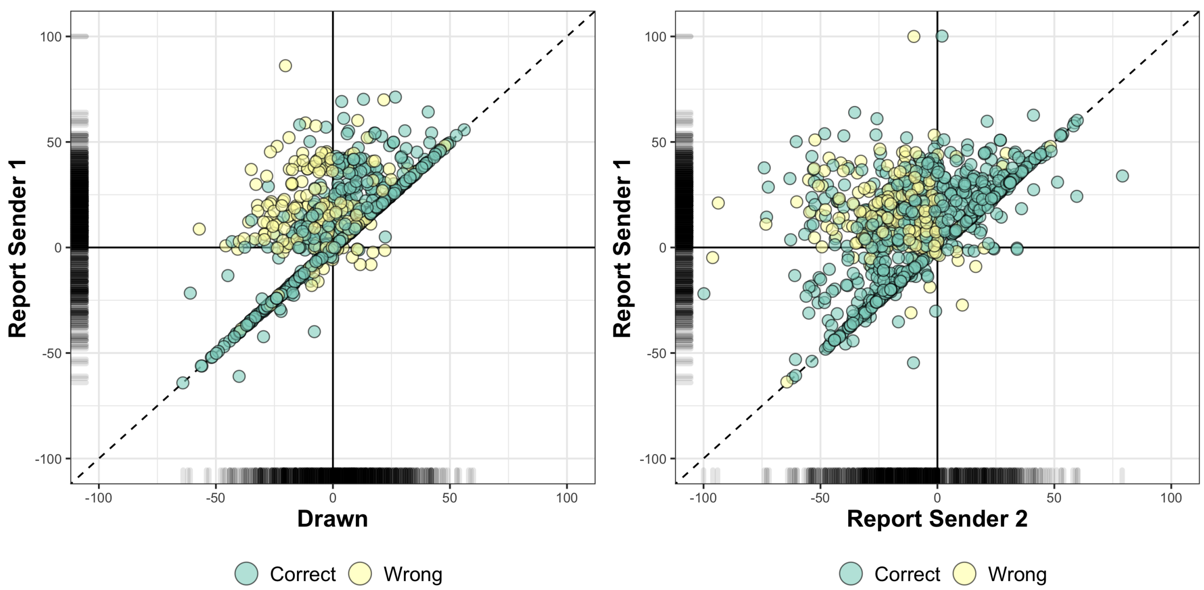
Treatment	Role	N	Mean	SD	Median
MONO	A	960	85.859	134.664	0.000
COMP	A	960	88.533	127.372	16.667
	B	960	93.090	145.950	0.000

Table 2 Signal Costs (individual observations).

Individual average costs appear to be similar between the two treatment conditions. However, in *COMP* the average total costs per group are 181.623, more than twice those in *MONO*.

5.2 Decision-Makers

Figure 2 provides a representation of the correct and wrong choices of the decision-maker. The left panel (a) refers to the monopoly treatment and shows DM's guesses conditional on Sender_1's report and the drawn value. The right panel (b) represents DM's choices in competition conditional on reports of the two senders.



(a) *MONO* **(b)** *COMP*

Figure 2 Decision-makers accuracy by treatment. Note: The figure shows DM accuracy in *MONO* (a) and *COMP* (b). The y-axis reports the unconditional frequency of Sender_1 reports. The x-axis shows the unconditional frequency of drawn values (a) and Sender_2 reports (b).

In *MONO*, the overall frequency of correct guesses is 72.2%. As expected, the decision-maker is less likely to make a correct guess when Sender_1 misreports the state at their advantage (29.3%). Instead, when a positive number is drawn and the monopolist reports a positive value, the percentage of correct guesses increases up to 83.2%. In *COMP*, the overall frequency of correct choices is 74.0%, very similar to the *MONO*. However, this percentage depends on the signs of the reported values. When reports have different signs, the decision-maker makes the correct choice about half the time (48.9%). Instead, DM's accuracy increases when the two reports have the same sign (95.4%). This evidence suggests that reports are an essential determinant of choices, as decision-makers try to cross-validate the reports.

The results presented above show that the introduction of competition directly translates into a wasteful use of resources, as the decision-makers do not benefit, on average, from an additional information source.

5.3 Welfare

The misreporting costs and DMs' choices directly translate into participants' payoffs. We take the net payoffs of participants as a direct measure of their welfare and as our primary unit of analysis. Table 3 reports descriptive statistics of net payoffs by treatment at the individual and group levels.

Treatment	Role	N	Mean	SD	Median
MONO	Sender_1	960	778.307	386.615	900.000
	Sender_2	960	735.833	395.026	400.000
	DM	960	488.750	179.323	600.000
	Group	960	2002.891	263.205	2191.667
COMP	Sender_1	960	738.967	404.176	862.500
	Sender_2	960	679.410	397.577	400.000
	DM	960	495.833	175.636	600.000
	Group	960	1914.210	310.067	2033.333

Table 3 Net Payoffs (individual observations).

The table shows individual net payoffs are generally higher in *MONO* than in *COMP* for both senders: +5.3% for Sender_1 and +8.3% for Sender_2. In contrast, for DMs the average payoff is lower in the monopolistic than in competitive treatment (−1.4%). On average, total payoffs in a group are 4.6% higher in *MONO* than in *COMP*.

The regression output of Table 4 provides us with a statistical analysis of the descriptive results reported above. Each column represents a linear mixed-effect model relating the individual net payoff earned in a round with treatment and individual variables. The table provides an estimate for each type of player separately and for pooled data (*Group*).[21] The individual net payoff is regressed against a set of main explanatory variables: *COMP* is a dummy for the main treatment variable (*COMP*=1, *MONO*=0), *Drawn* represents the drawn value observed by senders, and *Round* is the progressive round number. For senders, we control for the drawn value, as we are interested in the impact of the randomly drawn number on senders' payoffs. Because the coefficient of *Drawn* has no clear meaning for either DMs nor groups, we focus on the impact of extreme drawn values instead. Hence, we report the estimated effect of the absolute value of *Drawn* ($|Drawn|$). The table also controls for individual characteristics and attitudes elicited in the final questionnaire.[22]

Net payoff	Sender_1	Sender_2	DM	*Group*
COMP	−58.166 (22.831)*	−42.114 (18.838)*	−25.561 (16.365)	−59.807 (24.510)*
Drawn	10.456 (0.518)***	−8.765 (0.544)***		
$COMP \times Drawn$	1.432 (0.734)	−3.200 (0.760)***		
$\lvert Drawn \rvert$			2.589 (0.452)***	1.118 (0.525)*
$COMP \times \lvert Drawn \rvert$			2.090 (0.636)**	1.790 (0.739)*
Round	−0.017 (0.849)	−0.375 (0.887)	1.384 (0.444)**	0.481 (0.515)
Male (=1)	−2.442 (22.002)	−2.335 (16.808)	−12.974 (12.597)	−7.964 (20.593)
Age	1.375 (4.534)	6.762 (3.230)*	0.005 (3.148)	0.016 (3.580)
Risk	−4.285 (5.509)	8.078 (4.696)	0.742 (3.183)	0.663 (5.270)
Trust	−8.975 (12.549)	4.423 (10.901)	−4.570 (5.906)	−10.068 (11.359)
Honesty	28.465 (18.762)	−10.934 (16.220)	−6.104 (11.790)	−6.314 (17.994)
Constant	747.561 (103.270)***	554.838 (74.679)***	432.068 (50.382)***	661.643 (87.167)***
Observations	1890	1890	1920	5700
Subjects	63	63	64	190

Table 4 Net Payoffs.
Note: Linear mixed-effects model with net payoff as a dependent variable. The models include random intercepts at session and subject level. Standard errors in parentheses. Significance levels: $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

The regression outputs for both senders show that competition significantly and negatively impacts their net payoffs. As expected, larger drawn values have a positive (negative) effect for Sender_1 (Sender_2). Hence, as a spectator, Sender_2 benefits from a negative drawn value. This effect is more pronounced in the competitive treatment. For DM, competition does not significantly impact net payoffs. Larger drawn values, in absolute terms, have a positive impact on the net payoff and the effect is stronger in competition. The estimated coefficient of *Round* suggests that the performances of DMs improve over time. Finally, when considering all type of players together (*Group*), competition has a negative impact on welfare. Larger drawn values, in absolute terms,

[21] As a robustness check, we also run a regression on the sum of net payoffs at the group level, which implies dropping individual controls. Results from this check further corroborate those reported in Table 3.

[22] The observations of one participant are missing from the regression for Sender_1 because they did not answer the questionnaire. The observations of one participant are missing from the regression for Sender_2 because they identified neither as a male nor as a female. However, results reported in Table 4 are confirmed when including all observations and omitting controls for individual characteristics.

improve welfare, and this effect is stronger under competition. The outcomes of the table echo the results discussed previously: introducing a sender with an opposed bias decreases the total welfare.

5.4 Additional results

5.4.1 Benchmark

In Section 4 we derive some theoretical predictions about expected net payoffs in alternative equilibria of the game. Although in our preregistration we only mention comparison with the full information benchmark, we also compare data with the other theoretical predictions. Table 5 shows the percentage deviations from the no information (*No Info*) and the full information (*Full Info*) benchmarks. Moreover, we also compare net payoffs with the games' least informative equilibrium (*Least Info*), as calculated in Section 4. For the monopolistic condition, the least informative equilibrium is the equilibrium with the least transmission of information among all the perfect Bayesian equilibria satisfying the Intuitive Criterion. By contrast, we analyze only two equilibria in the competitive condition, of which only one is fully revealing. In this case, the least informative equilibrium is the non-revealing one, which we dubbed "adversarial equilibrium" in Section 4.[23]

	MONO		*COMP*	
Benchmark	Senders	DM	Senders	DM
No Info	-5.4^{***}	22.2^{***}	-11.4^{***}	24.0^{***}
Full Info	-5.4^{***}	-18.5^{***}	-11.4^{***}	-17.3^{***}
Least Info		-3.3		-4.3^{**}

Table 5 Percentage deviations of net payoffs from theoretical benchmarks.
Note: The symbols refer to the significance level of a Wilcoxon Signed Rank test on individual averages. Significance levels: $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

As shown in the table, senders are generally worse-off than in the no information and full information benchmarks, as in both cases persuasion would not occur. This result holds for both treatment conditions. The decision-maker is better off than in the *No Info* benchmark but worse off than in the *Full Info* benchmark. This testifies to partial information transmission in the experiment. In *COMP*, the decision-maker obtains a lower payoff than in the non-revealing adversarial equilibrium. In *MONO*, the decision-maker obtains a payoff that is not significantly different from the one predicted by the least

[23]The test is performed against a lower bound estimation of the decision-maker's theoretical payoff in this non-revealing equilibrium.

informative equilibrium. Hence, there is evidence of under-communication, that is, that subjects communicate less than theory predicts in the most informative equilibrium.

5.4.2 Decision times

The time subjects spend making a decision might help us understand whether subjects react to the different strategic incentives of our treatments. In what follows, we present an exploratory analysis (not preregistered) of decision times for both senders and decision-makers. We take the individual average time to make a decision as a proxy for the degree of deliberation of choice. All times are measured in seconds. To send a report, senders take, on average, 20.3 and 20.5 seconds in *COMP* and *MONO*, respectively. The two averages are similar and not significantly different (WRT on individual averages, $p = 0.570$). Overall, misreporting requires significantly more time than telling the truth, 26.2 and 17.9 seconds, respectively (Wilcoxon Signed Rank Test (WST) on individual averages, $p < 0.001$). The same pattern also emerges when considering treatments separately. Hence, misreporting requires a longer time to deliberate, but no effect of the treatment variation on decision times is found for senders.

Decision-makers require slightly more time to choose in *COMP* (13.4) than in *MONO* (11.6). However, this difference is not statistically significant (WRT on individual averages, $p = 0.344$). Despite average times do not seem to differ between treatments, in *COMP* decision times depends on whether reports have the same sign. The time taken to choose when the two reports have different signs is about 60% more than when they are aligned (16.5 and 10.8, respectively; WST on individual averages, $p < 0.001$).

5.4.3 Spectator beliefs

In the monopolistic treatment, Sender_2 is not allowed to communicate. Instead, the spectator is asked to answer two belief elicitation questions using an incentive-compatible mechanism.[24] First, we ask the spectator how likely is Sender_1 to report truthfully given the realized drawn number. The average belief of a truthful report is equal to 67.3% for positive and 49.7% for negative drawn values. Hence, Sender_2 correctly anticipates that the likelihood of misreporting is higher for drawn values that conflict with the monopolist interest (WST on individual averages, $p < 0.001$). However, the spectator seems to fail to predict the behavior of the monopolist with whom they are matched. The average belief when the matched sender tells the truth is higher (60.9%) than when the matched player lies (55.2%). However, this difference is not statistically significant (WST, $p = 0.304$), and the central tendency of both sets of beliefs is close to the 50% value, suggesting indecisiveness.

[24] Beliefs are collected over five equally-spaced probability intervals. Here, we compute average beliefs by taking the median value of each interval as a reference.

The second question asks how likely it is that the decision-maker chooses *Black* given the number reported by Sender_1. Data show that firmer beliefs that the decision-maker will choose *Black* are more associated with a positive than a negative report, 69.0%, and 31.5%, respectively (WST on individual averages, $p < 0.001$). Hence, the spectator correctly anticipates that DM will base their choice mainly on the observed reports. Regarding correctness relative to actual behavior, higher beliefs are observed when DM chooses *Black* compared to when they choose *Red*, 69.6% and 41.1%, respectively. The marked difference between the two sets of beliefs is statistically significant (WST, $p < 0.001$) and shows that observers maintain an overall correct representation of DM's choices.

6 Conclusion

We use a controlled experiment to study the welfare effects of competition between senders in a strategic communication environment. In contrast with related work, we introduce an exogenous cost that senders incur when misreporting information. This cost is increasing in the size of the lie. Hence, our setup combines elements of standard communication games with those of all-pay contests. Typically, competition benefits decision-makers in the former, whereas it may harm contestants in the latter. This tension plays a central role in several applications, ranging from organizational design to judicial decision-making.

In our experiment, there are two senders with opposed interests and one uninformed decision-maker. Senders are perfectly and equally informed; hence, there is no scope for information aggregation. We implement two experimental conditions by varying the number of senders allowed to communicate. In the first, only one sender communicates with the decision-maker. In the second, both senders privately communicate with the decision-maker.

We find that decision-makers do not make more informed decisions when they consult two senders instead of one. This result does not originate from over-communication in the monopolistic treatment, as previously observed in related work. Information transmission is coherent with what theory predicts in the least informative equilibrium. Competition makes both senders worse off compared to the monopolistic treatment and the benchmark case where players do not communicate. Overall, competition between senders decreases the total welfare. The whole economy benefits in cases where the cost of influencing the decision-maker is higher, as less resources are wasted in misreporting.

Our results have implications for settings with common information and limited scope for information aggregation. The findings suggest that improvements in decision-making may not justify the detrimental effects of competition. In our environment, the dissipation of resources caused by competitive pressures is not compensated by concurrent informational gains. Overall, our findings partially support and validate Tullock's criticism of adversarial communication systems.

References

Abeler, J., Nosenzo, D., & Raymond, C. (2019). Preferences for truth-telling. *Econometrica*, *87*(4), 1115–1153.

Agranov, M., Dasgupta, U., & Schotter, A. (2020). *Trust me: Communication and competition in psychological games* (Tech. Rep.).

Battaglini, M. (2002). Multiple referrals and multidimensional cheap talk. *Econometrica: Journal of the Econometric Society*, *70*(4), 1379–1401.

Battaglini, M., Lai, E. K., Lim, W., & Wang, J. T.-Y. (2019). The informational theory of legislative committees: An experimental analysis. *American Political Science Review*, *113*(1), 55–76.

Baye, M. R., Kovenock, D., & De Vries, C. G. (1999). The incidence of overdissipation in rent-seeking contests. *Public Choice*, *99*(3), 439–454.

Bayindir, E. E., Gurdal, M. Y., Ozdogan, A., & Saglam, I. (2020). Cheap talk games with two-senders and different modes of communication. *Games*, *11*(2).

Block, M. K., & Parker, J. S. (2004). Decision making in the absence of successful fact finding: theory and experimental evidence on adversarial versus inquisitorial systems of adjudication. *International Review of Law and Economics*, *24*(1), 89–105.

Block, M. K., Parker, J. S., Vyborna, O., & Dusek, L. (2000). An experimental comparison of adversarial versus inquisitorial procedural regimes. *American Law and Economics Review*, *2*(1), 170–194.

Blume, A., DeJong, D. V., Kim, Y.-G., & Sprinkle, G. B. (1998). Experimental evidence on the evolution of meaning of messages in sender-receiver games. *The American Economic Review*, *88*(5), 1323–1340.

Blume, A., DeJong, D. V., Kim, Y.-G., & Sprinkle, G. B. (2001). Evolution of communication with partial common interest. *Games and Economic Behavior*, *37*(1), 79–120.

Blume, A., Lai, E. K., & Lim, W. (2020). Strategic information transmission: A survey of experiments and theoretical foundations. In *Handbook of experimental game theory* (pp. 311–347). Edward Elgar Publishing.

Boudreau, C., & McCubbins, M. D. (2008). Nothing but the truth? experiments on adversarial competition, expert testimony, and decision making. *Journal of Empirical Legal Studies*, *5*(4), 751–789.

Boudreau, C., & McCubbins, M. D. (2009). Competition in the courtroom: When does expert testimony improve jurors' decisions? *Journal of Empirical Legal Studies*, *6*(4), 793–817.

Cai, H., & Wang, J. T.-Y. (2006). Overcommunication in strategic information transmission games. *Games and Economic Behavior*, *56*(1), 7–36.

Chen, D. L., Schonger, M., & Wickens, C. (2016). oTree—an open-source platform for laboratory, online, and field experiments. *Journal of Behavioral and Experimental Finance*, *9*, 88–97.

Cho, I.-K., & Kreps, D. M. (1987). Signaling games and stable equilibria. *The Quarterly Journal of Economics*, 179–221.

Crawford, V. P., & Sobel, J. (1982). Strategic information transmission. *Econometrica: Journal of the Econometric Society*, 1431–1451.

Dickhaut, J. W., McCabe, K. A., & Mukherji, A. (1995). An experimental study of strategic information transmission. *Economic Theory*, *6*(3), 389–403.

Enke, B., & Zimmermann, F. (2019). Correlation Neglect in Belief Formation. *The Review*

of Economic Studies, *86*(1), 313–332.
Gentzkow, M., & Shapiro, J. M. (2008). Competition and truth in the market for news. *The Journal of Economic Perspectives*, *22*(2), 133–154.
Gilligan, T. W., & Krehbiel, K. (1989). Asymmetric information and legislative rules with a heterogeneous committee. *American Journal of Political Science*, 459–490.
Gneezy, U., Kajackaite, A., & Sobel, J. (2018). Lying aversion and the size of the lie. *American Economic Review*, *108*(2), 419–53.
Hurkens, S., & Kartik, N. (2009). Would i lie to you? on social preferences and lying aversion. *Experimental Economics*, *12*(2), 180–192.
Kartik, N. (2009). Strategic communication with lying costs. *The Review of Economic Studies*, *76*(4), 1359–1395.
Kartik, N., Ottaviani, M., & Squintani, F. (2007). Credulity, lies, and costly talk. *Journal of Economic Theory*, *134*(1), 93–116.
Kawagoe, T., & Takizawa, H. (2009). Equilibrium refinement vs. level-k analysis: An experimental study of cheap-talk games with private information. *Games and Economic Behavior*, *66*(1), 238–255.
Krishna, V., & Morgan, J. (2001a). Asymmetric information and legislative rules: Some amendments. *American Political Science Review*, *95*(02), 435–452.
Krishna, V., & Morgan, J. (2001b). A model of expertise. *The Quarterly Journal of Economics*, *116*(2), 747–775.
Kübler, D., Müller, W., & Normann, H.-T. (2008). Job-market signaling and screening: An experimental comparison. *Games and Economic Behavior*, *64*(1), 219–236.
Lai, E. K., Lim, W., & Wang, J. T. (2015). An experimental analysis of multidimensional cheap talk. *Games and Economic Behavior*, *91*, 114–144.
Milgrom, P. (1988). Employment contracts, influence activities, and efficient organization design. *Journal of political economy*, *96*(1), 42–60.
Milgrom, P., & Roberts, J. (1986). Relying on the information of interested parties. *The RAND Journal of Economics*, 18–32.
Minozzi, W., & Woon, J. (2013). Lying aversion, lobbying, and context in a strategic communication experiment. *Journal of Theoretical Politics*, *25*(3), 309–337.
Minozzi, W., & Woon, J. (2016). Competition, preference uncertainty, and jamming: A strategic communication experiment. *Games and Economic Behavior*, *96*, 97–114.
Minozzi, W., & Woon, J. (2019). The limited value of a second opinion: Competition and exaggeration in experimental cheap talk games. *Games and Economic Behavior*, *117*, 144–162.
Müller, W., Spiegel, Y., & Yehezkel, Y. (2009). Oligopoly limit-pricing in the lab. *Games and Economic Behavior*, *66*(1), 373–393.
Posner, R. A. (1999). An economic approach to the law of evidence. *Stanford Law Review*, 1477–1546.
Sánchez-Pagés, S., & Vorsatz, M. (2007). An experimental study of truth-telling in a sender–receiver game. *Games and Economic Behavior*, *61*(1), 86–112.
Sánchez-Pagés, S., & Vorsatz, M. (2009). Enjoy the silence: an experiment on truth-telling. *Experimental Economics*, *12*(2), 220–241.
Tullock, G. (1975). On the efficient organization of trials. *Kyklos*, *28*(4), 745–762.
Vaccari, F. (2021a). Competition in signaling. *arXiv preprint arXiv:2108.11177*.
Vaccari, F. (2021b). Influential news and policy-making. *arXiv preprint arXiv:2108.11177*.
Vespa, E., & Wilson, A. J. (2016). Communication with multiple senders: An experiment. *Quantitative Economics*, *7*(1), 1–36.

Wang, J. T.-y., Spezio, M., & Camerer, C. F. (2010). Pinocchio's pupil: Using eyetracking and pupil dilation to understand truth telling and deception in sender-receiver games. *American Economic Review*, *100*(3), 984–1007.

Zywicki, T. J. (2008). Spontaneous order and the common law: Gordon tullock's critique. *Public Choice*, *135*(1-2), 35–53.

Online Appendix for "Welfare in Experimental News Markets"

Andrea Albertazzi, Matteo Ploner, Federico Vaccari

Table of Contents

A Experimental Instructions

In this section we report the on-screen experimental instructions shown to participants. We use different colours (*COMP*, *MONO*) to highlight differences among treatments.

General Information

Welcome and thank you for participating in this experiment. These instructions are identical for all participants. From now on, communication with other participants is not allowed. If you do not conform to these rules, we will have to exclude you from the experiment.

The Experiment This experiment studies decision making between three individuals. You will participate in 30 rounds of decision making. Please read all the instructions carefully; the payment that you will receive at the end of the experiment will depend on your decisions and those of other participants. At the end of the experiment, you will be asked to fill in a short questionnaire.

Your earnings For your participation you will receive a 4 EURO participation fee. Additional earnings that you can realize during the experiment will be expressed in terms of points with the following conversion rate: 100 points = 1 EURO.
At the end of the experiment the computer will randomly select two rounds of play. Your additional earnings from the experiment will be determined by the average of the points you earned in the two selected rounds. Because during the experiment you might incur losses, your payment can be negative. If this is the case, then we will deduct your negative profits from the participation fee. If the fee is not enough to cover your losses, then at end of the experiment you will be asked to complete an additional task whose duration is proportional to your losses.

Participation Your participation in this study is completely voluntary. Choosing not to take part will not disadvantage you in any way. You can withdraw from the experiment at any time without consequences.

Confidentiality All your answers will be treated confidentially and only used for research purposes only. Experimental data will be anonymized to ensure that no personal information can be linked to your answers. The data will be deposited in a completely confidential manner so that it can be used for future research and learning.

Should you have any questions, please contact the experimenter that will answer to your questions.

Please DO NOT click the NEXT button to read the rest of the instructions until you are told otherwise.

Role assignment

In each round you will be randomly and anonymously matched in groups of three participants.
The three group members will be referred to as Player A, B, and C. Each of you will be assigned to one of these three roles only. Thus, your role will remain fixed throughout the experiment.
Participants will be randomly rematched after each round to form new groups, for a total of 30 rounds. Each round is a separate decision task.

Decision

In each round, an integer number will be randomly selected from the interval $[-100, 100]$. We will refer to this number as the $Drawn\ Value$. The following figure (Figure 1) illustrates an example of how often each number is selected. You can see that the frequency with which a number is selected increases as one approaches the top of the bell curve. Thus, it is much more likely that the $Drawn\ Value$ is closer to zero than further away from it.

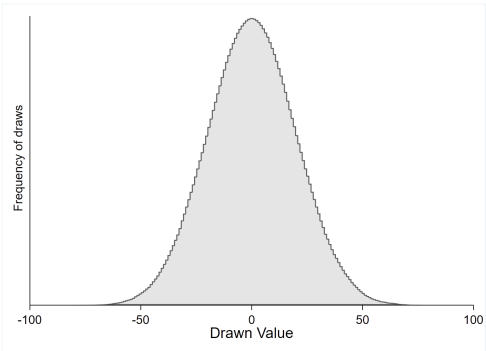


Figure 1: Frequency of draws for the random number $Drawn\ Value$.

The $Drawn\ Value$ determines the state of the world. If this number is smaller than zero, we will say the state is **RED** and, if it is greater than zero, **BLACK**. If $Drawn\ Value = 0$, then the state is either **RED** or **BLACK** with equal probability. Hence, state **RED** and state **BLACK** are equally likely to occur.

COMP: The $Drawn\ Value$ will be observed only by Players A and B, which in turn will have to privately report a number to Player C. Player C, after observing the reports delivered by the other two players (but without observing the $Drawn\ Value$), has to guess the state by selecting either action *Red* or *Black*.

MONO: The *Drawn Value* will be observed only by Players A and B. Player A will have to privately report a number to Player C while Player B will be a spectator. Hence, Player B does not send any report. However, Player B will be asked her/his beliefs about the actions of the other players. Details about the expression of beliefs will be provided on screen to Player B. These beliefs will not be known to either Player A or C, and will have no consequences on their earnings. Player C, after observing the report delivered by Player A (but without observing the *Drawn Value*), will have to guess the state by selecting either action *Red* or *Black*.

Players A and B's decisions (Players A's Decision)

You will be presented with three lines on your screen (Figure 2). All lines range from -100

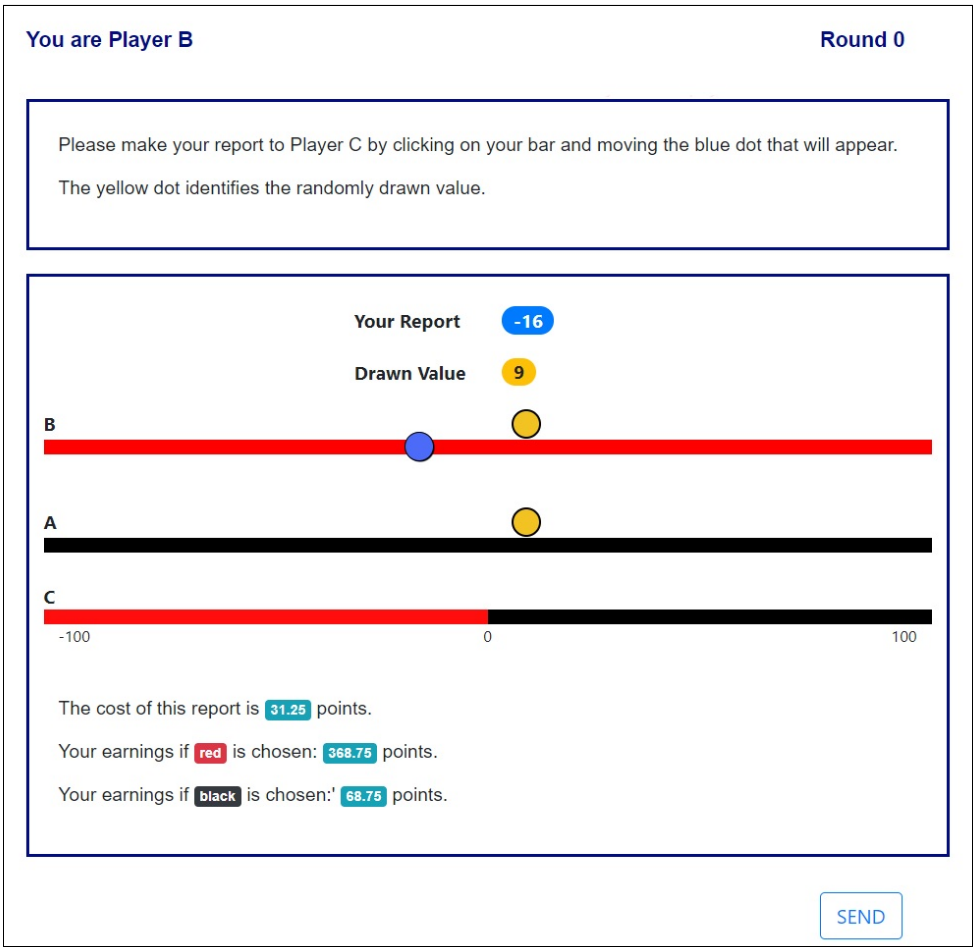


Figure 2: Example of decision screen for Player B. (In *MONO* we used a decision screen from Player A.)

to 100. The first line will be the line corresponding to your role. The lines corresponding to Players A and B (The line corresponding to Player A) will include a yellow circle representing the *Drawn Value*.

You will be asked to privately report to player C a number of your choice by clicking on the line corresponding to your role. You can click on the line as many times as you want until you reach the number you wish to report. Remember, you are free to choose any number between $[-100, 100]$. Once your choice is made, click the button "Send" on your screen.

Player C's decision

You will be presented with the same three lines on your screen. After seeing Player A's and Player B's reports represented by a circle on their respective lines, you will be asked to make your decision by choosing either *Red* or *Black*.

Your payoff

Each group member can obtain either a higher or a lower payoff that is determined by the choice made by Player C. You can see this in the previous figure. The colour of the segments illustrate for what $Drawn\ Values$ each player obtains a higher payoff if the action of the same colour is chosen. To sum up:

- Player A always receives a higher payoff if *Black* is chosen.
- Player B always receives a higher payoff if *Red* is chosen.
- Player C receives a higher payoff if he/she chooses:
  - *Red* when the state is **RED** ($Drawn\ Value <= 0$),
  - *Black* when the state is **BLACK** ($Drawn\ Value >= 0$).

COMP :

Players A and B's payoffs

Player A receives 1200 points if Player C chooses action *Black*, 400 otherwise.

Player B receives 1200 points if Player C chooses action *Red*, 400 otherwise.

Moreover, there is a cost for sending your report: $cost = \frac{25}{3} \cdot |Drawn\ Value - report|$. This cost increases with the distance between the $Drawn\ Value$, and the number you report. For your convenience, this cost will be automatically calculated and your expected earnings will be displayed on your screen while you are making your choice.

In summary,

$$\text{Payoff (Player A)} = \begin{cases} 1200 - cost & \text{if Player } C \text{ chooses } Black \\ 400 - cost & \text{otherwise.} \end{cases}$$

$$\text{Payoff (Player B)} = \begin{cases} 1200 - cost & \text{if Player } C \text{ chooses } Red \\ 400 - cost & \text{otherwise.} \end{cases}$$

MONO:

Players A's payoff

Player A receives 1200 points if Player C chooses action *Black*, 400 otherwise.

Moreover, there is a cost for sending your report: $cost = \frac{25}{3} \cdot |Drawn\ Value - report|$. This cost increases with the distance between the *Drawn Value*, and the number you report. For your convenience, this cost will be automatically calculated and your expected earnings will be displayed on your screen while you are making your choice.

In summary,

$$\text{Payoff (Player A)} = \begin{cases} 1200 - cost & \text{if Player } C \text{ chooses } Black \\ 400 - cost & \text{otherwise.} \end{cases}$$

MONO:

Players B's payoff

Player B receives 1200 points if Player C chooses action *Red*, 400 otherwise.

Because Player B does not send any report, his/her payoff only depends from the action chosen by Player C.

$$\text{Payoff (Player B)} = \begin{cases} 1200 & \text{if Player } C \text{ chooses } Red \\ 400 & \text{otherwise.} \end{cases}$$

All treatments:

Player C's payoff

The amount of points you earn in a round depends on whether the colour of your choice matches with that of the state.

$$\text{Payoff per round} = \begin{cases} 600 & \text{if choice is } Red \text{ and state is } \textbf{RED} \ (Drawn\ Value < 0) \\ 600 & \text{if choice is } Black \text{ and state is } \textbf{BLACK} \ (Drawn\ Value > 0) \\ 200 & \text{otherwise} \end{cases}$$

Remember, when the *Drawn Value* equals zero, the state is equally likely to be **RED** or **BLACK**.

Summary information

COMP:

At the end of each round, you will be provided with a summary of the round: what the

$Drawn\ Value$ was, Player A's and Player B's reports, Player C's choice, and the points earned by each member of the group.

MONO:
At the end of each round, you will be provided with a summary of the round: what the $Drawn\ Value$ was, Player A's report, Player C's choice, and the points earned by each member of the group.

Payment

At the end of the experiment the computer will randomly select two rounds out of 30 to calculate your cash payment. Thus, it is in your best interest to take each round seriously. You will receive the average of the points that you earned in the two selected rounds. Your total payment will then be this average, converted in EURO, plus a 4 EURO participation fee. Note that during the experiment you might incur losses. Thus, your payment from the two selected rounds might be negative. If that happens, then your negative payment will be deducted from your participation fee. If this amount of money is not enough to cover your losses, then you will be asked to complete an additional task whose duration is proportional to your losses.

Instructions for Spectator (*MONO*)

Question 1: The panel above provides you with a description of Value Drawn and of the incentives of Player A and Player C: Player C earns more when he/she chooses Red and the Drawn Value is negative or when he/she chooses Black and the Drawn Value is positive; Player A earns more if Black is chosen.
In the panel below, you are asked to state your beliefs about the probability that Player A is going to report the value truthfully.
The table also reports the points you earn for each probability and the actual choice of A. As an example, if you estimate that the probability that the report is truthful is between 0% and 20%, you earn 50 points if the actual report is truthful and 250 otherwise. If you estimate that the probability that the report is truthful is between 81% and 100%, you earn 250 points if the actual report is truthful and 50 otherwise.
At the end of the experiment, one of the 30 beliefs about A will be randomly selected and paid to you.

Probability that Player A reports truthfully?

Question 2: The panel above provides you with a description of Value Drawn and of the incentives of Player A and Player C: Player C earns more when he/she chooses Red

	0%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Points if the report is truthful	50	100	150	200	250
Point if the report is not truthful	250	200	150	100	50

and the Drawn Value is negative or when he/she chooses Black and the Drawn Value is positive; Player A earns more if Black is chosen.
In the panel below, you are asked to state your beliefs about the probability that Player C is going to choose *Black*.
The table also reports the points you earn for each probability and the actual choice of C. As an example, if you estimate that the probability that Player C chooses *Black* is between 0% and 20%, you earn 50 points if the actual choice is *Black* and 250 otherwise. If you estimate that the probability that that Player C chooses *Black* is between 81% and 100%, you earn 250 points if the actual choice is *Black* and 50 otherwise.
At the end of the experiment, one of the 30 beliefs about C will be randomly selected and paid to you.

Probability that Player C chooses Black?

	0%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Points if *Red* is chosen	50	100	150	200	250
Points if *Black* is chosen	250	200	150	100	50

Final Questionnaire

1. What is your gender?
2. What is your age?
3. What is your nationality?
4. What is your field of study?
5. Do you consider yourself a person who is completely ready to take risks or try to avoid taking risks? Mark one of the numbers below, where the value 0 means "absolutely not willing to take risks" and value 10 means "completely willing to take risks."
6. In general, do you think most people can be trusted?
   - No, you always have to be careful
   - No, you have to be careful in most cases
   - Yes, you can trust in most cases
   - Yes, you can always trust them
7. In general, do you think most people try to take advantage of others if they have the opportunity?
   - No, they always behave correctly
   - No, they behave correctly in most cases
   - Yes, they try to take advantage of it in most cases
   - Yes, they always try to take advantage of it
8. Do you have any comment about the experiment?

Bankruptcy Task

Please insert here your loss:
As an example, if your loss is 3 Euro and 20 cents write "3.20".
To clear your loss, you must count the number of zeroes in a series of tables similar to the following.
Given your loss, you must count "X" tables (one table every 0.5 Euro).

In this specific example, the number of zeroes is equal to 37.

0	0	0	0	1	1	1	1	1	0
1	0	1	0	0	0	1	0	1	0
1	0	1	0	0	1	0	1	0	0
0	0	1	1	0	0	0	0	1	1
0	0	0	1	1	1	0	0	0	0
0	1	0	0	1	1	1	1	1	0
0	1	0	0	1	1	1	1	1	1

B Tables

VARIABLES	(1) Age	(2) Gender	(3) Risk	(4) Trust	(5) Honesty
COMP	1.783***	-0.00526	-0.327	0.0834	0.0123
	(0.421)	(0.0742)	(0.282)	(0.0865)	(0.0851)
Constant	21.42***	1.500***	5.938***	3.927***	3.167***
	(0.297)	(0.0524)	(0.199)	(0.0610)	(0.0600)
Observations	191	191	191	191	191
R-squared	0.087	0.000	0.007	0.005	0.000

Table B.1 Balancing checks.
Note: One subject in *COMP* did not complete the final questionnaire.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

	MONO	*COMP*
Subjects	96	96
Sessions	4	3

Table B.2 Number of participants by treatment.

	MONO	*COMP*
Mean (SD)		
Age	21.42	23.2
	(3.10)	(2.70)
Risk	5.93	5.61
	(1.81)	(2.08)
%		
Gender:		
Female	47.92	49.47
Male	51.04	50.53
Non-Binary	1.04	0
Trust:		
No, you always have to be careful	13.54	17.89
No, you have to be careful in most cases	66.67	65.26
Yes, you can trust in most cases	18.75	16.84
Yes, you can always trust them	1.04	0.00
Honesty:		
No, they always behave correctly	0.00	0.00
No, they behave correctly in most cases	27.08	27.37
Yes, they try to take advantage of it in most cases	62.50	63.16
Yes, they always try to take advantage of it	10.42	9.47
Observations	96	95

Table B.3 Questionnaire variables.
Note: One subject in *COMP* did not complete the final questionnaire. Standard deviations in parenthesis.

C Equilibrium Analysis (not for publication)

C.1 The Monopolistic Communication Game

The proofs and the game studied in this Appendix are, with some minor modificatons, adapted from Vaccari (2021b).

There are two players: a sender (S) and a receiver (R). The sender privately observes the realization of a state $\theta \in \Theta \subseteq \mathbb{R}$, and then delivers a news report $r \in \Theta$. The receiver has to choose an action $a \in \{P, N\}$. Before taking an action, the receiver observes the sender's report r but not the state θ.

Denote player j's "threshold" with $\tau_j \in \mathbb{R}$. The utility $u_j(a, \theta)$ of player $j \in \{S, R\}$ is non-decreasing in θ and such that $u_j(P, \theta) > u_j(N, \theta)$ for all $\theta > \tau_j$ and $u_j(P, \theta) < u_j(N, \theta)$ for all $\theta < \tau_j$. We assume that $\tau_S < \tau_R$ and that the utilities $u_j(\cdot)$ are continuous for all θ greater and lower than τ_j, $j \in \{P, N\}$. This specification allows u_j to have a discontinuity at τ_j and be, e.g., a step utility function. In addition, the sender incurs misreporting costs $kC(r, \theta)$, where k is a strictly positive and finite scalar. Denote the sender's total utility as $v_S(r, a, \theta) = u_S(a, \theta) - kC(r, \theta)$. The misreporting cost function $C(r, \theta)$ is continuous on Θ^2 with $C(r, \theta) \geq 0$ for all $r \in \Theta$ and $\theta \in \Theta$, $C(x, x) = 0$ for all $x \in \Theta$. The cost function $C(\cdot)$ satisfies $C(r, \theta) > C(r', \theta)$ if $|r - \theta| > |r' - \theta|$ for all $\theta \in \Theta$, and $C(r, \theta) > C(r, \theta')$ if $|r - \theta| > |r - \theta'|$ for all $r \in \Theta$.

We assume that the set Θ is convex and that the state θ is randomly drawn from a common knowledge distribution f, which has full support in Θ, a continuous pdf, and is symmetric around τ_R. Given the sender's utility and misreporting costs, we define the functions $l(r)$ and $\bar{r}_S(\theta)$ as follows: for a $r > \tau_S$,

$$l(r) = \max \left\{ \tau_S, \min \left\{ \theta \in \Theta | kC(r, \theta) = u_S(P, \theta) - u_S(N, \theta) \right\} \right\},$$

while for a $\theta > \tau_S$,

$$\bar{r}_S(\theta) = \max\{r \in \Theta | kC(r, \theta) = u_S(P, \theta) - u_S(N, \theta)\}.$$

We further assume that the state space is large enough, that is, $\Theta \supseteq [l(\tau_R), \bar{r}_S(\tau_R)]$.

A reporting strategy for the sender is a function $\rho : \Theta \to \Theta$ that associates a report $r \in \Theta$ to every state $\theta \in \Theta$. We say that a report r is off-path if, given strategy $\rho(\cdot)$, r will not be observed by the voter. Otherwise, we say that r is on-path. A belief function for the receiver is a mapping $p : \Theta \to \Delta(\Theta)$ that, given any news report $r \in \Theta$, generates posterior beliefs $p(\theta|r)$, where $p(\cdot)$ is a probability density function. Given a report r and posterior beliefs $p(\theta|r)$, the receiver takes an action in the sequentially rational set $\beta(r) = \arg\max_{a \in \{P,N\}} \mathbb{E}_p[u_S(a, \theta) \,|\, r]$.

We use the term "generic equilibrium" to denote a perfect Bayesian equilibrium of this communication game $\hat{\Gamma}$ that is robust to the Intuitive Criterion (Cho & Kreps, 1987). A "sender-preferred equilibrium" of the communication game $\hat{\Gamma}$ is the generic equilibrium preferred by the sender.

Proposition C.1 builds on Lemmata C.1 to C.5 and shows all the generic equilibria of $\hat{\Gamma}$. A sufficient condition on the state space for the existence of all generic equilibria in Proposition C.1 is $\Theta \supseteq [\tau_s, \bar{r}_s(\tau_R)]$. We assume that such a condition is always satisfied.

The set of all the receiver's pure strategy best responses to a report r and posterior beliefs $p(\cdot|r)$ such that $\int_{\theta \in T} p(\theta|r)d\theta = 1$ is defined as[1]

$$B(T, r) = \bigcup_{p: \int_T p(\theta|r)d\theta=1} \arg\max_{a \in \{P,N\}} \int_{\theta \in \Theta} p(\theta|r) u_R(a, \theta) d\theta.$$

Fix an equilibrium outcome and let $v_S^*(\theta)$ denote the sender's expected equilibrium payoff in state θ. The set of states for which delivering report r is not equilibrium-dominated for the sender is

$$J(r) = \left\{ \theta \in \Theta \middle| v_S^*(\theta) \leq \max_{a \in B(\Theta, r)} v_S(r, a, \theta) \right\}.$$

An equilibrium does not survive the Intuitive Criterion refinement if there exists a state $\theta' \in \Theta$ such that, for some report r', $v_s^*(\theta') < \min_{a \in B(J(r'), r')} v_S(r', a, \theta')$.

In Lemma C.5, we use the following notation to denote the limits of the reporting rule $\rho(\cdot)$ as θ approaches state t from, respectively, above and below: $\rho^+(t) = \lim_{\theta \to t^+} \rho(\theta)$ and $\rho^-(t) = \lim_{\theta \to t^-} \rho(\theta)$.

Lemma C.1. *In a generic equilibrium of $\hat{\Gamma}$, $\rho(\theta)$ is non-decreasing in $\theta < \tau_S$ and $\theta > \tau_S$.*

Proof. Consider a generic equilibrium and suppose that there are two states $\theta'' > \theta' > \tau_S$ such that $\rho(\theta') > \rho(\theta'')$. We can rule out that $\beta(\rho(\theta')) = \beta(\rho(\theta'')) = N$, as in such case the equilibrium would prescribe $\rho(\theta') = \theta' < \theta'' = \rho(\theta'')$. If $\beta(\rho(\theta')) = \beta(\rho(\theta'')) = P$, then in at least one of the two states θ', θ'' the sender could profitably deviate by delivering the report prescribed in the other state. Consider the case where $\beta(\rho(\theta')) = P$ (N) and $\beta(\rho(\theta'')) = N$ (P). In equilibrium, it has to be that $\rho(\theta'') = \theta''$ $(\rho(\theta') = \theta')$. Given $\rho(\theta') > \rho(\theta'') = \theta'' > \theta'$ $(\theta'' > \theta' = \rho(\theta') > \rho(\theta''))$ and $C(\rho(\theta'), \theta'') < C(\rho(\theta'), \theta')$ $(C(\rho(\theta''), \theta'') > C(\rho(\theta''), \theta'))$, the sender could profitably deviate in state θ'' (θ') by reporting $\rho(\theta')$ $(\rho(\theta''))$. A similar argument applies for any two states $\theta' < \theta'' < \tau_S$, completing the proof. □

Lemma C.2. *In a generic equilibrium of $\hat{\Gamma}$, if $\rho(\theta)$ is strictly monotonic and continuous in an open interval, then $\rho(\theta) = \theta$ for all θ in such an interval.*

Proof. Consider a generic equilibrium and suppose that the reporting rule $\rho(\cdot)$ is strictly increasing (decreasing) and continuous in an open interval (a, b), but $\rho(\theta) > \theta$ for some $\theta \in (a, b)$. There always exist an $\epsilon > 0$ such that the sender prefers the same alternative

[1] For $T = \varnothing$, we set $B(\varnothing, r) = B(\Theta, r)$.

in both states θ and $\theta - \epsilon$, and $\theta < \rho(\theta - \epsilon) < \rho(\theta)$ (resp. $\rho(\theta - \epsilon) > \rho(\theta) > \theta$). The sender never pays misreporting costs to implement its least preferred alternative; therefore, it must be that $\beta(\rho(\theta)) = \beta(\rho(\theta - \epsilon))$. Since $C(\rho(\theta - \epsilon), \theta) < C(\rho(\theta), \theta)$ (resp. $C(\rho(\theta), \theta - \epsilon) < C(\rho(\theta - \epsilon), \theta - \epsilon)$), the sender has a profitable deviation in state θ (resp. $\theta - \epsilon$), contradicting that $\rho(\cdot)$ is in equilibrium. □

Lemma C.3. *In a generic equilibrium of $\hat{\Gamma}$, $\rho(\theta) = \theta$ for almost every $\theta \leq \tau_S$.*

Proof. Consider a generic equilibrium and suppose that $\rho(\theta) \neq \theta$ for all $\theta \in \hat{\Theta}$, where $\hat{\Theta}$ is an open set such that $\sup \hat{\Theta} \leq \tau_S$ and $\hat{\Theta} \subset \Theta$. Beliefs must be such that $\beta(r) = P$ for all $r \in \hat{\Theta}$. Suppose that a report $r' \in \hat{\Theta}$ is off-path. It must be that $v_S^*(\theta) \geq v_S(r', P, \theta)$ for all $\theta \geq \tau_S$. Since $\sup J(r') \leq \tau_S < \tau_R$ and $B(J(r'), r') = N$, the sender can profitably deviate by reporting truthfully when $\theta = r' \in \hat{\Theta}$. Hence, all reports $r \in \hat{\Theta}$ must be on-path. To have $\beta(r') = P$ for a $r' \in \hat{\Theta}$, it must be that $\rho(\theta') = r'$ for some $\theta' \geq \tau_R$. In all states $\theta > \tau_S$ such that $\rho(\theta) \in \hat{\Theta}$, the sender must deliver the same least expensive report $r' \in \hat{\Theta}$ such that $\beta(r') = P$. Thus, $\hat{\Theta}$ has measure zero and $\rho(\theta) = \theta$ for almost every $\theta \leq \tau_S$. □

Lemma C.4. *In a generic equilibrium of $\hat{\Gamma}$, $\rho(\cdot)$ is discontinuous at some $\theta \in \Theta$.*

Proof. Suppose by way of contradiction that there is a generic equilibrium where $\rho(\theta)$ is continuous in Θ. From Lemma C.3, we know that $\rho(\theta) = \theta$ for $\theta \leq \tau_S$. If $\rho(\theta) = \theta$ also for all $\theta > \tau_S$, then the equilibrium would be fully revealing. In such case, the sender could profitably deviate by reporting τ_R when the state is $\theta \in (\tau_R - \epsilon, \tau_R)$ for some $\epsilon > 0$. Therefore, it must be that $\rho(\theta') \neq \theta'$ for some state $\theta' > \tau_S$. By Lemma C.2, it has to be that $\rho(\theta') < \theta'$, or otherwise $\rho(\cdot)$ would be discontinuous; therefore Lemmata C.1 and C.2 imply that $\rho(\theta) = \rho(\theta')$ for all $\theta \in (\max\{\rho(\theta'), \tau_S\}, \sup \Theta)$. There always exists a report $r' \geq \theta'$ such that $\inf J(r') \geq \max\{\rho(\theta'), \tau_S\}$. Since $\beta(\rho(\theta')) = P$, it must be that $B(J(r'), r') = P$. Therefore, there are states where the sender would have a profitable deviation, contradicting that a continuous $\rho(\cdot)$ can be part of a generic equilibrium. □

Lemma C.5. *In a generic equilibrium of $\hat{\Gamma}$, $\rho(\cdot)$ has a unique discontinuity in state θ_δ, where $\theta_\delta \in [\tau_S, \tau_R]$. The reporting rule[2] is such that $\rho(\theta) = \rho^+(\theta_\delta) > \theta_\delta = l(\rho^+(\theta_\delta))$ for $\theta \in (\theta_\delta, \rho^+(\theta_\delta))$ and $\rho(\theta) = \theta$ for all $\theta \in (\inf \Theta, \theta_\delta) \cup [\rho^+(\theta_\delta), \sup \Theta)$.*

Proof. I denote by θ_δ the lowest state in which a discontinuity of $\rho(\cdot)$ occurs. By Lemmata C.3 and C.4, we know that in equilibrium such a discontinuity exists and $\theta_\delta \geq \tau_S$.

Suppose that $\rho^-(\theta_\delta) \neq \theta_\delta$. If $\rho^-(\theta_\delta) < \theta_\delta$, then by Lemmata C.1 and C.2 we have that $\rho(\theta) = \rho^-(\theta_\delta)$ for all $\theta \in (\max\{\rho^-(\theta_\delta), \tau_S\}, \theta_\delta)$ and $\rho(\theta) = \theta$ for $\theta \leq \max\{\rho^-(\theta_\delta), \tau_S\}$. In equilibrium, it has to be that $\beta(\rho^-(\theta_\delta)) = P$ and $\beta(r') = N$ for every off-path $r' \in (\max\{\rho^-(\theta_\delta), \tau_S\}, \theta_\delta)$. Hence, every report $r' \in (\max\{\rho^-(\theta_\delta), \tau_S\}, \theta_\delta)$ is equilibrium dominated for all $\theta < \theta'$, where $\theta' = \{\theta \in \Theta \,|\, C(\rho^-(\theta_\delta), \theta) = C(r', \theta)\}$. Therefore,

[2] Recall that $\rho^+(t) = \lim_{\theta \to t^+} \rho(\theta)$ and $\rho^-(t) = \lim_{\theta \to t^-} \rho(\theta)$.

$B(J(r'),r') = P$, and the sender could profitably deviate by reporting r' instead of $\rho^-(\theta_\delta)$ when $\theta \in (\theta', \theta_\delta)$. Suppose now that $\rho^-(\theta_\delta) > \theta_\delta$. By Lemma C.1 we have $\rho^-(\tau_S) = \tau_S$, and thus it has to be that $\theta_\delta > \tau_S$. Similarly to the previous case, in equilibrium it must be that $\rho(\theta) = \rho^-(\theta_\delta)$ for all $\theta \in (\tau_S, \theta_\delta)$. This is in contradiction to θ_δ being the lowest discontinuity, as we would have $\rho^+(\tau_S) > \tau_S$. Therefore, in every generic equilibrium, $\rho^-(\theta_\delta) = \theta_\delta \geq \tau_S$ and $\rho(\theta) = \theta$ for $\theta < \theta_\delta$.

From Lemmata C.1 and C.2, it follows that $\rho^+(\theta_\delta) > \theta_\delta$ and $\rho(\theta) = \rho^+(\theta_\delta)$ for every $\theta \in (\theta_\delta, \rho^+(\theta_\delta)]$: since it must be that $\beta(\rho^+(\theta_\delta)) = P$, the sender would profitably deviate by reporting $\rho^+(\theta_\delta)$ in every state $\theta \in (\theta_\delta, \rho^+(\theta_\delta)]$ such that $\rho(\theta) > \rho^+(\theta_\delta)$. To prevent other profitable deviations, $\rho^+(\theta_\delta)$ must be such that $u_S(P,\theta) - u_S(N,\theta) \leq kC(\rho^+(\theta_\delta),\theta)$ for $\theta \in (\tau_S, \theta_\delta)$ and $u_S(P,\theta) - u_S(N,\theta) \geq kC(\rho^+(\theta_\delta),\theta)$ for all $\theta \in [\theta_\delta, \rho^+(\theta_\delta)]$. Together, these conditions imply that $\theta_\delta = l(\rho^+(\theta_\delta))$. Any off-path report $r' > \rho^+(\theta_\delta)$ would be equilibrium-dominated by all $\theta \leq \rho^+(\theta_\delta)$, yielding $B(J(r'),r') = P$. Therefore, it must be that $\rho(\theta) = \theta$ for all $\theta \geq \rho^+(\theta_\delta)$, and $\rho(\theta) = \rho^+(\theta_\delta)$ for $\theta \in (\theta_\delta, \rho^+(\theta_\delta))$.

Suppose now that $\theta_\delta > \tau_R$. Given the reporting rule, posterior beliefs p must be degenerate on $\theta = r$ for all $r \in [\tau_R, \theta_\delta)$. In this case, there always exists an $\epsilon > 0$ such that the sender can profitably deviate by reporting τ_R instead of θ in states $\theta \in (\tau_R - \epsilon, \tau_R)$. Therefore, $\theta_\delta \in [\tau_S, \tau_R]$. □

Proposition C.1. *A pair $(\rho(\theta), p(\theta \,|\, r))$ is a generic equilibrium of $\hat{\Gamma}$ if and only if, for a given $\lambda \in [\tau_R, \mathbb{E}_f[\theta|\theta \in (\tau_R, \bar{r}_S(\tau_R))]]$,*

i) The reporting rule $\rho(\theta)$ is, for a $\lambda \in [\tau_R, \mathbb{E}_f[\theta|\theta \in (\tau_R, \bar{r}_S(\tau_R))]]$,

$$\rho(\theta) = \begin{cases} \hat{r}(\lambda) = \min\left\{\{r \in \Theta | \mathbb{E}_f[\theta|\theta \in (l(r), r)] = \lambda\}, 2\lambda - \tau_S\right\} & \text{if } \theta \in \left(l\left(\hat{r}(\lambda)\right), \hat{r}(\lambda)\right) \\ \theta & \text{otherwise.} \end{cases}$$

When $\lambda = \mathbb{E}_f[\theta|\theta \in (\tau_R, \bar{r}_S(\tau_R))]$, $\rho(\theta) = \hat{r}(\lambda)$ for $\theta \in [l(\hat{r}(\lambda)), \hat{r}(\lambda))$, and $\rho(\theta) = \theta$ otherwise.[3]

ii) Posterior beliefs $p(\theta \,|\, r)$ are according to Bayes' rule whenever possible and such that $\mathbb{E}_p[\theta \,|\hat{r}(\lambda)] = \lambda$, $\mathbb{E}_p[\theta \,|r] < \tau_R$ for every off-path r, and $p(\theta \,|\, r)$ are degenerate on $\theta = r$ otherwise.

Proof. Given the reporting rule $\rho(\cdot)$ described in Lemma C.5, beliefs p must be such that $\beta(\rho^+(\theta_\delta)) = P$, and thus $\mathbb{E}_p[\theta \,|\, \rho^+(\theta_\delta)] = \mathbb{E}_f[\theta|\theta \in (\theta_\delta, \rho^+(\theta_\delta))] \geq \tau_R$, where $\theta_\delta = l(\rho^+(\theta_\delta)) \leq \tau_R$ and, similarly, $\rho^+(\theta_\delta) = \bar{r}_S(\theta_\delta) > \tau_R$. It follows that the expectation $\mathbb{E}_p[\theta \,|\, \rho^+(\theta_\delta)]$ induced by the report $\rho^+(\theta_\delta)$ has to be between τ_R and $\mathbb{E}_f[\theta|\theta \in (\tau_R, \bar{r}_S(\tau_R))]$. I define the pooling report $\hat{r}(\lambda)$ as

$$\hat{r}(\lambda) := \{r \in \mathbb{R} \mid \mathbb{E}_f[\theta \,|\, l(r) < \theta < r] = \lambda\}.$$

[3]Up to changes of measure zero in $\rho(\theta)$ due to the sender being indifferent between reporting $l(\hat{r}(\lambda))$ and $\hat{r}(\lambda)$ when the state is $\theta = l(\hat{r}(\lambda)) > \tau_S$.

For a $\lambda \in [\tau_R, \mathbb{E}_f[\theta|\theta \in (\tau_R, \bar{r}_S(\tau_R))]]$, we can rewrite the reporting rule described in Lemma C.5 as

$$\rho(\theta) = \begin{cases} \hat{r}(\lambda) & \text{if } \theta \in (l(\hat{r}(\lambda)), \hat{r}(\lambda)) \\ \theta & \text{otherwise.} \end{cases} \tag{2}$$

Alternatively, (2) can have $\rho(l(\hat{r}(\lambda)) = \hat{r}(\lambda)$ as long as $l(\hat{r}(\lambda)) > \tau_S$. If $\lambda = \mathbb{E}_f[\theta|\theta \in (\tau_R, \bar{r}_S(\tau_R))]$, then it must be that (2) has $\rho(l(\hat{r}(\lambda))) = \hat{r}(\lambda)$; otherwise the sender would profitably deviate by reporting τ_R when the state is $\theta \in (\tau_R - \epsilon, \tau_R + \epsilon)$ for some $\epsilon > 0$. Since θ is symmetrically distributed around τ_R, we have $\hat{r}(\lambda) = \{r \in \Theta | \mathbb{E}_f[\theta|\theta \in (l(r), r)] = \lambda\}$ if $l(\hat{r}(\lambda)) > \tau_S$ and $\hat{r}(\lambda) = 2\lambda - \tau_S$ otherwise.

By applying Bayes' rule to (2), we obtain that posterior beliefs $p(\theta|r)$ are such that $\mathbb{E}_p[\theta \,|\, \hat{r}(\lambda)] = \lambda \in [\tau_R, \mathbb{E}_f[\theta|\theta \in (\tau_R, \bar{r}_S(\tau_R))]]$, and are degenerate on $\theta = r$ for all $r \notin [l(\hat{r}(\lambda)), \hat{r}(\lambda))$. For every off-path report $r' \in (l(\hat{r}(\lambda)), \hat{r}(\lambda))$ it must be that $\mathbb{E}_p[\theta \,|\, r'] < \tau_R$ to have $\beta(r') = N$. These off-path beliefs are consistent with the Intuitive Criterion since for every $r' \in (l(\hat{r}(\lambda)), \hat{r}(\lambda))$ we have that $\inf J(r') < l(\hat{r}(\lambda)) \leq \tau_R$, and thus $N \in B(J(r'), r')$. The proof is completed by the observation that the pair $(\rho(\theta), p(\theta|r))$ described in Proposition C.1 is indeed a generic equilibrium of $\hat{\Gamma}$ for every $\lambda \in [\tau_R, \mathbb{E}_f[\theta|\theta \in (\tau_R, \bar{r}_S(\tau_R))]]$. $\square$

C.2 The Competitive Communication Game

The equilibria of the competitive game with two active senders are studied in Vaccari (2021a). First, consider the fully revealing equilibrium with two active senders as discussed in Section 4. On-path beliefs are pinned down by the senders' reporting strategies, which are revealing because of Sender$_2$'s truthful strategy. The decision-maker's beliefs after observing an off-path pair of reports are such that DM selects action *Black* only if $r_1 \geq \bar{r}_1(0)$, and selects *Red* otherwise. Since there are no individual profitable deviations from the prescribed strategies, this is an equilibrium.

Second, consider the *adversarial* equilibrium strategies. Denote by $U_{dm}(r_1, r_2)$ the decision-maker's expected differential utility from selecting *Black* rather than *Red* in an adversarial equilibrium given the pair of reports (r_1, r_2). The decision-maker's posterior beliefs satisfy three properties: (i) for every $r_j \geq r'_j$ and $j \in \{1, 2\}$, we have $U_{dm}(r_1, r_2) \geq U_{dm}(r'_1, r'_2)$; (ii) for every pair of reports (r_1, r_2) such that $r_2 \leq 0 \leq r_1$, and for $j \in \{1, 2\}$, we have $dU_{dm}(r_1, r_2)/dr_j > 0$; (iii) $U_{dm}(\bar{r}_1(0), \bar{r}_2(0)) = U_{dm}(0, 0) = 0$. Vaccari (2021a) shows that, given these properties and the players' symmetric features, posterior beliefs are such that the decision maker follows the recommendation of the sender delivering the highest report in absolute value. That is, given $r_1 \geq 0 \geq r_2$, the decision maker selects *Black* if $r_1 \geq |r_2|$, and selects *Red* otherwise. The posterior beliefs are coherent with the senders' reporting strategies. Given these beliefs, no sender has an individual profitable deviation. Therefore, this is an equilibrium.

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