Contributions

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Cheap Talk and Editorial Control

Abstract: This paper analyzes simple models of editorial control. Starting from the framework developed by Krishna and Morgan (2001a), we analyze two-sender models of cheap talk where one or more of the senders has the power to veto messages before they reach the receiver. A characterization of the most informative equilibria of such models is given. It is shown that editorial control never aids communication and that for small biases in the senders' preferences relative to those of the receiver, necessary and sufficient conditions for information transmission to be adversely affected are (i) that the senders have opposed preferences relative to the receiver and (ii) that both senders have powers of editorial control. It is shown that the addition of further senders beyond two weakly decreases information transmission when senders exercising editorial control are anonymous, and weakly increases information transmission when senders exercising editorial control are observed.

Keywords: cheap talk, editorial control, Wikipedia

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1 Introduction

The seminal paper "Strategic Information Transmission" by Crawford and Sobel (1982) featured a very simple model of communication between a sender who holds private information and a receiver who has to decide on an action in the case when there is a degree of strategic complementarity between the sender and the receiver. Since then, there have been many extensions of their model. Extensions that have been analyzed include making changes to the number of

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senders and receivers, the dimension of the variable which is private information, the number of times the parties can communicate and the type of equilibria examined.[1] The rationality of the players in the game has also been limited in various ways in several papers.[2]

Krishna and Morgan (2001a) examine the case where there are two senders who both possess some information that a single receiver does not possess and who send simultaneous messages to the receiver about this information. They show that with two senders, equilibria are possible in which the receiver always learns the private information of the senders.[3]

Krishna and Morgan set their model in the context of a policy maker (the receiver) looking for advice from two experts (the senders). The current paper builds from the premise that not all experts are equal, that experts often subcontract to or employ other experts, that information is often distributed through media over which nonneutral entities have control, and that disagreement among experts can sometimes result in purposeful destruction, obfuscation and discrediting of information. We build a model in which two senders choose messages, then with knowledge of one another's messages have some opportunity to block message transmission. For example, a model in which only one sender has a chance to block message transmission could represent an expert writing a report for a policy maker: the expert solicits further advice from another expert and can then choose whether to include the other expert's advice in the final report.[4]

This paper tackles the question of whether giving veto power to senders changes the amount of information that can be transmitted in the most informative equilibria of the game, whether veto power reduces or enhances information transmission and whether the effects depend on whether one or both senders have this power. The form and interpretation of equilibria in sender–receiver games with this veto power included are also of interest.

As a first step, we look at the model in which after the senders choose their messages, each of them has the opportunity to block both messages. That is, if a

1 See Krishna and Morgan (2001b); Farrell and Gibbons (1989); Battaglini (2002); Chakraborty and Harbaugh (2007).

2 See Chen (2011); Ottaviani and Squintani (2006); Kartik, Ottaviani, and Squintani (2007).

3 Krishna and Morgan (2001b) also study the case where the two senders send messages sequentially rather than simultaneously. In such a model, it is impossible to achieve full revelation of private information. As the goal of the paper is to present the simplest model of editorial control, the author chooses to present results stemming from the simultaneous senders model.

4 Although both experts have the same information, the sender with editorial control can still gain from employing a further sender when payoffs are compared to equilibrium payoffs of the one sender game.

sender chooses to block then neither of the messages will reach the receiver. This formulation of the model can be seen as a model of a situation where the apparent validity of any conclusions reached by a duo of experts is almost entirely dependent on their opinions being included in some kind of official report. Each expert has a veto over the report's publication and no method external to the report of sending a message.[5]

For this model we find that when senders' preferences are both biased in the same direction relative to the receiver, there is no effect on the degree of informativeness in information transmission that can be achieved. When the senders are biased in opposite directions, however, there is a reduction in informativeness: there is always a set of states of nature over which message transmission is vetoed and the minimum size of this set increases proportionately to the bias of the less-biased sender. Moreover, in the most informative equilibria, vetoing takes place only when the senders' private information is extreme: close to one of the boundaries of the state space. Hence, when in the real world we see, for example, diplomats failing to reach agreement on joint communiques it may indicate that the real state of the world is toward one of its possible extremes.

With the results from this model in hand, we then go on to analyze some variations and extensions of it. It turns out that informativeness in some of the other extensions we analyze is no different from the model without veto power. We conclude that message blocking (veto power) sometimes does not affect and sometimes reduces the maximum amount of information that can be transmitted in equilibrium. We find that for information transmission to be reduced, it is necessary that both senders have the ability to block messages: a sole sender having this ability is not enough. This last point would suggest that the potential rewards from editorial control may be somewhat limited when your target audience is rational and would help to explain the large percentages of readers of national daily newspapers who persist in voting for political parties whose politics are opposed by their newspaper of choice.[6]

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5 Such a situation is by no means unusual. Research for policy formation bodies – "think tanks" – is often undertaken by people who are by no means experts in any sense of the word. The entire weight attributed to their opinions comes from the fact that they are operating under the aegis of a well-known organization. Were they to leave the organization and write some research on their own it is unlikely that many people would read it or that any press coverage would be achieved.

6 For example, in every UK general election since 1992, at least 28% of readers of the most read newspaper in the United Kingdom, the Sun, have voted for the largest party opposed to the party supported by the newspaper. The Sun supported the Conservatives in 1992, 2010; Labor in 1997, 2001, 2005. Source: http://www.ipsos-mori.com/researchpublications/researcharchive/2476/Voting-by-Newspaper-Readership-19922010.aspx.

One important alternative editorial protocol is one in which after both senders have selected messages, each has an opportunity to remove his own message, the other sender's message or even both messages from the final information transmission. The most obvious example of this is Wikipedia, which rapidly became the most widely used encyclopaedia in the world, expanding through the contributions of millions of users via the use of wikis. According to Wiktionary, a wiki is a "collaborative website which can be directly edited by anyone with access to it." Users contribute to an article on Wikipedia and can also alter, delete and supplement the writings of previous contributors. Our model is like this with both of our senders representing contributors and our sole receiver representing a representative audience. Although there also exists a system of arbitration on Wikipedia for use as a method of last resort if discussion and multiple re-editing of an article does not lead to a broad degree of consensus, arbitration is used so infrequently as to make its omission from this model a minor one.[7] We find that information transmission can attain exactly the same level of informativeness under any editorial protocol in which each sender has the ability to prevent all messages from reaching the receiver without the receiver knowing which sender has exercised this veto. This is important as the extended model is much broader and can be applied to a much wider range of situations, such as any type of collaborative editing project or a committee where participants can veto individual parts of a report.

It is shown that the addition of further senders beyond two weakly decreases information transmission when the identity of the sender/s exercising editorial control is unobservable to the receiver. However, this comparative static is reversed when the identity of the sender/s exercising editorial control is observed by the receiver: the addition of further senders beyond two weakly increases information transmission. Moreover, there is more information transmission when editors' identities are observed than when they are not. The implication from a policy perspective is that a reduction in anonymity can mitigate, or even eliminate, the harmful effects of editorial control.[8]

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7 As of January 7th 2012, English Wikipedia contained 3,840,444 articles. During 2011 there were 59 requests to open arbitration cases, only 13 of which were accepted. 16 cases were heard and settled by the arbitration committee in 2011. See: http://en.wikipedia.org/wiki/Wikipedia: Requests for arbitration/Statistics 2011

8 In the context of Wikipedia, such a reduction in anonymity is provided by the availability of the IP addresses of those who make changes to articles. This information can be used to identify possible editing by interested parties, such as edits of the biographical information of US congressmen via congressional IP addresses. See: http://en.wikipedia.org/wiki/U.S. Congressional staff edits to Wikipedia.

2 Model

First, the basic model is presented. It will be seen later in the paper that results derived from this model extend to more complex models of editing.

There are three players, sender 1 ($S1$), sender 2 ($S2$) and a receiver (R).

$S1$ and $S2$ observe the state of the world which is modeled as a random variable θ which is uniformly distributed on $\Theta = [0, 1]$.

$y \in \mathbb{R}$ is the action taken by R upon receiving one or more messages.

The preferences of all players are represented by von Neumann–Morgenstern utility functions:

$$U^1(y, \theta, b_1) = g_1(|y - (\theta + b_1)|), \quad U^2(y, \theta, b_2) = g_2(|y - (\theta + b_2)|),$$

$$U^R(y, \theta) = g_R(|y - \theta|)$$

where g_1, g_2, g_R are strictly decreasing and continuous, and g_R is strictly concave.

$b_1, b_2 \in \mathbb{R}$ are the biases of $S1$ and $S2$ respectively. R has a bias of zero: as can be seen from her payoff function her ideal action is always $y = \theta$. $S1$ would ideally like R to play $y = \theta + b_1$ and $S2$ would ideally like R to play $y = \theta + b_2$. The payoffs of all three players decrease as y gets further in distance from their ideal points.

The three players' ideal actions all have a complementary aspect: they are all increasing in θ. Hence $S1$ and $S2$ have an incentive to give R some information about θ via messages.

M is a message space with an uncountable number of elements. For the sake of argument, we can take M equal to the real interval [0,1]. The "meaning" of a message in a cheap talk game is a property of a particular equilibrium.[9] Messages sent in equilibrium will be interpreted by $S1$, $S2$ and R as having the same meaning. Note that this is not an assumption but rather a consequence of equilibrium demanding that $S1$, $S2$ and R know one another's equilibrium strategies.

Everything except θ is common knowledge.

The game $\Gamma(B)$ is:

Period 0: θ chosen by nature.

Period 1: $S1$ and $S2$ observe θ and choose messages $m_1 \in M$ and $m_2 \in M$.

Period 2: $S1$ and $S2$ observe (m_1, m_2) and $S1$ and $S2$ make simultaneous decisions on whether or not to "block". If either $S1$ or $S2$ decide to "block" then both

9 For example, if there existed a message "black" that a sender sent in equilibrium when the state was "white" then the "meaning" of "black" would be "white".

messages are blocked and R does not observe a message. The actions block and not to block are represented by $\mathcal{B}$ and $\mathcal{A}$ respectively.

Period 3: If the messages have not been "blocked" in period 2, R observes m_1 and m_2. R can therefore observe both or neither of the messages depending on the actions of $S1$ and $S2$. Given the messages received (or lack thereof), R chooses an action y.

At all stages, players are assumed to choose actions to maximize their expected payoffs. The solution concept employed here is Perfect Bayesian Equilibrium.

On occasion we refer to the game without blocking, i.e. the same game without Period 2, as Γ.

A strategy for Sender i is of the form:

$$s_i = \left\{ s_i^1(\theta) : \theta \to M, s_i^2(\theta, m_1, m_2) : \Theta \times M \times M \to \{\mathcal{B}, \mathcal{A}\} \right\}.$$

That is, each sender chooses a message for each possible state of the world and also for each θ chooses a set of message pairs which he will block in Period 2 rather than allow to be observed by R.

To save on notation we define $s_1 \equiv (s_1^1, s_1^2)$, $s_2 \equiv (s_2^1, s_2^2)$, $s \equiv (s_1, s_2)$.

We define a variable z as equal to "*block*" if either $S1$ or $S2$ has played $\mathcal{B}$ and equal to (m_1, m_2) otherwise. z is what is observed by R. $z \in Z = (M \times M) \bigcup \{\text{“}block\text{”}\}$. z is a function of the strategies of the players and of θ, $z = z(s_1, s_2, \theta)$.

A strategy for R is of the form $y(z) : Z \to \mathbb{R}$.

That is, R chooses an action to take for every possible message pair she could observe and also chooses an action to take when the messages are blocked and do not reach her.

As we look at PBE, equilibrium also includes a set of beliefs $\mu(\theta|z)$ of the receiver after receiving each set of messages $z \in (M \times M) \bigcup \{\text{“}block\text{”}\}$. $\mu(\theta|z)$ is a probability density function over Θ and is updated according to Bayes' rule with respect to the strategy of the senders wherever this is possible. The unconditional distribution $\mu(\theta)$ is uniform on Θ. An equilibrium of the model is a strategy profile (s^*, y^*) and a belief function μ such that given the beliefs μ and the strategies of the other players, each player maximizes his expected payoff over the state space. As R's only task is to choose an action given her available information, she chooses this action to maximize her payoff. As utility is strictly concave, there is a unique maximizing action:

$$y^*(z) = \arg\max_y \mathbb{E}_{\mu(\theta|z)} \left[U^R(y, \theta) \right]$$

Strategies for $S1$, $S2$ are *sequentially rational* if $\forall\, \theta \in \Theta$, $\forall\, (m_1, m_2) \in M \times M$:

$$s_i^* \in \arg\max_{s_i} U^i(y^*(z(s_i, s_{-i}^*, \theta)), \theta, b_i)$$

$$s_i^{2*} \in \arg\max_{s_i^2} U^i(y^*(z(m_i, s_i^2, m_{-i}, s_{-i}^{2*}, \theta)), \theta, b_i)$$

and beliefs $\mu(\theta|z)$ must be *consistent* with the strategies:

$$\mu(\theta|z, s^*) = \frac{\mathbb{P}(z|\theta, s^*)\mu(\theta)}{\mathbb{P}(z|s^*)}$$

whenever z is observed in equilibrium for some value of θ. $\mu(\theta|z, s^*)$ is arbitrary when z does not occur in equilibrium.

In this paper, we use the concept of informativeness. A more informative equilibrium is one in which R receives more information about θ. As R's expected payoff is directly linked to the amount of information he can expect to receive about θ, we use R's payoff to tell us how informative an equilibrium is.

An equilibrium (s^*, y^*, μ^*) is **more informative** than an equilibrium (s, y, μ) if and only if:

$$\mathbb{E}_{\mu^*(\theta|z)}\left[U^R(y^*(z(s^*, \theta)), \theta)\right] > \mathbb{E}_{\mu(\theta|z)}\left[U^R(y(z(s, \theta)), \theta)\right]$$

We define a **monotonic equilibrium** as an equilibrium where the equilibrium actions $y^*(z(s_1^*, s_2^*, \theta))$ are a nondecreasing function of θ.[10]

This paper focuses on the most informative equilibria of the cheap talk games it analyzes. The reasons for this are twofold. Firstly, in many situations it will be the case that the receiver is employing the senders as "experts" on the subject matter in question, and in that capacity would have some control over expectations of which equilibrium would be played. Given the choice, she would choose the most informative equilibrium. Secondly, even in situations where this line of argumentation is not applicable, the most informative equilibrium gives a bound on the informativeness that can be achieved in equilibrium. The skeptical reader may therefore choose to interpret results in this way.

2.1 Only one sender and no blocking

Crawford and Sobel (1982) analyze the one sender, one receiver game without blocking, that is, without the second sender and Period 2 of our game. They show that when the sender has a strictly positive bias, a finite number of actions are played in the equilibria of their game. All equilibria of their model are

10 Non-monotonic equilibria do exist. An example is given in Appendix B.

partition equilibria where the sender tells R the cell of the partition in which θ falls.

2.2 Two senders without blocking

Because many of the results in this paper build upon Krishna and Morgan (2001a), it is worth describing some of their results. They analyze cheap talk when two senders send messages simultaneously and $|b_1|, |b_2| < \frac{1}{4}$. If both senders are biased in the same direction, say $b_1, b_2 > 0$, then there exists a fully revealing equilibrium in which each sender tells the receiver the true state of the world and if the receiver receives two different messages he believes the lower of the two to be correct. They show that full revelation is also possible if the senders are biased in opposite directions. Assume without loss of generality that $|b_2| > |b_1| > 0 > b_1$. They give a construction in which $S1$ tells the receiver the true state of the world ($s_1(\theta) = \theta$) and $S2$ plays $s_2(\theta) = \theta + 2b_2$ when $\theta < 1 - 2b_2$ and $s_2(\theta) = \theta - 2b_2$ when $\theta > 1 - 2b_2$. If R receives messages which are not consistent with equilibrium play, R is assumed to believe that $S1$ is giving the true state of the world except in the case where $S2$ would lose payoff were he believed, in which case R believes $S2$ to be giving the true state of the world.[11]

3 Similar biases

We show that with similar biases, the most informative equilibrium possible in $\Gamma(B)$ is exactly as informative as the most informative equilibrium in Γ. In other words, when both senders are biased in the same direction, the addition of veto power to the game does not reduce the informativeness of the most informative equilibrium: there exists a fully revealing equilibrium of $\Gamma(B)$.

Theorem 1. *With similar biases,*
(i) There exists a fully revealing equilibrium of $\Gamma(B)$.

11 We note that criticisms of Krishna and Morgan (2001a) also apply to the current paper. In particular, the equilibrium constructions rely on the perfect observation of the θ by the senders (Battaglini 2002). It is plausible to think that disagreement between senders over the state of the world could be a reason for message blocking. The current paper abstracts from such possibilities to focus on strategic considerations.

(ii) In any fully revealing equilibrium of $\Gamma(B)$ *blocking only occurs at the edge of the state space*:

$$\textit{If} \quad b_1, b_2 > 0, \quad \textit{then} \quad \mu(\theta = 0|\text{“}\textit{block}\text{”}) = 1, \ \textit{and}$$

$$\textit{If} \quad b_1, b_2 < 0, \quad \textit{then} \quad \mu(\theta = 1|\text{“}\textit{block}\text{”}) = 1.$$

Proof.

(i) Assume without loss of generality that $b_2, b_1 > 0$. The proof for $b_2, b_1 < 0$ is similar. When R observes “*block*” let her believe that $\theta = 0$. Let all other beliefs be identical to those in the fully revealing equilibrium of the game without blocking, i.e.:

$$\mu(\theta = 0|\text{“}\textit{block}\text{”}) = 1, \qquad \mu(\theta = \min\{m_1, m_2\}|(m_1, m_2)) = 1$$

Let strategies be:

$$s_1^1 = \theta, \qquad s_2^1 = \theta$$

$$\forall\ m_1, m_2, \theta : \quad s_i^2 = \begin{cases} \mathcal{A}, & U^i\big(y^*(m_1, m_2), \theta, b_i\big) \geq U^i(0, \theta, b_i\big) \\ \mathcal{B}, & \text{otherwise.} \end{cases}$$

As $\mu(\theta = 0|\text{“}\textit{block}\text{”}) = 1$ implies that $y^*(\text{“}\textit{block}\text{”}) = 0$, s_1^2, s_2^2 as defined above imply that a player will only play $\mathcal{B}$ when this is strictly better for him than is allowing R to observe (m_1, m_2). These are clearly optimal strategies for any subgame starting in Period 2. In the game starting in Period 1 any unilateral deviation by a sender can only lead to an action below θ being played by R: if sender i sends a message $m_i > \theta$ and plays $\mathcal{A}$ then R's beliefs will be unaffected. If sender i sends a message $m_i \leq \theta$ and/or plays $\mathcal{B}$ then R will believe θ to be lower than its true value and will play a correspondingly lower action. As any action below θ gives either sender a lower payoff than when the state is revealed and θ is played, the strategies and beliefs above constitute an equilibrium.

(ii) Continue to assume that $b_2, b_1 > 0$. Assume that $\mu(\theta = 0|\text{“}\textit{block}\text{”}) < 1$. Then it must be the case that $\xi := y^*(\text{“}\textit{block}\text{”}) > 0$. Then there exists a range of states, $\theta \in (\max\{0, \xi - 2b_i\}, \xi)$ in which sender i would rather play $\mathcal{B}$ than reveal the true θ. So there can be no fully revealing equilibrium with $\mu(\theta = 0|\text{“}\textit{block}\text{”}) < 1$. □

Intuitively, $S1$ and $S2$ have no incentive to lie about the state as R will always believe the lower of any two messages he receives. By believing that if he observes "*block*" then θ is at its lowest possible value, R removes any incentive for the senders to deviate and disrupt the transmission of messages by playing $\mathcal{B}$.

4 Opposed biases

4.1 Initial results

To give some intuition as to why the effect of blocking is different when biases are opposed we look at why a fully revealing equilibrium cannot be sustained in $\Gamma(B)$ when the senders have opposed biases. For the rest of this section, we assume without loss of generality that $b_1 < 0$ and $b_2 > 0$.

Lemma 4.1. *Full revelation is not supported by any equilibrium of* $\Gamma(B)$.

Proof. Assume there exists a fully revealing equilibrium of $\Gamma(B)$. Because of the concavity of U^R, R's best response will always be a pure strategy so we can let $\xi = y^*$("***block***"). If $\xi \in (0,1]$ then:

$$\forall\ \theta \in (\max\{0, \xi - 2b_2\}, \xi), \qquad U^2(\xi, \theta, b_2) > U^2(\theta, \theta, b_2)$$

so when $\theta \in (\max\{0, \xi - 2b_2\}, \xi)$ $S2$ would prefer to block rather than allow the true value of θ to be revealed. Therefore, it must be that $\xi = 0$. But then:

$$\forall\ \theta \in (0, -2b_1), \qquad U^1(\xi, \theta, b_1) = U^1(0, \theta, b_1) > U^1(\theta, \theta, b_1)$$

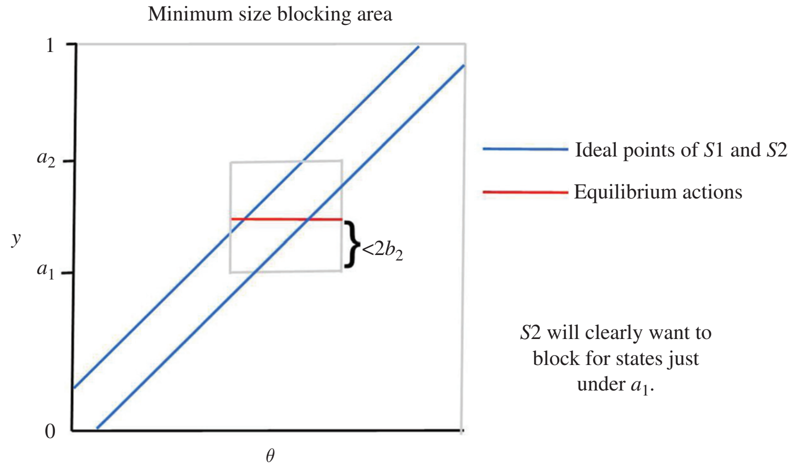
so when $\theta \in (0, -2b_1)$ $S1$ would prefer to block rather than allow the true value of θ to be revealed. Therefore, there is no possible value of ξ compatible with full revelation. Contradiction. □

We see here that blocking prevents us from implementing full revelation because for any action taken by R after observing "block", there will always be an interval of values of θ where one of the senders would rather play $\mathcal{B}$ than allow the correct value of θ to be revealed.

Lemma 4.2. *In any monotonic equilibrium* (s_1, s_2, y, μ), *the set* $\{\theta : y(z(s_1, s_2, \theta)) = y(\text{'block'})\}$ *is an interval of width at least min*$\{-4b_1, 4b_2\}$.

This lemma means that in any monotonic equilibrium there is an interval in Θ where the action taken by R is the same as the action she would take if she observed "*block*". This does not mean that blocking occurs in equilibrium.

Indeed, equilibria exist where no blocking occurs and $y(``block")$ is induced without $S1$ or $S2$ playing $\mathcal{B}$. What this lemma does mean is that any monotonic equilibrium is outcome equivalent to an equilibrium where "block" is played in an interval at least $\min\{-4b_1, 4b_2\}$ in size (see Figure 1). With this in mind we refer to the set $\{\theta : y(z(s_1, s_2, \theta)) = y(``block")\}$ as the "blocking interval".



Q6 **Figure 1:** The size of the blocking interval is bounded below by $\min\{-4b_1, 4b_2\}$

Proof. Assume an equilibrium with a smaller blocking interval $[a_1, a_2]$. Let $\xi = y(``block")$. The blocking interval clearly has ξ as its midpoint. Noting that monotonicity implies that actions below ξ are not played in or above the blocking interval in equilibrium:

$$\{\theta > a_1 : y(z(s_1, s_2, \theta)) < \xi\} = \emptyset$$

and defining $Z_\xi \subset Z$ as the set of all equilibrium observations that lead to actions below ξ being played:

$$Z_\xi = \{z \in Z : z = z(s_1, s_2, \theta) \text{ for some } \theta;\ y(z) < \xi\}$$

we can see that $z \in Z_\xi$ will never occur for $\theta > a_1$:

$$\forall\, z \in Z_\xi, \qquad \mu(\theta > a_1 | z, s) = 0.$$

As the payoff of R decreases in the distance between y and θ, this equality implies that:

$$\forall\, z \in Z_\xi, \qquad y(z) \leq a_1$$

So for $\theta < a_1$ no actions above a_1 are played in equilibrium. If $a_2 - a_1 < 4b_2$ then at states just under a_1 $S2$ would then prefer to block and induce ξ rather than the equilibrium action. To see this let $\hat{\theta} = a_1 - \epsilon$ for ϵ small. Then ξ is $\frac{a_2 - a_1}{2} + \epsilon - b_2$ from $S2$'s ideal point $a_1 - \epsilon + b_2$. As $y(z(s_1, s_2, \hat{\theta})) \leq a_1$ we know that $y(z(s_1, s_2, \hat{\theta}))$ is at least $b_2 - \epsilon$ from $S2$'s ideal point. Thus we get that $S2$ will deviate and play $\mathcal{B}$ when $a_2 - a_1 < 4b_2$. This contradicts equilibrium. So $a_2 - a_1 \geq 4b_2$, unless the blocking interval is of the form $[0, a_2]$ as then there exists no $\theta < a_1$. An almost identical argument holds for $S1$ and $-4b_1$, giving that $a_2 - a_1 \geq -4b_1$ unless the blocking interval is of the form $[a_1, 1]$. Hence the minimum of $-4b_1$ and $4b_2$ gives a lower bound on the size of $a_2 - a_1$. □

So we see that the biases of the senders place a lower bound on the size of the blocking interval in equilibrium. This seems to make sense: the more biased the senders, the less information transmission there can be in equilibrium. The minimum size of the blocking interval depends on the less biased of the senders because the effects of the more biased sender's bias on the minimum size blocking area can be removed by placing the blocking interval at the edge of the state space in the direction of the less-biased sender's bias. If both senders are very biased then there is a large interval of states where R does not observe any messages, or equivalently he observes messages telling him to play y(“*block*”).

Now an example is given of a possible equilibrium for the case where $S1$ and $S2$ have opposed biases, $b_1 < 0$, $b_2 > 0$, and $S2$ is the more biased of the two senders, $|b_2| > |b_1|$.

4.2 Example: left blocking equilibrium (LBE)

Let $s_1^1 = s_2^1 = -2b_1$ when $\theta \leq -4b_1$. Let any other message in $[0, -4b_1]$ have the same meaning as $-2b_1$, i.e. R's beliefs are the same after receiving any such message. Let $s_1^1(\theta) = \theta$, $s_2^1(\theta) = \theta + 2b_2$ when $\theta \in (-4b_1, 1 - 2b_2]$. Let $s_1^1(\theta) = \theta$, $s_2^1(\theta) = \theta - 2b_2$ when $\theta > 1 - 2b_2$. Let:

$$\forall\, m_1, m_2, \theta: \quad s_i^2 = \begin{cases} \mathcal{A}, & U^i(y^*(m_1, m_2), \theta, b_i) \geq U^i(-2b_1, \theta, b_i) \\ \mathcal{B}, & \text{otherwise.} \end{cases}$$

If R observes (m_1, m_2), $m_1, m_2 > -4b_1$ consistent with these equilibrium strategies then:

$$\mu(\theta = m_1 | (m_1, m_2)) = 1.$$

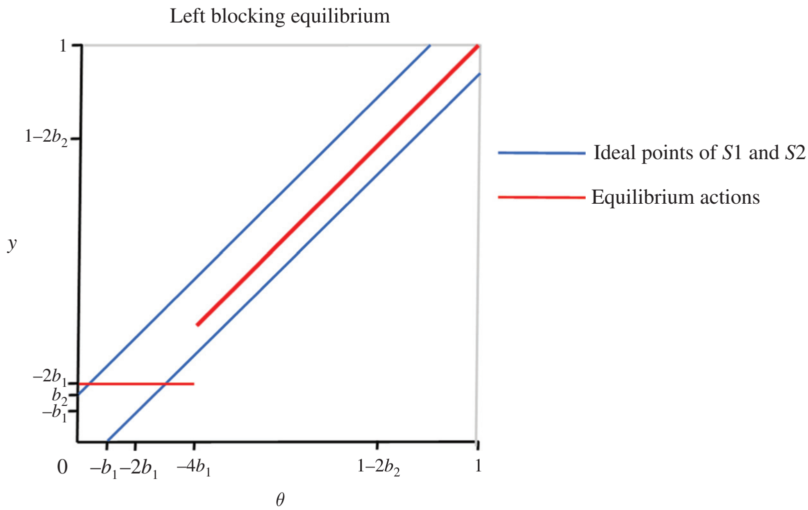


Figure 2: An equilibrium with the blocking interval on the left-hand side of the state space

If R observes (m_1, m_2), $m_1, m_2 > -4b_1$ which are inconsistent with these equilibrium strategies then:

$$U^2(m_2, m_1, b_2) > U^2(m_1, m_1, b_2) \Rightarrow \mu(\theta = m_1 | (m_1, m_2)) = 1,$$

$$U^2(m_2, m_1, b_2) \leq U^2(m_1, m_1, b_2) \Rightarrow \mu(\theta = m_2 | (m_1, m_2)) = 1.$$

Hence $S2$ is believed only when it would not be profitable to him for R to believe his message when $S1$'s message correctly indicates θ. If R observes either "*block*" or (m_1, m_2), $m_i \in [0, -4b_1], m_j \notin [0, -4b_1]$ for some i, j then:

$$\mu(\theta | (m_1, m_2)) = \mu(\theta | \text{“}block\text{”}) \sim \text{Uniform}[[0, -4b_1]].$$

These strategies and beliefs are an equilibrium. For $\theta > -4b_1$, given the other sender's strategy, a sender cannot gain by deviating as he will only be believed if he damages his own payoffs. For $\theta < -4b_1$ a unilateral deviation by a sender cannot change R's beliefs. This equilibrium, the LBE, is illustrated in Figure 2.

4.3 Characterization

Theorem 2 gives a characterization of the most informative equilibrium of the model with opposed biases. It is already known from Lemma 4.1 that this equilibrium is less informative than the most informative equilibrium of the model without blocking. Theorem 2 uses Lemma 4.2 to give the result that when blocking occurs in a most informative equilibrium of $\Gamma(B)$ it will always indicate a state of the world close to one of the extremes. The blocking interval is smallest when the bias of the more biased sender has no effect on its size. This is achieved by placing the blocking interval so that should the more biased of the two senders have a positive (negative) bias, he will never be able to induce the receiver to take a higher (lower) action than any of the actions played in equilibrium. Full revelation is induced over the remainder of the state space.

Theorem 2. *With opposed biases,*

(i) *The most informative monotonic equilibrium of* $\Gamma(B)$ *has a blocking interval of length* $\min\{-4b_1, 4b_2\}$ *and is fully revealing over the rest of the state space.*

(ii) *If* $|b_1| \neq |b_2|$, *the blocking interval of the most informative equilibrium is either* $[0, -4b_1]$ *or* $[1-4b_2, 1]$. *Blocking occurs at the extremes of the state space.*

Proof.

(i) Assume $|b_1| < |b_2|$, the construction when the converse holds is symmetric. From Lemma 4.2 we know that the length of the blocking interval $\{\theta : y(z(s_1, s_2, \theta)) = y(\text{“}block\text{”})\}$ is bounded below by $\min\{-4b_1, 4b_2\} = -4b_1$. This bound is attained in the LBE described above. The LBE is fully revealing over the rest of the state space and therefore must be a most informative equilibrium.

(ii) The smallest possible equilibrium blocking intervals $\{\theta : y(z(s_1, s_2, \theta)) = y(\text{“}block\text{”})\}$ of the form $[0, a]$ or $[a, 1]$ are $[0, -4b_1]$ or $[1-4b_2, 1]$. If the blocking interval is not bounded below by 0 or above by 1 it must have length of at least $\max\{-4b_1, 4b_2\}$. If $b_1 \neq b_2$ this implies that such an equilibrium must be less informative than either the LBE or its symmetric equivalent.

From Theorems 1 and 2 it is a simple step to see that similar results pertain if there are 3 or more senders. In fact, strategies to support the revealing areas of the state space become even simpler: if for some θ, $s_i^1(\theta) = \theta$ for all i and R's beliefs are such that he believes the majority of senders to be telling the truth, then there is no individual who can increase his payoffs through deviating. In the case of similar biases, full revelation for the whole state space can still be obtained as before. For the case of opposed biases adding more senders can reduce informativeness as the area of the state space in which at least one sender would like to play $\mathcal{B}$ is increasing in biases.

Corollary 1. *In the game with $n > 2$ senders.*

(i) If $b_1, \ldots, b_n$ all have the same sign then there is a fully revealing equilibrium

(ii) $b_i > 0$ and $b_j < 0$ for some i, j then the most informative monotonic equilibrium has a blocking interval of length

$$\min\left\{\max_i\{4b_i : b_i > 0\}, \max_i\{-4b_i : b_i < 0\}\right\}$$

and is fully revealing over the rest of the state space.

Proof.

(i) Setting R's beliefs to be identical to those in Theorem 1, the result follows immediately.

(ii) The minimum size blocking interval result of Lemma 4.2 can be extended using the maximum bias in either direction, i.e. the largest positive bias determines the restriction placed on the size of the blocking interval by positive biases: $\max_i\{4b_i : b_i > 0\}$, and the largest negative bias determines the restriction placed on the size of the blocking interval by negative biases: $\max_i \{-4b_i : b_i < 0\}$. As before, the possibility of placing the interval at the edge of the state space means that only one of these restrictions need be satisfied.

The most informative monotonic equilibria of $\Gamma(B)$ have now been characterized. It has been shown that maximum information transmission can be reduced by message blocking when the two senders have biases in different directions. Moreover, the addition of any further senders beyond two has a (weakly) negative effect on information transmission. From the receiver's point of view, two senders who are biased in the same direction are preferable to two senders biased in different directions. A similar result regarding the preference of the receiver over the biases of the senders in the verifiable messages literature is found in the recent work of Bhattacharya and Mukherjee (2013). However, these results stem from different sources. In Bhattacharya and Mukherjee (2013), the senders do not always know the true state of the world and having senders who are similarly biased increases the chance of a sender existing who both knows the true state of the world *and* has an incentive to inform the receiver. In the model of the current paper, the result stems from the fact that there exists an outcome of the messaging protocol, "*block*", which can be induced by either of the senders.

Note that the equilibrium construction for similar biases does not rely on the magnitude of the senders' biases being known to one another or to the receiver.

The construction for opposed biases, the LBE, requires that both senders know $S1$'s bias and that the receiver knows the bias of both of the senders. The former is implicit in the equilibrium construction as the pooling part of the state space has length $-4b_1$. The latter is necessary for the receiver to suitably punish senders should they deviate from equilibrium play. Note that equilibria in which the strategy of each sender is not conditioned upon the bias of the other sender, nor the strategy of the receiver conditioned upon b_1 or b_2, cannot be more informative than the equilibria given in this paper.

Now attention turns to the consequences of altering Period 2 of the game to allow for different blocking protocols. Do more subtle ways of editing, for example blocking the other sender's message but still sending your own, allow for more or less informative equilibria than the ones which have already been analyzed?

5 Different ways of blocking

The explicit construction of the LBE in the lead up to the proof of Theorem 2 allows the statement of a corollary for more generalized blocking protocols. Define a generalized blocking protocol as (Δ, S_1^2, S_2^2), where Δ is a function which maps any strategies $s_1^2 \in S_1^2$, $s_2^2 \in S_2^2$ to another function $\Delta_{s_1^2, s_2^2}$ and:

$$\Delta_{s_1^2, s_2^2} : \Theta \times M \times M \rightarrow (M \cup \{\text{“}block\text{”}\}) \times \left(M \bigcup \{\text{“}block\text{”}\}\right)$$

such that:

$$\Delta_{s_1^2, s_2^2}(\theta, m_1, m_2) \in \{(m_1, m_2), (m_1, \text{“}block\text{”}), (\text{“}block\text{”}, m_2), (\text{“}block\text{”}, \text{“}block\text{”})\}$$

That is, the blocking strategies s_1^2, s_2^2 determine which of the messages sent by the senders will be observed by R.

Corollary 2. *Any alternative blocking protocol in Period 2 will give rise to a most informative equilibrium exactly as informative as that in the proof of Theorem 2 provided that each sender has the ability to prevent any message transmission at all from happening, that is they can each guarantee that neither of their messages is observed by* R.

Proof. The fact that either sender can induce $z = (\text{“}block\text{”}, \text{“}block\text{”})$ gives the minimum size blocking area result from Lemma 4.2, so no equilibrium can be more informative than the equilibrium in the proof of Theorem 2. By defining

$\mu(\theta|(m_1, \text{“}block\text{”})) = \mu(\theta|(\text{“}block\text{”}, m_2)) = \mu(\theta|(\text{“}block\text{”}, \text{“}block\text{”}))$ for all m_1, m_2 and letting senders' strategies be the same as in the LBE, we obtain an equilibrium which is as informative as the LBE.

This corollary suggests that for many applications, the simple blocking protocol of $\Gamma(B)$ may suffice as an adequate modeling tool for one-shot editorial control. For example, a model where either sender has the option to block his own message, the message of the other sender or both messages give the same level of maximum informativeness as $\Gamma(B)$. The proceeding sections look at what can happen if the conditions of the corollary are not satisfied.

5.1 Any blocking protocol, similar biases

Say $b_1, b_2 > 0$. Define R's beliefs so that when she observes any kind of block she believes that $\theta = 0$:

$$\begin{aligned}\mu(\theta = 0|(m_1, \text{“}block\text{”})) &= \mu(\theta = 0|(\text{“}block\text{”}, m_2)) \\ &= \mu(\theta = 0|(\text{“}block\text{”}, \text{“}block\text{”})) = 1\end{aligned}$$

Then the equilibrium construction in Theorem 1 still works and we obtain full revelation.

5.2 $\Gamma(2)$: only sender 2 can block, opposed biases

Define R's beliefs so that when she observes a block she believes that $\theta = 0$. $S2$ would then never benefit from blocking rather than fully revealing θ. The same equilibrium construction as for the LBE only without the blocking interval is a fully revealing equilibrium. Full strategies are described in Appendix A. Note that in comparison to a one sender, one receiver setting, the sender with editorial control can gain from employing the services of a further sender, despite their having the same information. This is due to the higher level of information transmission that is possible with two senders.[12]

12 This is similar to the observation of Dessein (2002) that R may want to commit to playing the best action for the sender (allow the sender to choose the action) to induce full revelation.

5.3 $\Gamma(O)$: both senders can block own message, opposed biases

Define R's beliefs:

$$\mu(\theta = m_1 | (m_1, \text{“}block\text{”})) = 1, \quad \mu(\theta = 1 | (\text{“}block\text{”}, m_2)) = 1,$$

$$\mu(\theta = 1 | (\text{“}block\text{”}, \text{“}block\text{”})) = 1 \quad \forall m_1, m_2 \in M.$$

A similar construction as that for the LBE only without the blocking interval is a fully revealing equilibrium. $S1$ will not wish to deviate and block his own message as this leads R to adjust her inferences about θ in the opposite direction to the bias of $S1$. $S2$ will not wish to block his own message as this cannot affect the outcome when $S1$ plays his equilibrium strategy. There are some slight, yet important, differences to the strategies and beliefs of the LBE. In particular, $S2$'s strategy now depends on the bias of $S1$: for $\theta \leq 1 - 2b_2$, $s_2^1(\theta) = \theta - 2b_1$ rather than $\theta - 2b_2$. Furthermore, if $m_2 < m_1 - 2b_1$ then $\mu(\theta = m_1 | (m_1, m_2)) = 1$. These adjustments are necessary to prevent $S2$ from being able to manufacture situations in which $S1$ is forced to block and induce $y = 1$ rather than accept an unacceptably low y. Full strategies are described in Appendix A.

5.4 $\Gamma(\text{obs})$: both senders can block all messages, blocker observed, opposed biases

In the preceding section, we saw that full revelation can be obtained with opposed biases when senders can only block their own message. The question arises as to whether a similar construction can achieve full revelation in the case when all messages are blocked by either player playing $\mathcal{B}$, but the receiver can observe which of the players have engaged in blocking. Redefine z as equal to “*block*1” if $S1$ has played $\mathcal{B}$, “*block*2” if $S2$ has played $\mathcal{B}$, “*block*12” if both $S1$ and $S2$ have played $\mathcal{B}$, and equal to (m_1, m_2) otherwise. $z \in Z = (M \times M) \cup \{\text{“}block1\text{”}, \text{“}block2\text{”}, \text{“}block12\text{”}\}$.

It turns out that full revelation cannot be obtained in this setting. The reason for this is that even if the response of the receiver to “*block*1” and “*block*2” is unappealing to $S1$ and $S2$ respectively, there will be situations in which a sender can gain from the other sender playing $\mathcal{B}$ and can induce him to do so by choosing his message to make the alternative outcome suitably unappealing.

Proposition 5.4.1. *If* $|b_1|, |b_2| < 1/12$*, then there is no fully revealing equilibrium of* $\Gamma(\text{obs})$.

Proof. Assume a fully revealing equilibrium (s^*, y^*, μ^*). Denote:

$$\xi_1 = y^*(\text{“}\textit{block}1\text{”}), \quad \xi_2 = y^*(\text{“}\textit{block}2\text{”}), \quad \xi_{12} = y^*(\text{“}\textit{block}12\text{”}).$$

As the equilibrium is fully revealing, at most one state induces each of ξ_1, ξ_2, ξ_{12}. For $\theta \in (\max\{0, \xi_2 - 2b_2\}, \xi_2) \backslash \{\xi_1, \xi_{12}\}$, $S2$ would rather block than reveal the state, so this set must be empty in any fully revealing equilibrium, $\xi_2 = 0$. Similarly, $\xi_1 = 1$.

Let

$$\theta_1 \in (0, -2b_1) \backslash \{\xi_{12}\}, \qquad \theta_2 \in (1 - 2b_2, 1) \backslash \{\xi_{12}\},$$

$$\gamma = y^*(s_1^{1*}(\theta_2), s_2^{1*}(\theta_1)).$$

Then either $\gamma \notin (0, -4b_1 + 2b_2)$ and/or $\gamma \notin (1 - 4b_2 + 2b_1, 1)$. Assume without loss of generality that $\gamma \notin (0, -4b_1 + 2b_2)$. Then, for $\theta = \theta_1$, $S1$ and $S2$ prefer $y = 0$ to $y = \gamma$. $S1$ prefers $y = 0$ to $y = \theta$. From our conjectured equilibrium, if $\theta = \theta_1$ and $S1$ deviates to play $s_1^1(\theta_1) = s_1^{1*}(\theta_2)$ then the continuation equilibria in Period 2 must involve $S2$ playing $\mathcal{B}$ and possibly $S1$ playing $\mathcal{B}$ as well. $S1$ obtains a payoff of at least $U^1(\xi_2, \theta_1, b_1) = U^1(0, \theta_1, b_1)$ which is higher than $U^1(\theta_1, \theta_1, b_1)$. This contradicts equilibrium.

However, although a fully revealing equilibrium does not exist, there does exist an equilibrium of $\Gamma(\text{obs})$ that is more informative than any equilibrium of $\Gamma(B)$. The fact that the receiver knows the identities of the blocking sender when a block occurs allows the construction of an equilibrium with a blocking interval that can never be induced by $S2$. Beliefs when blocking occurs are

$$\mu(.|\text{“}\textit{block}1\text{”}) = \mu(.|\text{“}\textit{block}12\text{”}) \sim \text{Uniform}[[1 - 2b_2, 1]],$$

$$\mu(\theta = 1|\text{“}\textit{block}2\text{”}) = 1.$$

and because $S1$ plays $\mathcal{B}$ in equilibrium for $\theta \in [1 - 2b_2, 1]$, $S2$ can never induce $y = 1$ at any θ such that he prefers $y = 1$ to $y = \theta$, that is at any $\theta \in (1 - 2b_2, 1]$. Full strategies are described in Appendix A.

If there are more than two senders, then full revelation is possible. A fully revealing equilibrium exists in which every sender sends a message equal to θ and does not block. If a sender with positive bias is the only blocking sender, then the receiver believes $\theta = 0$ with probability 1. If a sender with negative bias is the only blocking sender, then the receiver believes $\theta = 1$ with probability 1.

Beliefs when more than one sender blocks can be arbitrary. Full strategies are described in Appendix A.

So, in contrast to $\Gamma(B)$, where additional senders beyond two are detrimental to information revelation, additional senders are beneficial to information revelation in $\Gamma(\text{obs})$. The comparative static is reversed when the identity of the blocking player is observed.

6 Conclusion

This paper has examined some basic models of editorial control over information transmission and reached several theoretical conclusions. (i) Veto power only reduces the degree of communication possible if the power is available to both senders in a two sender game. If only one sender has the power to veto messages, the same level of disclosure can be attained as in the game without editorial control. (ii) Only when the senders have opposed biases relative to the receiver's desired outcome is there a reduction in the amount of information transmission possible. When the senders have biases in the same direction, equilibrium can be as informative as in the game without editorial control. (iii) Messages are vetoed in a single interval of the state space and the most informative equilibria occur when this interval is at one extreme of the state space. (iv) If the identity of the vetoing player is unobservable to the receiver, the addition of each further sender beyond two weakly decreases information transmission. (v) If the identity of the senders who veto messages is made observable, then information transmission is improved relative to the unobservable case. Moreover, the comparative static in the number of senders is reversed, and full revelation can be obtained for three or more senders.

We have determined how editorial control over messages can lead to reduced information transmission in sender–receiver games with multiple senders. This suggests that in situations where a contracted expert has an option to consult another expert veto power will not reduce information transmission, whereas in cases where two parties have to sanction the release of a report then informativeness can be reduced. Furthermore, the paper suggests that in collaborative editing projects like Wikipedia, less information transmission will occur than would be the case if no participant could delete the contributions of others. It can be observed that this model ignores that listening to many messages may well have a cost for the receiver and that the receiver may well as a consequence prefer to consult material which has been subject to collaborative editing rather than unedited material. This could well be a subject for further research, as could models in which players' control over information flows takes a more subtle form. For example, a player could have the ability to add noise to his rivals' messages, rather than simply having the power to stop the message from being transmitted at all. Models with heterogeneous receivers and strategic targeting of communications could also be examined, possibly with information leakage between the target groups.

Appendix A

$\Gamma(2)$: only sender 2 can block, opposed biases

In Period 2, $S2$ decides to "block" $\mathcal{B}$ or "allow" $\mathcal{A}$ $S1$'s message.

Strategies for $S1$ and $S2$ are:

- $s_1(\theta) : \theta \to M$. For example, a strategy could be to inform R of the correct state or to inform R whether θ is below or above $1/2$.
- $\{s_2^1(\theta) : \theta \to M, s_2^2(\theta, m_1, m_2) : \theta \times M \times M \to \{\mathcal{B}, \mathcal{A}\}\}$. For example, a strategy could be to inform R of the correct state and never block, or to block m_1 when it indicates the state is below a certain threshold and otherwise give no further information.

Fully revealing equilibrium

Let $s_1(\theta) = \theta$, $s_2^1(\theta) = \theta + 2b_2$ when $\theta \in [0, 1 - 2b_2]$, $s_2^1(\theta) = \theta - 2b_2$ when $\theta > 1 - 2b_2$. Let:

$$\forall\, m_1, m_2, \theta : \quad s_2^2 = \begin{cases} \mathcal{A}, & U^2(y^*(m_1, m_2), \theta, b_2) \geq U^2(0, \theta, b_2) \\ \mathcal{B}, & \text{otherwise.} \end{cases}$$

If R observes (m_1, m_2) consistent with these equilibrium strategies then $\mu(\theta = m_1 | (m_1, m_2)) = 1$. If R observes (m_1, m_2) which are inconsistent with these equilibrium strategies then $\mu(\theta = m_1 | (m_1, m_2)) = 1$ when $U^2(m_2, m_1, b_2) > U^2(m_1, m_1, b_2)$, $\mu(\theta = m_2 | (m_1, m_2)) = 1$ when $U^2(m_2, m_1, b_2) \leq U^2(m_1, m_1, b_2)$. Hence $S2$ is believed only when it would not be profitable to him for R to believe his message when $S1$'s message correctly indicates θ. Set:

$$\mu(\theta = 0 | \text{"}\mathit{block}\text{"}) = 1.$$

$\Gamma(O)$: both senders can block own message, opposed biases

In Period 2 $S1$ and $S2$ decides to "block" $\mathcal{B}$ or "allow" $\mathcal{A}$ their own messages.

Strategies for $S1$ and $S2$ are:

$$\left\{s_i^1(\theta) : \theta \to M, s_i^2(\theta, m_1, m_2) : \theta \times M \times M \to \{\mathcal{B}, \mathcal{A}\}\right\}.$$

$$z(s_1, s_2, \theta) :=$$
$$\begin{cases} \left(s_1^1(\theta), s_2^1(\theta)\right) & \text{if } s_1^2\left(\theta, s_1^1(\theta), s_2^1(\theta)\right) = s_2^2\left(\theta, s_1^1(\theta), s_2^1(\theta)\right) = \mathcal{A} \\ (\text{“}block\text{”}, s_2^1(\theta)) & \text{if } s_1^2\left(\theta, s_1^1(\theta), s_2^1(\theta)\right) = \mathcal{B},\ s_2^2\left(\theta, s_1^1(\theta), s_2^1(\theta)\right) = \mathcal{A} \\ \left(s_1^1(\theta), \text{“}block\text{”}\right) & \text{if } s_1^2\left(\theta, s_1^1(\theta), s_2^1(\theta)\right) = \mathcal{A},\ s_2^2\left(\theta, s_1^1(\theta), s_2^1(\theta)\right) = \mathcal{B} \\ (\text{“}block\text{”}, \text{“}block\text{”}) & \text{if } s_1^2\left(\theta, s_1^1(\theta), s_2^1(\theta)\right) = \mathcal{B},\ s_2^2\left(\theta, s_1^1(\theta), s_2^1(\theta)\right) = \mathcal{B} \end{cases}$$

Fully revealing equilibrium

Let $s_1^1(\theta) = \theta$, $s_2^1(\theta) = \theta + 2b_2$ when $\theta \in [0, 1 - 2b_2]$, $s_2^1(\theta) = \theta - 2b_1$ when $\theta > 1 - 2b_2$. For all m_1, m_2, θ, let:

$$s_1^2 = \begin{cases} \mathcal{A}, & U^1(y^*(m_1, m_2), \theta, b_1) \geq U^1(1, \theta, b_1) \\ \mathcal{B}, & \text{otherwise.} \end{cases}$$

$$s_2^2 = \begin{cases} \mathcal{A}, & U^2(y^*(m_1, m_2), \theta, b_2) \geq U^2(m_1, \theta, b_2) \\ \mathcal{B}, & \text{otherwise.} \end{cases}$$

If R observes (m_1, m_2) consistent with these equilibrium strategies then $\mu(\theta = m_1 | (m_1, m_2)) = 1$. If R observes (m_1, m_2) which are inconsistent with these equilibrium strategies then $\mu(\theta = m_1 | (m_1, m_2)) = 1$ when $U^2(m_2, m_1, b_2) > U^2(m_1, m_1, b_2)$ and/or $m_2 < m_1 - 2b_1$. Otherwise, let $\mu(\theta = m_2 | (m_1, m_2)) = 1$. Hence $S2$ is believed only when it would not be profitable to him for R to believe his message when $S1$'s message correctly indicates θ. Set:

$$\mu(\theta = m_1 | (m_1, \text{“}block\text{”})) = 1, \quad \mu(\theta = 1 | (\text{“}block\text{”}, m_2)) = 1,$$

$$\mu(\theta = 1 | (\text{“}block\text{”}, \text{“}block\text{”})) = 1 \quad \forall m_1, m_2 \in M.$$

Note that for given m_1, the lowest y that could be induced by $S2$ is $m_1 - 2b_1$, so $S2$ can never incentivize $S1$ to play $\mathcal{B}$.

$\Gamma(\text{obs})$: both senders can block all messages, blocker observed, opposed biases

Strategies for $S1$ and $S2$ are as in $\Gamma(B)$.

$$z(s_1, s_2, \theta) := \begin{cases} (s_1^1(\theta), s_2^1(\theta)) & \text{if } s_1^2(\theta, s_1^1(\theta), s_2^1(\theta)) = s_2^2(\theta, s_1^1(\theta), s_2^1(\theta)) = \mathcal{A} \\ \text{“}block1\text{”} & \text{if } s_1^2(\theta, s_1^1(\theta), s_2^1(\theta)) = \mathcal{B},\ s_2^2(\theta, s_1^1(\theta), s_2^1(\theta)) = \mathcal{A} \\ \text{“}block2\text{”} & \text{if } s_1^2(\theta, s_1^1(\theta), s_2^1(\theta)) = \mathcal{A},\ s_2^2(\theta, s_1^1(\theta), s_2^1(\theta)) = \mathcal{B} \\ \text{“}block12\text{”} & \text{if } s_1^2(\theta, s_1^1(\theta), s_2^1(\theta)) = \mathcal{B},\ s_2^2(\theta, s_1^1(\theta), s_2^1(\theta)) = \mathcal{B} \end{cases}$$

Equilibrium with blocking area of size $2b_2$

Let $s_1^1(\theta) = \theta$, $s_2^1(\theta) = \theta + 2b_2$ when $\theta \in [0, 1 - 4b_2)$. Let $s_1^1(\theta) = \theta$, $s_2^1(\theta) = \theta - 2b_1$ when $\theta \in [1 - 4b_2, 1 - 2b_2)$. Let $s_1^1(\theta) = 1 - b_2$, $s_2^1(\theta) = 1 - b_2$ when $\theta \in [1 - 2b_2, 1]$. If R observes (m_1, m_2) consistent with these equilibrium strategies then $\mu(\theta = m_1 | (m_1, m_2)) = 1$. If R observes (m_1, m_2) which are inconsistent with these equilibrium strategies and $m_1 \geq 1 - 2b_2$ then let $\mu(.|(m_1, m_2)) \sim Uniform[[1 - 2b_2, 1]]$. If $m_1 < 1 - 2b_2$ and either

$$\text{(i) } m_1 < 1 - 4b_2 \text{ and } m_2 > m_1 + 2b_2, \text{ or}$$

$$\text{(ii) } m_1 \geq 1 - 4b_2 \text{ and } m_1 - 2b_1 < m_2 < m_1,$$

then $\mu(\theta = m_2 | (m_1, m_2)) = 1$. Otherwise, let $\mu(\theta = m_1 | (m_1, m_2)) = 1$. Beliefs when blocking occurs are

$$\mu(.|\text{“}block1\text{”}) = \mu(.|\text{“}block12\text{”}) \sim \text{Uniform}[[1 - 2b_2, 1]],$$

$$\mu(\theta = 1 | \text{“}block2\text{”}) = 1.$$

Let $y(z)$ be determined by these beliefs. Let

$$s_i^2 = \begin{cases} \mathcal{A}, & U^i(y^*(m_1, m_2), \theta, b_i) > U^i(\text{“}block\,i\text{”}, \theta, b_i) \\ \mathcal{B}, & \text{otherwise.} \end{cases}$$

Note the strict inequality above and that in this equilibrium both $S1$ and $S2$ play $\mathcal{B}$ when $\theta \in [1 - 2b_2, 1]$.

Fully revealing equilibrium with $n > 2$ players

Let μ be such that if $z = (m_1, \ldots, m_n)$, $m_i = m$ for a majority of $i \in \{1, \ldots, n\}$, then $\mu(\theta = m|z) = 1$. If $z = (m_1, \ldots, m_n)$ and no message is sent by a majority of senders, let $\mu(\theta = m_1|z) = 1$. If $b_i > 0$, then let $\mu(0|\text{“}block\, i\text{”}) = 1$. If $b_i < 0$, then let $\mu(1|\text{“}block\, i\text{”}) = 1$. For other blocking possibilities, let $\mu(0|\text{“}block\, j \ldots k\text{”}) = 1$. Let $y(z)$ be determined by these beliefs.

For all θ, for $1 \le i \le n$, let $s_i^1(\theta) = \theta$. Let

$$s_i^2(\theta, m_1, \ldots, m_n) = \begin{cases} \mathcal{A}, & U^i(y^*(m_1, \ldots, m_n), \theta, b_i) \ge U^i(\text{“}block\, i\text{”}, \theta, b_i) \\ \mathcal{B}, & \text{otherwise.} \end{cases}$$

Appendix B

We construct a non-monotonic equilibrium when $b_1 = b_2 = \frac{1}{2}$. We divide the available messages of $\Gamma(B)$ into two sets of messages ϕ_1, ϕ_2 so there are in effect only two messages available to the senders. R's beliefs are as follows:

$$\mu(\theta|(\phi_1, m_2)) \sim U\left[\frac{1}{10}, \frac{2}{10}\right] \quad \forall m_2$$

$$\mu(\theta|(\phi_2, \phi_1)) \sim U\left[\frac{1}{10}, \frac{2}{10}\right]$$

$$\mu(\theta|(\phi_2, \phi_2)) \sim U\left[\left[0, \frac{1}{10}\right) \bigcup \left(\frac{2}{10}, 1\right]\right]$$

$$\mu(\theta = 0|\text{“}block\text{”}) = 1$$

Equilibrium strategies for the senders are then as follows:

$$\theta \in \left[0, \frac{1}{10}\right) \bigcup \left(\frac{2}{10}, 1\right], \quad s_1^1(\theta) = s_2^1(\theta) = \phi_2$$

$$\theta \in \left[\frac{1}{10}, \frac{2}{10}\right], \quad s_1^1(\theta) = s_2^1(\theta) = \phi_1$$

$$s_i^2 = \begin{cases} \mathcal{A}, & U^i(y^*(m_1, m_2), \theta, b_i) \ge U^i(0, \theta, b_i) \\ \mathcal{B}, & \text{otherwise.} \end{cases}$$

References

Battaglini, M. 2002. “Multiple Referrals and Multidimensional Cheap Talk.” *Econometrica* 70:1379–1401.

Bhattacharya, S., and A. Mukherjee. 2013. “Strategic Information Revelation When Experts Compete to Influence.” *RAND Journal of Economics* 44:522–544.

Chakraborty, A., and R. Harbaugh. 2007. “Comparative Cheap Talk.” *Journal of Economic Theory* 132:70–94.

Chen, Y. 2011. “Perturbed Communication Games with Honest Senders and Naive Receivers.” *Journal of Economic Theory* 146:401–24.

Crawford, V., and J. Sobel. 1982. “Strategic Information Transmission.” *Econometrica* 50:1431–51.

Dessein, W. 2002. “Authority and Communication in Organizations.” *Review of Economics Studies* 69:811–38.

Farrell, J., and R. Gibbons. 1989. “Cheap Talk with Two Audiences.” AER 79:1212–23.

Kartik, N., M. Ottaviani, and F. Squintani. 2007. “Credulity, Lies, and Costly Talk.” *Journal of Economic Theory* 134:93–116.

Krishna, V., and J. Morgan. 2001a. “Asymmetric Information and Legislative Rules: Some Amendments.” *The American Political Science Review* 95:435–52.

Krishna, V., and J. Morgan. 2001b. “A Model of Expertise.” *QJE* 116:747–75.

Ottaviani, M., and F. Squintani. 2006. “Naive Audience and Communication Bias.” *International Journal of Game Theory* 35:129–150.