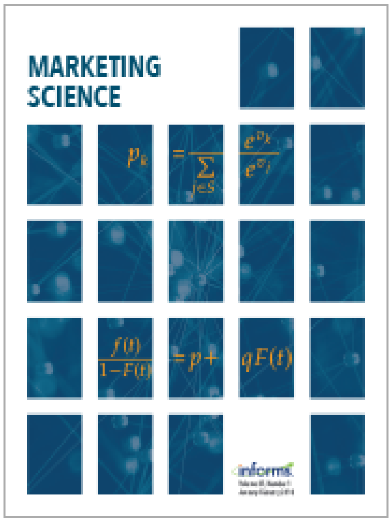

Marketing Science

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http://pubsonline.informs.org/journal/mksc/

MARKETING SCIENCE
Vol. 37, No. 5, September–October 2018, pp. 733–752
ISSN 0732-2399 (print), ISSN 1526-548X (online)

Tailored Cheap Talk: The Effects of Privacy Policy on Ad Content and Market Outcomes

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Received: May 9, 2017
Revised: October 6, 2017; April 10, 2018
Accepted: April 15, 2018
Published Online in Articles in Advance: October 18, 2018

https://doi.org/10.1287/mksc.2018.1102

Abstract. We consider a persuasion setting in which the sender of a message tries to elicit a desired action from a receiver by means of a compelling argument. To understand which arguments may indeed be compelling, the sender can use information about the receiver's preferences prior to the communication stage. We find that when the sender's motives are transparent to the receiver, communication is influential only if the sender is not well informed about the receiver's preferences. The sender prefers an interior level of information quality, whereas the receiver prefers complete privacy unless disclosure is necessary to induce communication. We also find that the parties may fail to trade at intermediate communication cost levels. In other cases, the content and cost of communication can affect market outcomes simultaneously. Finally, in general, the sender's first-best outcome involves pooling with unattractive sender types: the sender prefers to stay relatively guarded about which aspects he is knowledgeable about in order to hinder the receiver's discernment when topics he does not master are touched on. Our results are discussed in the contexts of matching markets, including online advertising, sales, expert advice, dating searches, and job searches.

History: Yuxin Chen served as the senior editor and Juanjuan Zhang served as associate editor for this article.

Keywords: persuasion • cheap talk • analytic models • marketing strategy • privacy policy

1. Introduction

Tailoring, the act of using information about an agent's preferences to improve persuasion, is a common matching ingredient in markets. Advertisers, salespeople, experts, job candidates, and romantic suitors put forth arguments to persuade their prospects of favorable match values. Because many of these claims are ex-ante unverifiable, the burden often lies with the sender to communicate in a way that merits a match in the eyes of the receiver. At the core of such persuasion efforts is a tension between information and communication effectiveness: when the sender is better informed, he is able to cater the communication to the receiver's preferences better. However, more information also increases the likelihood that the communication was tailored, potentially resulting in receiver skepticism.

In digital advertising markets, for example, firms tailor their communication in real time by users' search terms, demographics, cell phone usage/locations, browsing behaviors, device characteristics, etc. Personal selling agents, including automobile salespeople and real estate agents, also tailor their communication to individual buyers based on observable information, in hopes of inducing test drives and bids on properties. In job markets, applicants learn about employers and the activities they are expected to perform, and well-prepared applicants are likely to use such pieces of information during job interviews. Experts, negotiators, and romantic pursuers frequently use information about their counterparts to convince them of high match values.

Our focus is on cheap-talk communication settings (Crawford and Sobel 1982) with transparent motives, that is, settings in which communication is (at least immediately) unverifiable and in which the receiver is aware of the action the sender would like to induce (e.g., online advertisers seek clicks, job applicants seek placements).[1] We show that both parties may be hurt by the ability of the sender to identify the receiver's preferences. In particular, when the sender's motives are transparent to the receiver, we find that communication can only be influential if the sender is not very well informed about the receiver's preferences. The underlying intuition is that, when claims used in persuasion are not verifiable, the sender lacks commitment power to not say whatever he believes the receiver would like to hear. Put differently, ignorance provides persuaders with commitment power to not pander to the receiver's preferences.[2]

An equilibrium refinement, motivated by Farrell and Rabin (1996), allows us to focus primarily on the sender's communication policy, which is an object of primary concern in marketing contexts.[3] We find that uninformed senders communicate their types, whereas informed senders prefer to pool with uninformed senders at different rates, in order to shroud tailoring activities from the receiver. We find the sender and the social planner (e.g., a market maker or platform manager) are better off at higher levels of information, up to a threshold. Receivers, on the other hand, prefer complete privacy, except when information is pivotal for communication, in which case they prefer full disclosure. The welfare analysis has direct implications to the debate on data collection and privacy: in March 2017, the U.S. Congress voted to allow internet service providers to collect and distribute consumers' browsing behaviors to third parties.[4] Our results indicate that such policy has a positive impact in terms of total surplus, but that it benefits the demand side only to the extent that it allows firms to target niche/long tail consumers.

This paper makes contributions to a few literature streams. First, despite the extensive literature investigating settings with unverifiable communication, following Crawford and Sobel (1982), the marketing literature includes relatively few examples investigating the role of unverifiable communication: Wernerfelt (1990) considers the case in which consumers' brand choices are used as signals; Durbin and Iyer (2009) and Singh and Dai (2018) analyze truth-telling incentives in expert/customer interactions in the presence of reputational concerns; Gardete (2013) shows that information transmission is coarser at lower quality levels in vertically differentiated markets; Chakraborty and Harbaugh (2014) show that cheap talk can help sellers because of implicit trade-offs in emphasizing product attributes; and Gardete and Guo (2018) show that prepurchase information acquisition can induce communication credibility even in the presence of a homogeneous audience. We add to this literature by considering how the information environment and communication costs affect the sender's communication strategy as well as market outcomes.[5]

In the economics literature, limited attention has been paid to the implications of the information environment on market outcomes. Seidmann (1990) shows that when the receiver holds private information, cheap talk can be informative even when senders agree on the attractiveness ranking of the receiver's actions.[6]

Watson (1996) considers the case in which sender confusion may lead him to prefer to reveal his type truthfully. Barreda (2013) extends the Crawford and Sobel (1982) framework to allow the receiver to also hold private information. She finds that such information may hurt communication, in some cases making both agents worse off. Our main contribution to this literature is to characterize market outcomes as a function of the sender's informational advantage. In particular, in our setting, the sender may be informed about the receiver's otherwise privately known preferences. Being informed allows him to tailor the communication strategy.[7]

This paper also contributes to the literature on firm-side information acquisition and customer recognition. de Cornière and de Nijs (2016) consider the case of a platform that may release consumer valuation information to bidders in an advertising auction. Shen and Villas-Boas (2018) consider the case of a monopolist who uses first-period purchases to target advertising of another product at a later stage. Although these papers focus on modeling specific contexts, they do not address the role of information in communication and persuasion.[8]

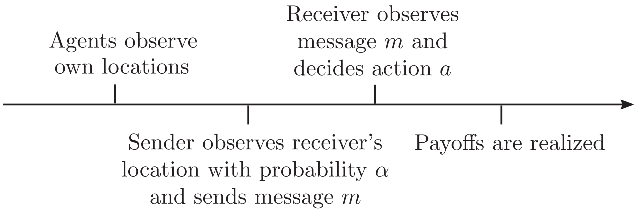
Our results also contribute to the literature on the interaction between cheap talk and costly signaling. Austen-Smith and Banks (2000) and Kartik (2007) consider the case of multidimensional signaling via cheap talk (Crawford and Sobel 1982) and burned money (Kihlstrom and Riordan 1984, Milgrom and Roberts 1986). They show that money-burning increases information transmission and that, except in knife-edge cases, it cannot expand the set of environments in which cheap talk is influential. Our setting is somewhat different in that the sender decides whether to incur a communication cost in order to communicate with the receiver. We find that both the cost and the content of communication can be informative simultaneously. Moreover, in some cases, trade breaks down at intermediate communication cost levels.[9]

The following section presents the main model and findings. Section 3 extends the analysis to consider the case of nontransparent motives. Section 4 provides a synthesis of the results and draws marketing and privacy policy implications. Section 5 analyzes the robustness of the findings and Section 6 concludes. Readers interested in general aspects related to cheap-talk communication may wish to refer to Appendix A for results established under a general preference structure and distribution over agent types.

2. Model

We now turn to the main analysis of the paper. We consider the case of agents uncertain about the fit they receive from matching. In this case, each agent has a unique optimal matching profile, and so the model captures the role of tailoring in horizontal differentiation settings. We also allow agents to differ on the vertical dimension, which is often easier to commit to and verify in matching markets. The model allows a precise characterization of (1) the sender's communication

Figure 1. Timing



policies; (2) the implications of communication costs; (3) the effects of the information level on the agents' welfare; and (4) market outcomes when the sender features nontransparent motives.

2.1. Preliminaries

Consider a persuasion setting in which a sender attempts to induce a match from a receiver through communication. The receiver and the sender can earn matching payoffs $u^R(\theta, q)$ and $u^S(\theta, q)$, where $\theta \in \Theta$ and $q \in Q$ index the receiver and sender types, respectively. If the sender fails to induce a match by the receiver, both parties earn payoffs of zero.

Agents' types are distributed by the joint probability distribution $F_{\theta,q}$, which is common knowledge. The sender is informed about the receiver's type θ with probability α. The level of information α is public, but the actual realization of whether the sender becomes informed is his own private information.[10] Finally, persuasion is conducted by use of a message $m \in Q$, communicated by the sender to persuade the receiver of the merits of the match.

The timing of the game is given in Figure 1. First, the sender and the receiver learn their respective types. Second, the sender learns the receiver's type with probability α and decides on a message m. Upon observing the message, the receiver decides whether to match, and payoffs are realized. We focus on perfect Bayesian equilibria (PBE), such that agents maximize their utilities given their beliefs, and on-equilibrium path beliefs are given by Bayes' rule at each information set. The latter requirement implies that the receiver's beliefs about the sender's type are consistent with the distribution induced by the communication policy. The receiver forms beliefs about the sender's type conditional on two pieces of information: her own type θ and the sender's message m. PBE implies

$$\widehat{f_{q|\theta,m,\alpha}} = \frac{f_{m^*|\theta,q,\alpha} \cdot f_{q|\theta}}{f_{m^*|\theta,\alpha}}. \tag{1}$$

Density $\widehat{f_{q|\theta,m,\alpha}}$ denotes the receiver's beliefs, and $f_{m^*|\theta,q,\alpha}$ is the probability density induced by informed and uninformed senders' equilibrium communication policies, $m_I^*(\theta, q)$ and $m_U^*(q)$, respectively.[11]

We focus on cases in which (1) the sender has transparent motives and (2) communication is influential. The first criterion implies that the sender is willing to match with all receiver types. It is operationalized by

$$u^S(\theta, q) \geq 0, \forall \theta \in \Theta, q \in Q. \tag{2}$$

Hence, transparent motives imply that the receiver understands that the sender always benefits from inducing a match.

The requirement that communication is influential ensures the receiver needs to, and can be, persuaded to match. It is operationalized by

$$E(u^R(\theta, q) \mid \theta) < 0, \forall \theta \in \Theta \tag{3}$$

and

$$\exists \theta \in \Theta, Q' \subset Q : E(u^R(\theta, q) \mid \theta, q \in Q') \geq 0. \tag{4}$$

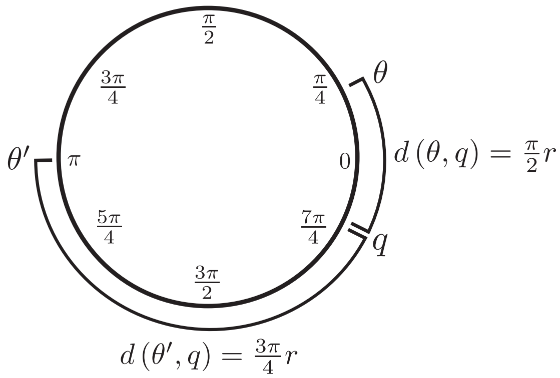
The first inequality guarantees we focus on receivers who need to be persuaded. The second inequality ensures that communication can induce trade from strategic agents, at least in some cases. Finally, we ignore "babbling" equilibria throughout the analysis, such that the receiver always ignores the message of the sender, ascribing it to uninformative randomization, and the sender becomes indifferent across all possible communication policies, including the one the receiver expects.

For the present analysis, we assume that if the receiver matches, she earns utility $u^R = v^R - d(\theta, q)$ and the sender earns utility $u^S = v^S - d(\theta, q)$, where v^R and v^S are positive and $d(\theta, q)$ is a distance function. (We include the analysis of a model with general preferences and distribution over types in the appendix. Although more technical, it provides a general result on the highest level of information supporting credible communication in cheap-talk communication with transparent motives.) The distance function can be understood in light of specific contexts. In online advertising markets, for example, the sender of the message is a firm advertising its product and the receiver is a consumer. In this case, the receiver's distance function has the natural interpretation of consumer/product fit. Moreover, the sender also has preferences over different consumers, because not all consumers who click on an ad impression will necessarily buy the product upon visiting the seller's website.[12]

During the main analysis we also assume that the sender and the receiver are independently located along a preference circle with uniform probability: the receiver's location is given by $\theta \sim U[0, 2\pi)$, and the sender's location is given by $q \sim U[0, 2\pi)$.[13]

The vertical components v^R and v^S are observable to both agents and can be interpreted by two different perspectives. First, they capture each agents' relative preference for a match versus the outside option. For example, in a bargaining situation between parties, gross utilities v^R

Figure 2. Illustration of the Distance Function $d(\theta, q)$



and v^S measure the relative preference for a given proposal versus the outside option (e.g., prolonging negotiations).

A second perspective is that v^R is earned by the receiver because of the sender's type and vice versa. For example, a seller certification can be seen as credible information of a seller's average value to a potential buyer. As such, v^R captures the average utility the customer should expect if she buys from the seller/persuader. This interpretation applies to a number of settings because verifiability mechanisms often arise in markets to measure vertical dimensions. These include posting price information through marketing materials, sharing pictures in the housing and dating markets, etc. In turn, cheap-talk communication often applies to horizontal components, which are less systematic and more difficult to verify, such as product fit in retail markets and preferences and values in dating markets.

The uncertain horizontal dimension is captured by the distance function $d(\theta, q)$, which represents the preference mismatch between the sender and the receiver. It can be intuitively understood as the shortest angular distance between θ and q, multiplied by scalar $r > 0$.[14] Figure 2 provides a representation. Parameter r captures the market differentiation level and simultaneously affects the match values of the sender and receiver by introducing a distance penalty. For example, in markets with large differentiation, which may be "thin" and/or exhibit long tails, r is large and parties expect to earn relatively low payoffs from matches on average.

The sender's message is denoted by m and lies in the circular domain $[0, 2\pi)$, and the publicly observed information level is $\alpha \in [0, 1]$.

In cheap-talk models, the space of receiver beliefs is generally large and often unproductive as a starting point for the analysis. To illustrate this, consider the extreme example in which receivers believe attractive senders select messages equal to "the rational number closest to their own locations, for which the second decimal digit is a prime number." Despite the arbitrariness of this rule, informed senders would then have an incentive to pool at these locations, giving rise to informative equilibrium outcomes. While theoretically valid, these outcomes are unappealing in terms of interpretation of the messages they produce. To make predictions about the content of messages more realistically, we borrow an insight from Farrell and Rabin (1996, p. 108), who argue that the literal meaning of messages is a focal starting point for receivers: "People don't usually take the destructively agnostic attitude that 'I won't presume that the words mean what they have always meant.' Rather, people take the usual or literal meaning seriously. This doesn't mean they believe whatever they hear; rather, they use the usual meanings as a starting point and then assess credibility, which involves asking questions such as, 'Why would she want me to think that?'"

We use the statement above to suggest that it is focal for receivers to interpret the distance of a message to their location as a claim about the value of the match. We adopt the following refinement:

Refinement (Farrell and Rabin). *An equilibrium satisfies refinement FR if, whenever a receiver θ is willing to match upon receiving a message at distance $d(\theta, m) = \Delta_1$, then she is also willing to match if she receives a message at a shorter distance, that is, in cases in which $d(\theta, m) = \Delta_2, \forall \Delta_2 \in (0, \Delta_1)$.*

The statement provides a belief ordering that induces a set of persuasive messages $M_\theta = \{m : d(\theta, m) \le \Delta\}$, for some $\Delta \ge 0$. In the respective equilibria, messages can be interpreted as claims about match values. Finally, in cases in which the receiver prefers never to match, we define M_θ as empty whenever $\Delta = 0$.[15]

Focusing first on a specification of Δ facilitates the analysis and allows us to characterize the agents' welfare as a function of the information level. In particular, we focus on the candidate parameterization $\Delta = \mathbf{1}(\alpha \le \bar{\alpha}).v^R$. The information threshold component $\mathbf{1}(\alpha \le \bar{\alpha})$ is motivated by Theorem A.1, presented in Appendix A, which shows that there always exists a level of information $\bar{\alpha} \in (0, 1)$ over which no communication is credible. The component v^R is informed by the fact that senders are attractive to the receiver as long as they are located in set $\{q : d(\theta, q) \le v^R\}$. We consider the general case of Δ in Section 2.4.

In this section, we also ignore welfare-destructive beliefs that imply the sender communicates in such a way as to never produce matches, even though there exist communication policies that would make matching attractive to both parties. We refer to these cases as fatalistic equilibria. These outcomes are related to the babbling equilibrium in that the sender becomes indifferent among all communication strategies, including the one the receiver expects, because no message can produce matches. The difference to babbling equilibria is that, albeit also inconsequential, communication can be informative in fatalistic equilibria.[16]

Under the current specification, the assumption that communication is influential implies

$$v^R < \frac{\pi r}{2} \quad (5)$$

and the assumption about the sender holding transparent motives implies

$$v^S \geq \pi r. \quad (6)$$

We extend the analysis to the case of nontransparent motives in Section 3.

2.2. Analysis

Consider first the case of costless communication. Immediately before sending the message, the sender can be in one of two states: with probability α he knows the receiver's location, and with probability $1-\alpha$ he does not. When the sender knows the location of the receiver, his match utility is given by

$$u^S_{Info} = \max_m \mathbf{1}(m \in M_\theta)(v^S - d(\theta, q)). \quad (7)$$

In this case, the sender is indifferent across messages in M_θ because all of them are successful in inducing his preferred action.

For some generic maximum matching distance Δ, an uninformed sender chooses the message that maximizes his expected utility:

$$\begin{aligned} u^S_{NoInfo} &= \max_m E(\mathbf{1}(m \in M_\theta)(v^S - d(\theta, q)) \mid q) \quad (8)\\ &= \max_m \frac{1}{2\pi}\int_{d(\theta,m)\leq\Delta} v^S - d(\theta,q)d\theta \\ &= \max_m \frac{1}{2\pi}\int_{m-\frac{\Delta}{r}}^{m+\frac{\Delta}{r}} v^S - d(\theta,q)d\theta. \end{aligned}$$

Differentiation w.r.t. m yields the first-order condition:

$$d\left(m^* + \frac{\Delta}{r}, q\right) = d\left(m^* - \frac{\Delta}{r}, q\right). \quad (9)$$

The optimal message is given by $m^* = q$ and minimizes the expected distance to a receiver located at θ. Intuitively, when the sender does not know the receiver's location, he is better off attracting a local receiver than one located far away. Consequently, in this case, the sender is better off revealing his type truthfully. Applying Theorem A.1 (presented in Appendix A), it is possible to establish the following result:

Corollary 1. *Under transparent motives, trade occurs if and only if*

$$\alpha \leq \bar{\alpha} \equiv \left(\frac{v^R}{\pi r - v^R}\right)^2, \quad (10)$$

and the set of persuasive messages is given by

$$M_\theta = \{m : d(\theta, m) \leq \mathbf{1}(\alpha \leq \bar{\alpha}).v^R\}.$$

This first part of the result is a direct application of Theorem A.1: Because uninformed senders report their types truthfully, existence is assured as long as $\alpha \leq \bar{\alpha}$. As for the second part, as we explain in Appendix B, information cutoffs falling below $\bar{\alpha}$ can only be induced by fatalistic beliefs; that is, the receiver would need to believe that, at particular levels of information, the sender communicated ''in the worst possible way'' for both parties: attractive informed senders would pool with unattractive uninformed ones, and unattractive informed senders would pool with attractive uninformed ones, so as to always make the utility from matching negative. However, the sender should be able to convince the receiver otherwise, because no party can benefit from such communication policy.

Because our focus is also on the characterization of the content of messages, we derive a communication policy that can generate the set of persuasive messages M_θ. We have already established that when the receiver's location is known, the sender selects a message within M_θ; otherwise, the sender prefers to reveal his location truthfully. The optimal communication policy induces a probability density:

$$f_{m^*|\theta,q,\alpha} = \alpha\phi_{m|\theta,q,\alpha} + (1-\alpha)\delta(m-q), \quad (11)$$

where $\phi_{m|\theta,q,\alpha}$ describes a mixing message policy of an informed sender, and $\delta(\cdot)$ is the Dirac-delta ''density'' function, representing a mass point.

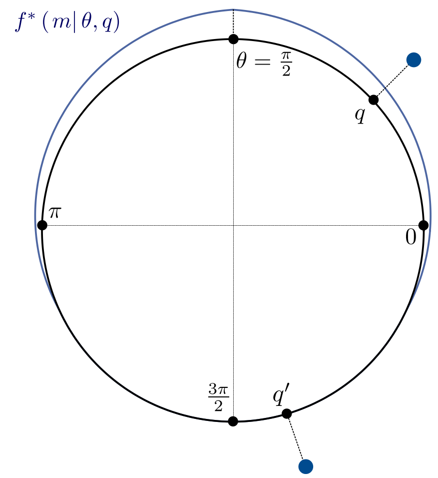
We obtain the following result:

Theorem 1 (Communication Policy). *The equilibrium set of persuasive messages $M_\theta = \{m : d(\theta, m) \leq \mathbf{1}(\alpha \leq \bar{\alpha}).v^R\}$ can be induced by communication policy (and consistent receiver beliefs)*

$$\begin{aligned} f^*_{m|\theta,q,\alpha} = {} & \alpha\frac{1-\bar{\alpha}}{\bar{\alpha}}\frac{v^R - d(\theta,m)}{\pi(\pi r - 2v^R)}\mathbf{1}(d(\theta,m) \leq v^R) \\ & + (1-\alpha)\delta(m-q), \alpha \leq \bar{\alpha}. \quad (12) \end{aligned}$$

The result states that the set of persuasive messages M_θ can be induced by a communication policy that samples from different messages at different rates. Figure 3 presents an example. Informed senders sample from persuasive messages near the receiver's location more frequently, while uninformed senders prefer to reveal their locations. The support of the mixing region of informed senders is given by $\{m : d(\theta, m) \leq v^R\}$. Mixing across this region enables informed senders to pool with attractive uninformed types to the largest extent possible, conditional on α. While informed senders are always successful in inducing matches, this does not

Figure 3. (Color online) Example of Sender's Communication Policy



Notes. The informed sender's communication policy assigns higher weight to messages near the receiver along support $\{m : d(\theta, m) \le v^R\}$. Uninformed senders located at q or q', in particular, reveal their locations, represented by mass points.

hold for uninformed ones, as shown by the case of sender q' in Figure 3. Hence, the receiver should be doubtful of a seemingly persuasive message, but can always trust the credibility of an unappealing one.

Finally, we characterize comparative statics as a function of the level of information. The sender's ex-ante utility is given by

$$E(U^S) = \alpha E(v^S - d(\theta, q) \mid q) + (1-\alpha)\Pr(q \in C_\theta)E(v^S - d(\theta, q) \mid q, q \in C_\theta), \quad (13)$$

where C_θ is induced by M_θ, and is given by $\{q : d(\theta, q) \le \mathbf{1}(\alpha \le \bar{\alpha}).v^R\}$. Similarly, the receiver's ex-ante utility is given by

$$E(U^R) = \alpha E(v^R - d(\theta, q) \mid \theta) + (1-\alpha)\Pr(q \in C_\theta)E(v^R - d(\theta, q) \mid \theta, q \in C_\theta). \quad (14)$$

Under transparent motives (i.e., $v^S \ge \pi r$), analysis of expressions (13) and (14) provides the following result.

Proposition 1 (Comparative Statics). The receiver is better off with a lower level of information, whereas the sender prefers a higher level, up to $\bar{\alpha}$.

As the level of information increases, so does the frequency with which informed senders pool with attractive uninformed ones. Hence, the receiver prefers full privacy, whereas the sender prefers information level $\bar{\alpha}$, that is, the maximum amount of information the receiver is willing to bear. We later describe the comparative statics more generally, including the case in which the sender does not hold transparent motives, and also investigate the social planner's optimal level of information.

2.3. Costly Communication

In most settings, the sender decides whether he should incur a cost $c > 0$ in order to communicate with the receiver. When c is high enough, two forces are in play. First, uninformed senders may refrain from communication. Second, informed senders located far away from the receiver may also refrain from communication. The first effect is generally negative for the receiver whereas the second one is positive. The rates at which each type of sender refrains from communication may be different, leading to different possible outcomes.

We first examine a case in which credible communication may fail because uninformed senders refrain from communicating at intermediate levels of c. Define c_U^* as the cost threshold that makes uninformed senders indifferent between communicating and not. Moreover, because distant informed senders refrain from communicating as the cost increases, there exists a cost level c_R^* that makes the receiver indifferent between matching exclusively with informed senders and not matching. When the agents' valuations are sufficiently different, we obtain the following result:

Proposition 2 (Existence of Trade and Costly Communication). *Trade cannot occur when the communication cost is intermediate, $c \in (c_U^*, c_R^*)$, if $v^S \ge \frac{4\pi r - v^R}{2(\pi r - v^R)} v^R$.*

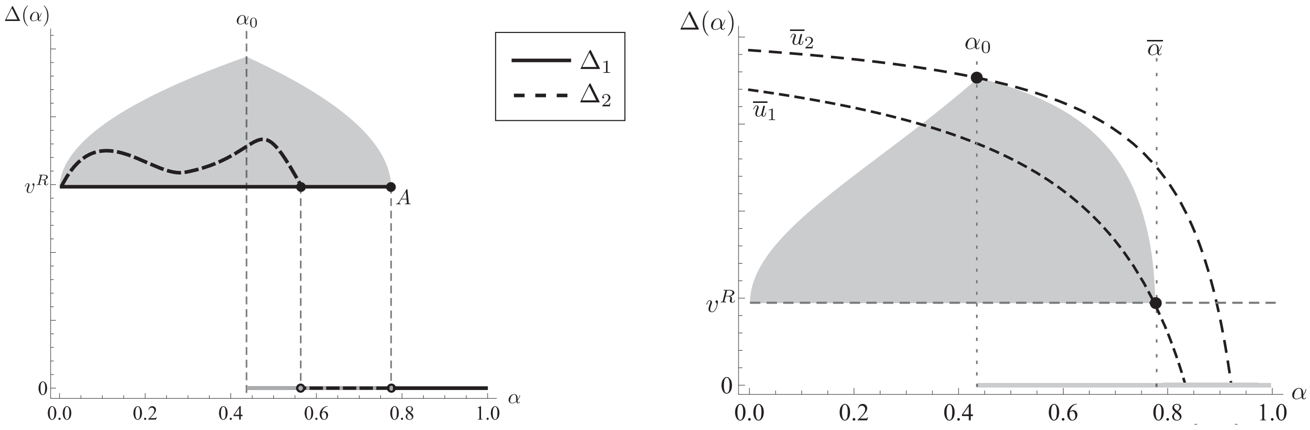
When v^S is relatively higher than v^R, the forces mentioned above play out in the following way. On one hand, uninformed senders refrain from communication because the probability of trade is low, given the low value of v^R. On the other hand, too many unappealing informed senders prefer to communicate, because they can earn a high gross match utility v^S if they can induce a match. In this case, trade breaks down irrespective of the level of information available to the sender.

When the communication cost falls outside interval (c_U^*, c_R^*), communication can support trade again. The intuition for low communication costs is the same as when $c = 0$. When communication costs are high, $c > c_R^*$, the receiver is also willing to match because senders can credibly signal that they provide enough utility from matches. In this case, trade relies solely on the communication cost and not on content, which is in line with the literature on money burning.

When the valuations of the agents are not too different, the content and cost of communication play different roles:

Proposition 3 (Roles of Message Cost and Content). *The communication cost affects the types of informed senders willing to communicate, whereas the content of the message affects the types of uninformed senders who are able to induce matches, if $v^S < \frac{2(\pi r)^2 - (v^R)^2}{2(\pi r - v^R)}$.*

Figure 4. Set $\mathcal{S}_\Delta$ as a Function of α (Left); Sender's Indifference Curves (Right)



The intuition for this result is as follows: at certain levels of the communication cost, a few unattractive informed senders may refrain from communication. However, the remaining senders still need to convey attractive messages in order to induce matches, which uninformed senders may fail to do. In this case, the receiver's beliefs as well as the match probabilities are affected by both the content and the cost of communication: the cost of communication determines the types of *informed* senders in the market, whereas the content of communication is used by the receiver to identify *uninformed* senders who do not merit a match. The result is that both the cost and the content of communication affect market outcomes through distinct mechanisms.

2.4. Generalized Matching Distance

We have characterized situations in which the receiver's beliefs induce a critical set $M_\theta = \{m : d(\theta, m) \le \Delta\}$, where $\Delta = \mathbf{1}(\alpha \le \bar{\alpha})v^R$. In general, the maximum distance Δ is a *function of the receiver's beliefs* about the sender's communication policies at different parameter values. For example, in some settings the receiver may have reason to believe that the sender changes the communication policy as a function of the information level, such that Δ is a more complex function of α. We provide a general characterization of beliefs and consistent communication policies when Δ is allowed to depend on the level of information. Per standard procedure, we first fix beliefs and then verify whether they can support Bayesian equilibrium. We focus on sequential equilibria, as defined by Kreps and Wilson (1982), in order to impose restrictions on the allowable off-equilibrium path beliefs. We obtain the following result:

Theorem 2 (Belief Characterization). *Under the sequential equilibrium refinement, the set of maximum matching distances is characterized by $\mathcal{S}_\Delta$ (defined in Appendix B).*

Theorem 2 establishes the set of distances $\mathcal{S}_\Delta$ that can be induced by receiver's beliefs. The left panel of Figure 4 depicts set $\mathcal{S}_\Delta$ as a shaded region, for possible levels of the information level α.

The shaded area describes the matching distances that can be supported by beliefs, as a function of the level of information α. For example, when $\alpha = 0$, the shaded area is a singleton equaling v^R. To see that v^R is the only allowable matching distance in this case, note that when the sender is uninformed with certainty, he prefers to reveal his type, and so the receiver is willing to match with messages located up to distance v^R. This distance increases up to α_0 and then decreases as α increases: at higher levels of information, the receiver may be willing to match when she receives farther messages, potentially supported by the belief that nearby attractive informed senders claim to be relatively far away.

The general properties of the triangle-like shape of $\mathcal{S}_\Delta$ are as follows. First, note that no strictly positive distance can occur below v^R in equilibrium.[17] Note that if the matching distance fell below v^R, this would imply that the receiver believed that unattractive informed senders would have pooled within the same region to the extent of rendering some messages unattractive, which cannot yield an equilibrium. Strikingly, the receiver may be willing to entertain messages farther away than v^R. This occurs whenever enough attractive informed senders select messages outside interval $\{m : d(\theta, m) \le v^R\}$. For example, when α increases from low levels, unattractive informed senders can pool close to the receiver's location with no effect to the matching distance. Attractive informed senders can pool just outside region $d(\theta, m) \le v^R$ and increase the matching distance as a result. As α increases, the size of the set of informed senders that can pool outside region $d(\theta, m) \le v^R$ increases as well.

The greatest matching distance is given by

$$\bar{\Delta} = \frac{\pi r v^R}{\pi r - v^R}, \tag{15}$$

which is attained at information level α_0, as shown in Figure 4. Beyond α_0, the maximum matching distance decreases because too many unattractive informed types pool with attractive uninformed senders within region $d(\theta, m) \leq v^R$, and, as a result, attractive informed senders cannot pool as far as before.

We depict two belief paths on the left panel of Figure 4. Path Δ_1 was the one examined in the previous section: receivers are willing to match as long as they observe a message within distance v^R and $\alpha \leq \bar{\alpha}$. Path Δ_2 is nonmonotonic on α, up to $\bar{\alpha}$. It is consistent with the belief that informed senders change their communication strategies as a function of the information level.

We plot the sender's indifference curves in the right panel of Figure 4. Clearly, the sender can do better than with level of information $\bar{\alpha}$:

Proposition 4 (Sender's First-Best Outcome). *The sender's first-best outcome is achieved at level of information $\alpha_0 < \bar{\alpha}$ (defined in Appendix B), under beliefs that induce the maximum matching distance $\bar{\Delta}$.*

Beliefs allowing, the result above states that the sender's first-best information level of information falls strictly below $\bar{\alpha}$, even if the receiver is willing to trade at higher information levels. The underlying intuition is that, by limiting the level of information to $\bar{\alpha}$, the sender is able to maximize the matching distance Δ.

Uninformed senders reveal their types as before. However, in this case, informed senders engage in a more complex communication policy: first, unattractive informed senders pool with attractive uninformed senders to the furthest extent possible, and second, attractive informed senders pool with unattractive uninformed ones, just enough to make them attractive.

Finally, the reason that the sender benefits from being believed to pool with unattractive ones is that the probability of a match increases as a result; because the sender can now induce matches even when he is slightly unattractive to the receiver. We develop the intuition further in Section 4.

3. Nontransparent Motives

We now investigate cases in which v^S can be lower than πr, such that the sender may not always want to induce a match. We return to the case in which $c = 0$, and $M_\theta = \{m : d(\theta, m) \leq \mathbf{1}(\alpha \leq \bar{\alpha}).v^R\}$. We consider the effects of the information level on the welfare of the sender, the receiver, and of the social planner.

When the sender does not hold transparent motives ($v^S < \pi r$), he is no longer willing to communicate in some cases: informed senders prefer not to communicate with distant receivers, and become indifferent at locations defined by

$$\begin{aligned} & E(u^S \mid Informed) &= 0 \\ \Leftrightarrow \quad & v^S - d(\theta, q_{Indifferent}) &= 0 \\ \Leftrightarrow \quad & d(\theta, q_{Indifferent}) &= v^S. \end{aligned} \tag{16}$$

As v^S decreases, the sender is able to increase the level of information beyond $\bar{\alpha}$, taking advantage of the fact that the receiver knows that messages no longer originate from distant informed senders. In Appendix B, we show that when $v^S \leq 2v^R$, the sender is able to collect perfect information about the receiver because the latter understands only few unappealing informed senders engage in communication. Formally, the first-best level of information of the sender is given by

$$\alpha_S^* = \begin{cases} 1, & v^S \leq 2v^R \\ \max_{v \in \{v^S, \pi r\}} \left(\dfrac{v^R}{v - v^R}\right)^2, & v^S > 2v^R \end{cases}$$

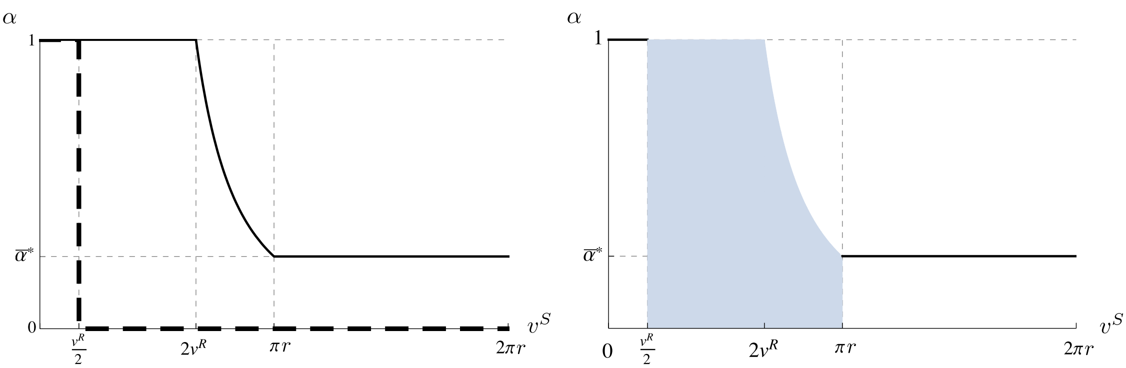
as depicted by the solid line on the left panel of Figure 5. Intuitively, the sender's first-best level of information is the highest one that ensures the receiver earns nonnegative ex-ante utility.

We have already shown that, under transparent motives, the receiver prefers not to disclose any information, so as to induce perfect revelation by the sender. However, when the valuation of the sender is low ($v^S < \frac{v^R}{2}$), the sender cares about the quality of the match enough that he is only willing to communicate if he is informed. In this case, the receiver prefers to reveal all information in order to maximize the likelihood of matching. We depict the result in the dashed line of the left panel of Figure 5.

Consider now the cases of regulators overseeing market interactions that involve persuasion, of private firms managing two-sided markets, and of search engines matching advertisers to buyers. These agents may prefer to affect the amount of information available in order to maximize joint welfare. The optimal information policy depends on the sender's valuation, and is depicted in the right panel of Figure 5.

When $v^S < \frac{v^R}{2}$, the sender is only willing to communicate if he is informed. In this case, all agents prefer there to be perfect information about the receiver's preferences. When the sender's valuation is high, $v^S > \pi r$, the sender's high value from matching offsets possible ex-post losses from the receiver, and so the optimal information level is equal to the sender's first-best level of information, $\bar{\alpha}$. Finally, in the intermediate range $v^S \in [\frac{v^R}{2}, 2v^R]$, changes to the level of information exactly transfer utility between the agents, as long as the receiver's participation constraint is satisfied, and no aggregate welfare effects result.[18] The intuition for this case is that when the information level increases

Figure 5. (Color online) First-Best Information Levels



Notes. Solid and dashed lines on the left panel represent first-best information levels for sender and receiver, respectively. The right panel represents the correspondence that maximizes joint welfare.

from low levels, a few informed sender types that are unattractive to the receiver become informed and are able to induce matches, and the sender's incremental gains equal the receiver's losses.

Overall, the fact that the sender's optimal information level is also optimal for the social planner derives from two reasons. First, trade generates a net surplus in the market and second, the receiver's ex-ante payoff is bounded below by zero, the value of the outside option. We summarize these results by the following proposition:

Proposition 5 (Welfare Comparative Statics). *The sender always prefers the maximum amount of information level the market can bear. The receiver prefers full privacy, unless information is pivotal for communication, in which case she prefers full disclosure. The optimal level of information for the sender is also optimal for the social planner.*

Finally, it is worth interpreting the results under the perspective that the parties' valuations depend on the types of their counterparts. In this case, valuation $v^S(v^R)$ is interpreted as the commonly known ability of the receiver (sender) to provide a high match value to her counterpart. Our results imply that high-type receivers (who provide a high v^S to the sender in case of a match) should refrain from disclosing preference information because they will always be communicated to, whereas low-type receivers (low v^S) prefer to reveal their preferences completely in order to induce communication by interested senders. This is consistent with the dating market, for example, where v^S is an observable measure of attractiveness of the receiver. In this case, the receiver should refrain from communicating, that is, sharing likes and dislikes, for example, to elicit truthful communication about the sender's preferences. If in contrast the receiver announced her type, she would hear exactly what she would like to hear, but be able to trust little of it. In comparison, a receiver that produces a lower match value to the sender is better off sharing personal information in order to elicit communication.

4. Marketing and Privacy Policy Implications

We have developed a model of one-to-one communication, in which a sender attempts to induce a favorable action from a receiver. While, in the past, the primary example for such settings may have been personalized sales, recent technology developments in data gathering and storing have since allowed personalized communication at scale through online advertising.[19] These trends naturally lead to the question of how much consumer data advertisers should be allowed to collect, and when it is worth for consumers to allow their data to be collected. Our main result is that allowing too much data collection can hurt all market agents. The idea that too much information may hurt market performance has previously been proposed in the literature, albeit due to different mechanisms. Levin and Milgrom (2010) propose, among other arguments, that sharing high quality information with firms can lead competition to disperse in online advertising markets and increase transaction costs. This explanation rationalizes why advertising platforms disclose a relatively small share of the consumer information they hold to its participants. Our research suggests that another peril of sharing very high quality targeting information with advertisers is that ad content may become less credible and persuasive to consumers.

Our research finds that regulators may prefer to take different actions depending on the social metric they would like to maximize. Under the joint welfare maximization criterion, it is optimal to allow firms themselves to determine information collection policies. This is consistent with the rollback of broadband privacy rules approved by U.S. Congress in March 2017.[20] Among other things, this legislation allows internet service providers to sell consumer behavioral information to advertisers and other players. Despite this, the deregulation has not stopped industry efforts in providing consumer control over behavioral targeting. For example, the Digital Advertising Alliance self-regulatory program has instituted the AdChoices link, which allows consumers to understand the types of data being used for advertising targeting and opt out from behavior-based targeting.[21]

Notwithstanding the above, our research does document that consumer interests may not always be aligned with those of advertisers. If consumer welfare maximization is used as a criterion, regulators should allow consumers to control the amount of information available to advertisers. Our work suggests a "bang-bang" privacy policy is best for consumers. Specifically, they should engage in full disclosure only when they would like to induce communication by sellers. For example, they are better off revealing preferences for niche products served by firms with limited advertising budgets. In contrast, consumers would not benefit by sharing their preferences for mainstream products. In such cases, revealing preference information has little impact on advertising exposure, but provides tailoring information which can affect consumers negatively.

Our results are also related to a long stream of literature on price discrimination and its effects on consumers and firms. This literature has found that preference sharing (or leaking) may induce a "ratchet effect," by which consumers who have revealed higher valuations may also pay higher prices.[22] Our results show that consumers may also become worse off by revealing preference information, due to communication tailoring by firms. When they do benefit from sharing preference information (as discussed above), they should consider whether the firm engages in price discrimination and, if so, whether the benefits of preference revelation outweigh the costs. With or without price discrimination, our recommendation for consumers is that they should share the necessary information to induce communication, but no further.

An important assumption in our model is that both the sender and the receiver care about the types of their counterparts. While this is a natural assumption for consumers in most markets, it is worth describing why sellers may exhibit matching preferences as well. The intuitive reason for this assumption is that buyer/seller interactions do not typically terminate immediately after a match takes place, but are often followed by postmatch allocation stages. For example, a consumer who clicks on an online advertiser's link has to subsequently decide whether to buy a product. Because of this, the advertiser prefers inducing clicks from consumers who are more likely to buy his product, and consumers would also like to click on advertisements of firms carrying offerings they like. More generally, sellers are likely to have more heterogenous preferences over the types of consumers they face early in the marketing funnel, because they would like to attract consumers who are likely to progress through the subsequent stages as well. For example, automobile salespeople would like to attract to the dealership consumers who are likely to agree to take a test drive, and once at the dealership, sellers would like to offer test drives to consumers who are likely to subsequently buy. In this case, a "match" in the model is the act of a seller successfully transitioning a consumer down the purchase funnel. Similarly, postpurchase behaviors may also determine seller preferences over different types of consumers: some consumers may return products and/or ask for refunds; other consumers may demand additional services (such as technical support time) that are costly for firms; yet other consumers may exhibit lower value in terms of future sales; for example, less satisfied customers may be less likely to purchase in the future.[23]

Related to this point, while different markets rely on different allocation rules (e.g., auctions in real estate, bargaining in automobile sales), the common aspect is that at each marketing funnel stage, agents hold expectations over future payoffs. Rather than modeling the ultimate payoff-splitting rules, we have focused on the payoffs agents expect to earn if a match, or a step forward, is produced. This assumption allows us to focus on the role of information in persuasion separately from the sender's increased ability to extract value.[24]

We have considered the role of communication costs simultaneously with content. As expected, these costs are irrelevant when they are low, and effectively determine matches when they are high. The market outcomes are less intuitive at intermediate levels: when the agents' valuations are far apart, uninformed senders are discouraged from communication at a higher rate than unattractive informed senders. As a result, the receiver understands that the message is likely to have been tailored, and trade relying on cheap-talk communication breaks down. When the agents' valuations are relatively similar, the cost and content of communication affect market outcomes simultaneously: the content of the message affects the types of uninformed senders who are able to induce matches, whereas the communication cost affects the types of informed senders who are willing to communicate. The findings are of consequence to market makers and managers in charge of two-sided platforms, because changes in institutional settings related to communication and advertising costs can have nonmonotonic implications to the occurrence of matches.

Finally, we have considered a generalized distance case, in which the receiver understands that the seller may change his communication strategy depending on the quality of the information available. The result survives common equilibrium refinements as well as changes to the modeling assumptions. As such, it is worth considering what this result means in the context of market communication. A striking feature of this result is that the beliefs that maximize the sender's payoffs involve attractive sender types pooling with unattractive ones. The reason these are beneficial for the sender is that they increase the match probability in cases in which the sender is uninformed. For example, under these beliefs, a salesperson with an attractive offering for a given consumer is better off underplaying the product benefits, while a less attractive offering should be played up in order to convince the consumer of the merits of the match. Taken together, these strategies reduce the ability of the receiver to discern the merits of the argument across cases and increase the probability of a match to the seller on average.

5. Robustness

5.1. Truth-telling by Uninformed Sender Types

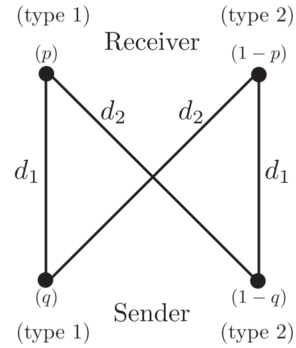
In the main analysis above, uninformed sender types maximize their expected utilities by reporting their locations truthfully. The result follows partly from the (circular) uniform receiver preference assumption. It is useful to consider the extent to which this communication strategy holds when different preference distributions are considered.

The first reason uninformed senders may be willing to reveal their types despite facing nonuniformly distributed receivers is when they face a misrepresentation penalty with positive probability from a regulatory entity, for example. For moderate levels of this penalty, it is straightforward to construct informative equilibria where only informed senders misrepresent, as before. The reason is that, unlike uninformed senders, informed senders are certain they can induce a match with the receiver.

In other contexts, however, such punishment mechanisms may be unrealistic in practice. For example, in cases like personal sales or contract negotiations, some degree of misrepresentation may be communicated in private, verbally, and/or through nuanced language, making regulation implementation challenging. Moreover, even if misrepresentation were proven to have occurred, the sender could in some cases claim he faced a strategic receiver who knew full well the distribution of utilities she faced. Finally, in some cases, punishing senders who engage in misrepresentation may be undesirable altogether, as suggested by the result in Proposition 5 that the social planner should allow for the sender's first-best information level (and misrepresentation) if she aims to maximize joint welfare.

These reasons lead us to further investigate the robustness of the truth-telling result with a two-type sender/receiver model in which agents are nonuniformly distributed. Let each receiver/sender belong to one of two types, 1 and 2. Like in the main model, both receiver and sender earn gross utility v^S and v^R from a match. They also face matching disutilities, as depicted in Figure 6.

Figure 6. Matching Disutilities



Sender/receiver combinations of the same type face matching disutility of d_1, and sender/receiver combinations of different types face matching disutility d_2, where $d_2 > d_1 > 0$. Moreover, let senders (receivers) be of type 1 with probability p (q). Transparent motives in this case imply that $v^S - d_2 > 0$, such that senders always prefer to induce a match, and moreover we assume $q(v^R - d_1) + (1-q)(v^R - d_2) < 0$ and $(1-q)\cdot(v^R - d_1) + q(v^R - d_2) < 0$, so that both receiver types need to be convinced of the merits of the match through communication (i.e., communication is influential). The message space is given by $M = \{1, 2\}$. We investigate the equilibrium where receivers match whenever they are communicated their own type. Under this policy, uninformed senders are better off revealing their types as long as

$$\text{Sender 1: } p(v^S - d_1) \geq (1-p)(v^S - d_2) \tag{17}$$

$$\text{Sender 2: } (1-p)(v^S - d_1) \geq p(v^S - d_2), \tag{18}$$

which can be summarized as

$$p \in \left[\frac{v^S - d_2}{2v^S - (d_1 + d_2)}, \frac{v^S - d_1}{2v^S - (d_1 + d_2)}\right]. \tag{19}$$

The result above implies that truth-telling does not require uniformity. Rather, it suffices that the receiver distribution is not overly skewed toward either receiver type.[25]

Finally, the result that uninformed senders may be better off revealing their types may also hold when receivers are continuously distributed. As long as randomization devices are not available to uninformed senders; that is, they have no way to coordinate their misrepresentation with other uninformed sender types, it is natural to expect such senders to bias their messages toward regions of higher probability mass on a one-to-one basis. In such cases, uninformed senders would be weakly better off reporting their types truthfully in the presence of arbitrarily low misrepresentation costs.[26]

5.2. Observability of the Information Level

It is worth considering the case in which the level of information is unobserved by the receiver. For example, if the sender could select the level of information in this case, he would always prefer perfect information, because such action would not affect the receiver's beliefs. The observability assumption does not affect our results when the sender's valuation is low ($v^S \le 2v^R$). However, it implies that the market would break down when the sender's valuation is high ($v^S > 2v^R$). We now explain that it is possible to avoid the market from collapsing as long as the receiver is imperfectly informed about the information level selected by the sender.

First, consider the case in which the receiver observes the level of information selected by the sender, α^*, with noise; that is, she observes $\alpha' = \alpha^* + \varepsilon$, where ε is a nuisance parameter. The results from Bagwell (1995) imply that, in our case, the pure strategy equilibrium on α can never induce a match. The intuition is as follows: if the sender selects level of information α^*, Nash equilibrium requires the receiver to best-respond to that same level. But, given the receiver's policy, the choice of α^* would never arise in equilibrium because the sender would be better off deviating to full information ($\alpha = 1$). Van Damme and Hurkens (1997) find that a mixed strategy equilibrium on α exists nonetheless, and argue that such outcome has attractive properties. Importantly, they find that the case of perfect observability of α yields the limit payoffs of a mixed strategy equilibrium as the noise approaches zero. The implication is that our model characterizes the limit of cases with imperfectly observed α, as the variance of ε approaches zero.[27]

Our results also characterize the limit outcome when the sender's choice of information level is affected by his own private information, as shown by Maggi (1999). For example, let κ be a sender's stochastic privately known cost of collecting information. In this case, the receiver reacts to policy $\alpha^*(\kappa)$ in equilibrium rather than to a constant level of information, and so she incorporates the noisy signal α' in her equilibrium response. Maggi (1999) shows that, as long as the amount of noise is small, there exist equilibria close to the ones we characterize in this paper.

In some other cases, our results apply directly. For example, consider the case in which α is communicated only some of the time, but whenever α is communicated, it is observed by the receiver precisely. As a result, the sender will prefer not to increase the level of information beyond α^* as long as the likelihood of α being communicated is high enough.[28]

6. Conclusion

We have investigated communication settings in which the sender can use the information available to tailor the communication to the receiver's preferences. At the center of our results is the fact that, while in principle the sender could benefit from higher levels of information, these in turn make the receiver skeptical of the merits of the message. As a result, trade always breaks down if the sender is sufficiently likely to be informed.

We consider a matching setting, and show that both the sender and the social planner always prefer the maximum amount of information that can support trade. The receiver, on the other hand, prefers complete privacy unless information is pivotal for communication, in which case she prefers full disclosure. Surprisingly, the sender becomes better off when he is believed to also pool with unattractive uninformed senders.

The analysis of communication costs also yields nontrivial results. At intermediate cost levels, we find that the market collapses when the sender's and receiver's valuations differ sufficiently. However, when valuations are similar, we find that the content and the cost of communication affect the likelihood of trade simultaneously: the communication cost affects which informed senders are willing to communicate, whereas the content of the message informs the receiver about the attractiveness of uninformed sender types.

Our results are relevant to multiple matching markets and related policy debates. For instance, we have found that information revelation by consumers increases their welfare only when such information is pivotal in inducing communication. Hence, in advertising markets, consumers may be better off disclosing their preferences to niche firms, but should shroud them from companies willing to engage in mass market communication. Our model also applies to settings in which the receiver selects the amount of information that is observed by the sender. In settings such as the job and dating markets, the receiver (e.g., a firm comparing applicants' vitae or an individual being romantically pursued) may have an incentive not to share too much information about what they are looking for, because the sender may use such information to tailor his message (e.g., claims to possess the needed skills for the job or shares the right set of interests) to ensure a successful match.

In terms of related future research opportunities, it may be worthwhile investigating cases in which the sender observes the receiver's type with noise (i.e., the emphasis is not on *whether* the sender has information about the receiver, but rather on *how much* information is available about the receiver's preferences). This case may generate novel insights, although the analysis is in general more complex. While we have considered the case of an exogenously set level of information (e.g., set by a regulator or by some previous interaction between the sender's information acquisition policy and receiver obfuscation activities), a formal investigation of costly information acquisition may be productive.

In particular, when preferences are not uniformly distributed, senders with less appealing preferences may have a higher incentive to acquire information, even if this costly activity is unobserved by the receiver. Contrary to our results, it is possible that in this case cheap-talk communication becomes credible when the sender is allowed to gather (costly) information prior to the communication stage.

Acknowledgments
The authors thank Kyle Bagwell, Matthew Gentzkow, Avi Goldfarb, Rick Harbaugh, Yuichiro Kamada, Nicolas Lambert, Michael Ostrovsky, Amin Sayedi, Jeff Shulman, Diogo Oliveira e Silva, Andrzej Skrzypacz, Upender Subramanian, and the review team for helpful comments.

Appendix A. General Model
The receiver matches with the sender if and only if

$$U_\theta^R(m) \equiv E(u^R(\theta, q) \mid \theta, m) \geq 0. \tag{A.1}$$

She uses beliefs $\widehat{f_{q|\theta,m,\alpha}}$ to assess the merits of the match, according to the expression above. As with several signaling settings, the space of beliefs $\widehat{f_{q|\theta,m,\alpha}}$ can be intractably large. Because of this, we instead focus on the space of messages that induces matches by the receiver. We start by defining set $M_\theta \subseteq Q$, which we refer to as the set of persuasive messages. Formally, it is given by $M_\theta \equiv \{m : U_\theta^R(m) \geq 0\}$; that is, it contains the messages that induce matches by receiver θ. Clearly, M_θ is directly induced by beliefs $\widehat{f_{q|\theta,m,\alpha}}$, generally on a many-to-one fashion. A message m is said to be persuasive for receiver θ if it belongs to set M_θ. We say an equilibrium supports trade (or alternatively, is a matching equilibrium) if and only if there exists a set of receiver beliefs and consistent communication policies that induce a nonempty set of equilibrium persuasive messages M_θ for some receiver θ.

Suppose a given receiver of type θ is willing to match with the sender in some equilibrium. Before observing the sender's message, the receiver's ex-ante utility is given by

$$EU^R = \alpha E(u^R(\theta, q) \mid \theta) + (1 - \alpha)\Pr(q \in C_\theta)E(u^R(\theta, q) \mid \theta, C_\theta). \tag{A.2}$$

The first and second terms capture the expected utilities of facing an informed and an uninformed sender, respectively.

Assuming M_θ is nonempty, the first term is given directly by the expected utility of matching with the sender, given that the latter is informed. The reason is that, by not deviating from sending a message inside region M_θ, an informed sender can induce a match with certainty. Moreover, the assumption that communication is influential implies that this term is negative.

Unlike informed senders, uninformed senders may not be able to secure matches with certainty, and so the second term of expression (A.2) is probabilistic: it introduces set $C_\theta \subseteq Q$, which is defined as $C_\theta = \{q : m_U^*(q) \in M_\theta\}$; that is, it is comprised of the uninformed sender types who send persuasive messages to receiver θ in equilibrium. Intuitively, this term is positive whenever trade occurs in the market.

Given the elements described above, it is possible to derive the following result (proved in the next section):

Theorem A.1 (Willful Ignorance). *Matches occur only if the level of information is at most $\bar{\alpha}$, defined as*

$$\bar{\alpha} \equiv \max_{\theta \in \Theta} \left\{ -\frac{\int_{u^R(\theta,q) \geq 0} u^R(\theta, q) dF_{q|\theta}}{\int_{u^R(\theta,q) < 0} u^R(\theta, q) dF_{q|\theta}} \right\} \in (0, 1). \tag{A.3}$$

The result implies that trade can only arise in equilibrium when the information level falls below $\bar{\alpha}$, independently of the communication policy employed by the sender. Moreover, under transparent motives, the information threshold does not depend on the utility the sender derives from a match. The only limiting factor is the relative difference between the receiver's (probability weighted) expected utilities of facing an attractive versus an unattractive sender. Matches can only occur under perfect information if the sender's motives are not transparent or if communication is not influential.

The underlying intuition for this result is that, when the information level increases, the receiver is required to be compensated either in terms of the frequency of facing an attractive sender, or in expected payoff, in order to be willing to match. The reason is that, under cheap-talk communication, informed senders cannot commit not to tailor their communication. When α is very high, ''too many'' informed senders take advantage of the set of persuasive messages M_θ, and no consistent beliefs can support trade as result.[29]

Without imposing further structure, testing existence of matching equilibria requires a full inspection of the agents' incentive compatibility constraints, under general receiver beliefs. A central reason is that uninformed senders can communicate in relatively arbitrary ways. However, when uninformed senders reveal their types, or, alternatively, if their messages allow the receiver to classify them as attractive or unattractive correctly, the receiver matches with uninformed types only when they provide positive match utility. It remains for informed senders to pool with attractive uninformed senders efficiently in order to maximize the level of information the receiver is willing to bear. It follows that all beliefs that induce revelation by uninformed senders (e.g., they bias their communication through a one-to-one mapping, which is invertible by receivers), generate trade as long as $\alpha \leq \bar{\alpha}$.[30]

Proof of Theorem A.1. Receiver θ's expected utility conditional on receiving message m is given by

$$U^R(m) \equiv \max\{E(u^R(\theta, q) \mid \theta, m), 0\}. \tag{A.4}$$

Averaging over all messages, the receiver's ex-ante utility is given by

$$EU^R = \alpha E(u^R(\theta, q) \mid \theta) + (1 - \alpha)\Pr(q \in C_\theta)E(u^R(\theta, q) \mid \theta, C_\theta), \tag{A.5}$$

where $C_\theta = \{q : m_U^*(q) \in M_\theta\}$ and $M_\theta \equiv \{m : u^R(m) \geq 0\}$, and $u^R(m) \equiv E(u^R(\theta, q) \mid \theta, m)$. It follows that

$$EU^R = E(U^R(m)), \tag{A.6}$$

and because $U^R(m) \geq 0 \forall m \in Q$, the receiver's ex-ante payoff EU^R is also positive.

The statement $EU^R \geq 0$ can be rewritten as

$$\alpha E(u^R(\theta,q)\,|\,\theta) + (1-\alpha)\Pr(q \in C_\theta)E(u^R(\theta,q)\,|\,\theta, C_\theta) \geq 0$$
$$\alpha \int_Q u^R(\theta,q)dF_{q|\theta} + (1-\alpha)\int_{C_\theta} u^R(\theta,q)dF_{q|\theta} \geq 0$$
$$\alpha \leq \frac{1}{1 - \frac{\int_Q u^R(\theta,q)dF_{q|\theta}}{\int_{C_\theta} u^R(\theta,q)dF_{q|\theta}}}, \tag{A.7}$$

where the right-hand side of (A.7) depends on α through C_θ. The assumption that communication is influential implies that expression $\int_Q u^R(\theta,q)dF_{q|\theta}$ is negative, making the right-hand side of (A.6) increasing in $\int_{C_\theta} u^R(\theta,q)dF_{q|\theta}$. Clearly, the support that maximizes $\int_{C_\theta} u^R(\theta,q)dF_{q|\theta}$ is given by $C^*_\theta = \{q : u^R(\theta,q) \geq 0\}$, such that the integral sum is made across positive integrands. Decomposing $\int_Q u^R(\theta,q)dF_{q|\theta}$ as $\int_{C^*_\theta} u^R(\theta,q)dF_{q|\theta} + \int_{Q\setminus C^*_\theta} u^R(\theta,q)dF_{q|\theta}$ completes the proof.

Appendix B. Remaining Proofs

Proof of Corollary 1. The result follows directly from the discussion of the general model and Theorem 1, above.

Proof of Theorem 1. We show this result by first considering a communication strategy that provides the receiver zero expected utility, point-by-point, at $\alpha = \bar{\alpha}$. Then, we show that the resultant communication policy of informed senders can be used at all levels of information below $\bar{\alpha}$, and induces $M_\theta = \{m : d(\theta,m) \leq \mathbf{1}(\alpha \leq \bar{\alpha}).v^R\}$.

We focus on communication policies of the form

$$f_{m^*|\theta,q,\alpha} = \alpha\phi_{m|\theta,\alpha} + (1-\alpha)\delta(m-q). \tag{B.1}$$

As discussed in the text, we restrict ourselves to the class of informed sender p.d.f.'s $\phi_{m|\theta,\alpha}$, invariant to the sender's location q.

When $\alpha = \bar{\alpha}$, the receiver cannot do better than earn zero matching utility in region M_θ. Together with Bayes rule, it follows that

$$E(u^R(\theta,q)\,|\,\theta, m \in S_\phi, \alpha = \bar{\alpha})$$
$$= \int_0^{2\pi} (v^R - d(\theta,q))d\widehat{F_{q|\theta,m,\alpha}}\,|_{\alpha=\bar{\alpha}} = 0 \tag{B.2}$$

$$\Leftrightarrow \int_0^{2\pi} (v^R - d(\theta,q))\frac{(\bar{\alpha}\phi_{m|\theta,\alpha} + (1-\bar{\alpha})\delta(m-q))}{f_{m|\theta,\alpha}} \cdot \frac{1}{2\pi}dq$$
$$= 0 \;\forall m \in S_\phi. \tag{B.3}$$

Solving for $\phi_{m|\theta,\alpha}$ yields

$$\phi_{m|\theta,\alpha} = \frac{1-\bar{\alpha}}{\bar{\alpha}}\frac{v^R - d(\theta,m)}{\pi(\pi r - 2v^R)}\mathbf{1}(m \in S_\phi), \tag{B.4}$$

where S_ϕ is the support of $\phi_{m|\theta,\alpha}$. The informed sender's p.d.f. candidate is hereafter referred to by $\phi_{m|\theta}$, because it is invariant to the information level α. For $\phi_{m|\theta}$ to be a density, it has to be positive over its support, and integrate to one. Assuming support $S_\phi = \{m : d(\theta,m) \leq v^R\}$ ensures the first condition.[31] We verify the density is valid over support S_ϕ by integrating $\phi_{m|\theta}$ over S_ϕ:

$$\begin{aligned}\int_0^{2\pi} \phi_{m|\theta}dm &= \int_0^{2\pi} \frac{1-\bar{\alpha}}{\bar{\alpha}}\frac{v^R - d(\theta,m)}{\pi(\pi r - 2v^R)}\mathbf{1}(m \in S_\phi)dm \\ &= \frac{1-\bar{\alpha}}{\bar{\alpha}\pi(\pi r - 2v^R)}\int_{S_\phi} v^R - d(\theta,m)dm \\ &= \frac{1-\bar{\alpha}}{\bar{\alpha}\pi(\pi r - 2v^R)}\int_{\theta - \frac{v^R}{r}}^{\theta + \frac{v^R}{r}} v^R - d(\theta,m)dm \\ &= \frac{1-\bar{\alpha}}{\bar{\alpha}\pi(\pi r - 2v^R)}\frac{(v^R)^2}{r} \\ &= 1.\end{aligned}$$

It follows that the ex-ante communication p.d.f. $\alpha\phi_{m|\theta} + (1-\alpha)\delta(m-q)$ also integrates to one. It remains to show that the receiver expects (weakly) positive utility whenever $m \in M_\theta$, and strictly negative utility whenever $m \notin M_\theta$. Bayes rule implies the receiver's consistent beliefs are given by

$$\widehat{f_{q|\theta,m,\alpha}} = \frac{\left(\alpha\frac{1-\bar{\alpha}}{\bar{\alpha}}\frac{v^R - d(\theta,m)}{\pi(\pi r - 2v^R)}\mathbf{1}(m \in S_\phi) + (1-\alpha)\delta(m-q)\right)}{f_{m|\theta,\alpha}}\frac{1}{2\pi}. \tag{B.5}$$

The receiver's expected utility, conditional on observing message m, becomes

$$\int_0^{2\pi} (v^R - d(\theta,q))\widehat{f_{q|\theta,m,\alpha}}dq = \tag{B.6}$$

$$= \int_0^{2\pi} (v^R - d(\theta,q))\frac{\left(\alpha\frac{1-\bar{\alpha}}{\bar{\alpha}}\frac{v^R - d(\theta,m)}{\pi(\pi r - 2v^R)}\mathbf{1}(m \in S_\phi) + (1-\alpha)\delta(m-q)\right)}{f_{m|\theta,\alpha}} \cdot \frac{1}{2\pi}dq, \tag{B.7}$$

$$\propto \alpha\frac{1-\bar{\alpha}}{\bar{\alpha}}\frac{v^R - d(\theta,m)}{\pi(\pi r - 2v^R)}\mathbf{1}(m \in S_\phi)\int_0^{2\pi} v^R - d(\theta,q)dq + (1-\alpha)(v^R - d(\theta,m)) \tag{B.8}$$

$$= (1-\alpha)(v^R - d(\theta,m)) - \alpha\frac{1-\bar{\alpha}}{\bar{\alpha}}(v^R - d(\theta,m))\mathbf{1}(m \in S_\phi), \tag{B.9}$$

where the third expression is obtained by eliminating positive constants. Whenever $m \in M_\theta$, expression (B.9) becomes

$$(1-\alpha)(v^R - d(\theta,m)) \geq \alpha\frac{\pi r(\pi r - 2v^R)}{(v^R)^2}(v^R - d(\theta,m)) \tag{B.10}$$

$$\Leftrightarrow 1 \geq \left(1 + \frac{\pi r(\pi r - 2v^R)}{(v^R)^2}\right)\alpha, \tag{B.11}$$

such that the receiver expects positive match utility, because (B.11) attains equality exactly at the highest level of the information level, $\alpha = \bar{\alpha}$. Whenever $m \notin S_\phi$, we require the receiver's expected utility to be strictly negative. Expression (B.9) becomes

$$(1-\alpha)(v^R - d(\theta, m)) < 0, \tag{B.12}$$

which holds for all $m \notin S_\phi$ for all information levels, concluding the proof.

Proof of Proposition 1. In the text, we have established $C_\theta = \{q : d(\theta, q) \le \mathbf{1}(\alpha \le \bar{\alpha}).v^R\}$, such that no trade takes place when $\alpha > \bar{\alpha}$, in which case both agents earn zero payoffs. Assuming $\alpha \le \bar{\alpha}$, the receiver's ex-ante surplus is given by

$$\begin{aligned} EU^R = {} & \alpha E(v^R - d(\theta, q)) + (1-\alpha)\Pr(d(\theta, q) \le v^R) \\ & \cdot E(v^R - d(\theta, q) \mid d(\theta, q) \le v^R), \end{aligned} \tag{B.13}$$

where the first term is negative (communication is influential), and the second term is positive. Hence, the receiver is better off with a lower level of information. When $\alpha = 0$, she earns

$$\int_{\theta - \frac{v^R}{r}}^{\theta + \frac{v^R}{r}} (v^R - d(\theta, q)) \frac{1}{2\pi} dq \tag{B.14}$$

$$= \frac{(v^R)^2}{r}, \tag{B.15}$$

which is strictly greater than zero.

As for the sender, his ex-ante surplus when $\alpha \le \bar{\alpha}$ is given by

$$\begin{aligned} EU^S = {} & \alpha E(v^S - d(\theta, q)) + (1-\alpha)\Pr(d(\theta, q) \le v^R) \\ & \cdot E(v^S - d(\theta, q) \mid d(\theta, q) \le v^R), \end{aligned} \tag{B.16}$$

where the first term is positive and dominates the second one because of transparent motives. Because trade breaks down at $\alpha > \bar{\alpha}$, the sender is better off at information level $\bar{\alpha}$.

Proof of Proposition 2. We first set up some notation. The level c_U^* that makes uninformed senders indifferent between communicating and not, is equal to

$$\begin{aligned} & EU^S_{Uninformed} - c_U^* && = 0 \\ \Leftrightarrow \quad & \frac{1}{2\pi} \int_{q - \frac{v^R}{r}}^{q + \frac{v^R}{r}} v^S - d(\theta, q) d\theta - c_U^* && = 0 \\ \Leftrightarrow \quad & c_U^* && = \frac{2v^S - v^R}{2\pi r} v^R. \end{aligned}$$

Also, consider the case in which the receiver is willing to match when only informed senders remain. This threshold is given by

$$\begin{aligned} & EU^R_{Communication} && = 0 \\ \Leftrightarrow \quad & \frac{1}{2\pi} \int_{\theta - \frac{v^S - c_R^*}{r}}^{\theta + \frac{v^S - c_R^*}{r}} v^R - d(\theta, q) dq && = 0 \\ \Leftrightarrow \quad & c_R^* && = v^S - 2v^R. \end{aligned}$$

When $c_U^* < c_R^*$, there exists an intermediate cost level such that receivers are not willing to match. Solving the inequality w.r.t. v^S completes the proof.

Proof of Proposition 3. Here we prove that the communication cost can make some informed senders refrain from communication while uninformed ones are still willing to communicate. The statement about the content of communication trivially follows from $M_\theta = \{m : d(\theta, m) \le \mathbf{1}(\alpha \le \bar{\alpha}).v^R\}$, and uninformed senders revealing their types.

Suppose $c < c_U^*$ such that uninformed senders participate. The farthest informed sender from the receiver is indifferent about communicating when $c = c_I^* \equiv v^S - \pi r$.

When $c_I^* < c_U^*$, there exists a cost region $c \in (c_I^*, c_U^*)$ such that distant informed senders refrain from communication, whereas uninformed ones still communicate, but may not find matches because of the content of their messages.

Proof of Theorem 2. Set $\mathcal{S}_\Delta$ is given by

$$\mathcal{S}_\Delta \equiv \{\Delta = 0 \wedge \alpha \ge \alpha_0\}$$

$$\cup \left\{ v^R \le \Delta \le \begin{cases} v^R\left(1 + \sqrt{\dfrac{\alpha}{1-\alpha}}\right), & \alpha \le \alpha_0 \\ v^R + \sqrt{\dfrac{(v^R)^2 - \alpha(\pi r - v^R)^2}{1-\alpha}}, & \alpha_0 < \alpha \le \bar{\alpha} \end{cases} \right\},$$

where $\alpha_0 \equiv \frac{(v^R)^2}{(\pi r - v^R)^2 + (v^R)^2}$.

A set of beliefs $\widehat{f_{q|\theta,m,\alpha}}$ induces a maximum distance Δ such that the receiver is willing to match as long as $d(\theta, m) \le \Delta$. We characterize the set of distances $\mathcal{S}_\Delta$ that can be induced by on-equilibrium path beliefs. We then apply the sequential equilibrium restriction to characterize the admissible set of off-equilibrium path beliefs.

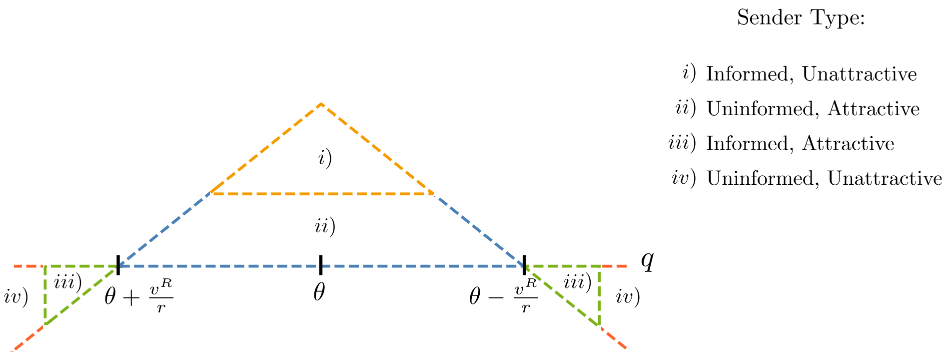
- Region $\mathcal{S}_\Delta$ contains two subregions. We consider the triangle-like subregion first, namely

$$v^R \le \Delta \le \begin{cases} v^R\left(1 + \sqrt{\dfrac{\alpha}{1-\alpha}}\right), & \alpha \le \alpha_0 \\ v^R + \sqrt{\dfrac{(v^R)^2 - \alpha(\pi r - v^R)^2}{1-\alpha}}, & \alpha_0 < \alpha \le \bar{\alpha}^*. \end{cases}$$

The lower bound v^R follows from the fact that messages in set $\{m : d(\theta, m) \le v^R\}$ are always persuasive in equilibrium. We have already shown that uninformed senders report their types, whereas informed senders are indifferent among messages that the receiver deems attractive according to his beliefs. In region $d(\theta, m) \le v^R$, the receiver earns positive utility from being matched with an uninformed type, and (unattractive) informed types would never pool in this region to the extent of making a message unappealing in equilibrium. Hence, if strictly positive, the distance between the message and the receiver's location that generates a match in equilibrium must be at least v^R.

The upper bounds on Δ arise from the following considerations. First, informed senders may pool with attractive and unattractive uninformed senders to different extents. When α is low, all informed senders are able to pool with attractive uninformed senders and produce matches. An alternative policy is for unattractive informed senders to pool with

Figure B.1. (Color online) Expected Utility for a Given Communication Policy



Note. q increases from right to left to be consistent with the counterclockwise angular definition.

attractive uninformed senders, while attractive informed senders pool with uninformed senders located just outside region $d(\theta,q) \le v^R$. In this case, under consistent beliefs, informed senders are able to secure matches by sending messages outside region $\{m : d(\theta,m) \le v^R\}$. Figure B.1 depicts the receiver's match utility, which decreases with the distance to the sender's location, and the areas of the triangular regions constitute expected match utilities for the receiver. For example, a receiver earns utility equal to the area of triangle *ii*)—partially hidden by region *i*)—if she matches with an attractive uninformed sender with uniform probability. Her matching utility may also be negative if she matches with uninformed senders located far away, as depicted by triangular regions *iv*), partially covered by regions *iii*). Moreover, the area of region *i*) depicts the receiver's *disutility* from matching with unattractive *uninformed* senders and the area of region *iii*) depicts the utility from matching with attractive informed senders.

When attractive informed senders pool with unattractive uninformed senders as depicted by regions *iii*) and *iv*), the receiver is willing to match for some messages beyond $\theta \pm \frac{v^R}{r}$. The maximum matching distance an informed sender can induce is attained by pooling with unattractive uninformed senders, so as to provide exactly zero match utility to the receiver over such messages. Multiple mixing schemes can accomplish this, but the maximum distance is always attained by providing zero utility to the receiver over the mixing region.

At low levels of α, the maximum matching distance is obtained by calculating the width of each of the *iii*) triangles that guarantees that the sender receives zero matching utility to the furthest extent possible. The utility from being matched with an attractive informed sender—area of *iii*)—is equal to

$$\frac{\alpha}{2\pi}\int_{\theta-\frac{v^R}{r}}^{\theta+\frac{v^R}{r}} v^R - d(\theta,q)dq = \frac{\alpha(v^R)^2}{2\pi r}.$$

The utility of matching with unattractive uninformed senders over some distance ω—region *iv*)—is equal to

$$\frac{1-\alpha}{2\pi}\left(\int_{\theta-\frac{\omega}{r}}^{\theta-\frac{v^R}{r}} v^R - d(\theta,q)dq + \int_{\theta+\frac{v^R}{r}}^{\theta+\frac{\omega}{r}} v^R - d(\theta,q)dq\right) \\ = -\frac{(1-\alpha)(\omega-v^R)^2}{2\pi r}.$$

Hence, the maximum distance to which attractive informed types can pool, while providing zero expected utility to the receiver, is given by

$$\begin{aligned} \frac{\alpha(v^R)^2}{2\pi r} - \frac{(1-\alpha)(\omega-v^R)^2}{2\pi r} &= 0 \\ \Leftrightarrow \qquad \omega &= v^R\left(1+\sqrt{\frac{\alpha}{1-\alpha}}\right). \end{aligned}$$

It follows that for low levels of α, there exist communication policies (and consistent beliefs) that induce matches up to messages $\left\{m : d(\theta,m) \le v^R\left(1+\sqrt{\frac{\alpha}{1-\alpha}}\right)\right\}$.

As α increases, so does the area of region *i*), which eventually matches the area of region *ii*). At this point, the expected utility from receiving a message in region $\{m : d(\theta,m) \le v^R\}$ yields zero utility to the receiver. The utility earned from matching with unattractive informed senders is given by[32]

$$\frac{\alpha}{2\pi}\left(\int_0^{\pi-\frac{v^R}{r}} v^R - r(\pi-q)dq + \int_{\pi+\frac{v^R}{r}}^{2\pi} v^R - r(q-\pi)dq\right) \\ = -\frac{\alpha(\pi r - v^R)^2}{2\pi r}.$$

Finally, the utility earned from attractive uninformed senders is equal to $\frac{(1-\alpha)(v^R)^2}{2\pi r}$. The receiver expects zero utility from a message in set $\{m : d(\theta,m) \le v^R\}$ when

$$\begin{aligned} -\frac{\alpha(\pi r - v^R)^2}{2\pi r} + \frac{(1-\alpha)(v^R)^2}{2\pi r} &= 0 \\ \Leftrightarrow \qquad \alpha &= \frac{(v^R)^2}{(\pi r - v^R)^2 + (v^R)^2} \equiv \alpha_0. \end{aligned}$$

When α increases beyond α_0, the matching utility in region $\{m : d(\theta,m) \le v^R\}$ would be negative for the receiver, which cannot happen in equilibrium as we have explained before. In this case, the maximum matching distance is attained by partial pooling of attractive senders into the inner region, to ensure the receiver earns zero matching utility throughout. The net surplus can still be spread on region *iv*) as before.

The net surplus available for mixing outside region $\{m : d(\theta, m) \le v^R\}$ by attractive informed senders is equal to

$$\underbrace{-\frac{\alpha(\pi r - v^R)^2}{2\pi r}}_{(Unattractive\ Informed)} + \underbrace{\frac{(1-\alpha)(v^R)^2}{2\pi r}}_{(Attractive\ Uninformed)} + \underbrace{\frac{\alpha(v^R)^2}{2\pi r}}_{(Attractive\ Informed)}$$
$$= \frac{(v^R)^2 - \alpha(\pi r - v^R)^2}{2\pi r}. \tag{B.17}$$

Relatedly, note that this surplus is equal to zero when $\alpha = \bar{\alpha}$, which is expected given the results of Theorem 1. Up to $\bar{\alpha}$, the maximum matching distance is given by ω' according to

$$\frac{(v^R)^2 - \alpha(\pi r - v^R)^2}{2\pi r} - \frac{(1-\alpha)(\omega' - v^R)^2}{2\pi r} = 0$$
$$\Leftrightarrow \qquad \omega' \qquad = v^R + \sqrt{\frac{(v^R)^2 - \alpha(\pi r - v^R)^2}{1-\alpha}}.$$

Finally, the upper bound on Δ is continuous at point $\alpha = \alpha_0$, and moreover $\bar{\alpha}^* > \alpha_0$.

- We now consider region

$$\{\Delta = 0 \wedge \alpha \ge \alpha_0\}.$$

There exist beliefs under which the receiver is unwilling to match with the sender, independently of the message she observes. Consider first the case $\alpha = 0$. In this case, no informed senders exist, and aside from babbling equilibria, the matching region is equal to $\{m : d(\theta, m) \le v^R\}$.

We now describe that there exist beliefs such that no persuasive messages exist when $\alpha \ge \alpha_0$. When α is high enough, it suffices that the receiver believes that attractive informed senders pool with unattractive uninformed senders, and that unattractive informed senders pool with attractive uninformed senders. Unlike babbling equilibria, in this case communication is informative because messages do affect the receiver's beliefs. However, no matches ever take place. As a result, informed senders are willing to communicate according to the receiver's beliefs, and a fatalistic equilibrium results. When $\alpha < \alpha_0$, these beliefs do not exist. The reason is that there exist too few unattractive informed types to offset attractive uninformed types, so as to make all messages unattractive.[33]

Finally, under the sequential equilibrium refinement, off-equilibrium path beliefs are also required to fall within $\mathcal{S}_\Delta$. Consider an equilibrium that implements an information level α^*, and let Λ be a totally mixed distribution over α. Sequential equilibrium implies the sender should best-respond to all possible outcomes of Λ and the receiver should hold consistent beliefs, which is the exact characterization of $\mathcal{S}_\Delta$.

Proof of Proposition 4. The sender's first-best outcome is characterized by an information level α, a communication policy m^* and a maximum distance (induced by receiver's beliefs). Assuming, as before, that the sender's expected payoff is given by

$$EU^S = \alpha E(v^S - d(\theta, q)) + (1-\alpha)\Pr(q \in C_\theta) E(v^S - d(\theta, q) \mid q \in C_\theta), \tag{B.18}$$

where $C_\theta = \{m : d(\theta, m) \le \Delta\}$, the sender's first-best outcome is attained by solving problem

$$\max_{\Delta, \alpha \in (0,1)} \quad EU^S \qquad \text{s.t.} \quad EU^R \ge 0,$$

where the constraint is equal to

$$EU^R = \alpha E(v^R - d(\theta, q)) + (1-\alpha)\Pr(q \in C_\theta) E(v^R - d(\theta, q) \mid q \in C_\theta) \ge 0. \tag{B.19}$$

Finally, note that $\Pr(q \in C_\theta) E(v^j - d(\theta, q) \mid q \in C_\theta)$, $j \in \{R, S\}$ yields

$$\frac{1}{2\pi}\int_{q-\frac{\Delta}{r}}^{q+\frac{\Delta}{r}} v^j - d(\theta, q)d\theta = \frac{(2v^j - \Delta)\Delta}{2\pi r}. \tag{B.20}$$

Restriction $EU^R \ge 0$ must bind in equilibrium. If this were not the case, then the sender would be able to alter his mixing strategy in order to create slack for messages within a fixed distance Δ, and increase α and his utility as a result. Rewriting this condition yields

$$E(U^R) = 0$$
$$\Leftrightarrow \quad \alpha\left(v^R - \frac{\pi r}{2}\right) + (1-\alpha)\frac{(2v^R - \Delta)\Delta}{2\pi r} = 0$$
$$\Leftrightarrow \quad \alpha = \frac{(2v^R - \Delta)\Delta}{(\pi r - \Delta)(\pi r - 2v^R + \Delta)}. \tag{B.21}$$

We analyze the two relevant regions of $\mathcal{S}_\Delta$ in turn.

- $\alpha \le \alpha_0$

In this region $\Delta \in \left[v^R, v^R\left(1 + \sqrt{\frac{\alpha}{1-\alpha}}\right)\right]$. Plugging (B.21) into the sender's utility function and taking a derivative w.r.t. Δ reveals that the sender's utility is increasing in Δ. Hence, constraint $\Delta \le v^R\left(1 + \sqrt{\frac{\alpha}{1-\alpha}}\right)$ is binding. Equalities $\Delta = v^R\left(1 + \sqrt{\frac{\alpha}{1-\alpha}}\right)$ and (B.21) imply

$$\alpha^* = \alpha_0$$
$$\Delta^* = \frac{\pi r v^R}{\pi r - v^R},$$

which falls in the correct region.

- $\alpha \ge \alpha_0$

In this region $\Delta \in \left[v^R, v^R + \sqrt{\frac{(v^R)^2 - \alpha(\pi r - v^R)^2}{1-\alpha}}\right]$. Along path $\Delta = v^R + \sqrt{\frac{(v^R)^2 - \alpha(\pi r - v^R)^2}{1-\alpha}}$, the receiver earns zero utility, and so the upper bound on Δ is equal to restriction $EU^R = 0$.

Moreover, there is a trade-off between Δ and α:

$$\frac{d\Delta}{d\alpha} = -\frac{\pi r(\pi r - 2v^R)}{(1-\alpha)^2}\frac{1}{2\sqrt{\frac{(v^R)^2 - \alpha(\pi r - v^R)^2}{1-\alpha}}} < 0. \tag{B.22}$$

Plugging the restriction $EU^R = 0$, w.r.t. α, into the sender's utility function, yields

$$EU^S|_{EU^R=0} = \frac{\Delta(v^S - v^R)}{\pi r - 2v^R + \Delta},$$

which increases in Δ. Hence, the sender's utility is decreasing in the level of information along $EU^R = 0$, and $\alpha = \alpha_0$. The sender's communication policy can be found relatively easily, through the same methods used in Theorem 1.

Proof of Proposition 5. We focus on the characterization of joint welfare. The remaining proofs are straightforward, and available from the authors.

When $v^S > \pi r$, joint welfare is given by

$$\begin{aligned} EU^R &+ EU^S \\ &= \frac{1}{2\pi}\left(\alpha \int_0^{2\pi} v^R - d(\theta,q)dq + (1-\alpha)\int_{\theta-\frac{v^R}{r}}^{\theta+\frac{v^R}{r}} v^R - d(\theta,q)dq\right) \\ &+ \frac{1}{2\pi}\left(\alpha \int_0^{2\pi} v^S - d(\theta,q)d\theta + (1-\alpha)\int_{q-\frac{v^R}{r}}^{q+\frac{v^R}{r}} v^S - d(\theta,q)d\theta\right) \\ &= \frac{1}{\pi r}(v^R v^S + \alpha(v^S - \pi r)(\pi r - v^R)), \end{aligned}$$

which is increasing in α.

When $v^S \in \left(\frac{v^R}{2}, \pi r\right)$, joint welfare is given by

$$\begin{aligned} EU^R &+ EU^S \\ &= \frac{1}{2\pi}\left(\alpha \int_{\theta-\frac{v^S}{r}}^{\theta+\frac{v^S}{r}} v^R - d(\theta,q)dq + (1-\alpha)\int_{\theta-\frac{v^R}{r}}^{\theta+\frac{v^R}{r}} v^R - d(\theta,q)dq\right) \\ &+ \frac{1}{2\pi}\left(\alpha \int_{q-\frac{v^S}{r}}^{q+\frac{v^S}{r}} v^S - d(\theta,q)d\theta + (1-\alpha)\int_{q-\frac{v^R}{r}}^{q+\frac{v^R}{r}} v^S - d(\theta,q)d\theta\right) \\ &= \frac{v^R v^S}{\pi r}, \end{aligned}$$

which is independent of the level of information α, although the receiver's rationality constraint requires $\alpha \le \bar{\alpha}$.

Finally, when $v^S < \frac{v^R}{2}$, uninformed senders do not communicate. Hence, matches only take place if the sender is nearby the receiver:

$$\begin{aligned} EU^R + EU^S &= \frac{\alpha}{2\pi}\left(\int_{\theta-\frac{v^S}{r}}^{\theta+\frac{v^S}{r}} v^R - d(\theta,q)dq \right. \\ &\left. + \int_{q-\frac{v^S}{r}}^{q+\frac{v^S}{r}} v^S - d(\theta,q)d\theta\right) \\ &= \alpha\frac{v^R v^S}{\pi r}, \end{aligned}$$

such that joint welfare increases in α.

Endnotes

[1] The cheap-talk assumption is realistic in a variety of contexts and specifically in advertising markets, because moderate misrepresentation is legal and sometimes even expected. Both the Federal Trade Commission in the United States and the Advertising Standards Authority in the United Kingdom allow advertisers to engage in ''puffery,'' that is, reasonable exaggerations in advertising claims (see also Chakraborty and Harbaugh 2014).

[2] We refer to the sender and receiver as male and female, respectively.

[3] The actual content of communication is seldom the main interest in cheap-talk research. Sobel (2016), for example, recently focuses on the content of communication.

[4] See Kang (2017).

[5] An important finding of this literature is that seemingly vertically differentiated markets may effectively behave as horizontally differentiated. For example, trade-offs in vertical attributes or price-quality relationships may induce different preference rankings across consumers. While our main analysis considers horizontal differentiation, this fact implies that our model can be interpreted as a vertically differentiated setting in which there exist trade-offs across vertical product attributes. For related examples, see also Bagwell and Ramey (1993) and Chakraborty and Harbaugh (2010).

[6] In our model, all sender types agree on the ranking of receiver actions. Seidmann (1990) showed that cheap-talk communication can be credible despite this common preference ordering. This result has been extensively used to analyze different communication contexts (e.g., Ottaviani and Sørensen 2006a, 2006b). The common preference ordering feature is also referred to frequently as the sender featuring ''transparent motives'' (Lipnowski and Ravid 2017) or the sender having state-independent preferences (Chakraborty and Harbaugh 2010). The result by Seidmann (1990) is related to that of Farrell and Gibbons (1989), in which a sender's credibility sources from sufficient receiver heterogeneity (e.g., two audiences), and the sender is unaware of the type of receiver she faces, whereas the receiver is aware of her own type. Like in Seidmann (1990), in our case the sender's uncertainty over the action distribution induced by each message yields credible cheap talk. Finally, note that the cheap-talk literature considers ''tailored communication'' by default. To be clear, our paper addresses settings where the level of information by the sender about the receiver's preferences may not be perfect.

[7] Relatedly, Che et al. (2013) consider a situation in which an adviser's communication policy depends on the characteristics of the distribution of projects available to the receiver.

[8] Also, Roy (2000), Esteban et al. (2001), Iyer et al. (2005), Deng and Mela (2018), and Tuchman et al. (2018) consider targeted advertising applications under monopoly and competition settings, but the mechanisms are different. In these cases, advertising affects the receiver's payoffs directly, through complementarities or by generating awareness. Sahni et al. (2018) consider the different mechanism of noninformative personalization. See also Acquisti et al. (2016) for a survey of the literature on the economics of privacy.

[9] There also exists an extensive literature on disclosure, including Anderson and Renault (2006), Ostrovsky and Schwarz (2010), Rayo and Segal (2010), Kamenica and Gentzkow (2011), and Mayzlin and Shin (2011). This paper (and the cheap-talk literature in general) is different in that, by uncoupling commitment from communication, it allows the sender to communicate arbitrary messages, in contrast to having him solely decide on which information to disclose.

[10] See Section 3 for a robustness discussion about the observability of the level of information by the receiver.

[11] We include α in $\widehat{f_{q|\theta,m,\alpha}}$, and $f_{m'|\theta,q,\alpha}$ to stress that the beliefs and communication policies may vary with the information level.

[12] We discuss this issue in depth in Section 4. Although we assume symmetric distance functions, the results are robust to the asymmetric assumption.

[13] See the appendix for the case with a general distribution over types. Somewhat related to our work, Spector (2000) and Filipovich (2008) extend the Crawford and Sobel (1982) setting by investigating circular action and state spaces, respectively. Also, note that traditional horizontal differentiation à la Hotelling (1929) would not exclusively describe horizontal uncertainty in our setting, because senders

nearest the mean receiver location would be ex-ante more attractive than others.

[14] Formally, it is given by $d(\theta, q) = r.\cos^{-1}(\cos(\theta - q))$.

[15] The refinement provides a focal point for beliefs and messages, and it rules out equilibria obtained from relabeling messages in a one-to-one fashion. Another implication is that, as we describe later, the restriction rules out uninformed types coordinating around a particular location on the circle, which is attractive given the absence of a randomization device in our model. While Δ may depend on parameters, we investigate cases in which m and θ are excluded from it, in order to keep the restriction from unraveling. Finally, in principle, the distance function Δ can depend on the model's parameters in complex ways. We impose a Markov-perfect equilibrium refinement on distance Δ (Maskin and Tirole 2001), such that it cannot depend on payoff-irrelevant factors, including the numerical properties of the model parameters.

[16] The restriction is not required for equilibrium analysis, but greatly increases the intuition and clarity of the results. We also include fatalistic equilibria in the analysis in Section 2.4.

[17] As before, we focus on situations where uninformed senders reveal their types.

[18] This result derives from the assumptions of uniformly distributed preferences and linear matching disutilities; empirical or laboratory research may be useful to characterize this region in specific contexts.

[19] See Google ad customizers (https://support.google.com/adwords/answer/6072565) and dynamic creatives (https://support.google.com/richmedia/answer/2691686) and Microsoft behavioral advertising (http://advertising.microsoft.com/en/behavioral-targeting), for example. See also the *Economist* (2014) for current tracking practices.

[20] See, for example, Snider (2017).

[21] See http://www.aboutads.info and http://youradchoices.com.

[22] See, for example, Weitzman (1980), Freixas et al. (1985), Hart and Tirole (1988), Villas-Boas (1999), Fudenberg and Tirole (2000), Chen et al. (2001), Villas-Boas (2004) and Acquisti and Varian (2005).

[23] We thank an anonymous referee for these suggestions.

[24] In some contexts, it may be lawful for a sender to use his informational advantage to appropriate additional value from the receiver (e.g., price discrimination). Our results are robust to these cases as long as the receiver is strategic. Our modeling assumptions also ensure that communication strategies do not depend on the sender's need to avoid the hold-up problem of fully extracting consumer surplus (see Anderson and Renault 2006), although it is not incompatible with such settings.

[25] The remaining conditions can be derived easily to show that, as before, matching occurs as long as the level of information is bounded above, that is, $\alpha \le \frac{v^R - d_1}{(1-q)(d_1 - d_2)}$ if $q \le \frac{1}{2}$ and $\alpha \le \frac{v^R - d_1}{q(d_1 - d_2)}$ if $q > \frac{1}{2}$.

[26] The inversion conditions by the receiver depend on the nature of the message space in relation to that of the space of receiver types and fall outside the scope of our analysis.

[27] In more recent work, Bagwell (2018) considers the case in which a leader is privately informed about her resolve to follow through on an announcement to a follower. Based on the idea of private resolve, Bagwell (2018) proposes a refinement that, when applied to our setting, selects as the unique equilibrium the case in which the sender selects a perfect level of information and is therefore unable to induce matches.

[28] Van Damme and Hurkens (1997) also discuss this case and mention a formal treatment by Chakravorti and Spiegel (1993).

[29] When the receiver's ex-ante utility is positive (i.e., communication is not influential), sufficient conditions for matching also exist. From the proof of Theorem 1, it is straightforward to show that undesirable informed senders are unable to pool with desirable uninformed sender types to the extent of making matching always unattractive to receivers as long as $\alpha < \frac{\int_{u^R(\theta,q) \ge 0} u^R(\theta, q) dF_{q|\theta}}{E(u^R(\theta, q)\theta)}$. In this case, matching always takes place and the threshold information level is higher than $\bar{\alpha}$, which is intuitive, because $E(u^R(\theta, q)\theta) > 0$; that is, the receiver is better off to start with, in this case.

[30] The result that uninformed senders may prefer to reveal their types may hold in cases in which receivers are nonuniformly distributed or also when there exist legal punishments related to misrepresentation. We discuss these possibilities in Section 5.

[31] Note that the assumption that communication is influential implies that $\pi r - 2v^R > 0$.

[32] In this calculation, we use $\theta = \pi$ for parsimony, but any θ can be used, provided the correct distance function is also used.

[33] The proof is straightforward and is available from the authors.

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