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MEANINGFUL TALK

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Meaningful talk*

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Abstract

In economics, the standard approach to language is that talk is cheap. Here, instead, language is a social convention that affects utility. Unless language is used in its ordinary sense, it cannot help to coordinate actions because there is no way of decoding it. This points to a unique informative equilibrium where words are used in their ordinary sense in natural language. Misrepresentation costs may eliminate uninformative, babbling, equilibria. More generally, meaningful talk provides a concrete mechanism through which consistent expectations are generated in Nash equilibria.

Resumen. En economía, el enfoque estándar es tratar al lenguaje como *sanata* (palabras vacías). Aquí en cambio el lenguaje es una convención social que afecta las preferencias. A menos que el lenguaje se utilice en su sentido usual, no permite coordinar acciones porque no hay modo de decodificarlo. Esto lleva a un único equilibrio informativo donde las palabras se utilizan con su sentido usual en el lenguaje natural. Por otro lado, los costos de distorsionar mensajes pueden eliminar equilibrios no informativos donde las palabras son pura *sanata*. Más en general, el lenguaje cargado de sentido provee un mecanismo concreto por el cual se generan expectativas consistentes en los equilibrio Nash.

JEL classification codes: D8, C7

Key words: cheap talk, symbols, meaning, encoding-decoding, common priors, Nash equilibria

1 Introduction

We try to capture the role of natural language in social interactions with a model of “meaningful talk”, where communication is done using a pre-existing language common to all players. The key difference between this approach and cheap talk models (Vincent Crawford and Joel Sobel 1982 and the subsequent literature) is the problem of decoding messages that the listener faces if a common language is not used by the speaker. Though talk here is in a sense still cheap, it rests on substantial sunk costs, like the learning process of native speakers while growing up.

More fundamentally, existing game-theoretic representations of verbal communication between a sender and a receiver in imperfect or incomplete information setups are misleading insofar as beliefs in the (perfect Bayesian) Nash equilibria are determined “as if” by equilibrium actions or types, when no

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such information is actually available to the players. Since language plays no role in cheap talk models even when there are unbiased senders, these models concentrate on beliefs induced in equilibrium, not on equilibrium messages (see, e.g., Hefei Wang 2009). The only actual information which is in fact added to the common priors, namely, symbolic information, is being ignored.

Our contention is that the decoding process of receivers explains why messages will not be understood if natural language is not used by the sender in its usual sense, leading the players to fall back on an uninformative (babbling) Nash equilibrium. Symbolic communication works much like blind faith, potentially eliminating uninformative equilibria and leading to an informative equilibrium. Meaningful talk can be seen as an extension of Thomas Schelling's (1960) idea of "tacit coordination" via focal points that are salient to all the players to "explicit coordination" through natural language. The key insight is that natural language can affect priors, allowing to select a specific Nash equilibrium. It also provides a low transaction cost mechanism (once it has been learned!) that can explain how a correlating device is set up, as in Robert Aumann's (1974) correlated equilibria, or how players can escape from prisoner dilemma's situations if they can communicate to commit to an agreement (Elinor Ostrom 1990).

This approach that incorporates the encoding-decoding process of natural language is complementary to models where there are misrepresentation costs (Steven Callander and Simon Wilkie 2006, Navin Kartik, Marco Ottaviani, and Francesco Squintani 2007). Misrepresentation costs of senders help to eliminate uninformative equilibria, and explain why linguistic symbols become signals, but they cannot explain by themselves why natural language, and not any other convention, is used in an informative equilibrium. Our view is that a model of communication using natural language needs to incorporate both features, the misrepresentation costs of senders and the decoding process of receivers.

Section 2 motivates our approach to natural language as meaningful talk, which draws on the nice distinction in Joseph Farrell (1993) between natural language, codes, and ciphers, as well as his point that natural language has a comprehensible meaning which might be credible or not. We then illustrate our approach by using the George Akerlof (1970) lemons problem to analyze market transactions. Since this is a decentralized market, Section 3 asks how the seller and the buyer get together. The pre-play communication game is a coordination game with a surplus from trade. We spell out the consequences of verbal communication through natural language for expectations. Section 4 moves to the second stage negotiation game. Despite asymmetric information and an incentive to misrepresent quality, sellers who want to cheat buyers do not pick the message "This car is a lemon", but rather "This car is great". Why? The encoding-decoding process, as well as subjective misrepresentation costs, act as anchors for words. Section 5 illustrates the application of this framework to two incomplete information games, and two imperfect information games. Section 6 examines general implications of our framework. Briefly put, it establishes the default priors if communication is not effective, and explains how consistent expectations may be generated through meaningful talk in the informative (perfect Bayesian) Nash equilibria of one-shot games. The final section has our closing remarks.

2 Conceptualizing communication

2.1 Cheap talk

The standard view in economics is that misrepresentation is a pervasive problem. In Joseph Schumpeter's (1942, p. 264) paradoxical terms, "Since the first thing man will do for his ideal or interest is to lie,

we shall expect, and as a matter of fact we find, effective information is almost always adulterated or selective.”¹ Furthermore, talk is not a move, like burning the bridges behind us to communicate to the enemy that our troops are not retreating (Schelling 1960, p. 158). As Schelling (1960, p. 117) puts it, “Moves can in some way alter the game, by incurring manifest costs, risks, or a reduced range of subsequent choice; they have an information content, or *evidence* content, of a different character from that of speech. Talk can be cheap, when moves are not.” This view, while powerful, has ultimately led economics to treat language as meaningless even when there are no incentives for misrepresentation. This state of affairs strikes us as odd, given the pervasive use of natural language in markets and society. Nobody involved expects a communication breakdown, otherwise, why bother saying anything?

We focus on unilateral communication where a sender provides information to a receiver. In this setup, Crawford and Sobel (1982) formalize language as cheap talk to study the maximal amount of information an expert (the informed party) may offer the decision maker (the uninformed party) when there are incentives to lie. Cheap talk sets language apart from signals: while signals are credible because choices are differentially costly, words are not because they have no direct payoff consequences (see, e.g., Robert Gibbons 1992, and Vijay Krishna and John Morgan 2005). A direct result of cheap talk is that there are always uninformative equilibria. Farrell (1993, p. 515) points out a more fundamental problem in using cheap talk: since its meaning cannot be learned from introspection, any permutation of messages across meanings gives another equilibrium. Hence, a major coordination problem subsists even in informative equilibria.

Farrell (1993, pp. 519-520) notes that, if a common pre-existing natural language is used, the receiver will be able to understand the different words the sender utters, though he does not apply this insight to the meaning of words in equilibrium but rather as a restriction to out-of-equilibrium beliefs. In this regard, Farrell (1993) compares the difference between a prearranged set of meanings for anticipated messages and a preexisting natural language as the difference between “codes” and “ciphers”. In codes, a list of meanings is fixed in advance and cryptic messages are chosen to convey those meanings, such as one light for “by land”, two for “by sea” used during the American revolution to alert if the redcoats were coming. In a cipher, messages are instead cryptically isomorphic to a natural language, so unanticipated messages such as “The redcoats are coming in balloons” can be added. These unanticipated out-of-equilibrium messages are called “meaningful neologisms” by Farrell (1993).

We use Farrell’s insight on the focal meaning of natural language, but we apply it instead to restrict equilibrium messages. Our interpretation is that cheap talk models actually do not model natural language but rather ciphers or, as the case may be, codes, because the meanings of words is determined by their use in each (perfect Bayesian) Nash equilibrium of each particular game. This approach is particularly problematic in one-shot games, the issue we address here. Our approach to language moves beyond cheap talk as a model of communication, and incorporates two features related to the human psychology of sending and receiving messages.

2.2 Meaningful talk

2.2.1 Idiosyncratic traits

From a psychological viewpoint words are a highly subjective phenomenon for each sender. Some people are willing to manipulate language at will, others stick to their word. The free manipulation of language

¹William Mitchell (1984, p. 82) discusses how Schumpeter applies this insight to political advertising.

brings to mind the strategic behavior of politicians, diplomats, spies, salesmen, and so forth. On the other hand, Schelling (1960, pp. 26-27) himself recognizes that “if part of the population belong to the cult in which ‘cross my heart’ is (or is believed to be) absolutely binding ... they can commit themselves, the others cannot”; for this cult, words are equivalent to moves, not to speech. We do not need to rely on a cult of fanatics, since for most people lying is not a free lunch, it has a psychic cost. As Brad Blanton (1996, chapter 5) puts it, lying is stressful and can make us sick. In this same line, Adam Smith’s (1759) view on veracity and deceit is that “common lying” is shameful (see Part VII, Section IV). Even if we let aside remorse for not acting correctly, being truthful is still less costly than making something up. Indeed, some lie detector tests are based on the idea that lies can be detected by more cerebral activity.²

These ideas has been formalized, using different approaches, by Callander and Wilkie (2006), and Kartik et al. (2007). In Callander and Wilkie (2006) there are either honest or dishonest political candidates, and the utility of honest candidates depends on campaign promises. In equilibrium all campaign platforms have some informative content about post-electoral intentions, a result that implies babbling equilibria are eliminated. Once the sender suffers disutility from misreporting private information, Kartik, et al. (2007) point out that this transforms the game from cheap talk to costly signaling. Below we will briefly consider what happens when people differ in character, and some individuals find it costly to misrepresent information, where as in Streb and Torrens (2011) the costs of misrepresentation are fixed but heterogeneous.³

2.2.2 Semiotic aspects

Ronald Coase (1976, pp. 544f) says, in relation to Adam Smith’s views on self-interest in a market economy, that “this should not lead us to ignore the part which benevolence and moral sentiments do play in making possible the market system ... the observance of moral codes must very greatly reduce the costs of doing business with others and must therefore facilitate market transactions.” Though moral codes may be important, we must not ignore the role of the linguistic conventions themselves which we grow into as we are brought up. Indeed, Smith (1776) gives our ability to speak and communicate a key role in explaining human cooperation through the division of labor and exchange (Ángel Alonso-Cortes 2008), which suggests it reduces transaction costs.

The idea of natural language as a social convention, i.e., as something both invented and ordinary, harks back to Plato and Aristotle, and is developed by Hume, while David Lewis (1969) constitutes the standard modern reference (Michael Rescorla 2010).⁴ This conventional feature, which is specific to natural language, is what we explore more in depth here resorting to the categories used in semiotics as described, among others, in Chandler (1994).

²See, e.g., http://en.wikipedia.org/wiki/Lie_detection.

³This resembles the honesty costs in Stefano Demichelis and Jörgen Weibull (2007), though there honesty only enters lexicographically to break ties in material gains. In our view, misrepresentation costs are present whether the message is believed or not by the receiver. This is particularly clear in relation to misrepresentation costs involved in making something up, but also applies to feeling remorse for lying.

⁴Rescorla (2010) distinguishes Hume’s position on social conventions from the views of Carnap and the logical positivists, who urge to replace unformalized natural language with a conventionally chosen formal language. For Hume, social conventions arise without need for either an explicit covenant or a tacit agreement. Hume’s approach, which is shared by Adam Smith, is described by Friedrich Hayek (1963) as an evolutionary view according to which institutions and traditions evolve spontaneously as the result of human actions, not of human design.

In semiotics, words are symbols, a type of signs that are characterized by being purely conventional. Though words, sentences, and the language as a whole, are in a sense arbitrary, in another they are not: we are born into them. Language is socially and historically determined, giving rise to natural languages specific to each society, which is why they can be seen as social conventions (Lewis 1969). So while a language is a set of conventions to communicate meaning, it is a shared social convention.⁵ For instance, in English the words “left” and “right” are used to describe the moves left and right, in Spanish the words “izquierda” and “derecha”. Words carry an arbitrary but common meaning for players that share the same natural language.

In semiotics, Ferdinand de Saussure introduced a dyadic model of signs, composed of signifier and signified. Charles S. Peirce proposed instead a triadic model that is closer to the modern representation of signs as composed of three elements.⁶ In the specific case of linguistic symbols –our concern here–, these three components are:

- (i) the signifier or sign vehicle, a sequence of letters or sounds, e.g., the word “lemon”;
- (ii) the signified, intension, or connotation, the concept that appears in our mind when we read or hear the signifier, e.g., a lousy car;⁷ and
- (iii) the referent, extension, or denotation, the actual object a symbol refers to, e.g., the car they are trying to sell us.

Though the signifier is only a part of the whole, it is also customary to refer to the signifier as the “symbol”. The three elements form what is sometimes called a “semantic triangle”. Combining two of these semantic triangles, we can model unilateral communication between a sender and a receiver in the following diagram in Figure 1, which describes an encoding-decoding sequence that slightly corrects the ordering in Kyung-Youn Park (1975). There is a word-to-world direction of fit where the message is encoded –the sender thinks of a symbol suited to the referent, word-to-fit-world– that is coupled with a world-to-word direction of fit where the message is decoded –the receiver thinks of a referent suited to the symbol, world-to-fit-word.

<Figure 1. Encoding and decoding sequence in unilateral communication>

Communication may be fully effective, when the starting and ending points coincide, but it may happen that not all the information is revealed. Partial revelation may arise due to wilful distortions of the sender –the issue we analyze here– or to errors of perception of either sender or receiver. Though the meaning of natural language may not always be reliable, it is certainly comprehensible to the receiver (Farrell 1993).

From a semiotic viewpoint, speakers do not randomly use any word in the dictionary to name something. Rather, when there is asymmetric information they rely on the ordinary words to convey meaning to the listener. If the priors in the society are that people usually mean what they say, coordination through verbal communication may work. On the other hand, if these conventions are not followed, the costs of decoding the message may be insurmountable, making language useless as a cheap coordination

⁵See Rescorla (2010). Also see [http://en.wikipedia.org/wiki/Code_\(Semiotics\)](http://en.wikipedia.org/wiki/Code_(Semiotics)).

⁶See Chandler (1994). Cf. also [http://en.wikipedia.org/wiki/Sign_\(linguistics\)](http://en.wikipedia.org/wiki/Sign_(linguistics)).

⁷Without intension of some sort, words have no meaning. See <http://en.wikipedia.org/wiki/Intension>.

device. The decoding process of receivers provides a semantic reason for why senders strictly prefer to employ natural language.⁸

3 How do buyer and seller get together?

We start by the pre-play communication game that leads to the market for lemons. Both parties are playing *rendez-vous*, a game of coordination: if they successfully meet, they can share the expected gains from trade. We first introduce communication in the coordination game using cheap talk, before moving to a more abstract representation that shows that what is crucially at stake in communication are the endogenous beliefs of receivers. The third subsection reintroduces the specific messages used in verbal communication, now in a model of meaningful talk that incorporates the feature that verbal messages determine beliefs and equilibrium outcomes. We then discuss how this is quite contrary to cheap-talk representations, where equilibrium messages are irrelevant and equilibrium actions that are unobservable to the receiver determine beliefs.

3.1 Cheap talk equilibria

The following messages must take place before buyer and seller get together in the second stage: (i) the seller posts an ad in the newspaper, with the quality of the car and a phone number; and (ii) the buyer calls the phone number listed in the ad, where the seller announces the place and time of meeting. In this stage we ignore the issue of quality, since the incentives for misrepresentation are addressed in the second stage. This leaves four pieces of information that must be conveyed from the seller (the sender) to the buyer (the receiver) in the first stage: that what is for sale is a car, the seller's phone number, the meeting time, and the meeting place.

Since the conceptual problem of cheap talk is the same for each piece of information, we concentrate on the problems of communicating the meeting place. Schelling's (1960, pp. 55-56) most famous example of tacit coordination precisely involves two people who have to meet in an unspecified spot of New York, at an unspecified hour. Instead of using focal points to tacitly coordinate among multiple Nash equilibria, one might think that talking beforehand over the phone is a much more trivial method of coordination. This is a game of imperfect information, since the receiver does not see the actual move of the sender, but verbal information about its stated intention is available. The possible meeting times and places are countless, but the key stumbling block turns out to be that, for each possible meeting time and place, the possible messages are also countless (and when talk is cheap, instead of saying that a car is for sale, the ad might say a horse is for sale, or the digits of the true phone number could be randomly scrambled).

Without loss of generality, let the expected payoffs for buyer and seller from meeting be normalized to 1, and, from not meeting, to 0.⁹ Table 1 represents a game where the sender may only adopt two actions

⁸A totalitarian regime provides an extreme case where it is utterly costly for regular citizens to express their true viewpoints. This may lead some expressions to mean the opposite of their meaning in plain language, for instance "defense of liberty" may come to mean "persecute dissidents". In his 1949 novel *Nineteen Eighty-Four*, Orwell describes a society where a Ministry of Truth is charged with editing words. Since past history is continually being rewritten according to the current political needs of the political leadership, it ends up meaning nothing.

⁹This is the standard representation of coordination games. We ignore the participation decision. If the second stage of the market for lemons, which is discussed later on, implies market breakdown, high-quality sellers will not participate in the first stage. The coordination problem for sellers and buyers of lemons still remains.

with positive probability in equilibrium, meeting left (L) or meeting right (R) at noon. In this game, there are two pure strategy equilibria, (L, L) and (R, R) , as well as a mixed strategy equilibrium that is Pareto dominated where each pure strategy is played with probability one half. When communication is explicitly modeled in this game through cheap talk, the equilibria can correspond to any of these.

<Table 1. Coordination game between buyer and seller>

Figure 2 represents an uninformative cheap talk equilibrium where the sender adopts two actions with equal probability in equilibrium, L or R . We represent the minimal messages possible, “meeting left” (“ L ”) or “meeting right” (“ R ”), where we distinguish between moves and messages about moves following the use-mention distinction between using a word and mentioning it (the same goes for types and messages about types).¹⁰ In this uninformative, or babbling, equilibrium, all sellers are expected to say the same thing, so the buyer does not pay attention to the equilibrium messages, and verbal communication does not prevent a coordination failure. There is nothing to give words any weight at all.¹¹

<Figure 2. Uninformative (pooling) equilibrium>

As to the informative equilibria, though there is an equilibrium where words are used in their conventional sense, Figure 3 represents one of the countless “unnatural” informative equilibria where words are used in an arbitrary sense.

<Figure 3. “Unnatural” informative (separating) equilibrium>

Hence, with cheap talk there are babbling equilibria, where the outcome corresponds to the mixed strategy equilibrium of the coordination game, and there are also an endless number of informative equilibria using different ciphers or codes, where the outcome corresponds to one of the two pure strategy equilibria. The sheer multiplicity of informative perfect Bayesian Nash equilibria leaves us just where we started, Schelling (1960). Selection arguments suggest that the only focal point is the informative equilibrium where natural language is used, i.e., where “ L ” is used for the move L , and “ R ” is used for the move R . We now explore a different argument to rule out unnatural informative equilibria.

3.2 Decoding messages

Given the receiver’s ignorance of the senders intentions, a better way to describe the receiver’s priors is that it believes the sender may play any random strategy $X \in \{1, 2, \dots, N\}$, where each has a prior probability of $1/N$ since, without further information, any potential place in the city is equally likely. With cheap talk, the sender may communicate this choice with any message that is potentially communicable. This double combination compounds the original problem of tacit coordination discussed by Schelling (1960), introducing the need of deciphering messages, a task more suited to intelligence agencies than to market participants. This viewpoint ignores the insurmountable costs of figuring out messages

¹⁰Cf. http://en.wikipedia.org/wiki/Use%E2%80%93mention_distinction.

¹¹We do not represent other messages, but similar responses of the receiver at other information sets assure there is no incentive for the sender to deviate.

that market participants would face when shared conventions are not used, which actually destroys the possibility of using talk as a cheap coordination device.

There is no salient interpretation if the words are not used in their conventional sense, since if the plain meaning of the message is not relevant, no other meaning is obvious when there are innumerable unnatural informative equilibria, the problem we address here. For example, if the message “Meet me at noon at the information booth of Grand Central Station” is not to be interpreted in its literal sense, no other meaning springs to mind to establish how to interpret the message. This is a one-time event, so any other use of words throws both back to a coordination failure.

We now model communication in a setup that is stripped down to its bare essentials. Since the possible moves, and the possible messages, are unbounded, a simple way of graphically representing how intentions are communicated in coordination games that captures the gist of the matter is to completely ignore the specific moves and messages. After all, neither party is particularly interested in these details. If natural language is the means of communication in markets, it becomes apparent that what is at issue in coordination games is not if language is understood, since natural language is composed of symbols that carry a conventional meaning; what is at issue is whether messages are credible.

Figure 4 presents the coordination problem in terms of a unilateral communication game where the seller may reveal or not the truth about the intended meeting place and time, and the buyer may believe or not the seller’s message.¹² This is a game of imperfect information, though there is another kind of information: verbal information. There are coordination failures either if the message is not believed by the receiver, or if the message is distorted by the sender. The plethora of alternatives blocks any alternative interpretation and only leaves the least informative mixed strategy equilibrium as a candidate.

<Figure 4. Communicating intentions in an imperfect information coordination game>

An equilibrium is possible where the seller sends a false message, and the buyer does not believe the message, so both parties are unable to coordinate a meeting by verbal means alone. These can be characterized as “pessimistic” equilibria. There are innumerable such equilibria, for example the seller can say it will be at the meeting place at twelve, when it intends to be there at 3 p.m., or to never go there at all. These equilibria correspond to the outcome of a mixed strategy equilibrium: with a indefinite number of meeting times and places, the possibility of encounter is nil.

On the other hand, in an “optimistic” equilibrium the seller reveals its true intentions, and the buyer believes the message. Once the problem of decoding messages is taken into account, the only informative equilibrium that remains is the one where language is used in its natural sense –though this informative equilibrium might be expressed in more than one way if words have synonyms, or if there are expressions that are equivalent.

What determines whether buyer and seller will end up in an optimistic or in a pessimistic equilibrium? If all senders are charlatans, absolutely nothing. However, if the receiver gives an infinitesimal probability to the belief that the sender may be saying the truth in Figure 4, the pessimistic equilibrium is destroyed because the sender has an incentive to say the truth. That is to say, if there are no costs of being trusting, the pessimistic equilibrium is not a trembling hand perfect equilibrium because it employs weakly dominated strategies that does not resist the slightest tremble (Reinhard Selten 1975).¹³

¹²Figure 4 ignores messages that are incomprehensible. The next subsection considers misrepresentation costs.

¹³If there is a cost of being trusting, e.g., because of the costs of being stood up, besides the two equilibria we discuss in

3.3 Misrepresentation costs of senders

The setup where all sellers are charlatans can be generalized to introduce a cost of misrepresentation, however slight, where words affect utility, in line with previous work by Callander and Wilkie (2006), and Kartik et al. (2007). As in Streb and Torrens (2011), disutility depends on the action of misrepresentation itself, not on its consequences for the other player. Suppose the ability of misrepresentation varies, so a slow type decreases utility by ε if it is necessary to imagine a message “ m' ” that differs from the intention m . Arranging a meeting between buyer and seller becomes a game of imperfect and incomplete information, since the buyer does not know either the action (place selected) or the type of the seller (charlatan or slow), as shown in Figure 5.

<Figure 5. Communicating intentions in an incomplete and imperfect information coordination game>

Slow types have a dominant strategy, so what they say can be taken at face value; it could also be that some types are honest and have an aversion to misrepresenting their actions, so they have a trustworthy character. Given that the payoff to the buyer of believing the message is strictly larger than not believing it, charlatans also have an incentive to strictly say the truth. So once there is a positive probability there is a slow (or honest) type that means what it says, the unique equilibrium is a “trust” equilibrium.¹⁴

Once some sellers have an infinitesimal cost ε from thinking about saying something different from their true intentions, words are not only symbols, they become signals. However, the semantic content of words is determined by its meaning in natural language plus the fact that we are in a trust equilibrium, which only requires the assessment that at least somebody uses language in a literal sense with positive probability. A “distrust” equilibrium is only possible with utterly negative expectations about both types and actions, for example, somebody who is disenchanted with human society and does not believe in anybody’s word anymore.

These costs of misrepresentation for themselves can eliminate babbling equilibria. However, they do not eliminate the excess of informative equilibria where any word can mean anything according to the equilibrium strategies. Figure 6 introduces costs of misrepresentation to show that they do not destroy the unnatural informative equilibrium of Figure 3, because if the sender deviates from the equilibrium message its payoff will fall from $1 - \varepsilon$ to 0. Hence, costs of misrepresentation alone are not enough to do away with unnatural separating equilibria, we need to introduce the encoding-decoding process. In that sense, the costs of using words for receivers and senders are complementary: costs for senders eliminate babbling equilibria, costs for receivers eliminate unnatural separating equilibria (and make babbling equilibria unlikely).

<Figure 6: “Unnatural” informative equilibrium with misrepresentation costs>

the text there would be an equilibrium that leaves players indifferent between being optimistic or pessimistic. In that more realistic case, pessimistic equilibria are robust to trembles. We ignore these issues in our simplified setup to concentrate on the semantic content of words.

¹⁴If there were a cost in being trusting, e.g., because of being stood up, this result has to be changed to the statement that receivers believe there is a sufficiently high proportion of truthful senders in the population to compensate these costs. We leave out pathological liars who derive pleasure from mistreating the other party, e.g., standing somebody up or calling a 911 number when there is no emergency.

3.4 Meaningful talk determines equilibrium expectations

There is an odd thing about the informative cheap talk equilibrium in Figure 3 (the same applies to Figure 6). Fixing the moves L and R , beliefs are determined by the equilibrium strategies. Our reservation about informative equilibria like this one is that in the final analysis beliefs are determined regardless of how that fact might be communicated from player to player in equilibrium. In other words, since these beliefs do not come from verbal communication between the players, it remains utterly unclear to us how these beliefs can originate at all. This is a strange way to model beliefs in a situation where the only additional information the receiver has in each information set is the verbal information on meeting place provided by the sender. This would require some meta-message that explains what each message in that equilibrium means, since each move is associated to an arbitrary equilibrium message. But if messages are cheap talk, why shouldn't meta-messages be cheap talk? Nobody can take any message at face value. And what agent sends these meta-messages? This would be like introducing a Walrasian auctioneer to set prices.

To understand what is wrong with the unnatural informative equilibrium in Figure 3, we now return to the specific messages used in equilibrium. As the previous subsection illustrates, Figure 3 is also artificial in its assumption that, of all the potential moves, the sender will choose in equilibrium between only two choices, and that this may be communicated by one of two messages. This is not a good depiction of the concrete problem the receiver faces. Because of graphical limitations, Figure 7 only represents two of the possible actions in Figure 4, L and R at noon, where the priors are that each action is adopted with probability $1/N$, and two of the possible messages, “ L ” and “ R ”.

<Figure 7. “Natural” informative equilibrium with decoding costs>

Whereas Figure 3 assumes that “ L ” can be interpreted to really mean “ R ”, in Figure 7 if the message “ L ” is not used in its literal sense the only salient interpretation is $\sim L$, which throws us back to the mixed strategy equilibrium as a default. Hence, it is the message that makes coordination possible if the verbal message is believed, not extraneous beliefs about equilibrium strategies that come from who knows where.

Figures 3 and 7 show that this coordination game is a game of imperfect information, since the receiver does not see the actual move of the sender, but verbal information is available. So what type of information does language provide? Words in sentences are symbols that carry their conventional meaning in a reliable way in an optimistic equilibrium of the coordination game because mutual confidence confers words that role. When words are taken at face value by both players, there is no coordination problem at all, and verbal communication makes a huge difference with respect to a game where both players cannot communicate. Optimism is blind, like faith: the receiver cannot observe the action of the sender, only the statement, but the very fact that the receiver believes the message of the sender makes the sender willing to mean what it says. Suppose the sender plays a mixed strategy, determining the potential meeting place by some random device. This would not be an obstacle to meeting if the sender communicates the outcome of the random device to the receiver. An outside observer will not be able to predict which move X will take place, but after the telephone conversation where the sender says “ X ”, the receiver will have clear expectations about the sender's move: from the receiver's point of view, it is a question of playing the pure strategy equilibrium singled out by the sender's verbal message. In this regard, the semantic content of natural language can be understood as the result of the shared commitment by individuals of

using words according to accepted social conventions, and of interpreting words according to those same conventions.

This framework can be compared to the discussion in Rescorla (2010) on the role of social conventions, and in particular on how social conventions generate linguistic meaning. Rescorla (2010, Section 7), points out that while Lewis (1969) initially describes conventions as regularities of action, Lewis (1975) extends them to also cover regularities of belief. Hence, the expectation of conformity to a convention, which gives everyone a good reason to conform, can be based on two types of reasons: either practical reasons (actions of others) or epistemic reasons (beliefs of others). Our optimistic and trust equilibria closely relates to his description of linguistic convention in Lewis (1975), where a language is used by a population if and only if senders are truthful and receivers are trusting most of the time (if not all the time).

This requirement of truthfulness and trust is unduly stringent if one does not recognize that a distrust equilibrium may also exist, where the outcome corresponds to the babbling equilibria of cheap talk games where anything can be said and nobody pays any attention to what is being said. The agreements that can be struck giving one's word will not only vary with the level of trust in each society, since in a given society they will be harder to strike when there are incentives for misrepresentation. In the case of a distrust equilibrium, one would expect an alternative coordination mechanism to spring up. In this example, one possible market solution would be to set up garage sales of cars. Another, with less search costs, would be the appearance of used car dealers, or of a fair where buyers and sellers of used cars can get together to do transactions.

3.5 Self-signaling neologisms

We now contrast our view on the semantic content of language with Farrell's (1993) "self-signaling neologisms". Farrell (1993) makes the nice point that natural language has messages that, though they may not be credible, are fully comprehensible. However, his focus is on refinements of beliefs in response to out-of-equilibrium messages. Farrell (1993) makes the assumption that an out-of-equilibrium message is always available for somebody to declare their type, which he calls a "neologism", and that these neologisms are credible if they are "self-signaling", i.e., if type θ actually wants the receiver to believe the message " θ " that it has type θ . We will later question the assumption that neologisms are always available.

Farrell uses this refinement to do away with babbling equilibria in coordination games, since unexpected out of equilibrium messages in natural language which have a focal meaning are self-signaling. In contrast, here uninformative equilibria of the coordination game can subsist if expectations are utterly pessimistic. Demichelis and Weibull (2007) interpret Farrell (1993) in the sense that credibility is a property of the message, while they analyze honesty in the context of the meaning correspondence, i.e., the relation between the announced message and the intended action. We follow this latter, semiotic, approach. Hence, though we cannot rule out a babbling equilibrium when all sellers are charlatans, we can once there are individuals that prefer to be truthful (or, more generally, there is a sufficient proportion of truthful individuals).

4 The market for lemons

We now move to the market for lemons, the second stage of the coordination game where the seller gets together with the buyer. We now analyze how the encoding-decoding process has implications for verbal communication in markets where there are incentives for misrepresentation, and the gains from trade may not be realized due to asymmetric information. Akerlof (1970, p. 495) introduces a model of asymmetric information which allows making some comments on the cost of dishonesty, since this may drive legitimate sellers out of business. Not only are gains from trade prevented by dishonesty, language can lose meaning and become cheap talk. But if language is cheap talk, not only may sellers state they have a high quality product, regardless of actual quality; sellers could alternatively state they have a low quality product. Indeed, the precise words become irrelevant. This leads to a plethora of babbling equilibria (Streb and Torrens 2011).

We consider a game with two types of sellers. Let all sellers be dishonest. Each seller owns a unit of a product of quality $\theta_i = \{\theta_L, \theta_H\}$, where $\theta_H > \theta_L$. The quality is known to the seller, but not to the buyer, at purchase time. The opportunity cost of each seller is $\alpha\theta_i$, with $\alpha < 1$, and $\alpha\theta_H > \theta_L$, so a market breakdown is possible. Buyers know that the product is high quality with probability $q > 0$ and low quality with probability $1 - q > 0$. Since buyers are willing to pay θ_i for a quality i product and sellers are willing to sell it at $\alpha\theta_i$, there is a potential gain from trade of $(1 - \alpha)\theta_i > 0$. To abstract from the bargaining problem, we follow standard practice by assuming buyers are risk neutral and willing to pay the average quality offered on the market.¹⁵ Hence, sellers reap all the potential surplus from trade.

This game moves beyond unilateral communication, since the seller first states quality, the buyer then makes a price offer to the seller, and the seller finally accepts or not. Though the seller can state anything, Figure 8 represents the minimal messages $m \in \{\text{“}\theta_L\text{”}, \text{“}\theta_H\text{”}\}$ required, namely, that the product is either low or high quality. Buyers can make a continuum of price offers in the interval $[\theta_L, \theta_H]$, but it suffices to represent the three price offers $p \in \{\theta_L, \mathbf{E}_q[\theta], \theta_H\}$, where the intermediate price $\mathbf{E}_q[\theta] = (1 - q)\theta_L + q\theta_H$ is determined by the priors. To facilitate the exposition, only the equilibrium payoffs in the terminal subgames are represented.

A seller can accept (a) or not ($\sim a$) the price offer made by the buyer. High-quality sellers will be willing to accept a price equal to the average expected quality if and only if the following condition holds:

$$q \geq \frac{\alpha\theta_H - \theta_L}{\theta_H - \theta_L}. \quad (1)$$

Figure 8 represents the case where (1) is satisfied, so all but low price offers to high-quality sellers will be accepted. This is a cheap-talk game insofar as the message itself does not affect payoffs.

<Figure 8. The market for lemons as a cheap-talk game>

One can rule out separating equilibria because sellers of lemons always have an incentive to mimic sellers of high-quality products. A babbling equilibrium in pure strategies exists in which all sellers pool on the same message, stating for example that they have a high quality product, $m = \text{“}\theta_H\text{”}$ regardless of

¹⁵This follows if demand is perfectly elastic at a price that equals the average quality that sellers effectively offer. As is standard in the lemons model, we assume for simplicity that in the second stage all the gains from trade accrue to sellers. This will imply that any transaction costs of putting an ad and arranging a meeting are borne by the seller. Actual sellers will have an expected surplus from trade that exceeds these transaction costs, else they would drop out of the market.

actual quality. For the proposed message to be part of a perfect Bayesian Nash equilibrium, the reaction to any other announcement has to be a low price, for example because buyers expect that anybody who deviates from the proposed message has a lemon.¹⁶ *Mutatis mutandis*, sellers could also pool on message $m = \theta_L$, or on any random message for that matter.

Once we take into account the process of decoding messages, we can be much more specific if condition (1) is satisfied and there is no market breakdown. Buyers need not doubt the message θ_L because it is comprehensible, and credible, since quality is always at least that high. If they do not believe this message, the alternative is to keep their priors, namely, that quality is given by $\mathbf{E}_q[\theta]$, and hence offer a price $\mathbf{E}_q[\theta]$ which is higher. As to message θ_H , it might correspond to a high-quality good, which is the literal interpretation, but it might also correspond to a low-quality good because sellers of lemons have an incentive to overstate the quality of their car, mimicking the message of owners of high quality cars. The buyer would on average overpay if it believed this message (Kartik et al. 2007 study receivers who are credulous or naive so they take the messages at face value; our receivers are instead all sophisticated). Hence, the only equilibrium is not to believe this message and keep their priors. What happens with messages other than θ_L or θ_H ? These messages do not correspond to any actual quality in the market. Hence, there is not only a problem of credibility, their very interpretation is problematic. If buyers expect all sellers to state θ_H and are willing to offer the price $\mathbf{E}_q[\theta]$, these alternative messages will be out-of-equilibrium messages since they cannot improve on the equilibrium outcome where message θ_H is sent. In a sense, misrepresentation simplifies the problem, because there is an incentive to inflate claims, except in the limit case where the receiver disregards all messages (Kartik et al. 2007 have a similar result of inflated claims with costly talk). This is unlike a coordination game where there is no expected direction for misrepresentation. Hence the encoding-decoding process is able to pin down one uninformative equilibrium, that were all sellers state θ_H , except of course in the limit case of absolute pessimism where receivers disregard all messages, so anything goes like in cheap talk games.

If condition (1) is not satisfied, only lemons are left on the market. Whatever the message, buyers will interpret the good is a lemon, so in this sense messages are irrelevant. Hence, the cheap talk interpretation seems absolutely appropriate for this situation.

If we were to add costs of misrepresenting quality, the main difference is that this always would lead to two markets, one were lemons are transacted, and another where both lemons and high-quality goods might be transacted. Furthermore, the pessimistic equilibrium where words are disregarded disappears, so those wanting to sell something as a high quality good will always announce it as θ_H with positive probability (Streb and Torrens 2011).

5 Other applications

We now illustrate further applications of meaningful talk. We first review two games of incomplete information and then two games of imperfect information.

¹⁶There are other pooling equilibria where the same outcome is supported by out-of-equilibrium beliefs that the conditional probability of high quality products is low enough for condition $\mathbf{E}_q[\theta] \geq \alpha\theta_H$ not to be satisfied.

5.1 Incomplete information

We present two games of incomplete information where there are incentives for misrepresentation or for withholding information, drawing on two examples in Farrell (1993). Here, communication does not lead to disclosure, so the priors are unaffected. However, meaningful talk allows to characterize equilibrium messages. In other setups, meaningful talk may be more effective at revealing new information.

5.1.1 Mimicking

In Example 3 in Farrell (1993), there is an incentive for B not to be distinguished from A . If the receiver cannot distinguish between both types, it prefers to chose a safe strategy that is best when all the information it has are its priors. Farrell points out that his criterion of a neologism-proof equilibrium implies that no perfect Bayesian Nash equilibrium exists, since A always has the incentive to send the self-signaling message “ A ”. There is a way out of this. We rephrase his Example 3 as Figure 9. Since B has an incentive to mimic A ’s message, if the equilibrium message in the pooling equilibrium is “ A ”, no self-signaling neologism is available for A to destroy that equilibrium, something Farrell himself acknowledges. This implies that, contrary to Farrell’s initial assumption, self-signaling neologisms may not always be available. To sustain the equilibrium, all we need to assume is that out-of-equilibrium messages, such as “ B ”, are not interpreted as informative by the receiver so they do not affect its priors. Though Farrell searches for some other out-of-equilibrium message that might destroy this uninformative equilibrium, if A were to say something like “I am really, really A ”, this would not help much.

<Figure 9. A mimicking game>

The market for lemons, analyzed above, shares features similar to this example. This requires that there be no market breakdown in the market for lemons, in which case both games lead to a pooling equilibrium where the receiver’s reaction will be to act according to its priors. There is a slight difference: while the seller of lemons wants to be mistaken for the high-quality type, in Farrell’s example type B seller wants the buyer not to be able to distinguish between both types. On the other hand, market breakdown in the market for lemons is equivalent in this game to knowing that all remaining types are type B .

5.1.2 Withholding information

In Example 2, Farrell (1993) presents a game where neither sender has an incentive to reveal its type. Given that, he wants to show that the only sensible equilibrium is the uninformative one, unlike cheap talk representations where there are both informative and uninformative Bayesian Nash equilibria. We fully agree. However, there is a deeper problem with the informative cheap talk equilibrium, as we show in Figure 10. The fact that an informative equilibrium exists is an artifact of cheap talk models, not of the actual information that the sender has an incentive to provide in this game. Once we realize that endogenous beliefs about types are determined by equilibrium messages, it is clear that the separating messages that reveal types will never be used by the senders: they have no incentive to reveal their types because this lowers their payoffs. Hence, receivers will have to take the message “I will not reveal my type” at face value, since no new information is revealed and all the receiver has are its priors. When there is no updating of priors, the best strategy for the receiver is to play $a(T)$, not $a(A)$ or $a(B)$, since the receiver does not have any alternative screening device.

<Figure 10. Withholding information>

5.2 Imperfect information games

In the coordination game, communication allows selecting a specific pure strategy Nash equilibrium. Here we look at two other classic games of imperfect information, the curse of the commons, and the battle of the sexes. Elaborating on an example in Ostrom (1990), we first show how adding a pre-play communication stage, combined with Ostrom's legally binding agreements, may allow escaping from a prisoner's dilemma situation. We then show how bilateral communication may allow reaching a correlated equilibrium in the battle of the sexes (if communication were unilateral, one would rather expect an outcome similar to the agenda setter model).

5.2.1 Escaping the curse of the commons

Table 2 represents a game that has the same payoffs as the prisoner's dilemma, the curse of the commons. Here the only Nash equilibrium is to defect, which leads to a Pareto-dominated outcome.

<Table 2. The commons>

Using this setup, Ostrom (1990, chapter 1) considers the case of common-property resources, which she distinguishes from open-access resources (Ostrom 2009, p. 419, lists both as instances of common-pool resources). With common-property resources, she points out that if the costs α of reaching a contractual agreement are not too high, the parties can voluntarily and in a decentralized manner reach the cooperative outcome without need of government intervention or privatization of the resource. If they do not both sign the agreement, on the other hand, the non-cooperative outcome envisaged by Hardin in the tragedy of the commons ensues. Empirically, Ostrom (2009, pp. 424f) points out to the literature that shows how in field settings formal cooperation is easier to achieve if there is verbal communication. This is not hard to understand in our framework. The non-cooperative outcome is what one can expect without communication and without binding commitments. Though binding commitments can be provided by a contractual agreement that is enforceable in courts of law, to apply this strategy one of the player has to explicitly propose the agreement (by the way, the very availability of a reliable legal system presupposes that language is meaningful talk, so a piece of paper can provide a binding commitment). If none gives the first step, it is like a situation where two people like each other but none of them dares say anything; if both are silent, they will never meet. The same happens here if none of the players proposes an agreement. This is represented in Figure 11, where we add to the original game in Ostrom (1990) a communication stage where one of the players may propose an agreement.

<Figure 11. The commons with communication and contracting>

There are multiple equilibria in this game. There is a Pareto dominated equilibrium where they never communicate, or where they do but none of them takes the proposal seriously and signs it. There is also a Pareto optimal equilibrium where an agreement is proposed, and both follow on this agreement, which is much like the optimistic outcome outlined in the coordination game with verbal communication; though this outcome is possible, the pessimistic outcome with coordination failure is also possible.

If we were to add the existence of honest agents that mean what they say, language plus honesty make decentralized cooperation a lot easier, once somebody proposes it: the only outcome is a trust equilibrium. Furthermore, if the individuals trust each other enough, the equilibrium might be set up without need of legal sanctions. In this regard, Ostrom (2009, p. 433) points out that “when face-to-face communication is possible, participants use facial expressions, physical actions, and the way that words are expressed to judge the trustworthiness of the others involved.” In this example, communication goes beyond meaningful talk, extending to body language. This implies empathetic communication, something which we touch in our closing remarks.

5.2.2 Correlated equilibria in the battle of the sexes

Table 3 presents the battle of the sexes. In the battle of the sexes, unilateral communication implies that one of the players has proposal powers so it can propose the equilibrium that it prefers, like in an example Schelling (1960, p. 59) gives of two persons who have to meet: one states his position, adding that his transmitter, but not his receiver, works, and that he will wait until the other arrives. This leaves the other no choice but to go look for him. This setup of unilateral communication resembles the agenda setter model (cf. Rosenthal 1990), with the difference that the other player does not have veto power to reject the offer, the other player can only choose to believe or not.

< Table 3. Battle of the sexes >

If messages are taken seriously, the incentive of the player that has proposal powers is to propose its preferred equilibrium, so we may have a natural communicative equilibrium. The players may also disregard the message altogether: without any priors about what the other will do because communication is meaningless, we can expect the mixed strategy equilibrium –there is no precise information on the pure strategy the other player will follow, so it might want to play its preferred strategy, or it might try to accommodate the other’s preferred strategy. Unnatural communicative equilibria are not possible because the person will typically interpret the wrong location, and when it realizes that the sender meant the other location (if it does not simply get angry, interpreting it is being stood up), the possibility of meeting on time for the event will be gone. To do away with the babbling equilibrium altogether, one has to resort to a framework where words affect the utility of the sender. If the sender has an ε -cost of misrepresenting its intentions, even if the message will not be heeded, then it has a strict preference to state its true intentions. Given that, the receiver has a strict preference to believe the message.

Rather than assuming that one of the players has proposal powers, a neutral way that does not arbitrarily give any of the parties first-mover advantage is to let one of them the opportunity of proposing, or not, to cast lots, e.g., to go shopping if the last number on a random license plate is even, and to a football game if it is odd. This is an example of using a public correlating device, as proposed by Aumann (1974). The proposal of random choice (“ R ”) assures fair treatment, leading to a correlated equilibrium of the game if both players decide to go along with the proposal (R), where the expected payoff of each player is $3/2$.¹⁷ If either of the players doesn’t actually adhere to the randomization proposal, ($-R$),

¹⁷This is a simplification of a situation of bilateral communication where both players take turns to say if they actually adhere to the proposal (“ A ”) or not (“ $-A$ ”). After each speech, it is necessary to specify if each player really means what it has just said, acting on that (R), or not ($-R$).

there is instead a mixed strategy equilibrium with an expected payoff of $2/3$.¹⁸

<Figure 12. Battle of the sexes with randomizing device>

6 Implications

6.1 Consistent expectations in Nash equilibria

John Nash (1950) offers one motivation in his original thesis for how his equilibrium concept can be connected with observable phenomena, the “mass-action” interpretation which is applicable to repeated games. “It is unnecessary to assume that the participants have full knowledge of the total structure of the game, or the ability and inclination to go through any complex reasoning processes” (Nash 1950, p. 21). These games allow participants to accumulate empirical information on the relative advantages of the various pure strategies at their disposal, so the mixed strategies that represent the average behavior in each of the populations form an equilibrium point. In large populations, each stage a player faces a different player. However, Nash adds that his interpretation may also hold in small groups as long as the participants are not aware of playing a non-cooperative game (p. 23).

This interpretation is already provided by Cournot (1838) with his tâtonnement-like process, where he formalizes the assumption of self-interested individuals acting in markets as an optimization problem, that of maximizing profits, and extends it to game theory, as a problem of mutual best responses. The equilibrium is not discovered rationally but through trial and error.¹⁹ For instance, a monopolist does not know the demand curve, but using the price-elasticity of demand, the optimum price can be discovered in a step-wise process by raising or lowering prices. Or when describing how agents arrive at a Cournot-Nash equilibrium in a duopoly, this is accomplished by optimal responses to the other player’s action in the previous stage, a process now called “best-response dynamics” in evolutionary game theory (cf. Gardner 1995, p. 225).

This mass-action interpretation does not help much in the case of our telephone conversation between two complete strangers. Though Nash (1950) also offers a “strongly rationalistic and idealizing interpretation” for games that are played but once, it applies to solutions, i.e., this interpretation is restricted to equilibrium points of solvable games (a large restriction).²⁰ In this interpretation, “By using the principles that a rational prediction should be unique, that the players should be able to deduce and make use of it, and that such knowledge on the part of each player of what to expect the others to do should not lead him to act out of conformity with the prediction, one is led to the concept of solution defined before ...we need to assume the players know the full structure of the game in order to be able to deduce the prediction for themselves.” (p.23).

Our problem of how buyer and seller get together is a one-shot game that is not solvable in the sense of Nash (1950). How can we model expectations? Any of the potential pure strategy equilibria can be rationalized. Can we expect any rationalizable strategy? In a sense, yes. If communication is not

¹⁸With costs of misrepresentation, the pessimistic outcome can be ruled out since the player that first makes the proposal to randomize always means it, so it is a best reply for the other player to go along with the randomization scheme.

¹⁹More generally, the theory of learning in games investigates this interpretation. See, for instance, Fudenberg and Levine (1998).

²⁰In this regard, the interpretation in Leonard (1994) is a bit misleading, since it is taken as a general motivation of equilibrium points, i.e., Nash equilibria.

informative, nothing is added to the common priors, so our interpretation is that the expected payoffs in a pessimistic equilibrium are given by a unique prediction, the least informative mixed strategy equilibrium that has in its support any of the rationalizable strategies, as we explain in more generality in the next subsection on priors. Things change in an optimistic equilibrium. Verbal communication replaces rational prediction, and provides an explanation of how consistent expectations are generated in one-shot games with rational players like these that can talk. This is a linguistic explanation of consistent expectations in Nash equilibria.

Besides this imperfect information game where communication affects priors, we discussed three incomplete information games where there were incentives for misrepresentation. In these games, though meaningful talk does not affect priors, it provides a precise structure to the verbal messages expected in equilibrium.

6.2 Common priors

It is standard since John Harsanyi (1967-8) to define common priors in incomplete information games using the beliefs on the distribution of types. In this regard, Akerlof's (1970) market for lemons and Farrell's two disclosure games have well defined common priors. There are no similar common priors for imperfect information games.

In our examples of imperfect information games where all senders are charlatans we implicitly rely on a well-specified default outcome in case communication is not effective, what we call a "pessimistic equilibrium". The pessimistic equilibrium we have been proposing for imperfect information games relies on the mixed strategy Nash equilibrium that we have loosely called "least informative". In other setups, however, the non-informative equilibrium might lead to the Pareto optimal outcome, so we can more generally refer to it as the "default" equilibrium.

In our coordination game of Section 3 where there are 2 pure strategies, this default equilibrium involves mixed strategies in which each available pure strategy is given a prior of 1/2. These beliefs correspond to a mixed strategy Nash equilibrium which has all rationalizable pure strategies in its support. In the battle of the sexes in Section 5, the default equilibrium involves imputing the other player the probabilities of a Nash equilibrium in mixed strategies, since these beliefs are the only way to rationalize why a player may want to play mixed strategies; otherwise, a pure strategy would be preferred. We cannot always rationalize fully mixed strategies. In the problem of the commons in Section 5, our default equilibrium implies giving a prior of 1 to the strategy of defecting. In this game, there are no beliefs that lead to rationalize mixed strategies, since the strategy of cooperation is always strictly dominated for both players. At the same time, there is no mixed strategy Nash equilibrium, so both go hand in hand.

We briefly explore the relation of the default priors used in our examples to the ideas of Bernheim (1984) and Pearce (1984), who introduce rationalizable strategies when players do not share common priors about what each will do. We change the focus in rationalizable strategies to consider what beliefs of each player make these strategies rationalizable, following Harsanyi's (1973) idea of mixed strategies as the uncertainty of a player in relation to what other players may do. The difference in our approach is that we are interested in the beliefs that allow supporting the largest set of rationalizable strategies, and the resulting mixed strategies that may be played when all the players give non-negative probabilities to these rationalizable strategies of the other player. We take these as the default priors, since if information is not effective, rationality does not rule out any strategy, except for special cases like the curse of the commons where there are strictly dominated strategies.

We formally look at the case with two players and two strategies, to establish that the beliefs that underlie the mixture of the largest set of rationalizable pure strategies are given by a mixed strategy Nash equilibrium.

Proposition 1 *Consider a game in normal form with two players and two pure strategies. If each player expects the other to play any non-degenerate mixed strategy that it is rationalizable, the beliefs that underlie these strategies must form a Nash equilibrium.*

Proof: Let $A_i = \{a_{i1}, a_{i2}\}$ denotes the set of pure strategies of player $i = 1, 2$, let R_i denotes the set of rationalizable mixed strategies of player $i = 1, 2$, and let $\mu_{-i} \in R_{-i}$ denote the beliefs that underlie the rationalizable strategies $\sigma_i \in R_i$, for $i = 1, 2$. There are three possible cases.

(i) There may exist a profile of strategies (σ_1, σ_2) such that each $\sigma_i \in R_i$ is a non-degenerate mixed strategy, for $i = 1, 2$. Since σ_1 is a best response to some (possibly non-unique) strategy μ_2 in the set R_2 , it must be the case that $u_1(\sigma_1, \mu_2) = u_1(a_{11}, \mu_2) = u_1(a_{12}, \mu_2)$; since σ_2 is a best response to some (possibly non-unique) mixed strategy μ_1 in the set R_1 , it must be the case that $u_2(\mu_1, \sigma_2) = u_2(\mu_1, a_{21}) = u_2(\mu_1, a_{22})$. Hence, since $u_1(\mu_1, \mu_2) = u_1(\sigma_1, \mu_2)$, μ_1 is also a best response to μ_2 , and since $u_2(\mu_1, \mu_2) = u_2(\mu_1, \sigma_2)$, μ_2 is also a best response to μ_1 . Therefore, the beliefs (μ_1, μ_2) form a Nash equilibrium.

(ii) There may exist a profile of strategies (a_{11}, σ_2) such that $\sigma_2 \in R_2$ is a non-degenerate mixed strategy, while $a_{11} \in R_1$ is a pure strategy (the labelling of strategies and players is arbitrary, so this is without loss of generality). Since player two can only rationalize $\mu_1 = a_{11}$, it must be true for player one that $u_1(a_{11}, \mu_2) \geq u_1(a_{12}, \mu_2)$, for all possible beliefs μ_2 about non-degenerate mixed strategies of player two, so $u_1(\mu_1, \mu_2) \geq u_1(a_{12}, \mu_2)$ and μ_1 is a best response to μ_2 . For player two, the only way a non-degenerate mixed strategy σ_2 can be a best response to a pure strategy μ_1 is for $u_2(\mu_1, \sigma_2) = u_2(\mu_1, a_{21}) = u_2(\mu_1, a_{22})$. This implies in particular that $u_2(\mu_1, \mu_2) = u_2(\mu_1, \sigma_2)$, so μ_2 is also a best response to μ_1 . Hence, the beliefs (μ_1, μ_2) form a Nash equilibrium.

(iii) Else, the remaining case is a profile of strategies (a_{11}, a_{21}) such that $a_{i1} \in R_i$ is a pure strategy (since the labelling of strategies 1 and 2 is arbitrary, this is without loss of generality). The beliefs μ_{-i} that underlie the rationalizable strategies, for $i = 1, 2$, are given by $\mu_{-i} = a_{-i1}$. This forms a Nash equilibrium, since $u_1(\mu_1, \mu_2) \geq u_1(a_{12}, \mu_2)$, and $u_2(\mu_1, \mu_2) \geq u_2(\mu_1, a_{22})$. QED.

A few comments. An example of case (i) are our previous examples of the two by two coordination game and the battle of the sexes. Though the set of rationalizable strategies is the set of all possible strategies, beliefs imply unique rationalizable mixed strategies.

An example that fits the mold of both cases (i) and (ii) is the following game where the row player has two strategies with identical payoffs:

< Table 4. An indifferent player >

The Nash equilibria of this game are (a_{11}, a_{21}) ; (a_{12}, a_{22}) ; and $(\sigma_1 = (1/2, 1/2), \sigma_2)$, where σ_2 is any mixed strategy, including the pure strategies a_{21} and a_{22} . Though the sets of rationalizable strategies are the set of all possible mixed strategies for each player, the only Nash equilibria we can rationalize if players may play any rationalizable mixed strategy are the ones given by $\mu_1 = (1/2, 1/2)$, $\mu_{21} \in [0, 1]$. Though beliefs are not unique for player one, since its payoffs are always identical it is absolutely indifferent about what player two may want to do. In particular, $\mu_1 = (1/2, 1/2)$, $\mu_2 = (1/2, 1/2)$ forms a Nash

equilibrium which corresponds to case (i), and $\mu_1 = (1/2, 1/2)$, $\mu_2 = (1, 0)$ forms a Nash equilibrium which corresponds to case (ii).

As to case (iii), this can happen not only when the second strategy is strictly dominated, but also when it is weakly dominated. An example is in Table 5.

< Table 5. Risk-dominant pure strategy >

The Nash equilibria of this game are: (a_{11}, σ_2) and (σ_1, a_{21}) , where σ_1 is any mixed strategy (not necessary non-degenerate) on A_1 and σ_2 is any mixed strategy (not necessary non-degenerate) on A_2 . Though the sets of rationalizable strategies are the set of all possible mixed strategies for each player, for any profile of non-degenerate mixed strategies (σ_1, σ_2) , the beliefs that underlie these strategies are (a_{11}, a_{21}) , which is a Nash equilibrium. And the only rationalizable strategies against the mixture of rationalizable strategies of the other player are the pure strategies (a_{11}, a_{21}) .

We now establish that, except in the degenerate case where one of the players is indifferent between both of its strategies, beliefs are uniquely determined.

Proposition 2 *The beliefs that underlie these rationalizable strategies are uniquely determined, except for the degenerate case where one player is indifferent between both strategies.*

Proof. If one of the pure strategies of player i strictly dominates the other strategy, for $i = 1, 2$, the beliefs of player $-i$ will be that the dominant strategy will always be chosen. Otherwise, both strategies may either have different or equal payoffs.

If both strategies of player i have different payoffs, let p_{-i} be the belief that player $-i$ will play a_{-i1} and $1 - p_{-i}$ the belief that player $-i$ will play a_{-i2} . Either player i 's strategy a_{i1} will dominate strategy a_{i2} over some initial range of beliefs $p_{-i} \in [0, 1]$, and the second strategy a_{i2} will dominate over the remaining range, or vice-versa. Let the payoffs of the first strategy be decreasing in p_{-i} , while the payoffs of the second strategy are increasing in p_{-i} (the argument is similar in the opposite case). Since the payoffs of both strategies are linear functions of p_{-i} , there is a unique point of intersection p_{-i}^* . If the point of intersection is one of the endpoints of the set $[0, 1]$, one of the strategies of player i is weakly dominated, so it cannot be rationalized as a best response to the mixed strategies of player $-i$. Otherwise, the intersection is at an interior point that uniquely determines beliefs of i about the fully mixed strategies of $-i$.

On the other hand, if both strategies of player i have identical payoffs, either the beliefs of player i cannot be uniquely determined since its payoffs are identical whatever the mixed strategy of player $-i$ (see example in Table 4 above), or the beliefs of player $-i$ cannot be determined, if it has a strictly dominant strategy that it will play regardless of what player i will do. QED.

Hence, beliefs are uniquely determined, except when they are irrelevant to determine a player's optimal strategy. With this caveat, this procedure of starting out from the hypothesis that all players will play with positive probability any of their rationalizable strategies leads, in terms of the priors of the players, to a unique Nash equilibrium for two by two imperfect information games.

These two propositions establish a link between rationality and one of the potential Nash equilibria, with the caveat just noted. When there are more than two strategies, unless some further restriction is imposed it is perfectly possible for the players to hold beliefs about mixed strategies that do not form a Nash equilibrium with consistent expectations. Thus, when we expanded the coordination game in Table

1 to N strategies, we added the restriction that *all* rationalizable pure strategies that may form part of a rationalizable mixed strategy be given positive weight, leading to a common prior of $1/N$ for each pure strategy. Our conjecture is that, using this restriction of focusing on the least informative mixed strategy equilibrium, the propositions for two players might be extended more generally from the two by two case to the N by M case.

7 Final remarks

In economics, the standard approach to language is that talk is cheap. Here, instead, language is a social convention that affects utility. We concentrate on communication between a sender and a receiver, combining two features of natural language, one on the side of senders and another on the side of receivers. On the side of receivers, we develop an insight in Farrell (1994) on the meaning of natural language. We extend this insight to differentiate natural language from ciphers and codes, which is our interpretation of what the cheap talk literature actually models. Cheap talk models ignore the problem of decoding messages. While natural language has a literal interpretation for a receiver due to the fact that is a shared social convention, ciphers and codes do not. On the side of senders, the previous literature has pointed out that costs of misrepresentation can eliminate uninformative, babbling equilibria, as Callander and Wilkie (2006) show for political campaigns with two honesty types. Kartik et al. (2007) additionally point out that honesty transforms language from cheap talk into signals. These two perspectives are complementary: while the encoding-decoding process eliminates informative equilibria where language is not used in its ordinary sense (and makes babbling equilibria unlikely), misrepresentation costs may eliminate babbling equilibria. Together, these two perspective show why language has evolved as a symbolic instrument for conveying information.

We apply our approach to the market for lemons, a decentralized market which can be seen as a two-stage game. In the first, coordination, stage, if the interpretation of a seller's message on the meeting time and place is not its ordinary sense, a coordination failure ensues from the myriad of potential interpretations. Abstracting from the concrete messages that may be sent, the equilibria are of two types: with "optimism", communication is successful and leads to coordination; with "pessimism", coordination fails and we fall back on the mixed strategy Nash equilibrium. Linguistic symbols may provide information, despite the fact that they are not moves: effective communication only requires a minimal probability that both sender and receiver abide by the conventional meanings. Once subjective costs of using language are introduced, so some sellers have a small cost of misrepresenting intentions, words become signals that assure coordination in a "trust" equilibrium. When we move to the second stage where there are incentives for misrepresentation, dishonest people that try to push a lemon do not advertise it as "my automobile is a lemon" (that is also the personal experience of the authors). There is a semantic reason for this, since that message is credible and may be taken at face value. With a continuum of honesty types, Streb and Torrens (2011) additionally show that agents will refrain from lying in equilibrium if it does not pay off. This view on meaningful talk, and the default priors if communication is not effective, has widespread applications, among which are assuring consistent beliefs in Nash equilibria, enabling correlated equilibria and helping to overcome Pareto-dominated outcomes.

More generally, our view on meaningful talk underlies government under rule of law. Olson (2000, p. 62) emphasizes the importance of state coercion for contract compliance, approvingly citing Hobbes' phrase that "covenants without the sword are but words". At the same time, he points out the importance

of an effective judicial system that can enforce long-term contracts, which helps to explain the difference between developed countries with deep capital markets and developing countries plagued by capital flight (pp. 42-43). In the final analysis, Olson’s view requires some form of meaningful talk. Without it, there would be no laws or contracts to interpret, no agreed-on legal system or constitutional polity to enforce it. In this regard, McNollgast (2007) discuss the legislative intent of the law, where they single out, amid the myriad of conflicting statements, those given in the name of the winning coalition to present the agreement with the pivotal voters that are key to pass the legislation. These statements represent legislative intent, others do not, allowing the courts, in case of ambiguity, to supplement the plain meaning of the laws –our main point– by the collective intent of Congress. If talk is not in some sense meaningful, there can be no *de jure* order. Indeed, in some countries policy is mostly *de facto*.^{21, 22}

We have been considering the communicative function of language, and in particular what some call “persuasive communication” where language is an instrument to inform about things, which leaves out “empathetic communication” to make known personal thoughts and feelings (see, e.g., the review in Alonso-Cortés 2007, p. 7, of Adam Smith’s views of language). This second kind of communication may not be as important for markets, though advertisement certainly tries to exploit it, and the references in Ostrom (2009) on decentralized cooperation show it at work. It certainly is key for politics, and for political campaigns where not only programs are at stake, but also the identification of voters with the candidates. For example, in the 2004 campaign George W. Bush’s colloquial language in the Presidential Debate was much closer to the “average” voter than John Kerry’s polished language.

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²¹Foreign policy is also mainly *de facto*. Take for example the 1938 Munich agreement, which Neville Chamberlain raised up in triumph on arriving to London; Hitler’s personal comment was that he had signed a mere piece of paper.

²²Montesquieu (1748), describes in Part 1, Book 2, despotic governments as having no fundamental laws and no depository of laws; instead religion, or custom, form a kind of permanent depository. This points to a special kind of meaningful talk, the word of God.

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Figure 1. Encoding and decoding sequence in unilateral communication

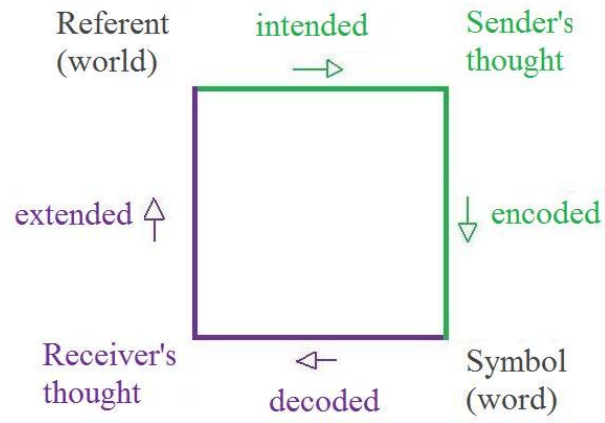


Table 1. Coordination game between buyer and seller

	<i>Left (L)</i>	<i>Right (R)</i>
<i>Left (L)</i>	1,1	0,0
<i>Right (R)</i>	0,0	1,1

Figure 2. Uninformative (pooling) equilibrium

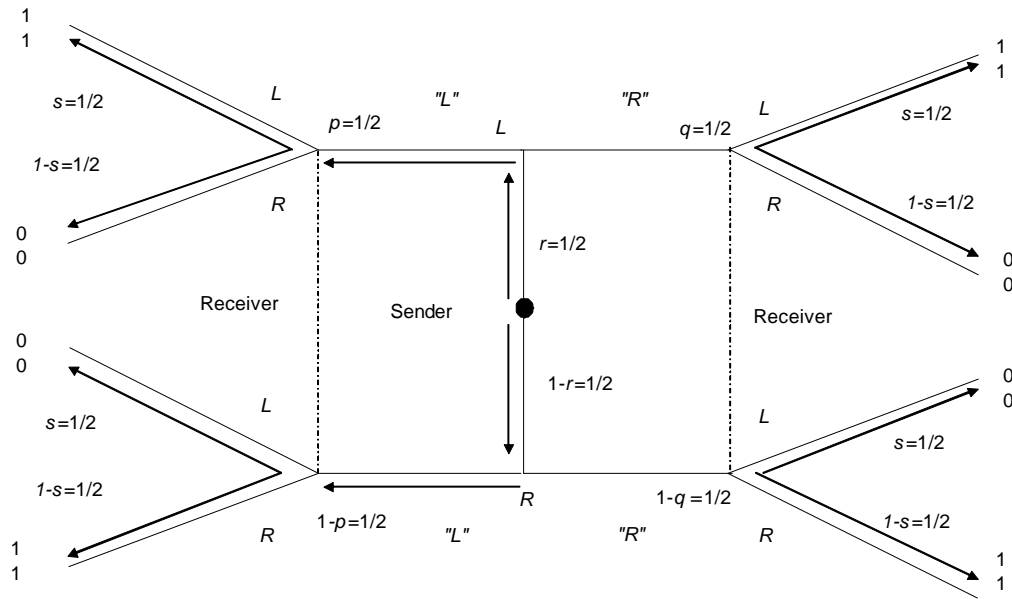


Figure 3. "Unnatural" informative (separating) equilibrium

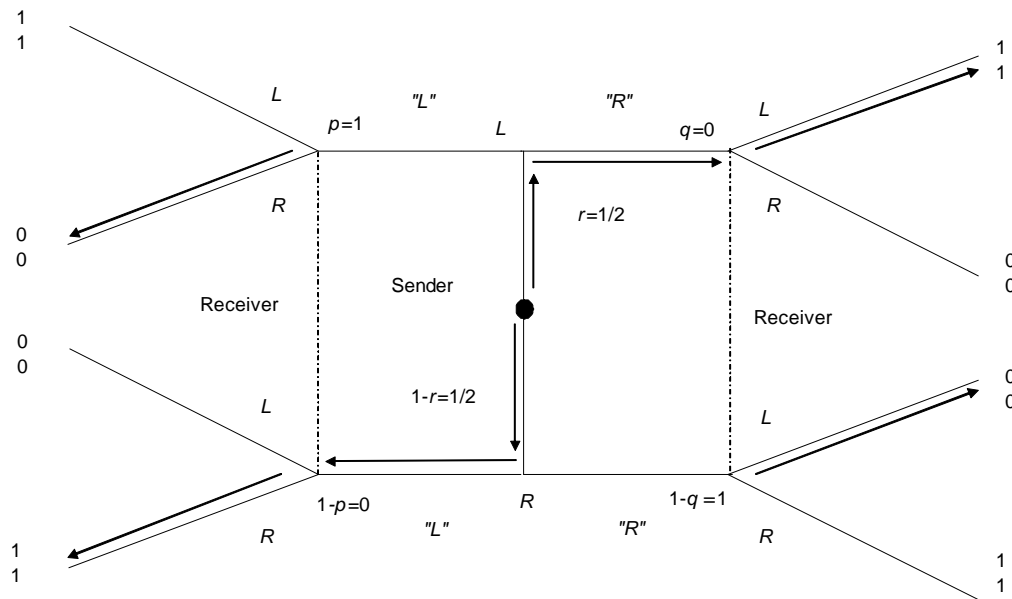


Figure 4. Communicating intentions in an imperfect information coordination game

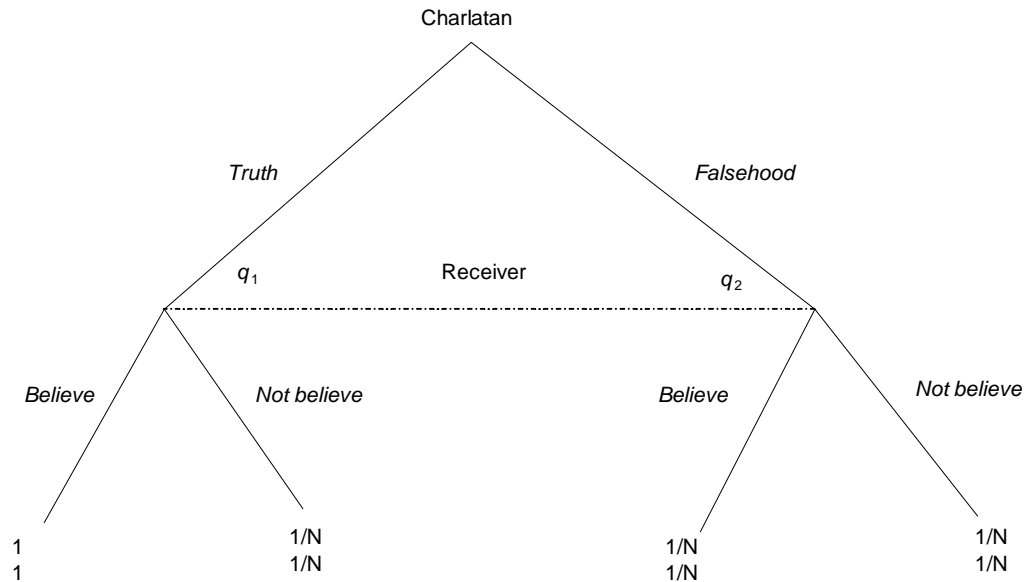


Figure 5. Communicating intentions in an incomplete and imperfect information coordination game

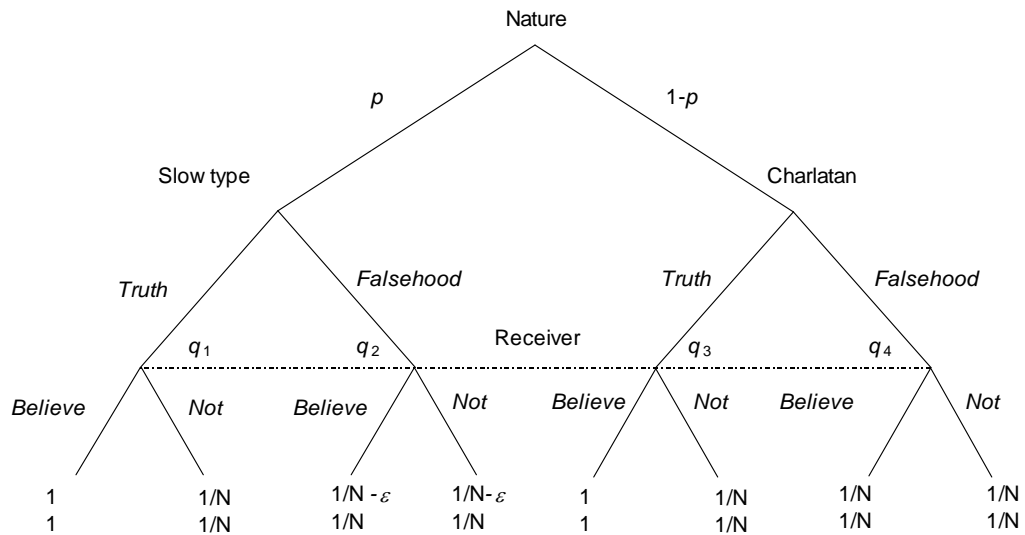


Figure 6. "Unnatural" informative equilibrium with misrepresentation costs

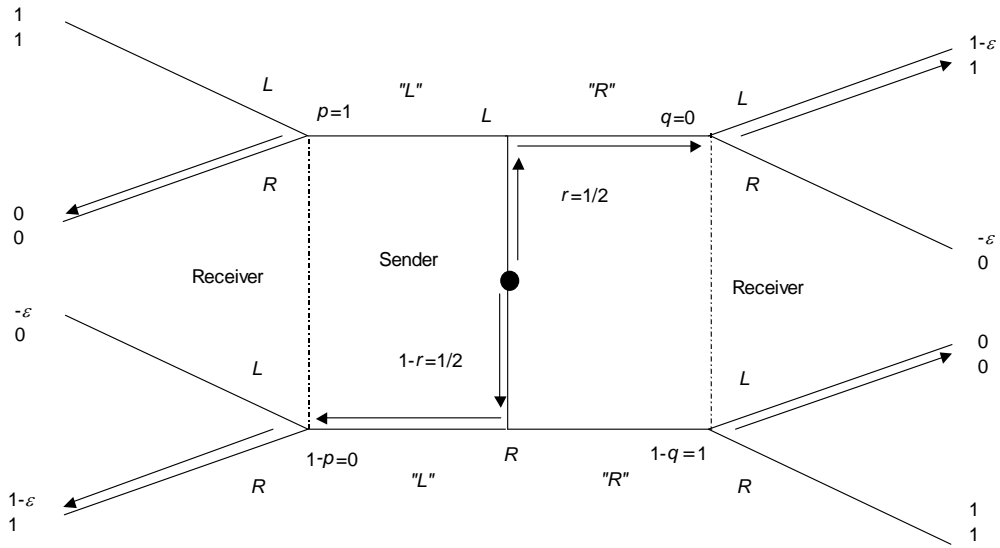


Figure 7. "Natural" informative equilibrium with decoding costs

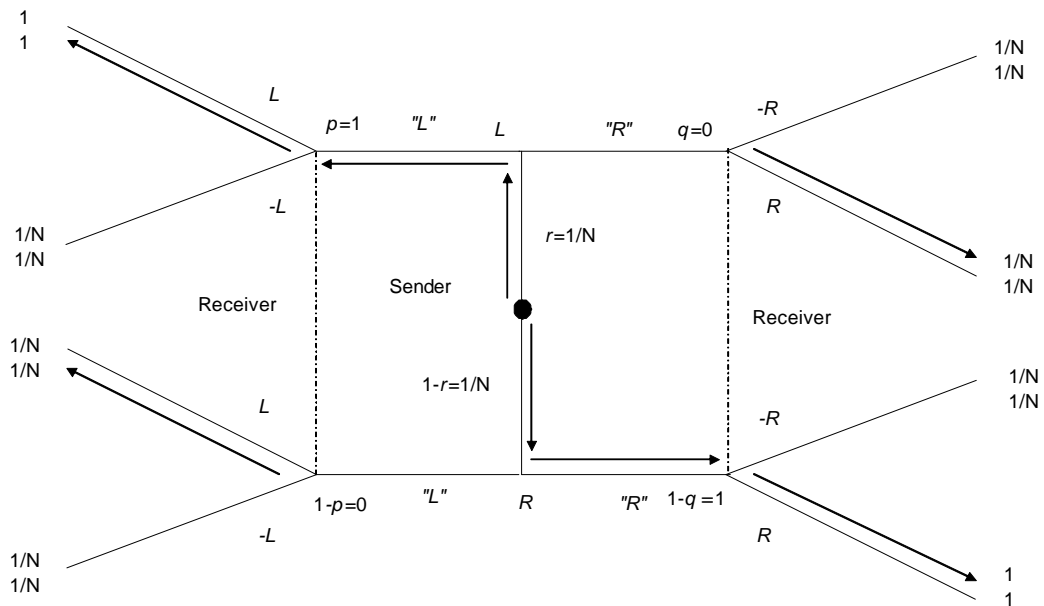


Figure 8. The market for lemons as a cheap-talk game

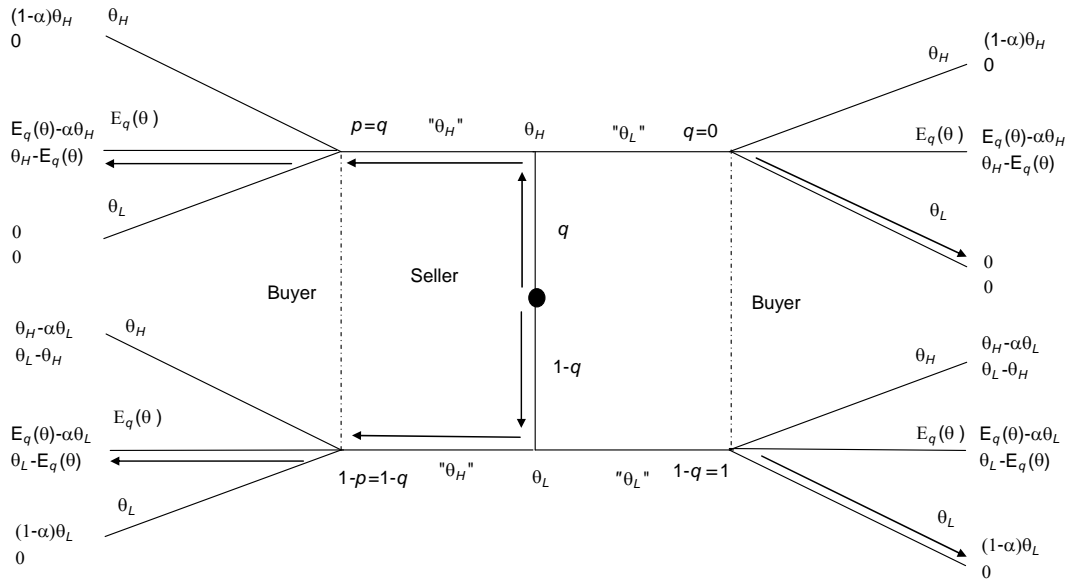


Figure 9. A mimicking game

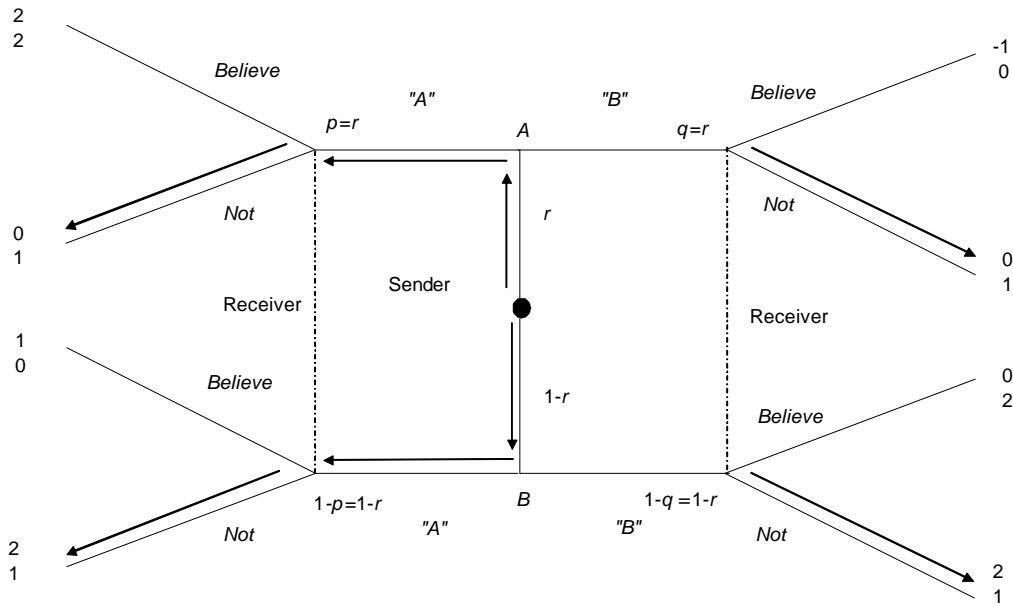


Figure 10. Withholding information

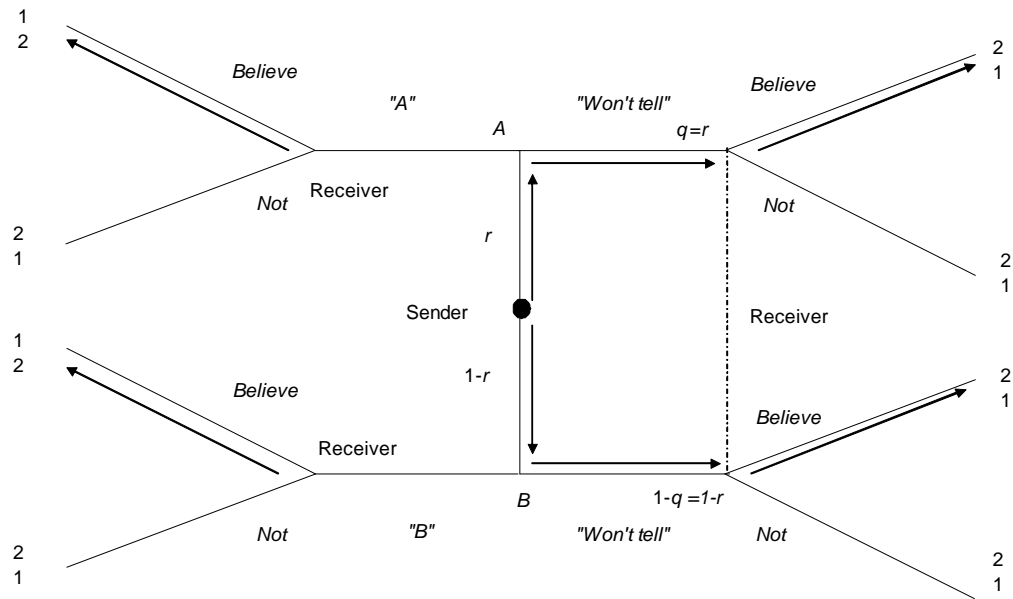


Table 2. The commons

	Cooperate (C)	Defect (D)
Cooperate (C)	10,10	-1,11
Defect (D)	11,-1	0,0

Figure 11. The commons with communication and contracting

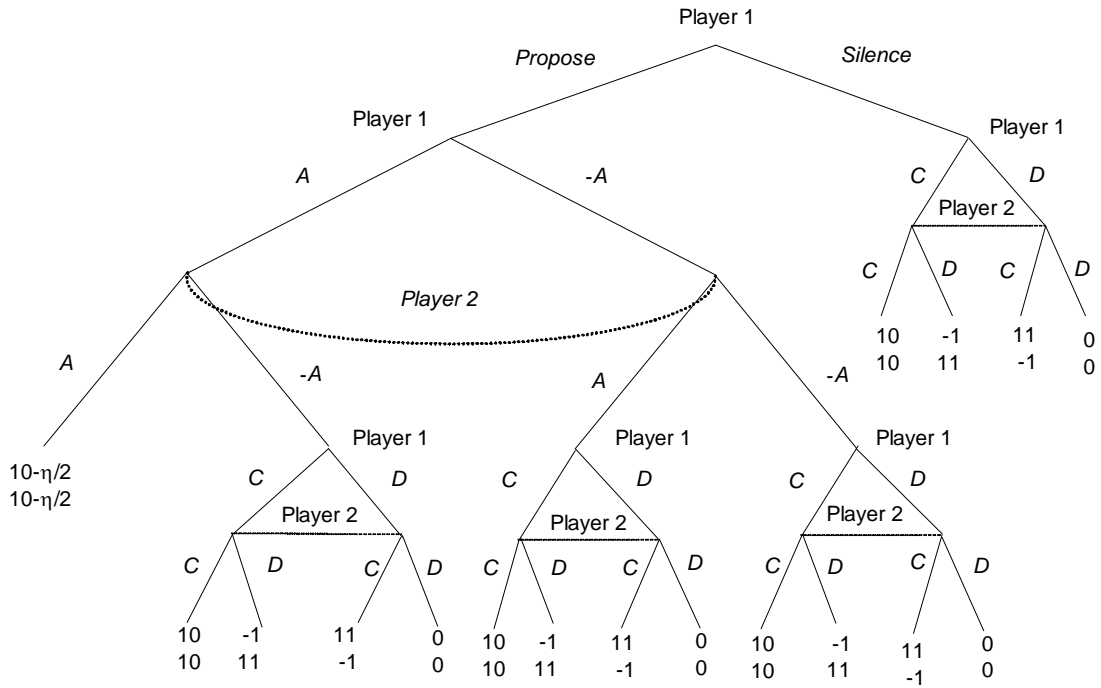


Table 3. Battle of the sexes

	Shopping (S)	Football (F)
Shopping (S)	2,1	0,0
Football (F)	0,0	1,2

Figure 12. Battle of the sexes with randomizing device

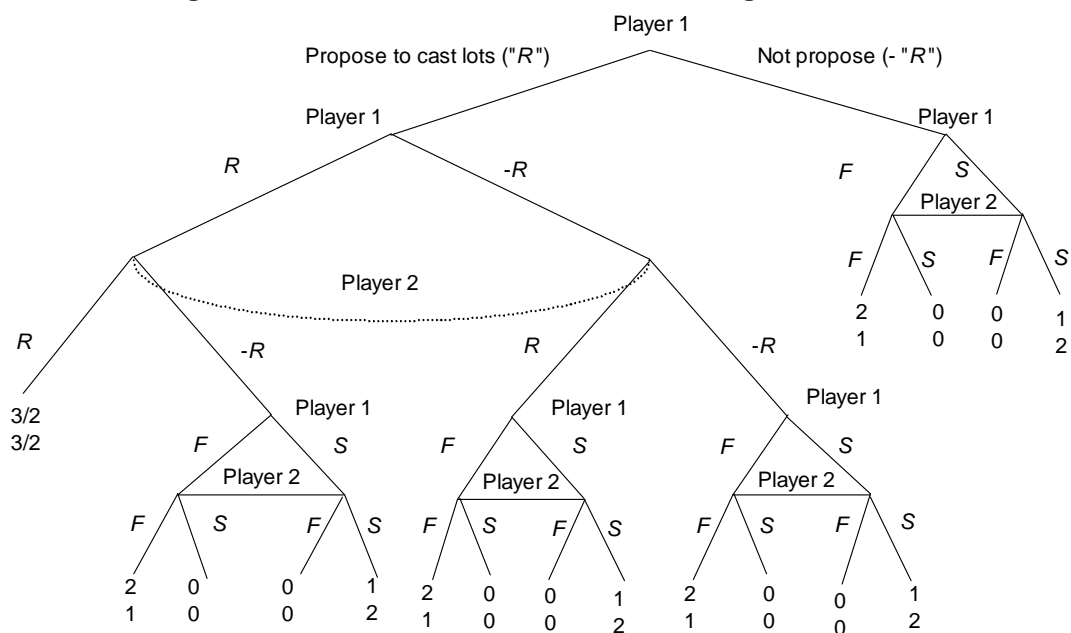


Table 4. An indifferent player

	a_{21}	a_{22}
a_{11}	1,2	1,0
a_{12}	1,0	1,2

Table 5. Risk-dominant pure strategy

	a_{21}	a_{22}
a_{11}	2,2	2,2
a_{12}	2,2	0,0