La función informativa del lenguaje en modelos de transmisión estratégica de información

Jorge M. Streb

Academia Nacional de Ciencias Económicas

26 de noviembre de 2014

Outline

1. Motivation
2. Symbolic information
3. Definition of equilibria
4. Implications for unilateral communication
5. Extensions to bilateral communication
6. Extensions to signaling games
7. Closing remarks

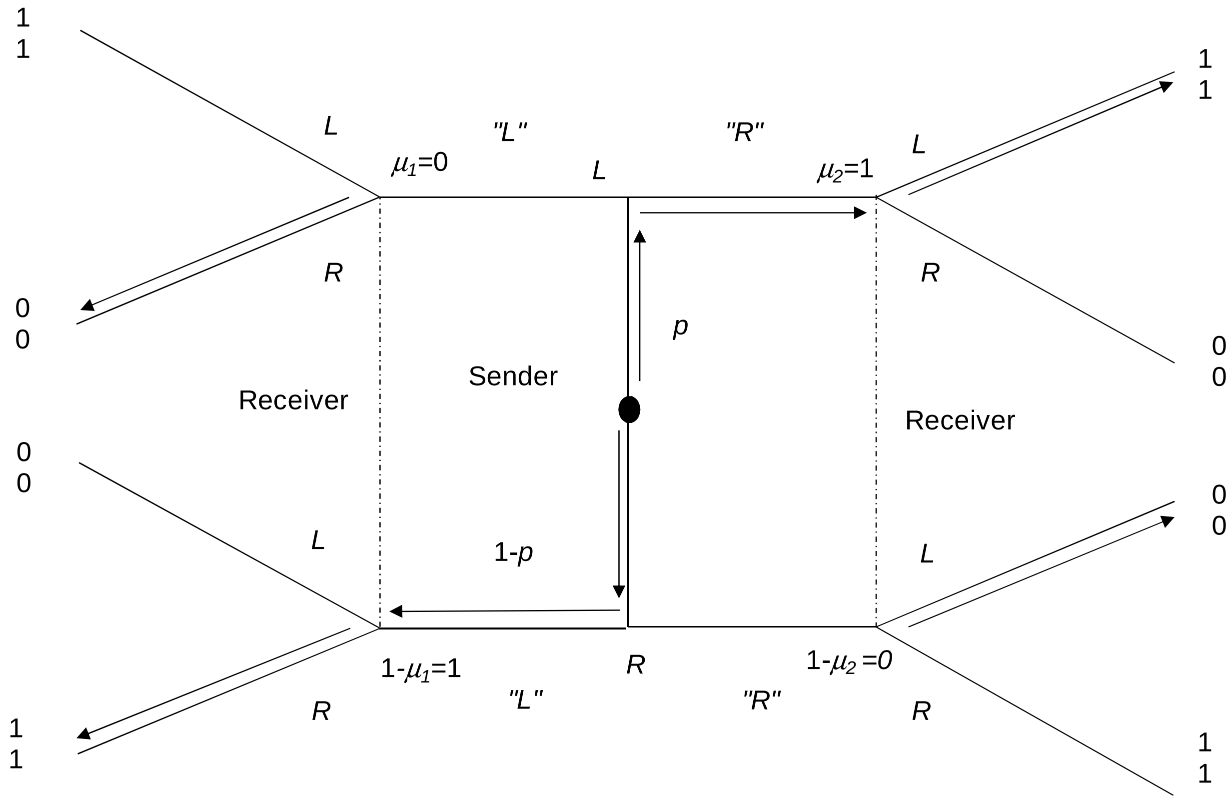
1. Motivation

- Joint work with Gustavo Torrens (meaningful talk) and Fernando Tohmé (bilateral communication and signaling)
- Cheap talk: unilateral communication between sender and receiver (Crawford and Sobel 1982)
- Epistemic problem: verbal information — only information actually added through communication — not taken into account in updating priors

Rendez-vous

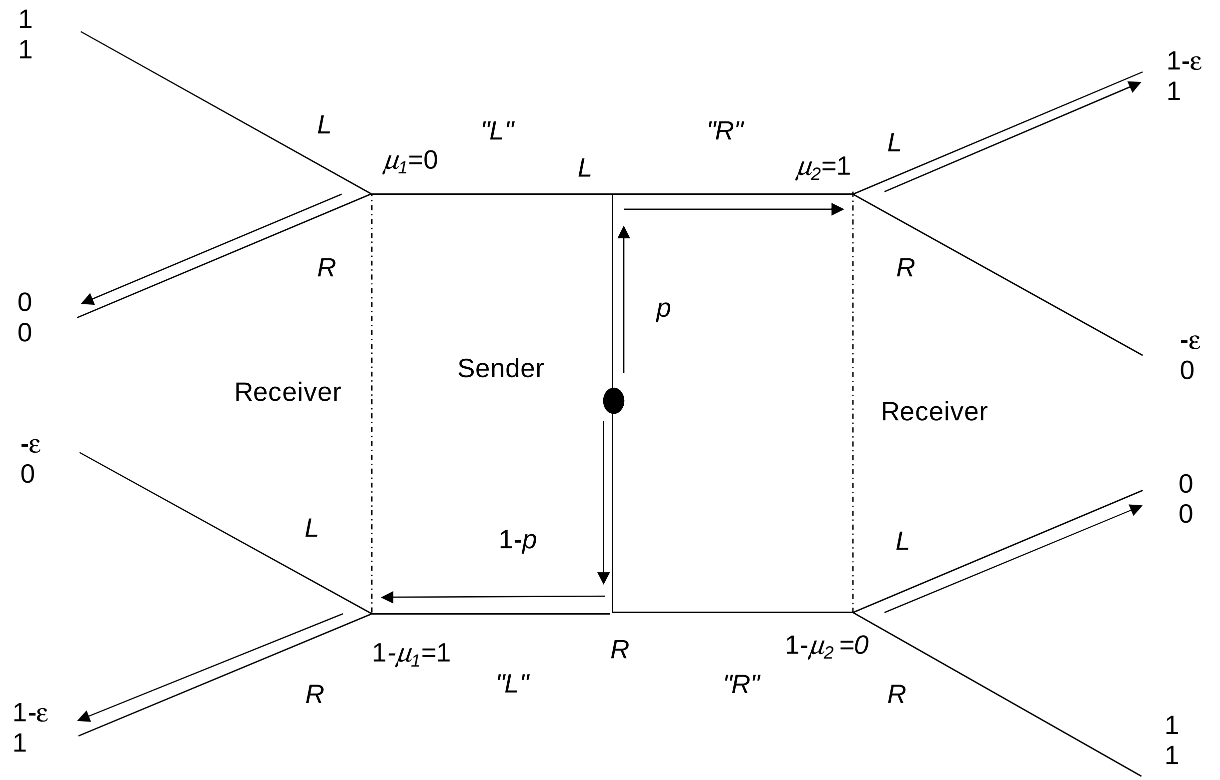
- See informative equilibria of *rendez-vous* — a coordination game — with cheap and costly talk
- How do seller and buyer get together in decentralized market for used cars?
- Four pieces of information: a car is for sale, seller’s phone number, meeting time and meeting place
  - Focus here on meeting place: this is pure coordination game

- Two sender types: left (L) and right (R)
- Priors: both types equally probable
- No communication: there is a Bayesian Nash equilibrium where receiver plays each pure strategy half the time
- Effect of talk: allow coordination, i.e., allow to select equilibrium
- Problem: both cheap and costly talk allow informative equilibria where language is used in non-standard (“unnatural”) way



-

CHEAP TALK: UNNATURAL INFORMATIVE EQUILIBRIUM



-

COSTLY TALK: UNNATURAL INFORMATIVE EQUILIBRIUM

2. Symbolic information

Linguistic signs are composed of:

(i) The signifier or sign vehicle: a sequence of letters or sounds "m".

(ii) The signified, sense, or intension: the concept $\widehat{m}$ we think about.

(iii) The referent or extension: the object m a signifier refers

Incorporate symbolic information in economic theory:

- Language composed of conventional signs that point to types and actions

- Terminology from semiotics and linguistics

- With asymmetric information, the only observable is the message (the signifier) with its accompanying meaning (the signified)

Encoding-decoding step

Encoding stage: sender S uses signifier $"m^S"$ to express signified $\widehat{m}^S$.

(1) $$"m^S" = e(\widehat{m}^S),$$

Decoding stage: receiver R uses signifier $"m^R"$ to recover the signified $\widehat{m}^R$.

(2) $$\widehat{m}^R = e^{-1}("m^R").$$

A *natural language* is bijection over the powerset of $\widehat{\mathbb{W}}$, $e: \mathrm{P}(\widehat{\mathbb{W}}) \rightarrow "\mathbb{L}"$.

Meaningful talk is natural language "$\mathbb{M}$" common to players.

ASSUMPTION 1: Receiver can understand literal meaning $\widehat{m}^R = e^{-1}("m^S")$ if and only if sender uses common natural language "$\mathbb{M}$" to utter message $"m^S" = e(\widehat{m}^S)$.

Inferential step

$"\mathrm{M}" \sqsubset "\mathbb{M}"$ refer to game $\mathrm{W} \sqsubset \mathbb{W}$.

Sender's *truth-function* $T^S\!: "\mathrm{M}" \mathrm{x} \mathrm{W} \rightarrow \{0,1\}$, where $T^S(\,"m", \mathrm{S}) = 1$ if and only if $"m" = "\mathrm{S}"$, $T^S("m", \mathrm{S}) = 0$ otherwise.

Receiver's *trust-function* $B^R\!: "\mathrm{M}" \rightarrow \{0,1\}$, where $B^R("m") = 1$ if message $"m"$ is trusted and $B^R("m") = 0$ if not.

ASSUMPTION 2: Receiver may either trust the message's literal meaning, $B^R(\text{"}m\text{"}) = 1$, and update its priors accordingly, or not trust it, $B^R(\text{"}m\text{"}) = 0$, ignoring the message and not using it to update priors.

Incomprehensible messages are $\text{"}m\text{"} \not\ni \text{"}\mathbb{M}\text{"}$.

Irrelevant messages "S": $\mathrm{S} \cap \mathrm{W} = \emptyset$ or $\mathrm{S} \cap \mathrm{W} = \mathrm{W}$.

LEMMA 1: *If all statements* $\text{"}m\text{"}$ *incomprehensible or irrelevant, cannot update beliefs.*

Credibility and belief

Farrell (1993): natural language might not be credible, but it is comprehensible. Unlike Farrell (1993), credibility and belief are here two distinct concepts.

DEFINITION 1: A message is *credible* in a given game if, when it is believed by the receiver, the message is either on the equilibrium path and true, or else off the equilibrium path.

3. Definition of equilibria

Sequence: First, priors $p(t) \in \mathrm{P}$ about types $t \in \mathrm{T}$ exogenously given. Second, sender S sends message "m" ∈" M". Third, receiver R updates its priors (through decoding and inferential steps). Fourth, receiver picks action $a^R \in \mathrm{A}^{\mathrm{R}}$. Finally, $v^l\!: \mathrm{WxA}^l \rightarrow \mathcal{R}$ is utility function of player $l = S, R$. Strategies and beliefs are given by $(\omega^S, \sigma^R, \mu)$, where:

- A strategy for the sender is composed of probability distributions on messages $"M"$ $\omega^S(w) = (\omega^S(w)("m_1"), \ldots, \omega^S(w)("m_M"))$ for each type $w \in W$ that form vector of probability distributions $\omega^S = (\omega^S(w_1), \ldots, \omega^S(w_W))$.
- A strategy for the receiver is composed of probability distributions on A^R, $\sigma^R("m") = (\sigma^R("m")(a_1^R), \ldots, \sigma^R("m")(a_W^R))$ for each

$"m" \in "M"$ that form a vector of probability distributions $\sigma^R = (\sigma^R("m_1"), \ldots, \sigma^R("m_M"))$.

- A belief for receiver is vector of probability distributions $\mu = (\mu("m_1"), \ldots, \mu("m_M"))$, where $\mu("m") = \left(\mu("m")(w_1), \ldots, \omega^S("m")(w_W)\right)$ is probability distribution on W for each $"m" \in "M"$.

DEFINITION 2 (*cheap talk*): Perfect Bayesian equilibrium satisfies:

(1) For each $w \in \mathrm{W}$, senders' messages $\widetilde{\omega}^S(w)$ are best response given strategies $\tilde{\sigma}^R("m")$ of receiver.

(2) For each $"m" \in "\mathrm{M}"$, movers of receiver $\tilde{\sigma}^R("m")$ are best response given strategies $\widetilde{\omega}^S(w)$ of senders.

(3) Equilibrium path: $\tilde{\mu}("m")(w_i) = \frac{\widetilde{\omega}^S(w_i)("m")p(w_i)}{\sum_w \widetilde{\omega}^S(w)("m")p(w)}$.

(4) Beliefs off equilibrium path: $\tilde{\mu}("m")(w) \in [0,1]$.

Critique 1: condition (3) determines beliefs by equilibrium strategies regardless of how that might be communicated from player to player in game by actual "*m*". In other words, mapping from types to messages not observable, only observable are messages.

Critique 2: by condition (4) analyst free to choose beliefs off the equilibrium path, can pull them out of a hat. Here impose restriction that beliefs determined by epistemic steps (coding-decoding and inferential steps).

DEFINITION 3 (*meaningful talk*): changes (3) and (4):

(3') Beliefs on equilibrium path:

(i) if "m" incomprehensible, irrelevant, or $B^R("m") = 0$ for all "m", $\tilde{\mu}("m")(w) = \frac{p(w)}{\sum_w p(w)}$;

(ii) if "m" comprehensible, relevant, and $B^R("m") = 1$ for "m"="S" ∈"M", all credible messages believed; $\tilde{\mu}("m")(w_i) = \frac{\tilde{\omega}^S(w_i)("m")p(w_i)}{\sum_w \tilde{\omega}^S(w)("m")p(w)}$.

Comment: condition (3') limits new information to messages actually uttered. Requires that if switch from mistrust to trust, receiver must be worse off.

(4') Beliefs off equilibrium path:

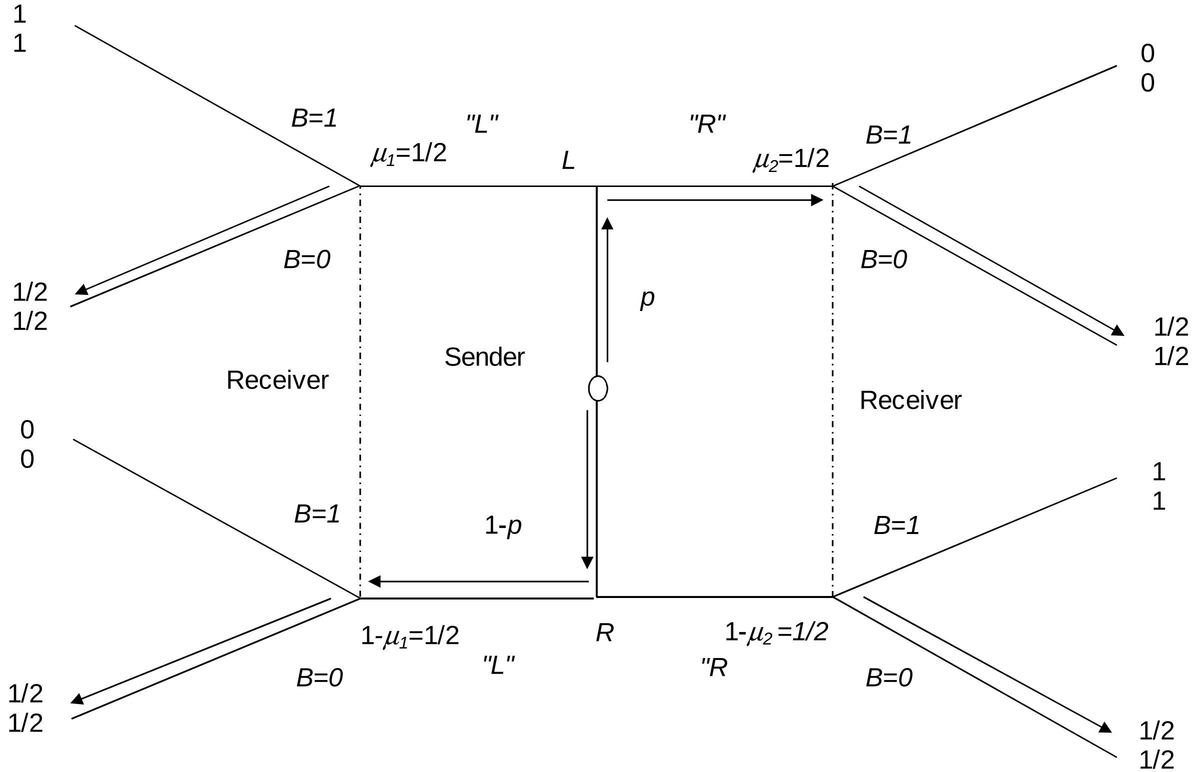
(i) either disregard message and keep priors, $\tilde{\mu}("m")(w) = \frac{p(w)}{\sum_w p(w)}$;

(ii) or accept literal meaning $"m"$=”S”, so $\tilde{\mu}("m")(w) = \frac{p(w)}{\sum_w p(w)}$ for $w \in$ S, $\tilde{\mu}("m")(w) = 0$ for $w \notin$ S.

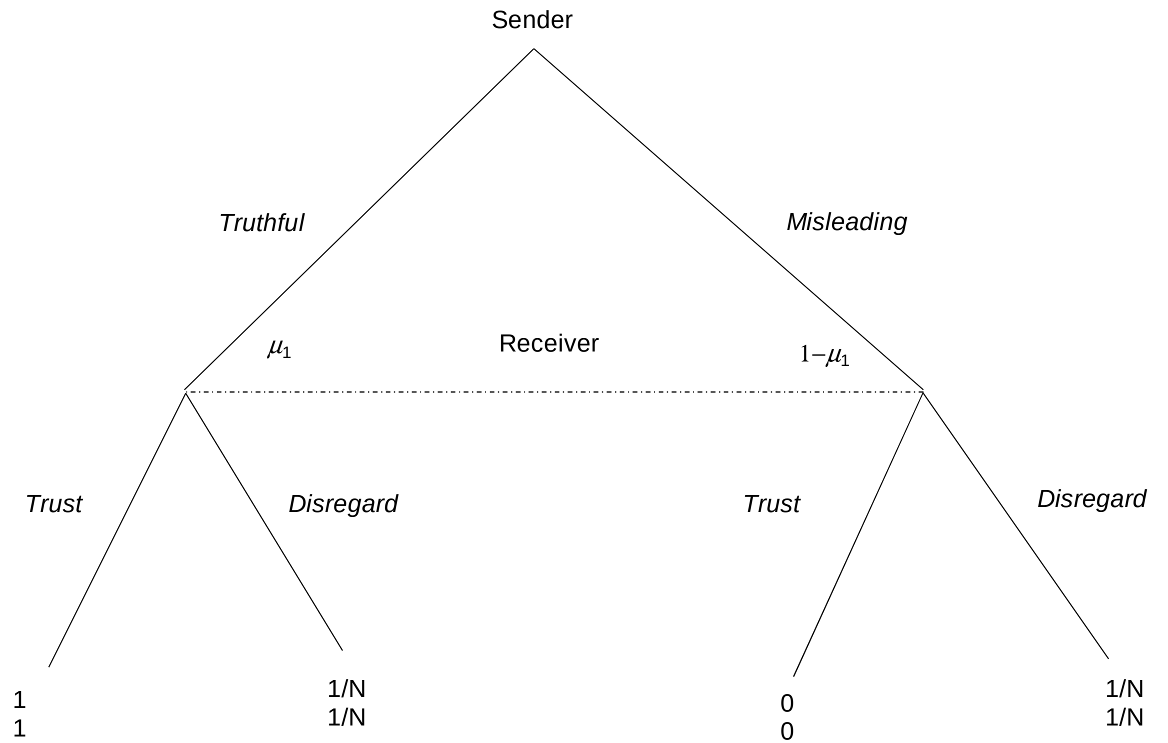
Comment: condition (4’) limits beliefs off the equilibrium path to either ignoring the verbal information or believing it literally.

4. Implications

- Informative equilibria use language in ordinary sense; encrypted messages no longer informative
- *Rendez-vous*: when indefinite number of meeting places, concentrate on truth and trust
- Uninformative equilibria always exist
- Necessary condition for informative equilibrium: sender must be better off
- Sufficient condition for informative equilibrium: additionally requires relevant messages that are credible



MEANINGFUL TALK: NO UNNATURAL INFORMATIVE EQUILIBRIUM

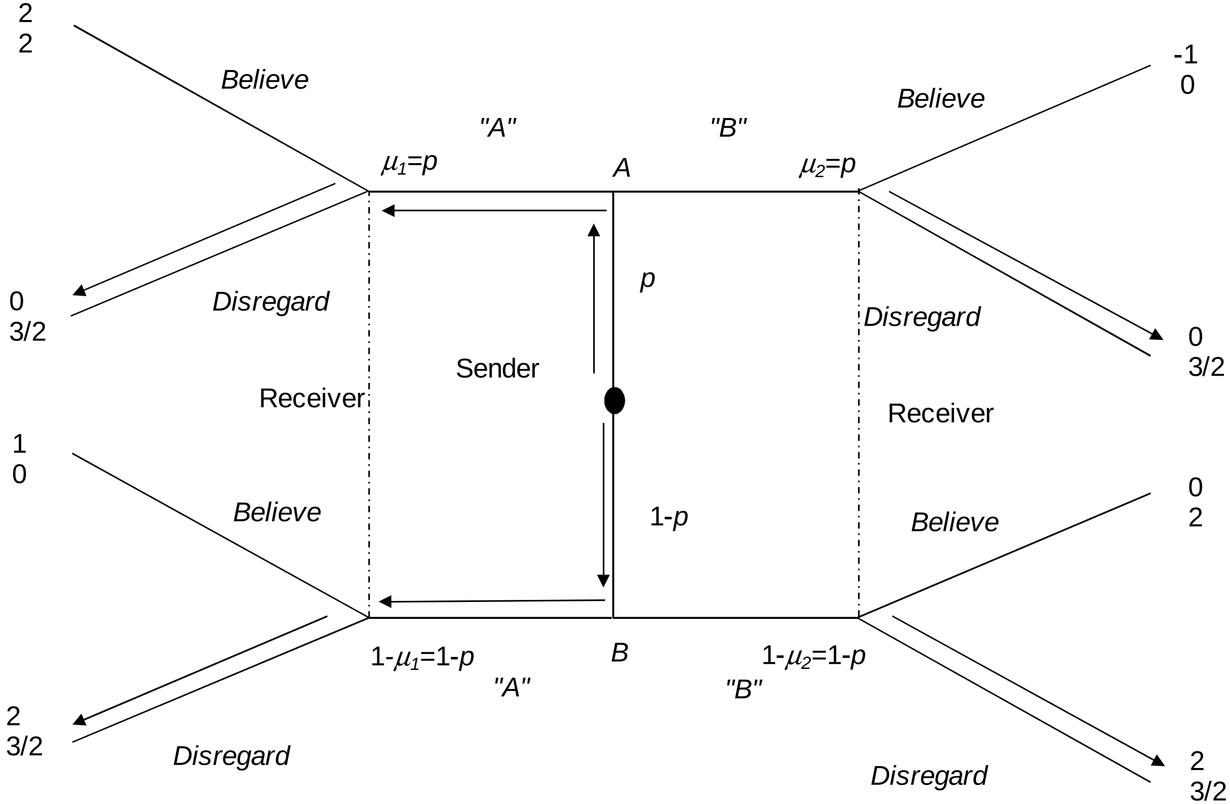


MEANINGFUL TALK: COORDINATING UNDER IMPERFECT INFORMATION

LEMMA 2: M*eaningful-talk equilibria always exist.*

PROOF**:** *Trivial. If receiver disregards all messages, sender has no incentive to choose message conditional on type. If sender sends message not conditional on type, receiver has no incentive to heed the messages.*

This contrasts with Farrell's (1993) *neologism-proof equilibria* which may refine away all cheap-talk equilibria: neologisms not always available.



MEANINGFUL TALK: NO MEANINGFUL NEOLOGISM AVAILABLE

THEOREM 1 (necessary): *Informative meaningful-talk equilibria exist only if not all sender types are worse than in an uninformative equilibrium.*

PROOF: *Suppose not, so all types of senders are worse off in informative equilibrium. Then no type has incentive to reveal any information. By Lemma 1, if no sender provides relevant information, beliefs given by priors.*

COROLLARY 1 (sufficient): *Informative equilibria with meaningful talk exist if not all sender types are worse off than in an uninformative equilibrium, and there are relevant messages that are credible.*

PROOF: *If the receiver believes all credible messages, the credible messages that a sender has an incentive to utter truthfully will be on the equilibrium path. If credible messaged on the equilibrium path are relevant, the priors will be affected by the equilibrium.*

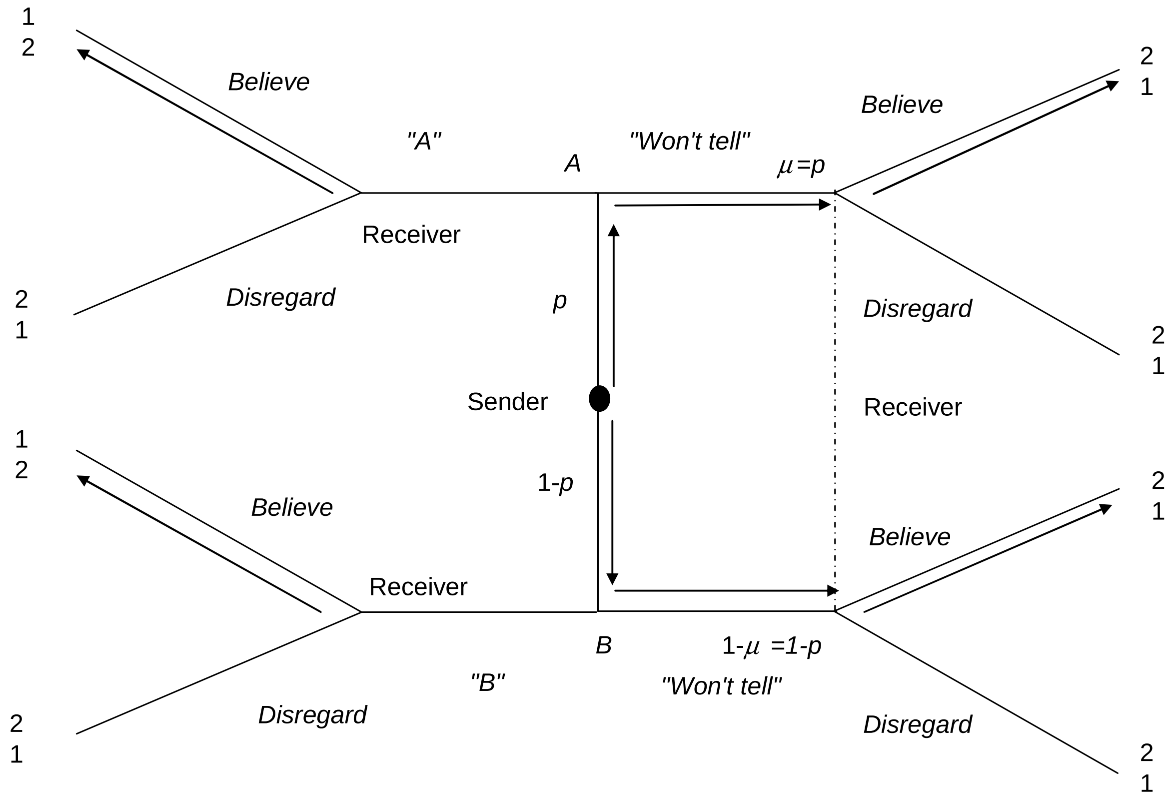
5. Bilateral communication

- Consider what happens if uninformed party can talk first and propose a threat or a menu

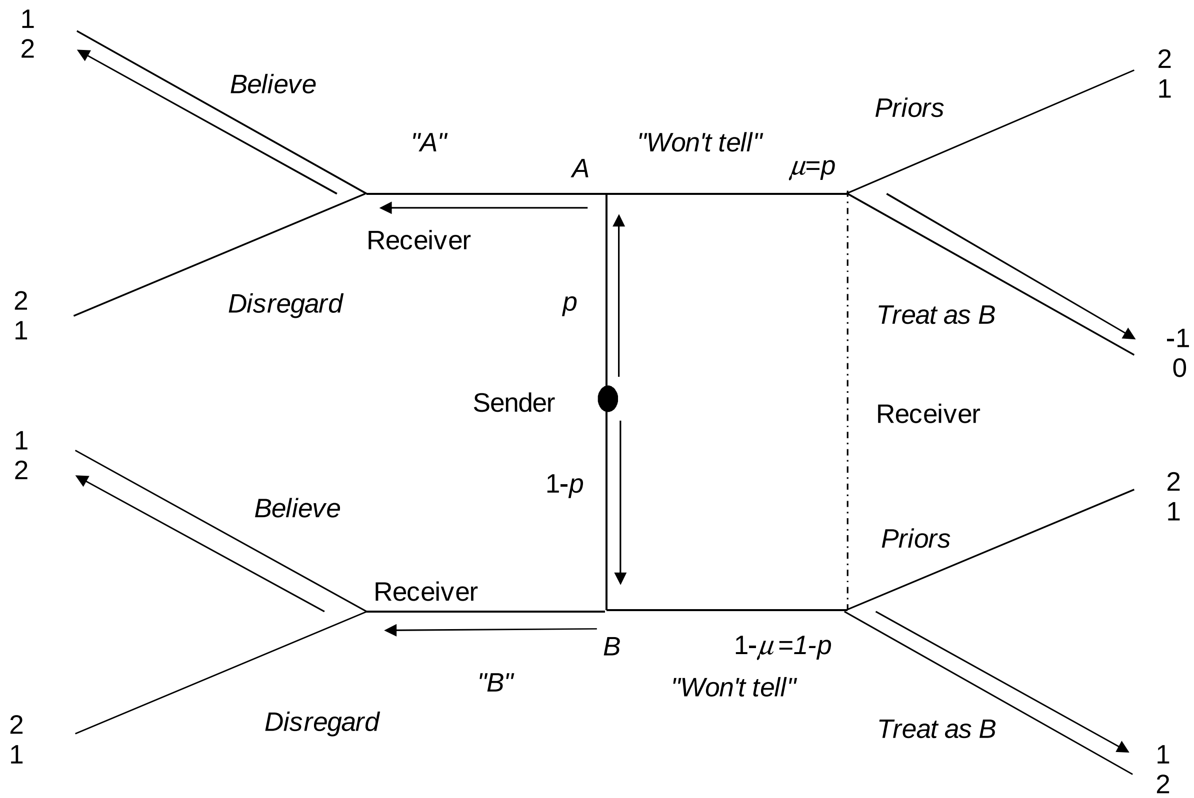
- This relates to literature on mechanism design where there is screening

- Some informative cheap-talk equilibria require, in our view, bilateral communication

- See example from Farrell (1993)



MEANINGFUL TALK: WITHHOLDING INFORMATION

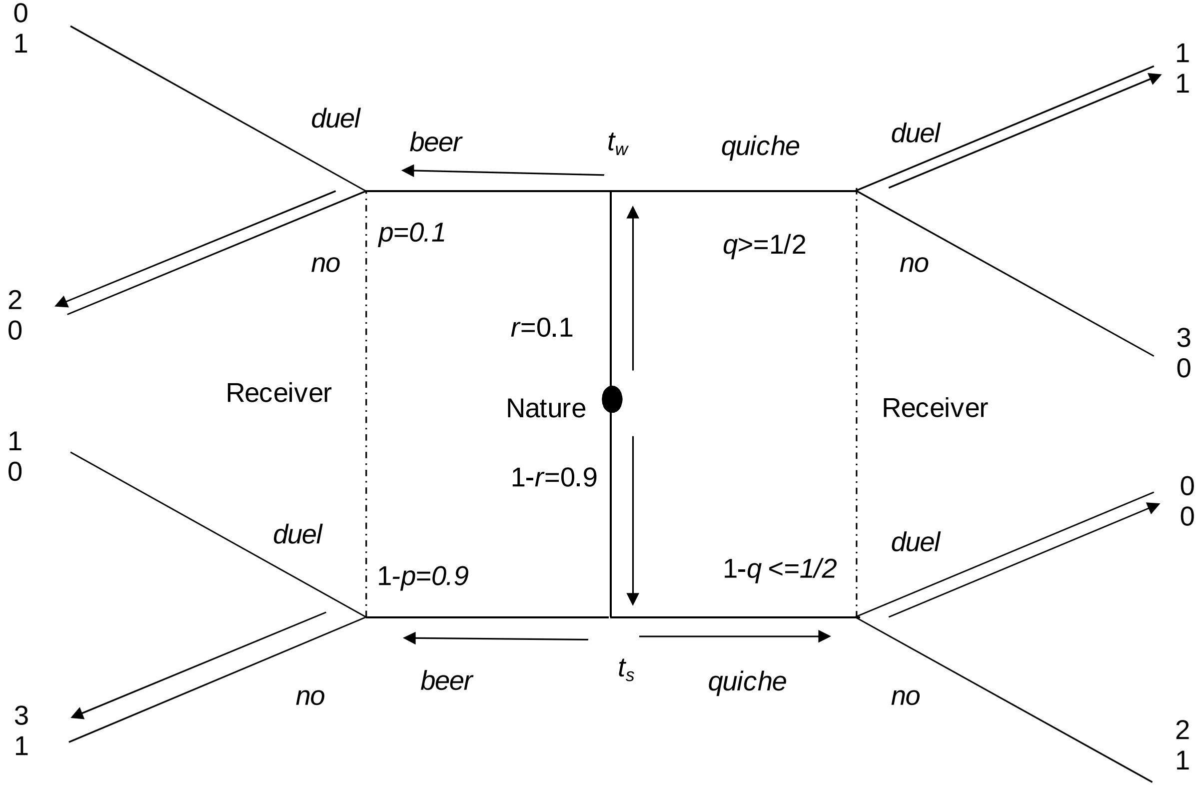


CHEAP TALK: NOT WITHHOLDING INFORMATION

6. Signaling games

Ideas from meaningful talk carry over to signaling games, refinement of Perfect Bayesian equilibrium:

- (i) If no signal in equilibrium, receiver cannot infer anything new
- (ii) Signals must be credible, i.e., they must be part of equilibrium
- (iii) Senders have incentive to perform equilibrium selection: works if there is “natural” equilibrium



CHO-KREPS BEER AND QUICHE GAME

7. Final Remarks

- Messages comprehensible if and only if common language used, but have to infer equilibrium meaning
- Natural language may convey information about moves and types though it provides no direct evidence

–Key result: optimal relevance (Sperber and Wilson)

- Generalization: sender selects equilibrium, applies to all signaling games