Two Theories of Implicatures (Parikh, Jäger)

Day 3 – August, 9th

Overview

- Prashant Parikh: A disambiguation based approach
- Gerhard Jäger: A dynamic approach

A disambiguation based approach

Prashant Parikh (2001)

The Use of Language

Repetition: The Standard Example

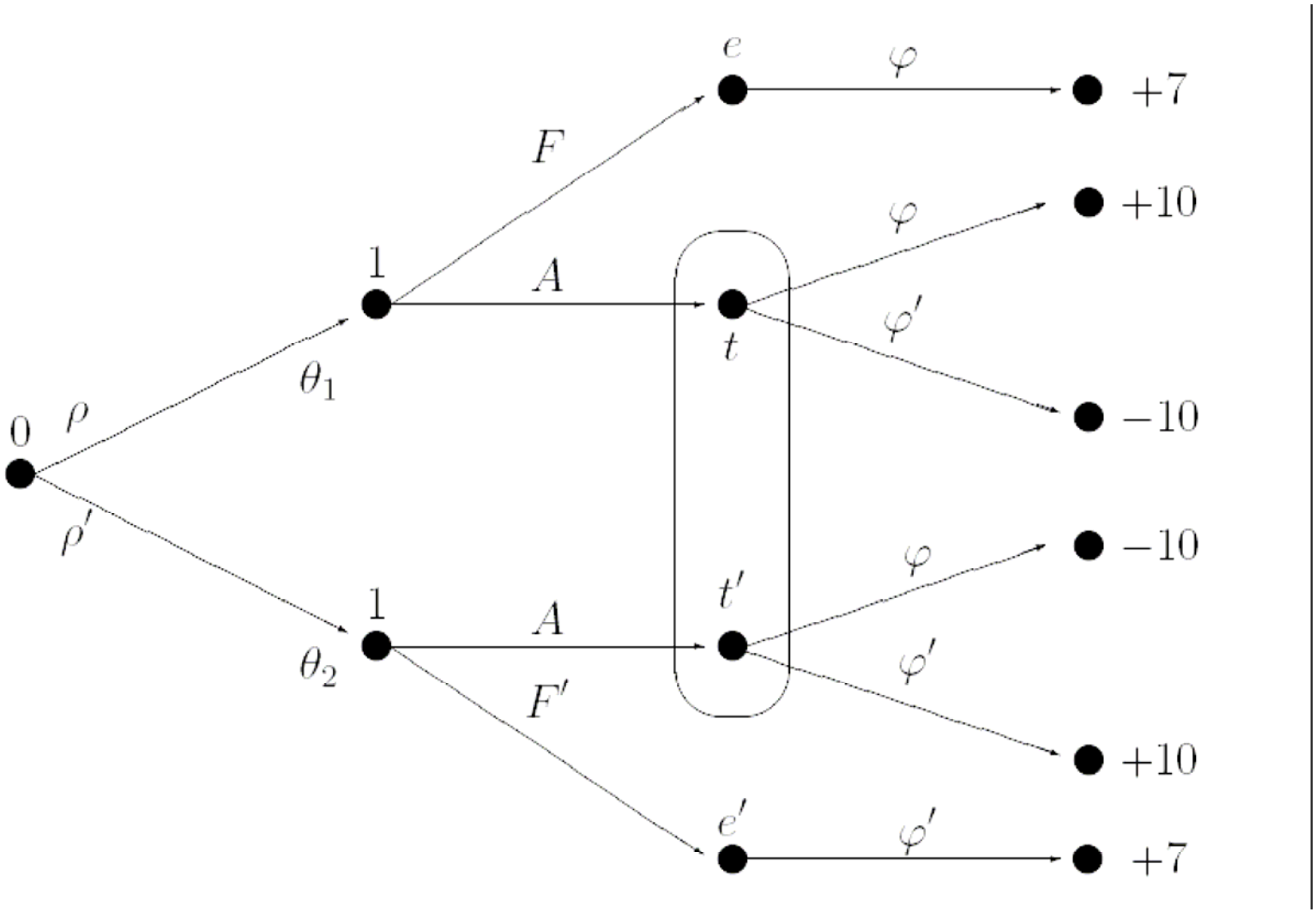
a) Every ten minutes a man gets mugged in New York. (A)
b) Every ten minutes some man or other gets mugged in New York. (F)
c) Every ten minutes a particular man gets mugged in New York. (F')

- How to read the quantifiers in a)?

Abbreviations

- φ: Meaning of `every ten minutes some man or other gets mugged in New York.'
- φ': Meaning of `Every ten minutes a particular man gets mugged in New York.'
- θ_1: State where the speaker knows that φ.
- θ_2: State where the speaker knows that φ'.

A Representation



General Characteristics

- There is a form A that is ambiguous between meanings φ and φ'.
- There are more complex forms F, F' which can only be interpreted as meaning φ and φ'.
- The speaker but not the hearer knows whether φ (type θ_1) or φ' (type θ_2) is true.

- It is assumed that interlocutors agree on a Pareto Nash equilibria (S,H).
- The actual interpretation of a form is the meaning assigned to it by the hearer's strategy H.

Implicatures

Classification of Implicatures

Parikh (2001) distinguishes between:

- **Type I implicatures:** There exists a decision problem that is directly affected.
- **Type II implicatures**: An implicature adds to the information of the addressee without directly influencing any immediate choice of action.

Examples of Type I implicatures

1. A stands in front of his obviously immobilised car.

   A: I am out of petrol.

   B: There is a garage around the corner.

   +>The garage is open and sells petrol.

2. Assume that speaker S and hearer H have to attend a talk just after 4 p.m. S utters the sentence:

   S: It's 4 p.m. (A)

   +> S and H should go for the talk. (ψ)

A model for a type I implicature

The Example

2. Assume that speaker S and hearer H have to attend a talk just after 4 p.m. S utters the sentence:

   S: It's 4 p.m. (A)

   +> S and H should go for the talk. (ψ)

The possible worlds

The set of possible worlds Ω has elements:

- s_1: it is 4 p.m. and the speaker wants to communicate the implicature ψ that it is time to go for the talk.
- s_2: it is 4 p.m. and the speaker wants to communicate only the literal content φ.

The Speaker's types

- Assumption: the speaker knows the actual world.
- Types:
  - $\theta_1 = \{s_1\}$: speaker wants to communicate the implicature ψ.
  - $\theta_2 = \{s_2\}$: speaker wants to communicate the literal meaning φ.

Hearer's expectations about speaker's types

- Parikh's model assumes that it is much more probable that the speaker wants to communicate the implicature ψ.
- Example values:

$$p(\theta_1) = 0.7 \text{ and } p(\theta_2) = 0.3$$

The speaker's action set

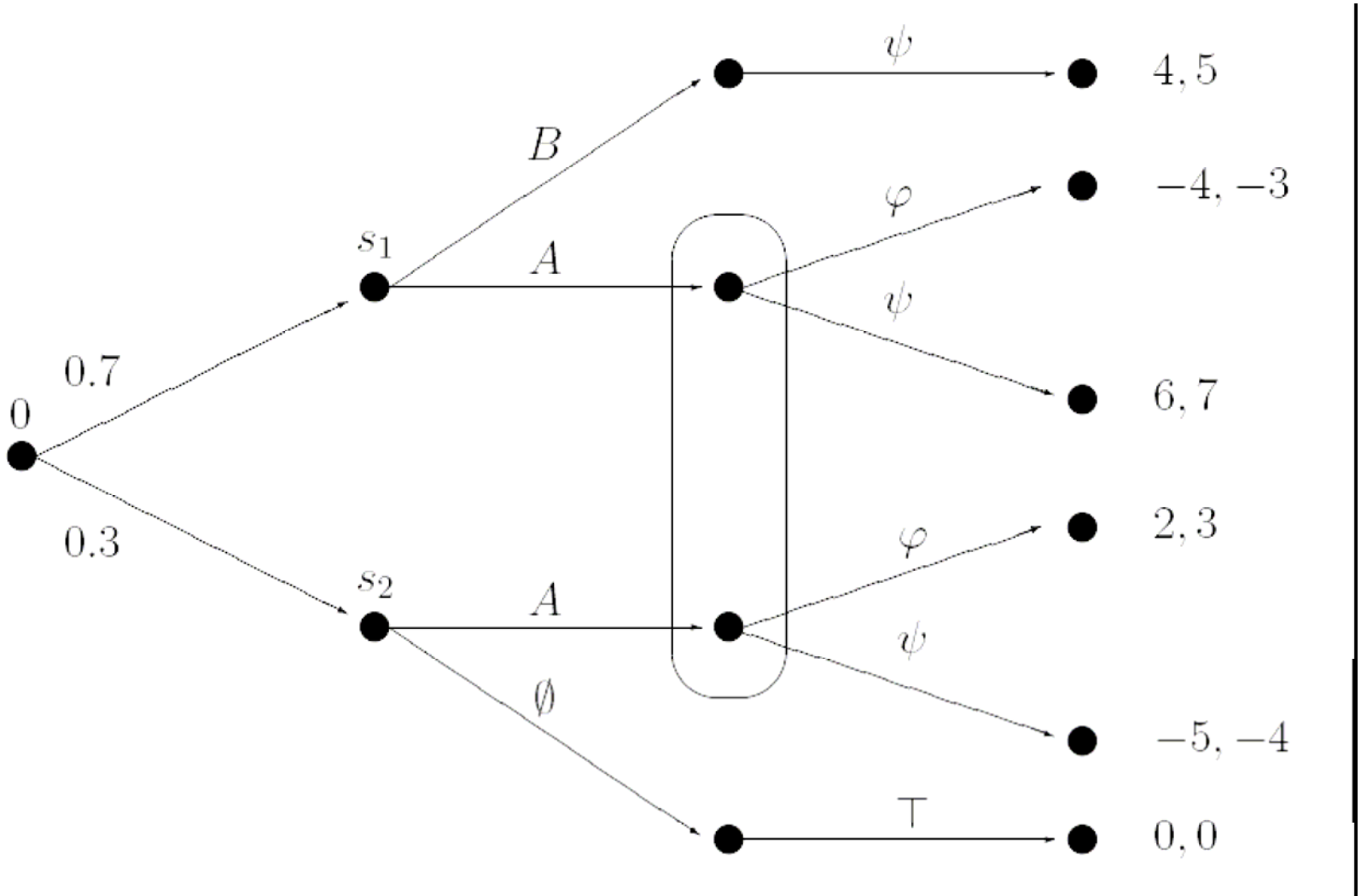
The speaker chooses between the following forms:

1. A $\equiv$ It's 4 pm. ([A] = φ)
2. B $\equiv$ It's 4 pm. Let's go for the talk. ([B] = $\psi \wedge \varphi$)
3. $\varnothing \equiv$ *silence*.

The hearer's action set

- The hearer interprets utterances by meanings.
- Parikh's model assumes that an utterance can be interpreted by any meaning χ which is stronger than its literal meaning φ.

The Game Tree



The Utility Functions

Parikh decomposes the utility functions into four additive parts:

1. A utility measure that depends on the complexity of the form and processing effort.
2. A utility measure that depends on the correctness of interpretation.
3. A utility measure that depends on the value of information.
4. A utility measure that depends on the intrinsic value of the implicated information.

Utility Value of Information

- Derived from a decision problem.
- Hearer has to decide between:
  - going to the talk
  - stay

probability	state	going	staying
0.2	time to go	10	-10
0.8	not time to go	-2	10

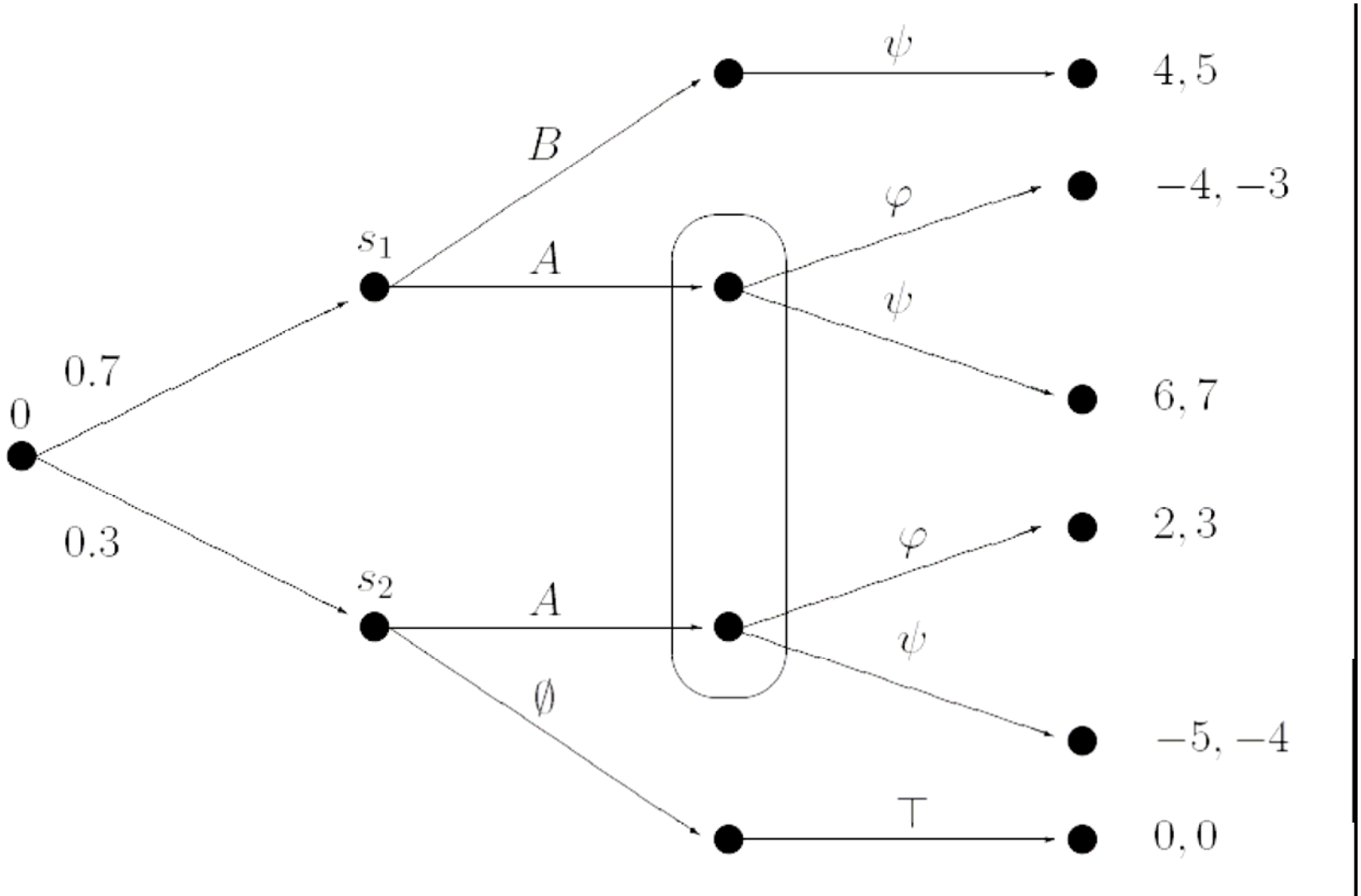
Utility Value of Information

- Before learning ‘It’s 4 p.m.’:
  - EU(leave) = 0.2×10 + 0.8×(-2) = 0.4
  - EU(not-leave) = 0.2×(-10) + 0.8×10 = 6
- After learning ‘It’s 4 p.m.’(A), hence that it is time to leave:
  - EU(leave|A) = 1×10 = 10
  - EU(not-leave|A) = 1×(-10) = -10
- Utility value of learning ‘It’s 4 p.m.’ (A):
  - UV(A) = EU(leave|A) - EU(not-leave) = 10 – 6 = 4

Other Utilities

- Intrinsic Value of Implicature: 5
- Cost of misinterpretation -2
  - In addition, Parikh assumes that in case of miscommunication the utility value of information is lost (*)
- Various costs due to complexity and processing effort.
  - Higher for speaker than hearer.

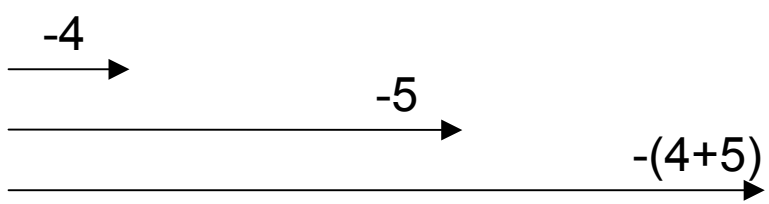
The Game Tree



Some Variations of the Payoffs

	(a)	(b)	(c)	(d)
$\langle \theta_1, B, \psi \rangle$	$4, 5$	$0, 1$	$-1, 0$	$-5, -4$
$\langle \theta_1, A, \varphi \rangle$	$0, 1$	$-4, -3$	$0, 1$	$-4, -3$
$\langle \theta_1, A, \psi \rangle$	$6, 7$	$2, 3$	$1, 2$	$-3, -2$
$\langle \theta_2, A, \varphi \rangle$	$2, 3$	$-2, -1$	$2, 3$	$-2, -1$
$\langle \theta_2, A, \psi \rangle$	$-1, 0$	$-5, -4$	$-1, 0$	$-5, -4$
$\langle \theta_2, \emptyset, \top \rangle$	$0, 0$	$0, 0$	$0, 0$	$0, 0$

a) without (*)
b) minus utility value
c) minus intr. val. of implic.
d) minus both



Result

In all variations it turns out that the strategy pair (S,H) with

- $S(\theta_1)$ = It's 4 p.m., $S(\theta_2)$ = *silence*, and
- H(It's 4 p.m) = [It's 4 p.m] $\wedge$ [Let's go to the talk]

is Pareto optimal.

A Dynamic Approach

Gerhard Jäger (2006)

Game dynamics connects semantics and pragmatics

General

- Jäger (2006) formulates a theory of implicatures in the framework of **Best Response Dynamic** (Hofbauer & Sigmund, 1998), which is a variation of evolutionary game theory.
- We will reformulate his theory using Cournot dynamics, a non–evolutionary and technically much simpler learning model.

Overview

- An Example: Scalar Implicatures
- The Model
- Other Implicatures

An Example

Scalar Implicatures

The Example

We consider the standard example:

Some of the boys came to the party.

+> Not all of the boys came to the party.

Possible Worlds

w_1: All boys came to the party.
w_2: Some but not all boys came to the party.
w_3: No boy came to the party.

Possible Forms and their Meanings

F_1: "Some of the boys came to the party."
F_2: "All of the boys came to the party."
F_3: "None of the boys came to the party."
F_4: "Some but not all of the boys came to the party."

$$[\![F_1]\!] = \{w_1, w_2\}$$
$$[\![F_2]\!] = \{w_1\}$$
$$[\![F_3]\!] = \{w_2\}$$
$$[\![F_4]\!] = \{w_3\}$$

Complexities

- F_1, F_2, and F_3 are about equally complex.
- F_4 is much more complex than the other forms.
- It is an **essential** assumption of the model that F_4 is so complex that the speaker will rather be vague than using F_4.

F_1: "Some of the boys came to the party."
F_2: "All of the boys came to the party."
F_3: "None of the boys came to the party."
F_4: "Some but not all of the boys came to the party."

The first Stage

- Hearer's strategy determined by semantics.
- Speaker is truthful, else the strategy is arbitrary.

S_0	H_0
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_4$	$F_2 \mapsto \{w_1\}$
$w_3 \mapsto F_3$	$F_3 \mapsto \{w_3\}$
	$F_4 \mapsto \{w_2\}$

The second Stage

- Hearer's strategy unchanged.
- Speaker chooses best strategy given hearer's strategy.

S_1	H_1
$w_1 \mapsto F_2$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_1\}$
$w_3 \mapsto F_3$	$F_3 \mapsto \{w_3\}$
	$F_4 \mapsto \{w_2\}$

The third Stage

- Speaker's strategy unchanged.
- Hearer chooses best strategy given speaker's strategy.

S_2	H_2
$w_1 \mapsto F_2$	$F_1 \mapsto \{w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_1\}$
$w_3 \mapsto F_3$	$F_3 \mapsto \{w_3\}$
	$F_4 \mapsto \{w_2\}$

Result

- The third stage is stabile. Neither the speaker nor the hearer can improve the strategy.
- The form

  F_1: `Some of the boys came to the party.'

  is now interpreted as meaning that some but not all of them came.
- This explains the implicature.

The Model

The Signalling Game

- $\Omega = \{w_1, w_2, w_3\}$ the set of possible worlds.
- $\Theta = \{\theta_1, \theta_2, \theta_3\} = \{\{w_1\}, \{w_2\}, \{w_3\}\}$ the set of speaker's types.

  (Speaker knows true state of the world)
- $p(\theta_i)=1/4$: hearer's expectation about types.
- $A_1 = \{F_1, F_2, F_3, F_3\}$ the speaker's action set.
- $A_2 = \wp(\Omega)$ the hearer's action set.

  (Speaker chooses a Form, hearer an interpretation)

- The payoff function divides in two additive parts:
  - c(.): measures complexity of forms:

    $c(F_1) = c(F_2) = c(F_3) = 1$; $c(F_4) = 3$.
  - inf(θ,M): measures informativity of information $M \subseteq \Omega$ relative to speaker's type $\theta = \{w\}$:

$$\inf(\theta, M) = \log_2 P_H(w|M)$$

- The game is a game of pure coordination, i.e. speaker's and hearer's utilities coincide:

$$u(\theta, F, M) = \inf(\theta, M) - c(F).$$

Additional Constraints

- It is assumed that the speaker cannot mislead the hearer; i.e. if the speaker knows that the hearer interprets F as M, then he can only use F if he knows that M is true, i.e. if $\theta \subseteq M$.

The Dynamics

- The dynamic model consists of a sequence of synchronic stages.
- Each synchronic stage is a strategy pair (S_i,H_i), i = 1,…,n
- In the first stage (i=1),
  - the hearer interprets forms by their (literal) semantic meaning.
  - the speaker's strategy is arbitrary.

The Second Stage (S_2,H_2)

- The hearer's strategy H_2 is identical to H_1.
- The speaker's strategy S_2 is a **best response** to H_1:

$$EU(S_2,H_2) = \max_S EU(S,H_2)$$

with

$$EU(S,H) = \sum_{\theta \in \Theta} u(\theta,S(\theta),H(S(\theta)))$$

The Third Stage (S_3,H_3)

- The speaker's strategy S_3 is identical to S_2.
- The hearer's strategy H_3 is a **best response** to S_3:

$$EU(S_3,H_3) = \max_H EU(S_3,H)$$

- This process is iterated until choosing best responses doesn’t improve strategies.
- The resulting strategy pair (S,H) must be a weak Nash equilibrium.
- *Remark: Evolutionary Best Response would stop only if strong Nash equilibria are reached.*

Implicatures

- An implicature F +> ψ is explained if in the final stable state H(F) = ψ.

Other Implicatures

I-Implicatures

What is expressed simply is stereotypically exemplified.

1. John's book is good. +> The book that John is reading or that he has written is good.
2. A secretary called me in. +> A female secretary called me in.
3. There is a road to the right. +> There is a hard-surfaced road to the right.

An Example

There is a road to the right.

- w_1: hard surfaced road.
- w_2: soft surfaced road.
- F_1: road
- F_2: hard surfaced road
- F_3: soft surfaced road

The first Stage

- Hearer's strategy determined by semantics.
- Speaker is truthful, else the strategy is arbitrary.

S_0	H_0
$w_1 \mapsto F_2$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_3$	$F_2 \mapsto \{w_1\}$
	$F_3 \mapsto \{w_2\}$

The second Stage

- Hearer's strategy unchanged.
- Speaker chooses best strategy given hearer's strategy.

S_1	H_1
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_3$	$F_2 \mapsto \{w_1\}$
	$F_3 \mapsto \{w_2\}$

The third Stage

- Speaker's strategy unchanged.
- Hearer chooses best strategy given speaker's strategy.
- Any interpretation of F_2 below yields a best response.

S_2	H_2
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1\}$
$w_2 \mapsto F_3$	$F_2 \mapsto ?$
	$F_3 \mapsto \{w_2\}$

M-implicatures

What is said in an abnormal way isn't normal.

1. Bill stopped the car. +> He used the foot brake.
2. Bill caused the car to stop. +> He did it in an unexpected way.

3. Sue smiled. +> Sue smiled in a regular way.
4. Sue lifted the corners of her lips. +> Sue produced an artificial smile.

An Example

1. Sue smiled. +> Sue smiled in a regular way.
2. Sue lifted the corners of her lips. +> Sue produced an artificial smile.

- w_1: Sue smiles genuinely.
- w_2: Sue produces artificial smile.
- F_1: to smile.
- F_2: to lift the corners of the lips.

The first Stage

- Hearer's strategy determined by semantics.
- Speaker is truthful, else the strategy is arbitrary.

S_0	H_0
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_2$	$F_2 \mapsto \{w_1, w_2\}$

The second Stage

- Hearer's strategy unchanged.
- Speaker chooses best strategy given hearer's strategy.

S_1	H_1
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_1, w_2\}$

The third Stage

- Speaker's strategy unchanged.
- Hearer chooses best strategy given speaker's strategy.
- Any interpretation of F_2 below yields a best response.

S_2	H_2
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto ?$

The third Stage continued

- There are three possibilities:

S_2	H_2
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_1\}$

S_2	H_2
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_2\}$

S_2	H_2
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_1, w_2\}$

A fourth Stage

- Speaker's optimisation can then lead to:

S_3	H_3
$w_1 \mapsto F_2$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_1\}$

S_3	H_3
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_2$	$F_2 \mapsto \{w_2\}$

S_3	H_3
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_1, w_2\}$

A fifth Stage

- Speaker's optimisation can then lead to:

S_4	H_4
$w_1 \mapsto F_2$	$F_1 \mapsto \{w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_1\}$

Anti-Horn

S_4	H_4
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1\}$
$w_2 \mapsto F_2$	$F_2 \mapsto \{w_2\}$

Horn

S_4	H_4
$w_1 \mapsto F_1$	$F_1 \mapsto \{w_1, w_2\}$
$w_2 \mapsto F_1$	$F_2 \mapsto \{w_1, w_2\}$