The Inquisitive Turn
—a new perspective on semantics, pragmatics, and logic—

Floris Roelofsen

www.illc.uva.nl/inquisitive-semantics

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People

- Martin Aher (ILLC MoL 2009, now Osnabrück PhD LING)
- Maria Aloni (ILLC postdoc)
- Scott AnderBois (UC Santa Cruz PhD)
- Kata Balogh (ILLC PhD 2009)
- Chris Brumwell (ILLC MoL 2009, now Stanford LAW)
- Ivano Ciardelli (ILLC MoL 2009, now Bordeaux PhD COMP)
- Irma Cornelisse (UvA BSc AI, now ILLC MoL)
- Inés Crespo (ILLC MoL 2009, now ILLC PhD PHIL)
- Jeroen Groenendijk (ILLC NWO prof)
- Andreas Haida (Berlin postdoc)
- Morgan Mameni (ILLC NWO PhD)
- Salvador Mascarenhas (ILLC MoL 2009, now NYU PhD LING)
- Floris Roelofsen (ILLC NWO postdoc)
- Katsuhiko Sano (Kyoto postdoc)
- Sam van Gool (ILLC MoL 2009, now Nijmegen PhD MATH)
- Matthijs Westera (ILLC NWO PhD)
Overview

Inquisitive semantics

• Motivation
• Definition and illustration
• Some crucial properties

Inquisitive pragmatics

Inquisitive logic

Disclaimer
• Definitions are sometimes simplified for the sake of clarity
• This is all work in progress, there are many open issues, many opportunities to contribute!
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The Traditional Picture

- Meaning = informative content
- Providing information = eliminating possible worlds
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- Meaning = informative content
- Providing information = eliminating possible worlds

- Captures only one type of language use: providing information
- Does not reflect the cooperative nature of communication
The Inquisitive Picture

- Propositions as proposals
- A proposal consists of one or more possibilities
- A proposal that consists of several possibilities is inquisitive
The Inquisitive Picture

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The Inquisitive Picture

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A Propositional Language

Basic Ingredients

- Finite set of proposition letters $\mathcal{P}$
- Connectives $\bot$, $\land$, $\lor$, $\rightarrow$

Abbreviations

- Negation: $\neg \varphi := \varphi \rightarrow \bot$
- Non-inquisitive projection: $! \varphi := \neg \neg \varphi$
- Non-informative projection: $? \varphi := \varphi \lor \neg \varphi$
Projections

Questions

 Assertions

$\varphi$

$\neg \varphi$

$\neg \varphi$
Semantic Notions

Basic ingredients

- Possible world: function from $\mathcal{P}$ to $\{0, 1\}$
- Possibility: set of possible worlds
- Proposition: set of alternative possibilities

Illustration, assuming that $\mathcal{P} = \{p, q\}$

<table>
<thead>
<tr>
<th></th>
<th>11</th>
<th>10</th>
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<tbody>
<tr>
<td>01</td>
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worlds

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possibility

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proposition
Semantic notions

Basic Ingredients

- **Possible world**: function from $\mathcal{P}$ to $\{0, 1\}$
- **Possibility**: set of possible worlds
- **Proposition**: set of alternative possibilities

Notation

- $[\varphi]$: the proposition expressed by $\varphi$
- $|\varphi|$: the truth-set of $\varphi$ (set of indices where $\varphi$ is classically true)

Classical versus inquisitive

- $\varphi$ is **classical** iff $[\varphi]$ contains exactly one possibility
- $\varphi$ is **inquisitive** iff $[\varphi]$ contains more than one possibility
Atoms

For any atomic formula $\varphi$: $[\varphi] = \{ |\varphi| \}$

Example:

```
   11  10
  01  00
```

$p$
Connectives

In the classical setting
connectives operate on sets of possible worlds:
  • negation = complement
  • disjunction = union
  • conjunction = intersection

In the inquisitive setting
connectives operate on sets of sets of possible worlds:
  • negation = complement of the union
  • disjunction = union
  • conjunction = pointwise intersection
Negation

Definition

• $[-\varphi] = \{ \bigcup [\varphi] \}$

• Take the union of all the possibilities for $\varphi$; then take the complement

Example, $\varphi$ classical:

$p$

\[
\begin{array}{c}
11 & 10 \\
01 & 00 \\
\end{array}
\]

$[-p]$

\[
\begin{array}{c}
11 & 10 \\
01 & 00 \\
\end{array}
\]
Negation

Definition

- \([-\varphi] = \{ \bigcup [\varphi] \}\)

  - Take the union of all the possibilities for \(\varphi\);
    then take the complement

Example, \(\varphi\) inquisitive:

\[
\begin{array}{cc}
11 & 10 \\
01 & 00
\end{array}
\]

\([-\varphi]\)
Disjunction

Definition

- \([\varphi \lor \psi] = [\varphi] \cup [\psi]\)

Examples:

\[\begin{array}{ccc}
11 & 10 \\
01 & 00 \\
\end{array}\]
\(p \lor q\)

\[\begin{array}{ccc}
11 & 10 \\
01 & 00 \\
\end{array}\]
\(?p \ (:= \ p \lor \neg p)\)
Conjunction

Definition

- \([\varphi \land \psi] = [\varphi] \cap [\psi]\)
- Pointwise intersection

Example, \(\varphi\) and \(\psi\) classical:

\[
\begin{array}{ccc}
11 & 10 & 11 \\
01 & 00 & 10 \\
01 & 00 & 01 \\
01 & 00 & 10 \\
01 & 00 & 11 \\
\end{array}
\]

\(p\) \hspace{1cm} q \hspace{1cm} p \land q
Conjunction

Definition

- \([\varphi \land \psi] = [\varphi] \cap [\psi]\)
- Pointwise intersection

Example, \(\varphi\) and \(\psi\) inquisitive:

\[
\begin{array}{cc}
11 & 10 \\
01 & 00
\end{array}
\quad \begin{array}{cc}
11 & 10 \\
01 & 00
\end{array}
\quad \begin{array}{cc}
11 & 10 \\
01 & 00
\end{array}
\quad \begin{array}{cc}
11 & 10 \\
01 & 00
\end{array}
\]

\(?p\)  \quad \(?q\)  \quad \(?p \land ?q\)
Implication

Intuition

\[ \varphi \rightarrow \psi \]

- Says that if \( \varphi \) is realized in some way, then \( \psi \) must also be realized in some way.
- Raises the issue of what the exact relation is between the ways in which \( \varphi \) may be realized and the ways in which \( \psi \) may be realized.
Example

If John goes to London, then Bill or Mary will go as well

\[ p \rightarrow (q \lor r) \]

- Says that if \( p \) is realized in some way, then \( q \lor r \) must also be realized in some way
Example

If John goes to London, then Bill or Mary will go as well

\[ p \rightarrow (q \lor r) \]

• Says that if \( p \) is realized in some way, then \( q \lor r \) must also be realized in some way

• \( p \) can only be realized in one way

• but \( q \lor r \) can be realized in two ways
Example

If John goes to London, then Bill or Mary will go as well

\[ p \rightarrow (q \vee r) \]

- Says that if \( p \) is realized in some way, then \( q \vee r \) must also be realized in some way
- \( p \) can only be realized in one way
- but \( q \vee r \) can be realized in two ways
- Thus, \( p \rightarrow (q \vee r) \) raises the issue of whether the realization of \( p \) implies the realization of \( q \), or whether the realization of \( p \) implies the realization of \( r \)
Example

If John goes to London, then Bill or Mary will go as well

\[ p \rightarrow (q \lor r) \]

- Says that if \( p \) is realized in some way, then \( q \lor r \) must also be realized in some way
- \( p \) can only be realized in one way
- but \( q \lor r \) can be realized in two ways
- Thus, \( p \rightarrow (q \lor r) \) raises the issue of whether the realization of \( p \) implies the realization of \( q \), or whether the realization of \( p \) implies the realization of \( r \)
- \[ [p \rightarrow (q \lor r)] = \{ |p \rightarrow q| , |p \rightarrow r| \} \]
Pictures, classical and inquisitive

If John goes, Mary will go as well.

If John goes, will Mary go as well?
Another way to think about it

Intuition

\[ \varphi \rightarrow \psi \]

- Draws attention to the potential *implicational dependencies* between the possibilities for \( \varphi \) and the possibilities for \( \psi \)
- Says that at least one of these implicational dependencies holds
- Raises the issue which of the implicational dependencies hold
Example

If John goes to London, Bill or Mary will go as well

\[ p \rightarrow (q \lor r) \]

- Two potential implicational dependencies:
  - \( p \leadsto q \)
  - \( p \leadsto r \)

- The sentence:
  - Says that at least one of these dependencies holds
  - Raises the issue which of them hold exactly
A more complex example

If John goes to London or to Paris, will Mary go as well?

\[(p \lor q) \rightarrow ?r\]

- Four potential implicational dependencies:
  - \((p \not\rightarrow r) \& (q \not\rightarrow r)\)
  - \((p \not\rightarrow \neg r) \& (q \not\rightarrow \neg r)\)
  - \((p \not\rightarrow r) \& (q \not\rightarrow \neg r)\)
  - \((p \not\rightarrow \neg r) \& (q \not\rightarrow r)\)

- The sentence:
  - Says that at least one of these dependencies holds
  - Raises the issue which of them hold exactly
Formalization

• Each possibility for $\varphi \rightarrow \psi$ corresponds to a potential **implicational dependency** between the possibilities for $\varphi$ and the possibilities for $\psi$;

• Think of an implicational dependency as a **function** $f$ mapping every possibility $\alpha \in [\varphi]$ to some possibility $f(\alpha) \in [\psi]$;

• What does it take to **establish** an implicational dependency $f$?

• For each $\alpha \in [\varphi]$, we must establish that $\alpha \Rightarrow f(\alpha)$ holds
Formalization

- Each possibility for \( \varphi \rightarrow \psi \) corresponds to a potential implicational dependency between the possibilities for \( \varphi \) and the possibilities for \( \psi \);
- Think of an implicational dependency as a function \( f \) mapping every possibility \( \alpha \in [\varphi] \) to some possibility \( f(\alpha) \in [\psi] \);
- What does it take to establish an implicational dependency \( f \)?
- For each \( \alpha \in [\varphi] \), we must establish that \( \alpha \Rightarrow f(\alpha) \) holds

Implementation

- \([\varphi \rightarrow \psi] = \{ \gamma_f | f : [\psi][\varphi] \} \) where \( \gamma_f = \bigcap_{\alpha \in [\varphi]} (\alpha \Rightarrow f(\alpha)) \)
Formalization

- Each possibility for $\varphi \rightarrow \psi$ corresponds to a potential implicational dependency between the possibilities for $\varphi$ and the possibilities for $\psi$;
- Think of an implicational dependency as a function $f$ mapping every possibility $\alpha \in [\varphi]$ to some possibility $f(\alpha) \in [\psi]$;
- What does it take to establish an implicational dependency $f$?
- For each $\alpha \in [\varphi]$, we must establish that $\alpha \Rightarrow f(\alpha)$ holds.

Implementation

- $[\varphi \rightarrow \psi] = \{ \gamma_f \mid f : [\psi][\varphi] \}$ where $\gamma_f = \bigcap_{\alpha \in [\varphi]} (\alpha \Rightarrow f(\alpha))$
- For simplicity, we usually define $\alpha \Rightarrow f(\alpha)$ in terms of material implication: $\overline{\alpha} \cup f(\alpha)$. But any more sophisticated treatment of conditionals could in principle be plugged in here.
Informativeness and Inquisitiveness

- $p \lor q$ is inquisitive: $[p \lor q]$ consists of more than one possibility
- $p \lor q$ is informative: $[p \lor q]$ proposes to eliminate indices

\[ \bigcup [\phi] \] captures the informative content of $\phi$
Informativeness and Inquisitiveness

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- $p \lor q$ is informative: $[p \lor q]$ proposes to eliminate indices

- $\bigcup [\varphi]$ captures the informative content of $\varphi$

- Fact: for any formula $\varphi$, $\bigcup [\varphi] = |\varphi|$

$\Rightarrow$ classical notion of informative content is preserved
Questions, assertions, and hybrids

- $\varphi$ is a question iff it is not informative
- $\varphi$ is an assertion iff it is not inquisitive

\[
\begin{array}{cc}
11 & 10 \\
01 & 00 \\
\end{array}
\]
Questions, assertions, and hybrids

- $\varphi$ is a question iff it is not informative
- $\varphi$ is an assertion iff it is not inquisitive

- $\varphi$ is a hybrid iff it is both informative and inquisitive
- $\varphi$ is insignificant iff it is neither informative nor inquisitive
Questions, assertions, and hybrids

Questions

Insignificant

Assertions

Hybrids

?φ

φ

!φ
Non-inquisitive closure

- Double negation always preserves the informative content of a sentence, but removes inquisitiveness

\[ \neg \neg (p \lor q) \]

\[ (p \lor q) \]

\[ \neg (p \lor q) \]

\[ \neg \neg (p \lor q) \]
Non-inquisitive closure

- Double negation always preserves the informative content of a sentence, but removes inquisitiveness

\[
\neg(\neg\neg\phi)
\]

Therefore, \(\neg\neg\phi\) is abbreviated as \(!\phi\)

and is called the non-inquisitive closure of \(\phi\)
Significance and inquisitiveness

• In a classical setting, non-informative sentences are tautologous, i.e., insignificant

• In inquisitive semantics, some classical tautologies come to form a new class of meaningful sentences, namely questions

• Questions are meaningful not because they are informative, but because they are inquisitive

• Example: \( ?p := p \lor \neg p \)
Alternative characterization of questions and assertions

Equivalence

• ϕ and ψ are equivalent iff \([ϕ] = [ψ]\)
• Notation: \(ϕ ≡ ψ\)

Questions and assertions

• ϕ is a question iff \(ϕ ≡ ?ϕ\)
• ϕ is an assertion iff \(ϕ ≡ !ϕ\)

Division fact

• For any ϕ: \(ϕ ≡ ?ϕ \land !ϕ\)
Pragmatics

- specifies how cooperative speakers should use the sentences of a language in particular contexts, given the semantic meaning of those sentences

Classical (Gricean) pragmatics

- identifies semantic meaning with informative content
- is exclusively speaker-oriented

- Quality: say only what you believe to be true
- Quantity: be as informative as possible
- Relation: say only things that are relevant for the purposes of the conversation
Inquisitive pragmatics

A new perspective

- Inquisitive semantics enriches the notion of semantic meaning
- This gives rise to a new perspective on pragmatics as well

Inquisitive pragmatics

- based on informative content, but also on inquisitive content
- speaker-oriented, but also hearer-oriented

- Quality: say only what you know, ask only what you want to know publicly announce unacceptability of a proposal
- Quantity: say more, ask less
- Relation: be compliant $\Rightarrow$ formal notion of relatedness
Logic

Traditionally

- logic is concerned with entailment and (in)consistency
- given these concerns, it makes sense to identify semantic meaning with informative content

Vice versa

- if semantic meaning is identified with informative content, propositions are construed as sets of possible worlds
- there are only three possible relations between two sets of worlds: inclusion, overlap, and disjointness
- these correspond to entailment and (in)consistency
- other relations between sentences cannot be captured
Inquisitive logic

A new perspective

- Inquisitive semantics enriches the notion of semantic meaning
- This gives rise to a new perspective on logic as well

New logical notions

- Besides classical entailment, we get a notion of inquisitive entailment: \( \varphi \) inquisitively entails \( \psi \) iff whenever \( \varphi \) is resolved, \( \psi \) is resolved as well;
- We also get logical notions of relatedness. In particular, \( \varphi \) is a compliant response to \( \psi \) iff it addresses the issue raised by \( \psi \) without providing any redundant information.
- Note: classical notions are not replaced, but preserved.
Computational tools and applications

Tools

- sites.google.com/site/inquisitivesemantics/implementation

Applications

- Dialogue systems, question-answer systems, negotiation protocols, ambiguity resolution.
Some references

Inquisitive semantics and pragmatics

Inquisitive logic

Disjunctive questions, intonation, and highlighting
Floris Roelofsen and Sam van Gool (2010) Logic, Language, and Meaning: selected papers from the Amsterdam Colloquium

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