The Inquisitive Turn

A new perspective on semantics, logic, and pragmatics

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based on joint work with
Jeroen Groenendijk and Ivano Ciardelli

Peking University, October 20, 2011

Mission statement

Inquisitive semantics

- Meaning is traditionally identified with informative content
- Our main aim is to develop a notion of meaning that captures both informative and inquisitive content

Inquisitive logic

- Logic is traditionally concerned with entailment, which rules the validity of argumentation
- We aim to develop logical notions of relatedness, which rule the coherence of conversation

Inquisitive pragmatics

- Gricean pragmatics specifies rules for providing information
- We aim to develop a pragmatics of exchanging information, taking both informative and inquisitive content into account

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Overview

Semantics

- Propositions as proposals
- Inquisitive algebra
- Attentive content
- Projection operators

Logic

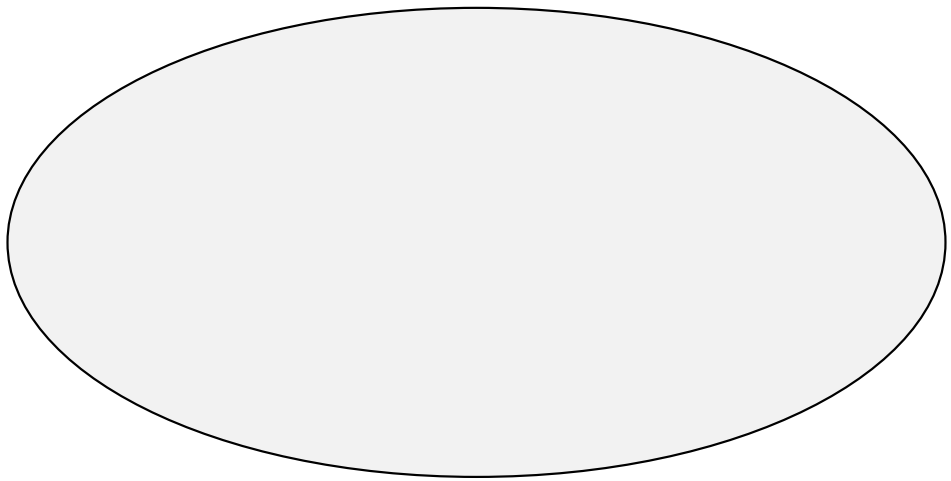
- Informative and inquisitive entailment
- Relatedness, compliance

Pragmatics

- Sincerity, Transparency, Relation

The Traditional Picture

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



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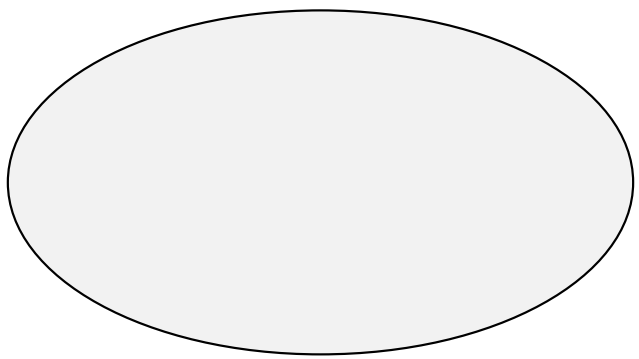

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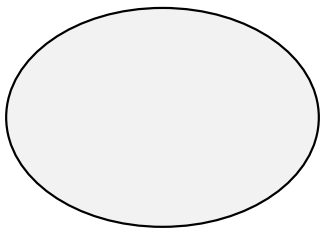

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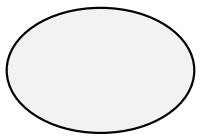

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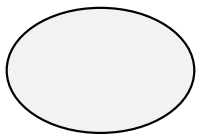
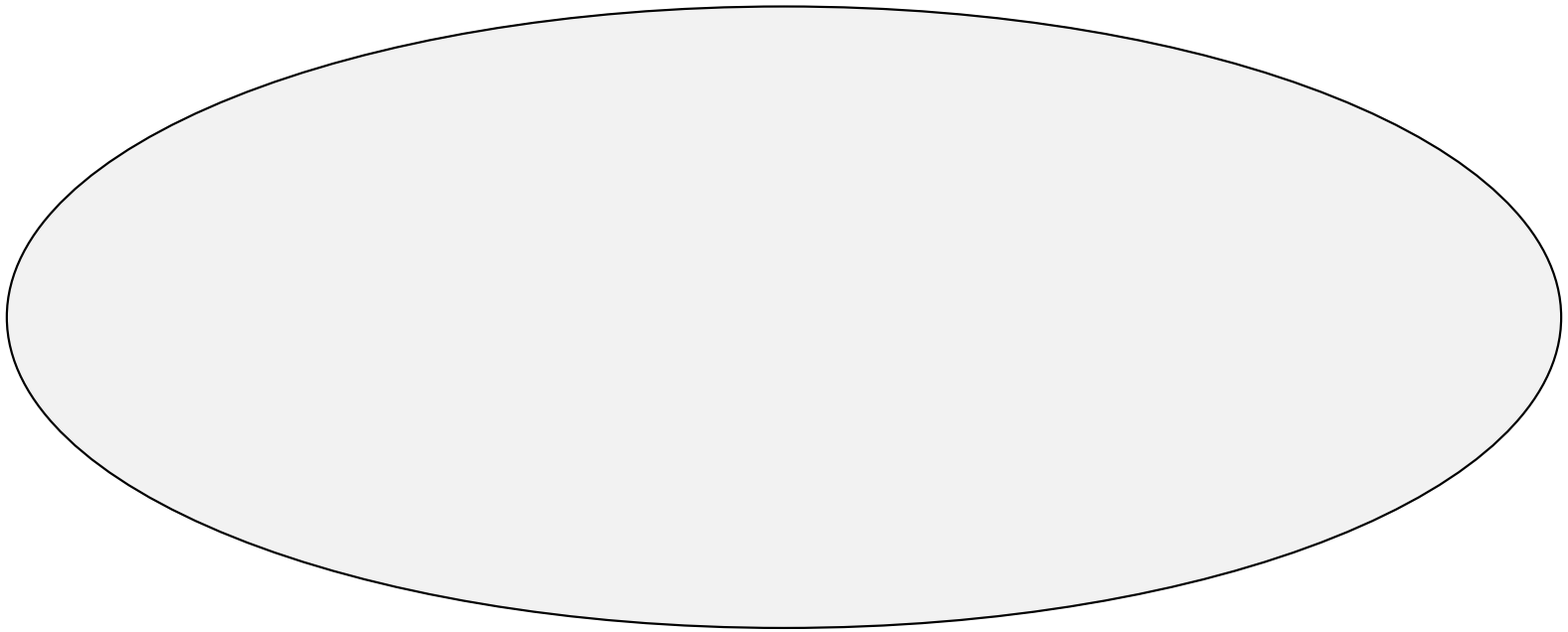


- Captures only one type of language use: providing information
- Does not reflect the cooperative nature of communication

The Inquisitive Picture

- Propositions as proposals
- A proposal consists of one or more possibilities
- An inquisitive proposal offers several alternative possibilities



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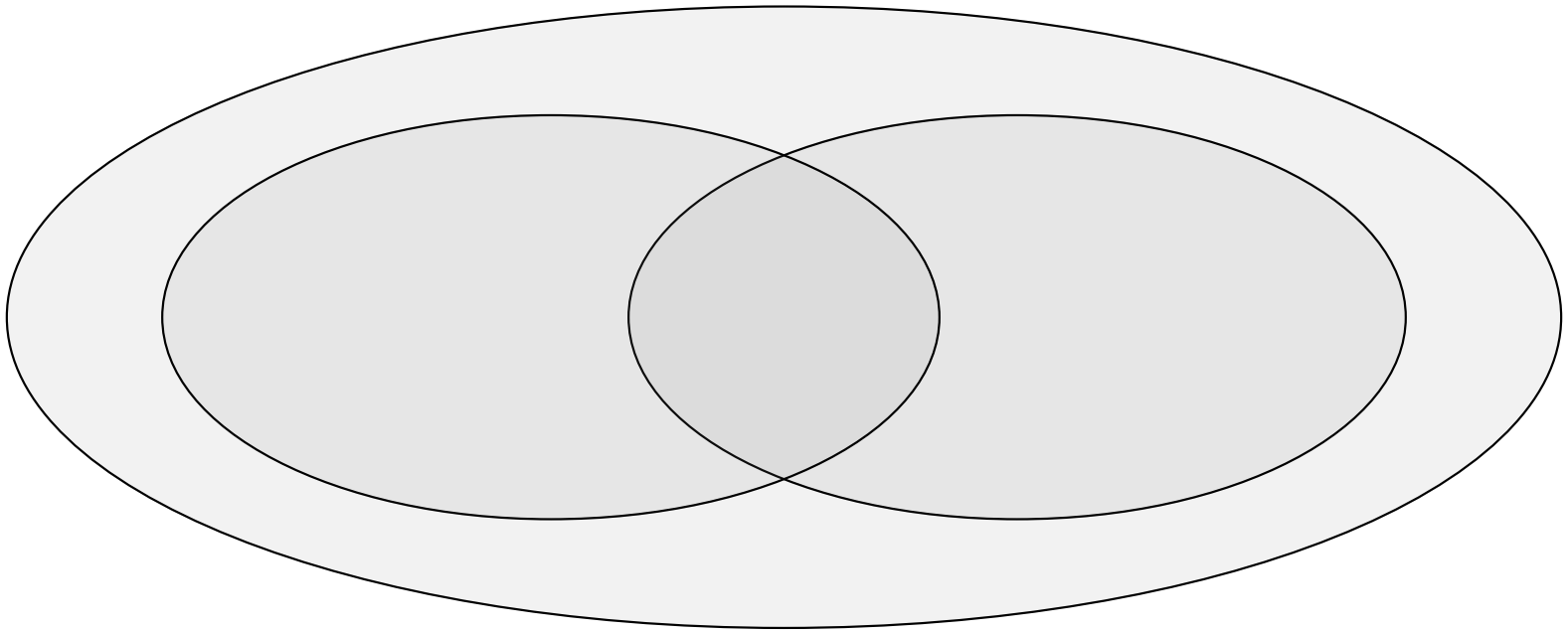

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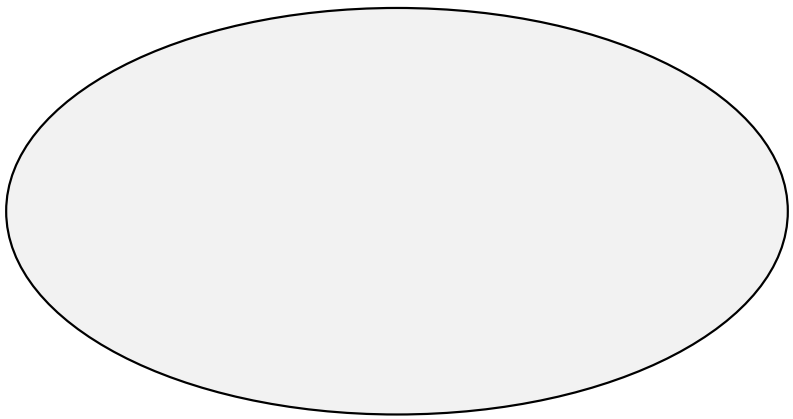

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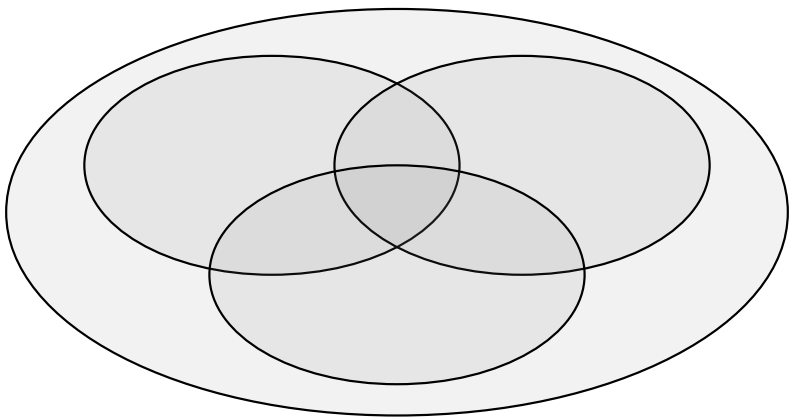

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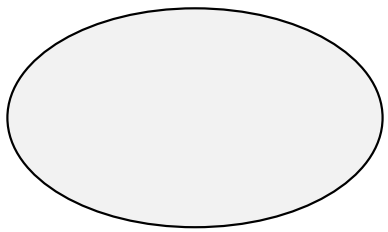
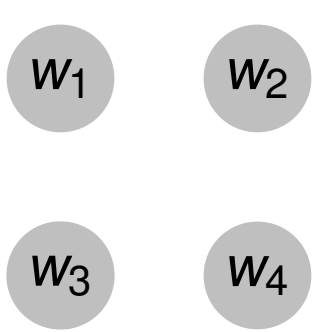


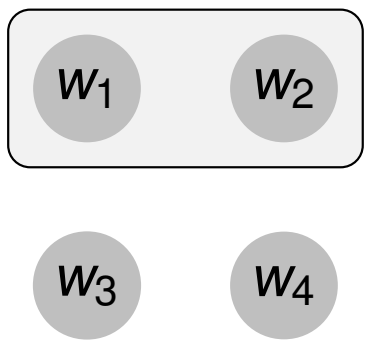
Worlds, possibilities, and propositions

- Start with a universe of possible worlds
- Possibility: set of possible worlds
- Proposition: set of possibilities

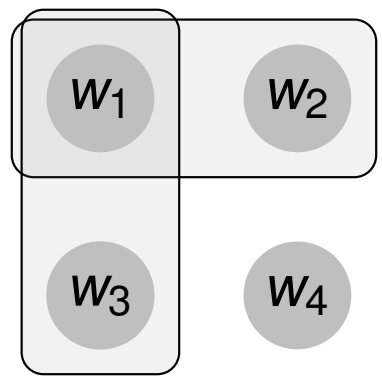
Illustration



worlds



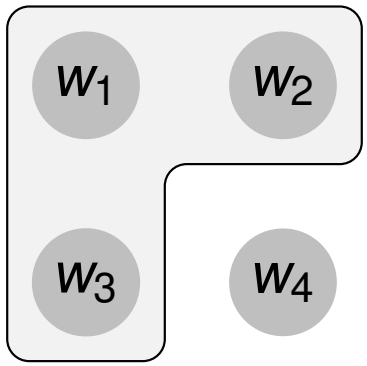
possibility



proposition

How to think of propositions?

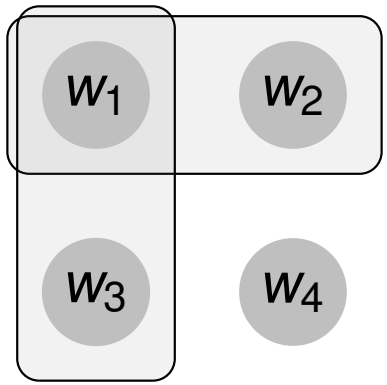
- Traditionally, a proposition is simply a set of possible worlds



- We think of such a proposition A as providing the information that the actual world corresponds to one of the worlds in A

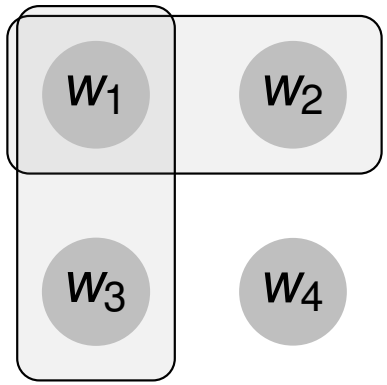
How to think of propositions?

- Now, a proposition is a set of possibilities



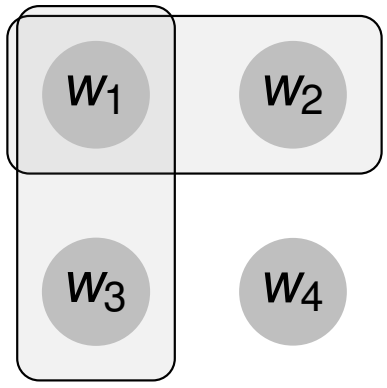
- How should we think of such propositions?
- What is the information that they provide?
- Could we think of them as representing something else besides informative content? If so, what exactly?

Informative and inquisitive content



- We think of a proposition A as representing a proposal to update the common ground in one or more ways
- A provides the information that the actual world must be one that survives at least one of the proposed updates
- At the same time, A requests a response that establishes at least one of the proposed updates

Informative and inquisitive content



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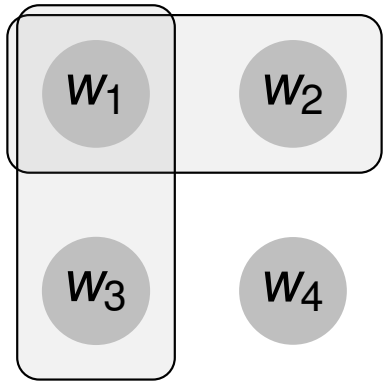
$\Rightarrow$ a single semantic object embodies both informative and inquisitive content

Informative content

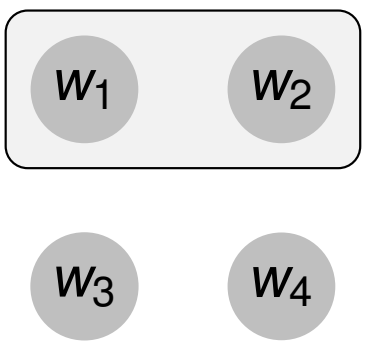


- A provides the information that the actual world must be one that survives at least one of the proposed updates
- This means that the actual world must lie in at least one of the possibilities in A
- So, the informative content of A, info(A), is determined by the union of all the possibilities in A:

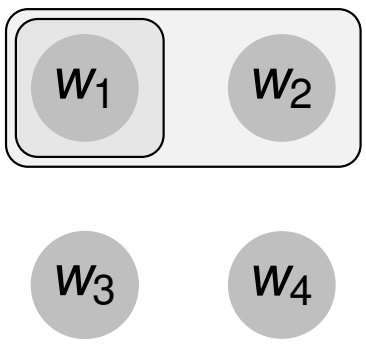
$$\text{info}(A) = \bigcup A$$

Inquisitive proposals

- A proposition A requests a response that establishes at least one of the updates that A proposes
- Sometimes, it suffices to accept the information provided by A
- If additional information is required, we call A inquisitive



non-inquisitive



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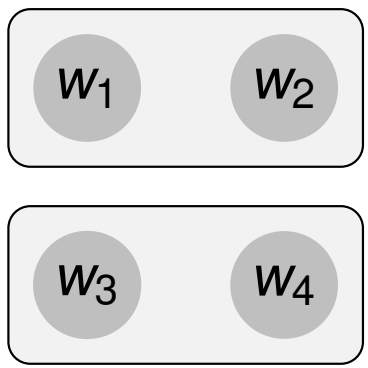

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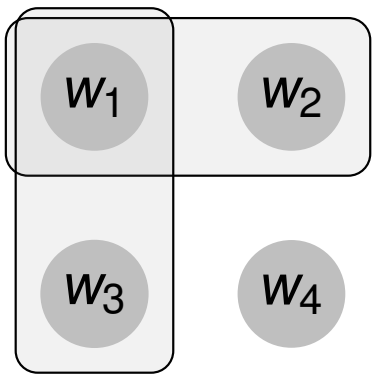
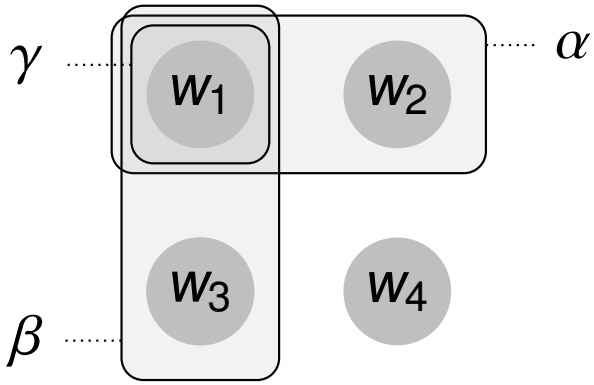


inquisitive

Alternative and residual possibilities

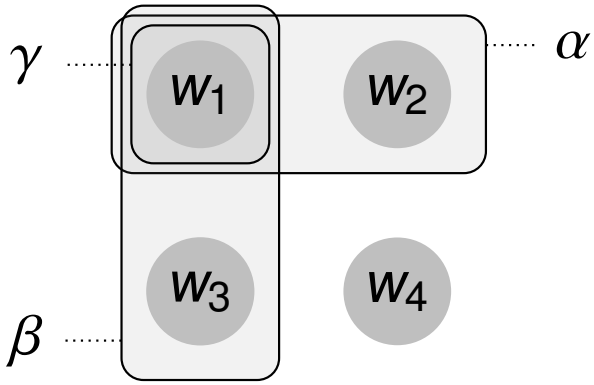


Three possibilities:

$$\begin{aligned} \alpha &= \{w_1, w_2\} \\ \beta &= \{w_1, w_3\} \\ \gamma &= \{w_1\} \end{aligned}$$

- Providing the information that at least one of $\{\alpha, \beta, \gamma\}$ contains the actual world is the same as providing the information that at least one of $\{\alpha, \beta\}$ contains the actual world
- Requesting a response that establishes at least one of $\{\alpha, \beta, \gamma\}$ is the same as requesting a response that establishes at least one of $\{\alpha, \beta\}$
- So γ does not play a role in determining the informative or inquisitive content of this proposition

Alternative and residual possibilities



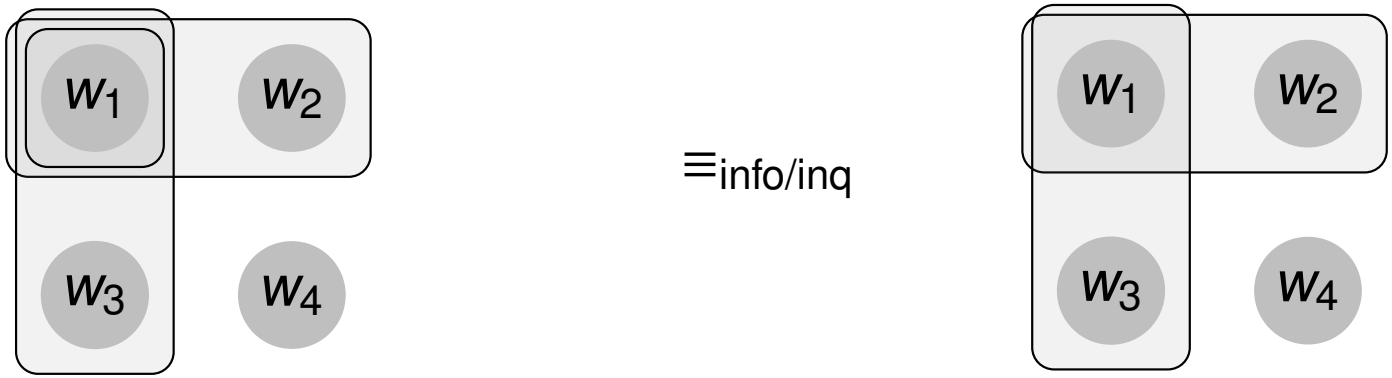
Three possibilities:

$$\begin{aligned} \alpha &= \{w_1, w_2\} \\ \beta &= \{w_1, w_3\} \\ \gamma &= \{w_1\} \end{aligned}$$

- In general, for any proposition A, we can distinguish:
- Alternative possibilities
  - not properly contained in a maximal possibility in A
  - completely determine informative and inquisitive content
- Residual possibilities
  - properly contained in a maximal possibility in A
  - do not play a role in capturing informative/inquisitive content

Informative + inquisitive content = meaning ?

- We set out to develop a notion of semantic meaning that captures both informative and inquisitive content
- In principle, the notion of a proposition as an arbitrary set of possibilities fits this purpose
- However, informative and inquisitive content do not exhaust meaning in this setup: different propositions do not necessarily have different informative or inquisitive content



Two ways to go

Option 1

- Associate possibilities with issue-resolving responses
- $\alpha \in A$ iff any response that provides the information that the actual world is contained in α resolves the issue raised by A

Consequence: persistent propositions

- For every proposition A, every $\alpha \in A$, and every $\beta \subseteq \alpha$, we must have that $\beta \in A$ as well

$\Rightarrow$ propositions are persistent non-empty sets of possibilities

Two ways to go

Option 2

- Associate possibilities with the proposed updates themselves
- Then propositions can be defined as arbitrary non-empty sets of possibilities
- If two propositions embody exactly the same informative and inquisitive content, but propose different updates, we could think of them as differing in attentive content: they draw attention to different possibilities
- We will see that this idea has interesting applications

Overview

Semantics

- Propositions as proposals ✓
- Inquisitive algebra
- Attentive content
- Projection operators

Logic

- Informative and inquisitive entailment
- Relatedness, compliance

Pragmatics

- Sincerity, Transparency, Relation

Key question

- How should the proposition expressed by a complex sentence be defined in terms of the propositions expressed by its simpler constituents?
- In particular, given $[\varphi]$ and $[\psi]$, how should we define:

  $[\neg\varphi]$ $[\varphi \vee \psi]$ $[\varphi \wedge \psi]$ $[\varphi \rightarrow \psi]$ $[\exists x.\varphi]$ $[\forall x.\varphi]$

- What is the semantic contribution of connectives and quantifiers in this richer setting?

Approach

- We take an algebraic perspective here
- The approach is familiar from classical logic, where:
  - $\vee$ is treated semantically as a join operator
  - $\wedge$ is treated semantically as a meet operator
  - $\neg$ and $\rightarrow$ as (relative) complementation operators
- We will show that this strategy can be applied in the inquisitive setting as well

Algebraic foundations of classical logic

Classical propositions

- Sets of possible worlds
- Embody informative content

Ordering propositions

- Propositions are ordered in terms of informative content
- $A \leq B$ iff A provides at least as much information as B
- Formally: $A \leq B \iff A \subseteq B$

Algebraic foundations of classical logic

Join and meet

- Relative to $\leq$, every two classical propositions have
  - a least upper bound (aka their join)
  - a greatest lower bound (aka their meet)
- The join of two propositions amounts to their union

$$\textsc{join}(A, B) = A \cup B$$

- The meet of two propositions amounts to their intersection

$$\textsc{meet}(A, B) = A \cap B$$

- The existence of meets and joins implies that the set of all propositions, Σ, together with $\leq$, forms a lattice

Algebraic foundations of classical logic

Top and bottom

- The lattice has a bottom element, $\emptyset$, and a top element, W
- That is, for every proposition A, we have that:

$$\emptyset \leq A \leq W$$

- Thus, $\langle \Sigma, \leq \rangle$ forms a bounded lattice

Algebraic foundations of classical logic

Complementation

- For every propositions A, there is exactly one other proposition $C(A)$ such that:
  - The meet of A and $C(A)$ is the bottom element of the lattice, $\emptyset$
  - The join of A and $C(A)$ is the top element of the lattice, W
- $C(A)$ is called the complement of A
- For every A, $\quad C(A) = \{w \mid w \notin A\}$
- The existence of complements, together with the fact that the join and meet operators distribute over each other, implies that $\langle \Sigma, \leq \rangle$ forms a Boolean algebra

Algebraic foundations of classical logic

Classical logic

- The semantic operators M, J, and C can be associated with syntactic connectives:
  - $[\varphi \wedge \psi] = M([\varphi], [\psi]) = [\varphi] \cap [\psi]$
  - $[\varphi \vee \psi] = J([\varphi], [\psi]) = [\varphi] \cup [\psi]$
  - $[\neg\varphi] = C([\varphi]) = W - [\varphi]$
- This is how classical propositional logic is obtained
- The approach can be extended to first-order logic as well

Algebraic inquisitive semantics

Ordering propositions

- Propositions: persistent non-empty sets of possibilities
- $A \leq B$ if and only if:
  - A provides at least as much information as B:

$$\bigcup A \subseteq \bigcup B$$

  - A requests at least as much information as B:

$$A \subseteq B$$

Simplification

- If $A \subseteq B$ then also $\bigcup A \subseteq \bigcup B$
- So $A \leq B$ if and only if $A \subseteq B$

Joins and meets

- As before, relative to $\leq$, every two propositions have
  - a least upper bound (aka their join)
  - a greatest lower bound (aka their meet)
- The join of A and B still amounts to their union:

$$\textsc{join}(A, B) = A \cup B$$

- The meet of A and B still amounts to their intersection:

$$\textsc{meet}(A, B) = A \cap B$$

- Conjunction and disjunction can still be taken to behave semantically as meet and join operators

$\langle \Sigma, \leq \rangle$ is not a Boolean algebra

- The existence of meets and joins implies that the set of all propositions Σ, together with the order $\leq$, forms a lattice
- Moreover, $\langle \Sigma, \leq \rangle$ has:
  - a top element, $\top = \wp(W)$
  - a bottom element, $\bot = \{\emptyset\}$
- This means that $\langle \Sigma, \leq \rangle$ forms a bounded lattice
- However, $\langle \Sigma, \leq \rangle$ does not form a Boolean algebra
- That is, not every $A \in \Sigma$ has a complement B such that:

$$\begin{aligned} \textsc{join}(A, B) &= \top \\ \textsc{meet}(A, B) &= \bot \end{aligned}$$

$\langle \Sigma, \leq \rangle$ is a Heyting algebra

- We do have that every proposition A has a pseudo-complement $\sim A$ such that:

$$\textsc{meet}(A, \sim A) = \bot$$

- Moreover, for every two propositions A, B there is a unique weakest proposition C such that

$$\textsc{meet}(A, C) \leq B$$

- This proposition C is called the relative pseudo-complement of A with respect to B, and is denoted as $A \Rightarrow B$
- The existence of relative pseudo-complements implies that $\langle \Sigma, \leq \rangle$ forms a Heyting algebra
- Implication and negation can be taken to behave semantically as (relative) pseudo-complement operators

Algebraic inquisitive semantics

- $[p] = \{\alpha \mid \forall w \in \alpha.\ w(p) = 1\}$
- $[\neg\varphi] = {\sim}[\varphi]$ pseudo-complement
- $[\varphi \wedge \psi] = [\varphi] \cap [\psi]$ meet
- $[\varphi \vee \psi] = [\varphi] \cup [\psi]$ join
- $[\varphi \to \psi] = [\varphi] \Rightarrow [\psi]$ relative pseudo-complement

Relevance for natural language semantics

- Natural languages are, of course, much more intricate than the language of propositional logic
- However, it is reasonable to expect that natural languages generally also have connectives which behave semantically as meet, join, and complementation operators
- Just like it is reasonable to expect that natural languages generally have ways to express basic operations on quantities, like addition, substraction, and multiplication

Relevance for natural language semantics

- Disjunction (JOIN) is a source of inquisitiveness
- This provides the basis for an explanation of the disjunctive-interrogative affinity observed cross-linguistically

(1) We eten vanavond boerenkool of hutspot.
We eat tonight boerenkool or hutspot.
'We will eat boerenkool or hutspot tonight.'

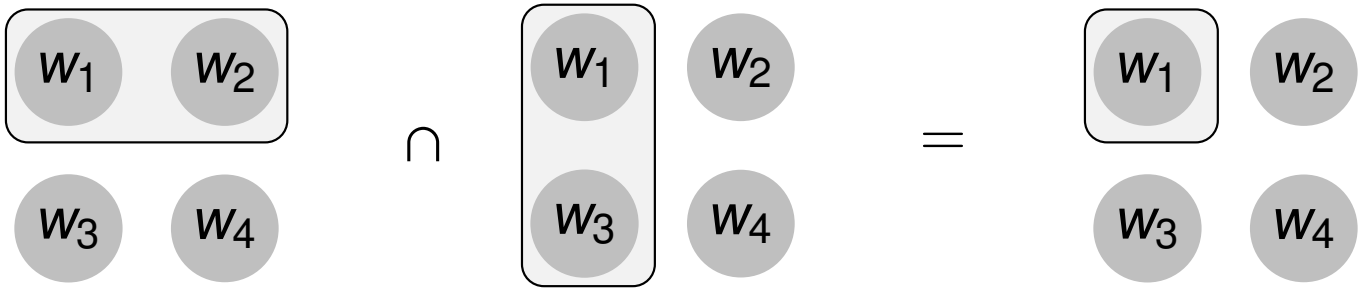
(2) Maria weet of we vanavond hutspot eten.
Maria knows or we tonight hutspot eat.
'Maria knows whether we will eat hutspot tonight.'

- See AnderBois (2009, 2010) on Yukatec Maya and Haida (2009, 2010) on Chadic languages

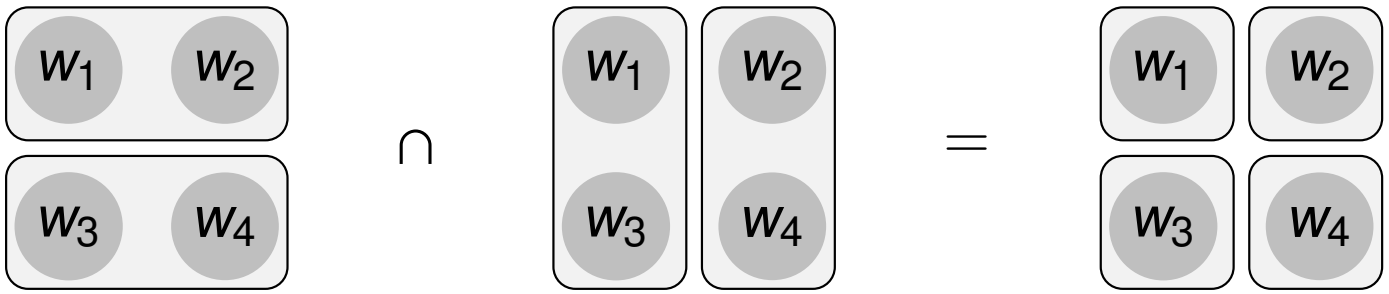
Relevance for natural language semantics

Conjunction (MEET) applies uniformly to questions and assertions

(3) John speaks Spanish and he speaks French.



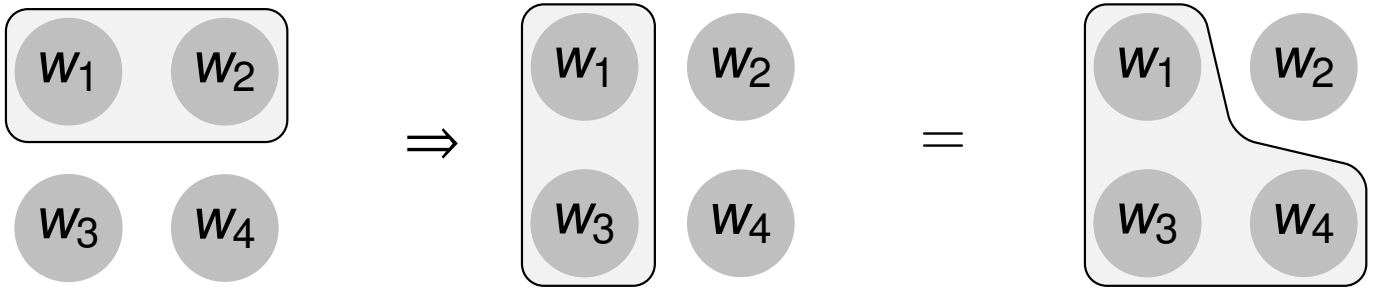
(4) Does John speak Spanish, and does he speak French?



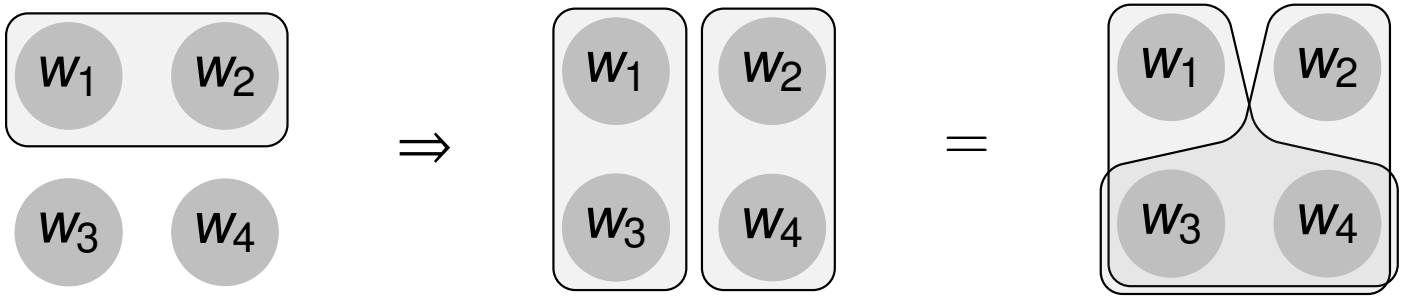
Relevance for natural language semantics

Implication ($\Rightarrow$) applies uniformly to questions and assertions

(5) If John will go to the party, Mary will go as well.



(6) If John will go to the party, will Mary go as well?



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Logic

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Pragmatics

- Sincerity, Transparency, Relation

Attentive content

- We now take propositions to be arbitrary non-empty sets of possibilities
- Besides providing and requesting information, we also think of a proposition A as drawing attention to every possibility in A
- Two propositions that provide and request exactly the same information may still draw attention to different possibilities

Pragmatic thrust of attentive content

Attentive sincerity

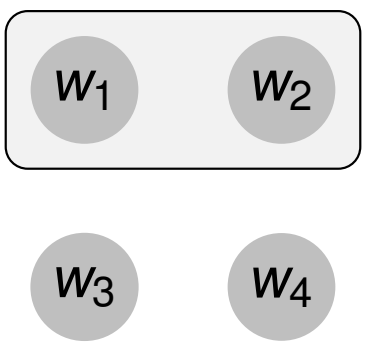
- Cooperative speakers should be attentively sincere
- That is, they should avoid drawing attention to possibilities that are inconsistent with their own information state

Licensing / safety

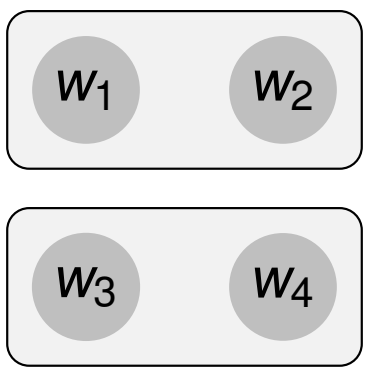
- Thus, drawing attention to a possibility α licenses any response that provides just enough information to establish α
- Such responses are safe: assuming attentive sincerity, they cannot fail to be consistent with the initiator's information state

Informative, inquisitive, and attentive propositions

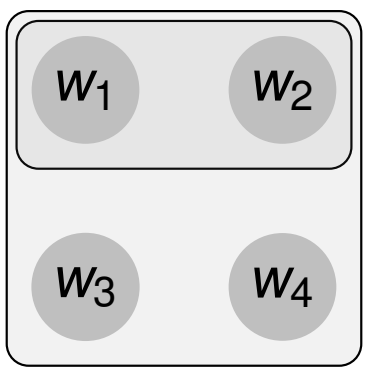
- A is informative iff it proposes to eliminate at least one world
- A is inquisitive iff it offers at least two alternative possibilities
- A is attentive iff it contains at least one residual possibility



purely informative



purely inquisitive



purely attentive

Relevance for natural language semantics

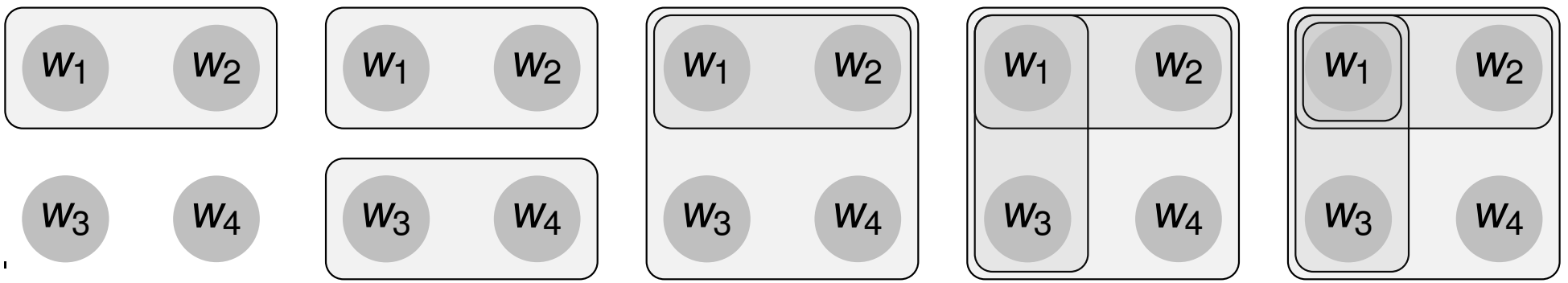
(7) John speaks Russian. informative

(8) Does John speak Russian? inquisitive

(9) John might speak Russian. attentive

(10) John might speak Russian or he might speak French. attentive

(11) John might speak Russian and he might speak French. attentive



(7) (8) (9) (10) (11)

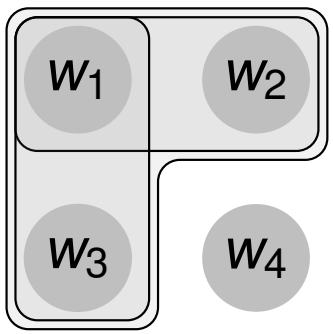
Relevance for natural language semantics

(12) John speaks Russian or French. informative & attentive

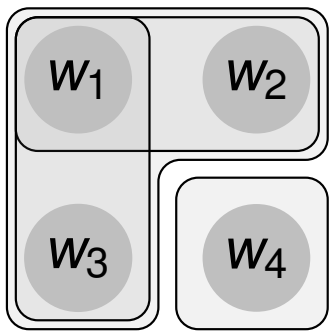
(13) Does John speak Russian-or-French↑? inquisitive & attentive

(14) John speaks Russian or he doesn't. purely attentive

(15) John speaks French or he doesn't. purely attentive



(12)



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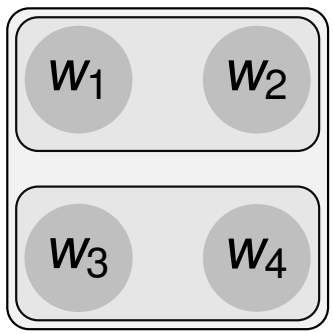

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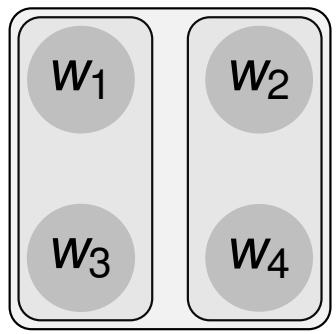
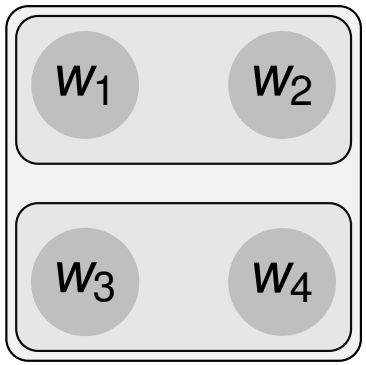


(15)

Relevance for natural language semantics

Romanian oare-questions

(16) Oare Petru a sosit deja?
oare Peter has arrived already?
'Has Peter arrived already?'



- Farkas & Bruce 2009:
  oare-questions are questions in the sense that they do not provide any information, but they differ from default questions in the sense that they do not require an informative response
- Similar phenomena in Hungarian (Gärtner and Gyuris, 2009), German (*insubordinate ob*, Truckenbrodt 2004), Danish, . . .
- Dubitatives, evidentials, . . .

Overview

Semantics

- Propositions as proposals ✓
- Inquisitive algebra ✓
- Attentive content ✓
- Projection operators

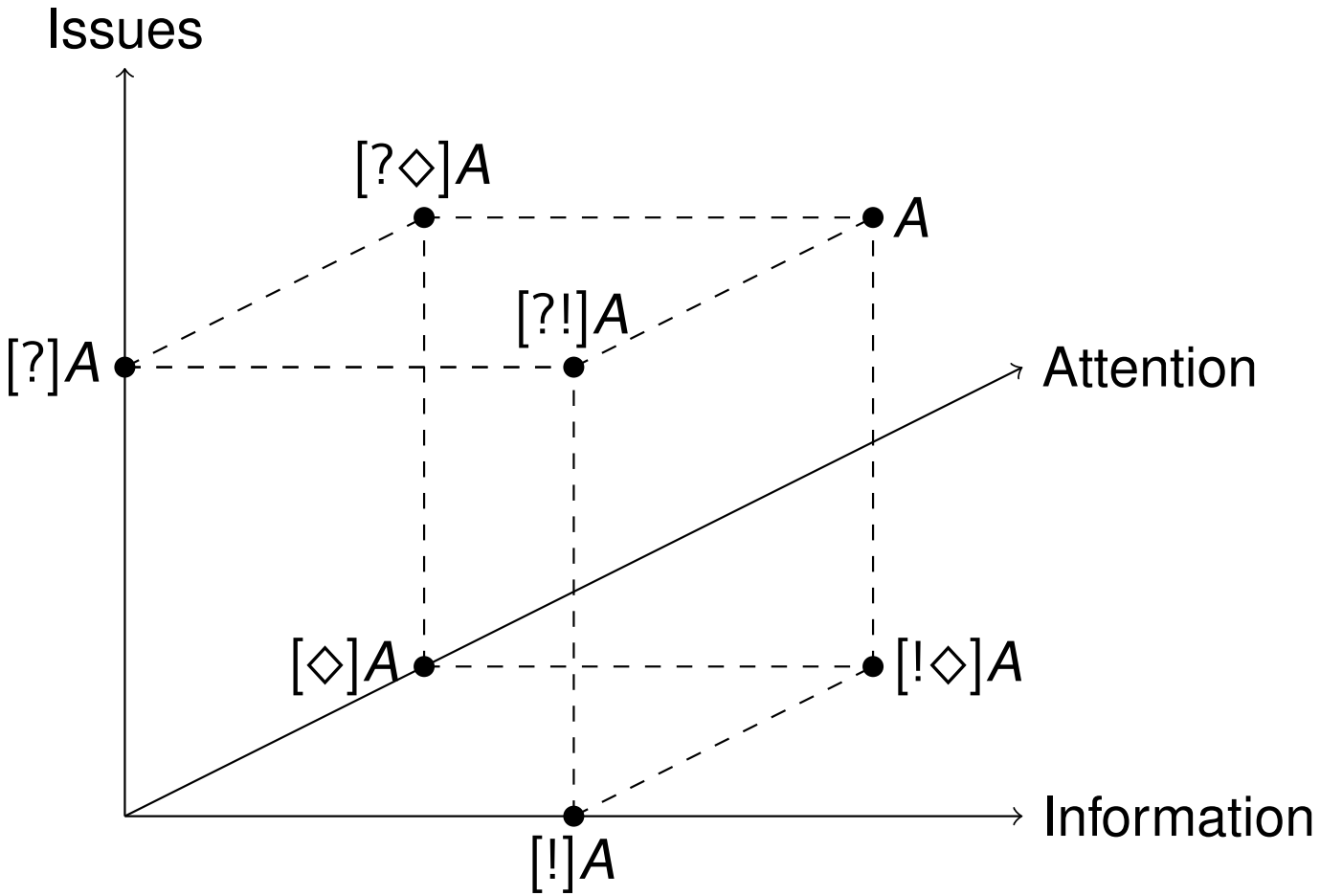
Logic

- Informative and inquisitive entailment
- Relatedness, compliance

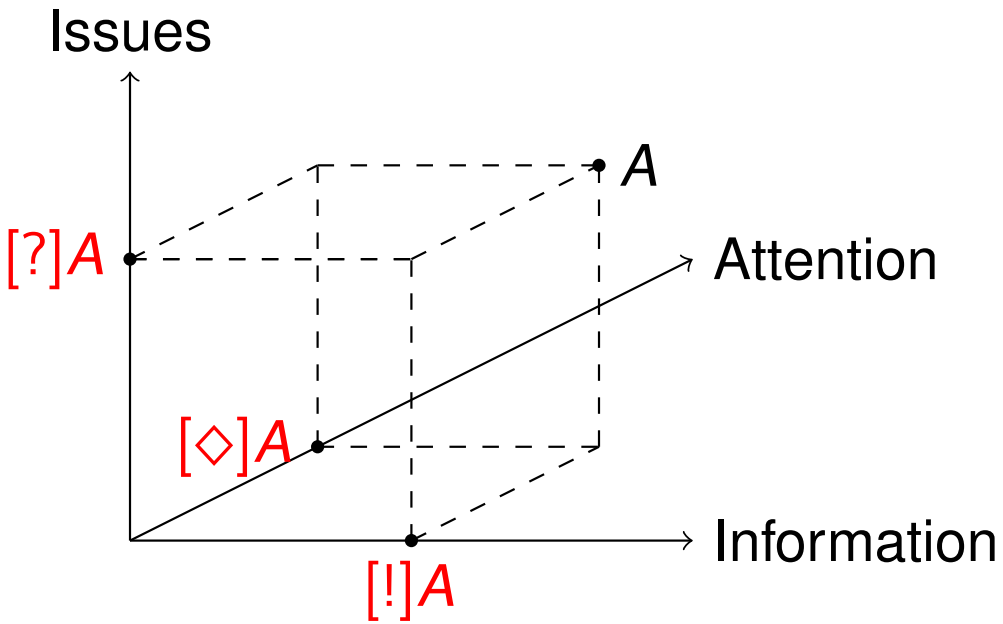
Pragmatics

- Sincerity, Transparency, Relation

Projection operators

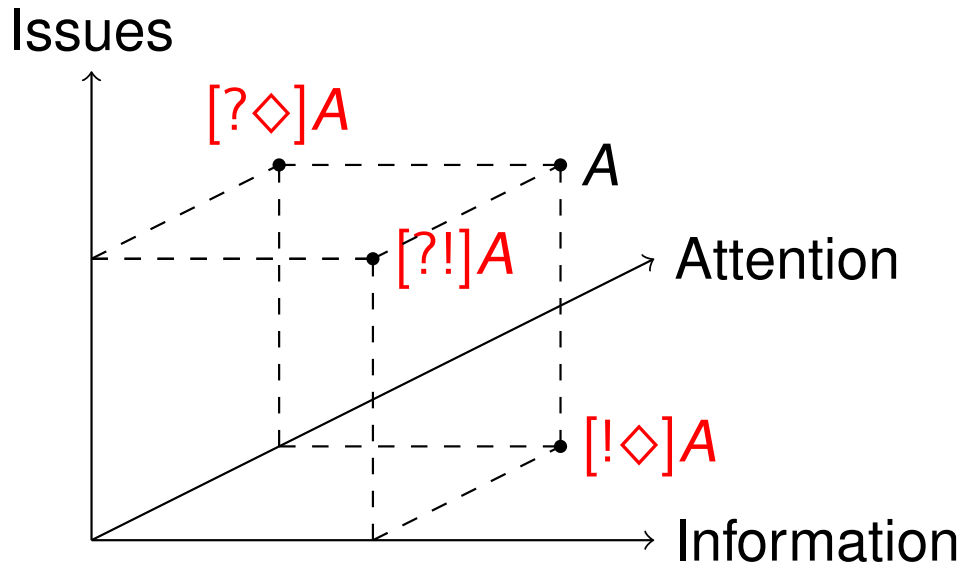


Projections onto the axes



$[!]A$	purely informative projection
$[?]A$	purely inquisitive projection
$[\diamond]A$	purely attentive projection

Projections onto the planes



$[?\diamond]A$ non-informative projection
$[!\diamond]A$ non-inquisitive projection
$[?!]A$ non-attentive projection

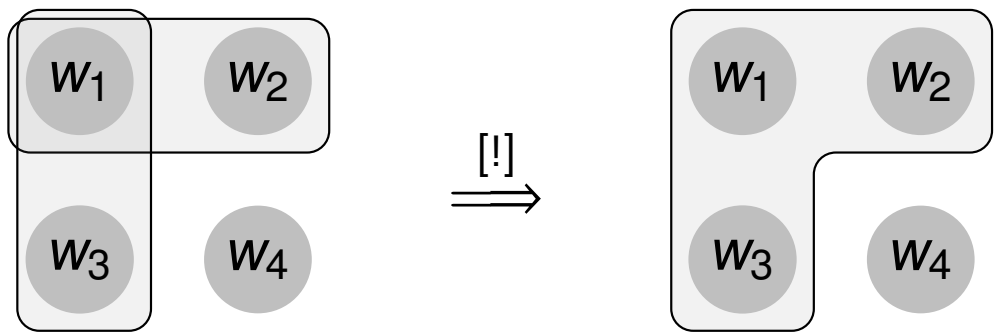
Example: purely informative projection

Requirements

- $[!]A$ should preserve the informative content of A
- $[!]A$ should be non-inquisitive
- $[!]A$ should be non-attentive

Implementation

- $[!]A = \{\bigcup A\}$



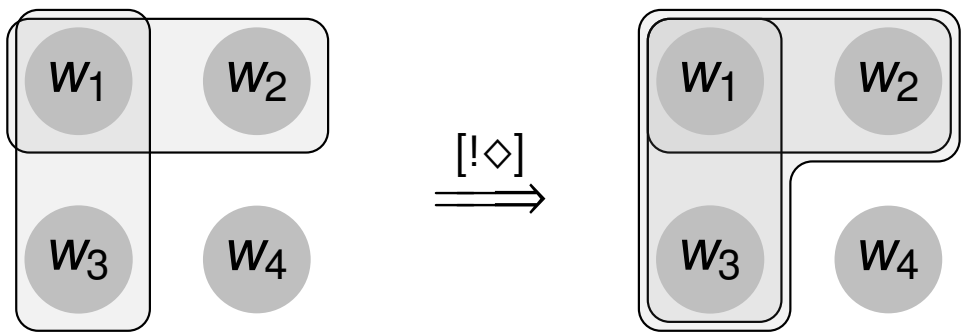
Another example: non-inquisitive projection

Requirements

- $[!\diamond]A$ should preserve the informative content of A
- $[!\diamond]A$ should be non-inquisitive
- $[!\diamond]A$ should preserve the attentive content of A

Implementation

- $[!\diamond]A = A \cup \{\bigcup A\}$

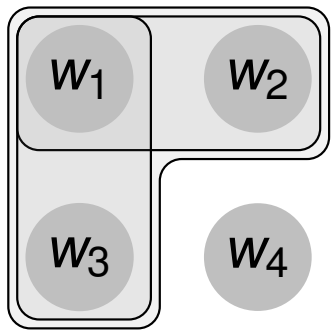


Relevance for natural language semantics

- It makes sense to think of non-interrogative complementizers as non-inquisitive closure operators

Earlier example:

(12) C_{-Q} John speaks Russian or French.



- Informative and attentive, but not inquisitive
- Alternatives introduced by disjunction, but closed off by C_{-Q}

Overview

Semantics

- Propositions as proposals ✓
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- Relatedness, compliance

Pragmatics

- Sincerity, Transparency, Relation

Logic

Traditionally

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

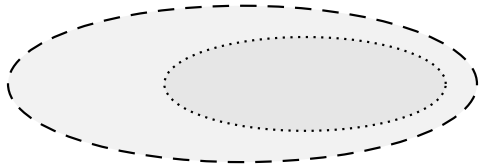
Vice versa

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

Entailment and (in)consistency

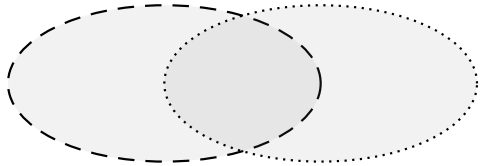
If propositions are construed as sets of possible worlds then two propositions can only be related in one of the following three ways

inclusion



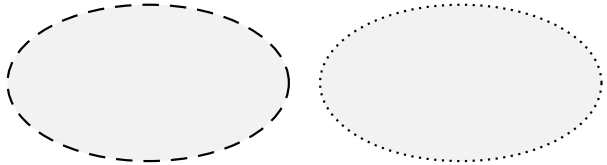
entailment

overlap



consistency

disjointness



inconsistency

Inquisitive logic

A new perspective

- Enriching the notion of semantic meaning
  leads to a new perspective on logic as well

New logical notions

- Besides classical entailment, we get a notion of
  inquisitive entailment: φ inquisitively entails ψ
  iff whenever φ is resolved, ψ is resolved as well
- We also get logical notions of relatedness. In particular,
  φ is a compliant response to ψ iff it addresses the proposal
  expressed by ψ without providing any redundant information.

Inquisitive logic

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New logical notions

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Note: classical notions are preserved; the logical agenda is extended, not revised (compare, e.g., with intuitionistic logic)

Pragmatics

Pragmatics specifies how cooperative speakers should use the sentences of a language, given a particular context and the semantic meaning of those sentences

Classical (Gricean) pragmatics

- identifies semantic meaning with informative content
- is 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

- Enriching the notion of semantic meaning leads to a new perspective on pragmatics as well

Inquisitive pragmatics

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

- Sincerity: only say what you know, only ask what you don't know, only draw attention to possibilities compatible with what you know
- Transparency: publicly announce unacceptability of a proposal
- Relation: compliantly address previous proposals

Conclusion

- The main purpose of inquisitive semantics is to develop a new notion of semantic meaning that captures both informative and inquisitive content
- Propositions are defined as sets of possibilities, representing proposals to update the common ground in one or more ways
- These new type of propositions are ordered in a natural way, based on their informative and inquisitive content
- This order yields algebraic operators like JOIN, MEET, $\sim$, and $\Rightarrow$
- The new conception of propositions also naturally gives rise to projection operators like [?] and [!]
- These algebraic operators and projection operators could be related to connectives and complementizers in formal and natural languages

Conclusion

- Changing the basic notion of semantic meaning gives rise to a new perspective on logic
- Besides informative entailment and consistency, new logical notions like inquisitive entailment and compliance enter the picture
- Changing the basic notion of semantic meaning also changes our perspective on pragmatics
- Speakers should not only be informatively sincere, but also inquisitively and attentively sincere
- Responders should be transparent and make a contribution that is related to previous proposals

Some references

Inquisitive semantics and pragmatics

Jeroen Groenendijk and Floris Roelofsen (2009)
Stanford workshop on Language, Communication and Rational Agency

Inquisitive logic

Ivano Ciardelli and Floris Roelofsen (2011)
Journal of Philosophical Logic 40(1), 55–94.

Information, issues, and attention

Ivano Ciardelli, Jeroen Groenendijk and Floris Roelofsen (2010)
In progress, latest version available at:

www.illc.uva.nl/inquisitive-semantics

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