An inquisitive perspective on meaning

The case of disjunction

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partly based on joint work with
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An inquisitive perspective on meaning

Point of departure

- A primary function of language is to exchange information
- Language is used both to provide and to request information
- Sentences have both informative and inquisitive potential
- Semantic theories have focused on informative content, inquisitive content has received far less attention

Key challenges

1. Develop a framework where the meaning of a sentence captures both its informative and its inquisitive content
2. Determine how differences in form and intonation affect the meaning of a sentence in this richer setting

Today: the case of disjunction

Today

Illustrate the advantages of an inquisitive perspective on meaning, focusing on the case of disjunction

Two views on disjunction

1. Classical logic: disjunction as a join operator
2. Alternative semantics: disjunction generates alternatives

Both appealing, but seemingly incompatible

Today: the case of disjunction

Part I: reconciliation

- If we adopt an inquisitive perspective on meaning, the two views can in fact be reconciled
- When treated as a join operator in the inquisitive setting, disjunction automatically generates alternatives

Part II: constructing meanings

The meaning of disjunctive sentences depends on:

- clause type: declarative vs interrogative
- intonation: prosodic phrase boundaries / rise vs fall

The semantic contribution of these formal and intonational features can only be captured uniformly in an inquisitive semantics

Part I

Two views on disjunction

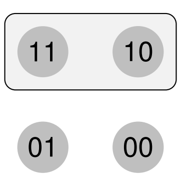
Roadmap

1. Classical logic: disjunction as a join operator
2. Alternative semantics: disjunction generates alternatives
3. How inquisitive semantics reconciles these two views
4. Further repercussions

(Roelofsen 2013)

Propositions in classical logic

- The proposition expressed by a sentence in classical logic is construed as a set of possible worlds
- Intuitively, a proposition carves out a region in the space of all possible worlds
- In asserting a sentence, a speaker provides the information that the actual world is located in this region



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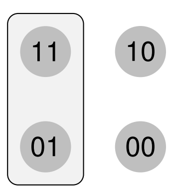

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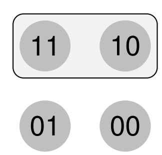
Connectives in classical logic

The basic connectives, negation, conjunction, disjunction, and implication, are taken to express simple operations on propositions



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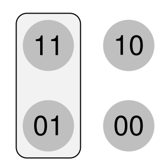

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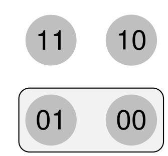
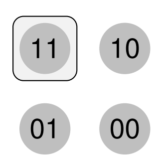
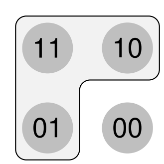


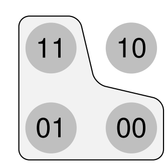
$\neg p$



$p \wedge q$



$p \vee q$



$p \rightarrow q$

The linguistic relevance of classical logic

Question

- What is the linguistic relevance of classical logic?
- What makes its treatment of the connectives so special?
- Why is this called the classical treatment?

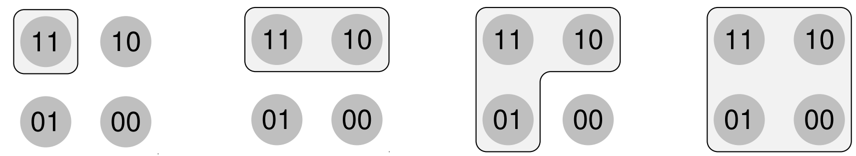
Answer

- To understand this, we need to take an algebraic perspective
- In classical logic, each connective expresses one of the most basic algebraic operations on propositions
- It is to be expected that natural languages will generally also have ways of expressing these basic operations

An algebraic perspective

Entailment

- Classical propositions are ordered in a natural way
- Intuitively, one proposition is stronger than another just in case it locates the actual world within a smaller region
- Formally, $A \models B \iff A \subseteq B$



$p \wedge q$ $\quad$ p $\quad$ $p \vee q$ $\quad$ $p \vee \neg p$

An algebraic perspective

- Every ordered set has a certain algebraic structure, and comes with certain basic algebraic operations
- The set of classical propositions, ordered by entailment, forms a so-called Heyting algebra
- This means that there are four basic operations:
  1. Join
  2. Meet
  3. Complementation
  4. Relative complementation

Basic algebraic operations: join and meet

Join

- The join of two propositions A and B is their least upper bound wrt entailment
- It can be computed by taking their union:

$$A \cup B$$

Meet

- The meet of two propositions A and B is their greatest lower bound wrt entailment
- It can be computed by taking their intersection:

$$A \cap B$$

Basic algebraic operations: complements

Complement

- The complement of a proposition A, denoted $\sim A$, is the weakest proposition C such that $A \cap C = \emptyset$
- It amounts to the set-theoretic complement of A:

$$\sim A \;=\; \{w \mid w \notin A\}$$

Relative complement

- The complement of A relative to B, denoted $A \Rightarrow B$, is the weakest proposition C such that $A \cap C \models B$
- It can be computed as follows:

$$A \Rightarrow B \;=\; \{w \mid \text{if } w \in A \text{ then also } w \in B\}$$

Connectives in classical logic

Each connective in classical logic expresses one of these four basic algebraic operations:

- $[\neg\varphi] \;=\; \sim[\varphi]$ complement
- $[\varphi \wedge \psi] \;=\; [\varphi] \cap [\psi]$ meet
- $[\varphi \vee \psi] \;=\; [\varphi] \cup [\psi]$ join
- $[\varphi \rightarrow \psi] = [\varphi] \Rightarrow [\psi]$ relative complement

In particular, disjunction expresses the join operation

In classical predicate logic, the existential quantifier also expresses the join operation, applying to a possibly infinite set of propositions

Relevance for natural language semantics

- It is to be expected that natural languages generally have ways to express these basic algebraic operations on propositions as well
- Words that may be taken to fulfill this purpose:

  English: and, or, not, if
  German: und, oder, nicht, wenn
  Dutch: en, of, niet, als

- The algebraic perspective on meaning provides a simple explanation of the cross-linguistic ubiquity of such words
- This makes the treatment of the basic connectives in classical logic linguistically highly relevant

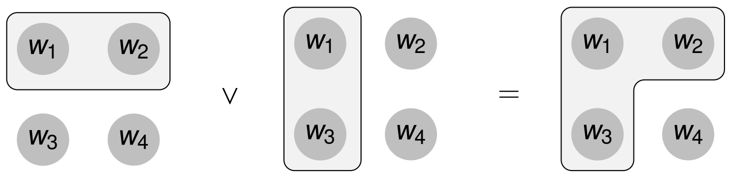
Disjunction in alternative semantics

- In recent years, many arguments have been made for an alternative treatment of disjunction
- These arguments involve a wide range of constructions:
  - modals
  - counterfactuals
  - conditional questions
  - alternative questions
  - imperatives
  - comparatives
  - unconditionals
  - sluicing
- Claim: disjunction generates alternatives

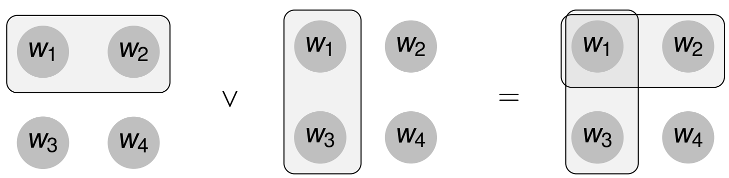
  Kratzer & Shimoyama '02, Simons '05, Alonso-Ovalle '06 '08 '09, Aloni '07, Groenendijk & Roelofsen '09, AnderBois '11, Biezma & Rawlins '12, a.o.

Generating alternatives

- Disjunction in classical logic:



- Disjunction in alternative semantics:



Impasse

- Alternative semantics yields improved predictions about the behavior of disjunction in all the constructions listed above
- However:
  - It forces us to give up the classical treatment of disjunction as expressing one of the basic algebraic operations on meanings
  - We no longer have a uniform treatment of disjunction, conjunction, negation, and implication
  - We no longer have an algebraic explanation for the cross-linguistic ubiquity of disjunction-words
- We seem to have reached an impasse

The road to reconciliation

1. Classical propositions only capture informative content
2. We will consider a richer notion of propositions, capturing both informative and inquisitive content
3. We will also consider a richer notion of entailment, sensitive to both informative and inquisitive content
4. As in the classical setting, we will find that the set of all propositions, ordered by entailment, forms a Heyting algebra
5. So we will have the same four basic algebraic operations: join, meet, complement, and relative complement
6. Treating disjunction as the join operator in this richer setting gives us exactly the desired alternative generating behavior

(Roelofsen '13)

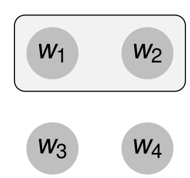
Propositions

- Assume, as before, a universe of possible worlds W
- Information state: set of possible worlds
- Proposition: non-empty, downward closed set of states

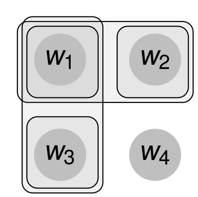
Something old something new

- Rooted in seminal work on questions (Hamblin '73, Karttunen '77)
- But with a crucial twist: downward closure

State:



Proposition:



The effects of an utterance

Common ground

- Body of shared information established in the conversation
- Modeled as an information state (Stalnaker '78)

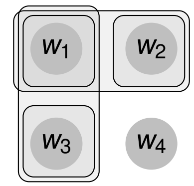
The effects of an utterance

In uttering a sentence φ, a speaker:

1. Provides the information that the actual world lies in $\bigcup[\varphi]$
2. Steers the common ground towards a specific state in $[\varphi]$

Example

Suppose that φ expresses the following proposition:



Then, in uttering φ, a speaker:

- Provides the information that the actual world is located in $\bigcup[\varphi] = \{w_1, w_2, w_3\}$
- Steers the common ground towards a state that is contained in $\{w_1, w_2\}$ or in $\{w_1, w_3\}$

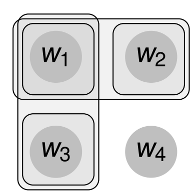
Settling propositions and downward closure

- If $s \in [\varphi]$, we say that the state s settles the proposition $[\varphi]$
- The requirement that propositions be downward closed ensures that if a given proposition is settled by a state s, then it is also settled by any more informed state $s' \subset s$

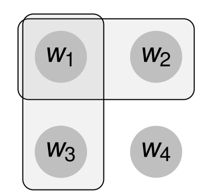
Alternatives

- Among all the states that settle $[\varphi]$, the ones that are easiest to reach are the ones that contain the least information
- These states are the maximal elements of $[\varphi]$
- We call these maximal elements the alternatives in $[\varphi]$
- In pictures, we will from now on only depict alternatives

Proposition:

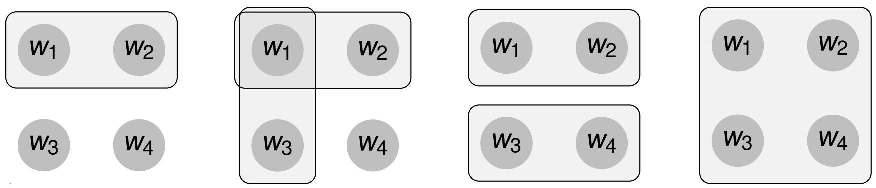


Alternatives:



Informativeness

- In uttering φ, a speaker provides the information that the actual world is contained in $\bigcup[\varphi]$
- We refer to $\bigcup[\varphi]$ as the informative content of φ, $\text{info}(\varphi)$
- We say that φ is informative iff $\text{info}(\varphi) \neq W$



+informative +informative −informative −informative

Inquisitiveness

- In uttering φ, a speaker steers the common ground of the conversation towards one of the states in $[\varphi]$
- Sometimes, all that is needed to reach such a state is for other participants to accept $\text{info}(\varphi)$

  $\Rightarrow$ This is the case if $\text{info}(\varphi) \in [\varphi]$
- Otherwise, additional information needs to be provided

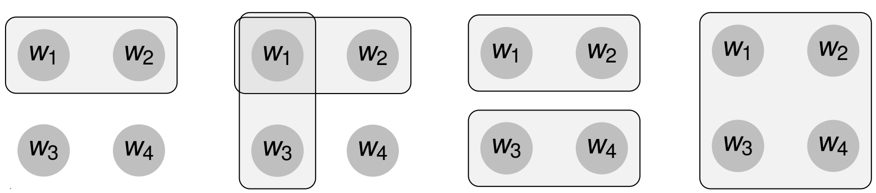
  $\Rightarrow$ In this case, i.e., if $\text{info}(\varphi) \notin [\varphi]$, we say that φ is inquisitive
- Useful fact: (if there are finitely many worlds)

  φ is inquisitive $\Leftrightarrow$ $[\varphi]$ contains at least two alternatives

Informativeness and inquisitiveness

Summary

- φ is informative $\Leftrightarrow$ $\text{info}(\varphi) \neq W$
- φ is inquisitive $\Leftrightarrow$ $\text{info}(\varphi) \notin [\varphi]$ $\Leftrightarrow$ at least two alternatives



+informative −inquisitive +informative +inquisitive −informative +inquisitive −informative −inquisitive

Entailment

Two natural conditions

In order for φ to entail ψ:

1. φ must be at least as informative as ψ: $\text{info}(\varphi) \subseteq \text{info}(\psi)$
2. φ must be at least as inquisitive as ψ: $[\varphi] \subseteq [\psi]$

   (every state that settles $[\varphi]$ also settles $[\psi]$)

Simplification

- The second condition implies the first
- So $\varphi \models \psi$ iff $[\varphi] \subseteq [\psi]$

Algebraic structure

- Just as in the classical setting, the set of all propositions, ordered by entailment, forms a complete Heyting algebra
- This means that we have the same four basic operations:
  1. Join
  2. Meet
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(for proofs see Roelofsen '13)

Basic algebraic operations: join and meet

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- It can be computed as follows:

$$A \Rightarrow B \;=\; \{\alpha \mid \forall \beta \subseteq \alpha\text{: if } \beta \in A \text{ then also } \beta \in B\}$$

Basic connectives

As before, negation, conjunction, disjunction & implication can be taken to express these four basic algebraic operations:

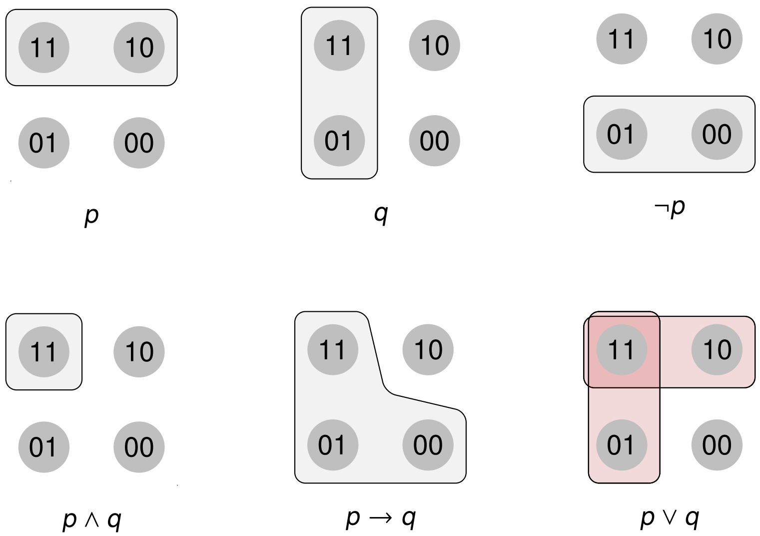
- $[\neg\varphi] = \sim[\varphi]$ complement
- $[\varphi \wedge \psi] = [\varphi] \cap [\psi]$ meet
- $[\varphi \vee \psi] = [\varphi] \cup [\psi]$ join
- $[\varphi \rightarrow \psi] = [\varphi] \Rightarrow [\psi]$ relative complement

In particular, disjunction can be taken to express the join operator

The approach can again be extended to quantifiers, letting $\exists$ express a join operator over possibly infinite sets of propositions

$\Rightarrow$ We enriched the notion of meaning, but we preserved the essence of the classical treatment of the connectives

Disjunction generates alternatives



Summary

- The treatment of disjunction in alternative semantics can be reconciled with the classical treatment of disjunction as join
- In the inquisitive setting, the two essentially coincide
- All the phenomena dealt with in alternative semantics can be accounted for without giving up the idea that disjunction expresses one of the basic algebraic operations on meanings
- The same holds, mutatis mutandis, for existentials/indefinites

Further repercussion: disjunction and interrogatives

- In many languages, there is a striking similarity between disjuntive, indefinite, and interrogative morphology

  (Jayaseelan '01 '08, Cable '10, Haida '10, AnderBois '11, a.o.)

(1) We eten vanavond pizza of pasta.
We eat tonight pizza or pasta.
'We will eat pizza or pasta tonight.'

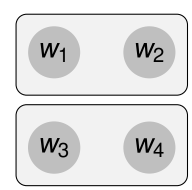
(2) Maria weet of we vanavond pizza eten.
Maria knows whether we tonight pizza eat.
'Maria knows whether we will eat pizza tonight.'

- The inquisitive join operator may be seen as the common semantic core of these constructions

Further repercussion: questions

- As may be expected, the inquisitive framework is particularly well-suited to capture the meaning of questions

(3) Does John speak Spanish?

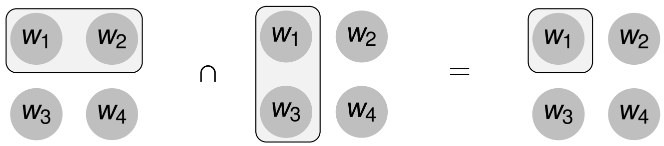


- Question meanings have two special properties:
  - They are always inquisitive $\Rightarrow$ at least two alternatives
  - They are never informative $\Rightarrow$ info$(\varphi) = W$

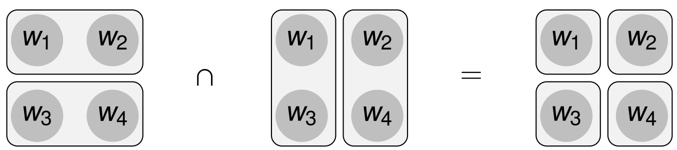
Further repercussion: conjunction

Conjunction applies uniformly to declaratives and interrogatives

(4) John speaks Spanish and he speaks French.



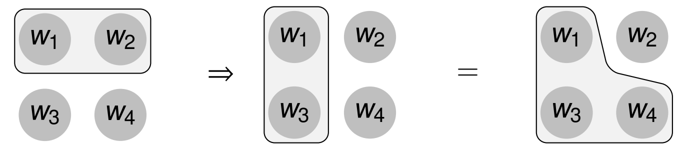
(5) Does John speak Spanish, and does he speak French?



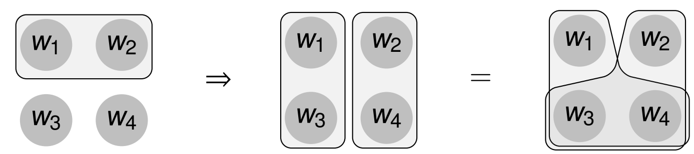
Further repercussion: implication

Implication applies uniformly to declaratives and interrogatives

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



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



Part II

Interpreting disjunctive lists

Disjunctive lists

Types of lists

(8)	Is he going to Spain, or to Italy↑?	open interrogative
(9)	Is he going to Spain, or to Italy↓?	closed interrogative
(10)	He is going to Spain, or to Italy↑.	open declarative
(11)	He is going to Spain, or to Italy↓.	closed declarative

Limit cases: lists with a single item

(12)	Is he going to Italy↑?	open interrogative
(13)	Is he going to Italy↓?	closed interrogative
(14)	He is going to Italy↑.	open declarative
(15)	He is going to Italy↓.	closed declarative

Roadmap

1. Formal and intonational factors in English
2. Semantic ingredients
3. Syntax-semantics interface
4. Empirical coverage

Formal and intonational factors in English

1. Phrasing

(16) Is he going to Spain, or Italy?

(17) Is he going to Spain-or-Italy?

- With phrase break: two list items
- Without phrase break: one list item

2. Final pitch contour

(18) Is he going to Spain, or Italy↑? L*H-H%

(19) Is he going to Spain, or Italy↓? H*L-L%

- Rise: leaves open the possibility that none of the items holds
- Fall: signals that exactly one of the items is supposed to hold

Formal and intonational factors in English

3. Clause type

(20) Is he going to Spain

(21) He is going to Spain

- Interrogative: always inquisitive
- Declarative: only inquisitive with final rise

Summing up: three factors

1. Phrasing: prosodic phrase boundaries separate list items
2. Final pitch contour: rise ⇒ open list / fall ⇒ closed list
3. Clause type: interrogative / declarative

Semantic ingredients

1. List completion

Needed for open lists and for interrogative lists

2. Exclusive strengthening

Needed for closed lists

3. Presuppositional closure

Needed for interrogative lists

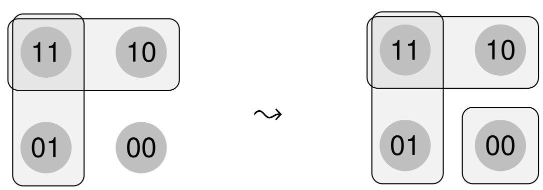
4. Non-inquisitive closure

Needed for closed declarative lists, and for basic list items

List completion

- Open lists leave open the possibility that none of the given alternatives hold
- This can be captured by adding the complement of the given alternatives as an additional alternative

(22) Is he going to Spain↑, or to Italy↑?

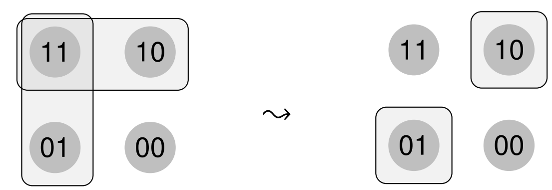


basic list items | list completion

Exclusive strengthening

- Closed lists signal that exactly one of the given alternatives is supposed to hold
- This can be captured by applying an exclusive strengthening operator, removing the overlap between the given alternatives

(Roelofsen & van Gool ’10)

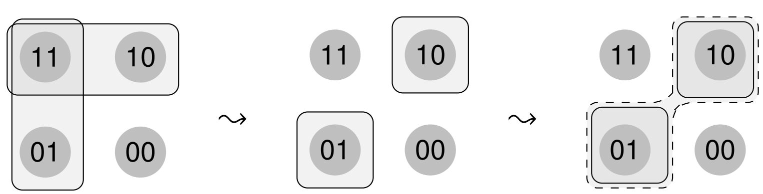


basic list items | ex-strengthening

Presuppositional closure

- Interrogative lists always presuppose that at least one of the given alternatives holds
- Captured by applying a presuppositional closure operator

(23) Is he going to Spain↑, or to Italy↓?



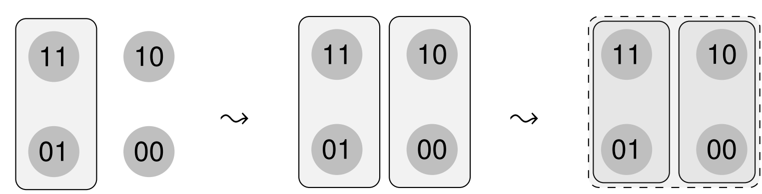
basic list items | ex-strengthening | pres-closure

- This could also be taken to apply to wh-interrogatives

Interrogative list completion

- Interrogative lists are always inquisitive: they invoke list completion if only one alternative is given explicitly
- Presuppositional closure applies vacuously in this case

(24) Is he going to Italy↓?

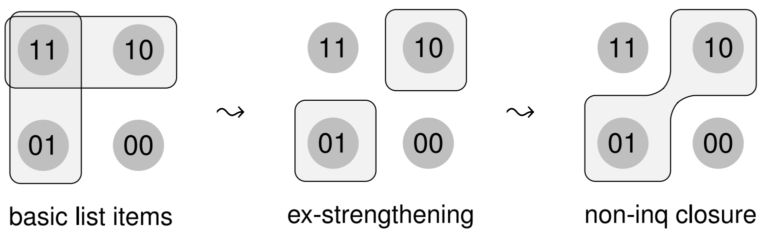


basic list item | list completion | pres-closure

Non-inquisitive closure

- Closed declarative lists are never inquisitive
- This is captured by applying a non-inquisitive closure operator, which removes inquisitiveness, while leaving informative content untouched

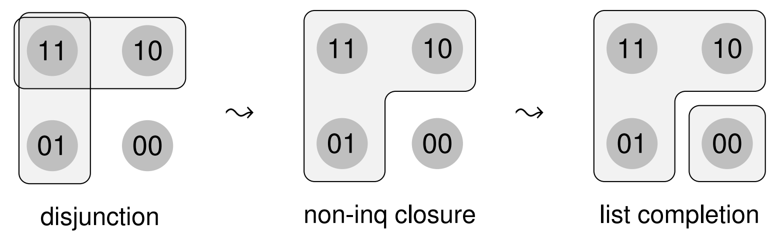
(25) He is going to Spain↑ or to Italy↓.



Non-inquisitive closure for basic list items

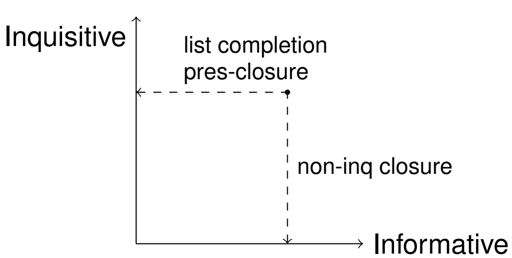
- Non-inquisitive closure is also needed to form basic list items
- Intonationally, the items are separated by phrase boundaries
- Semantically, they each contribute exactly one alternative

(26) Is he going to Spain-or-Italy↑?



Projection operators

- Propositions inhabit a two-dimensional space:



- All our semantic operators, except exclusive strengthening, behave like projection operators in this space
- The existence of such operators in natural languages is functionally motivated by the need for a clear division of labor

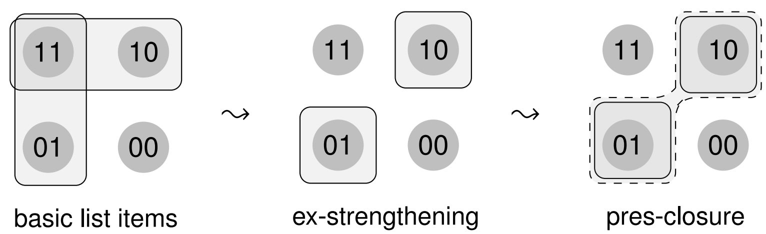
Interpretation procedure

1. Determine the basic list items
   - Detect prosodic phrase boundaries
   - Apply non-inquisitive closure to get one alternative per item
2. Determine whether the list is open or closed
   - Open: apply list completion
   - Closed: apply exclusive strengthening
3. Determine whether the list is declarative or interrogative
   - Interrogative: apply list completion if needed, and pres-closure
   - Declarative: if closed, apply non-inquisitive closure

Empirical coverage: interrogatives

Closed interrogative with multiple items

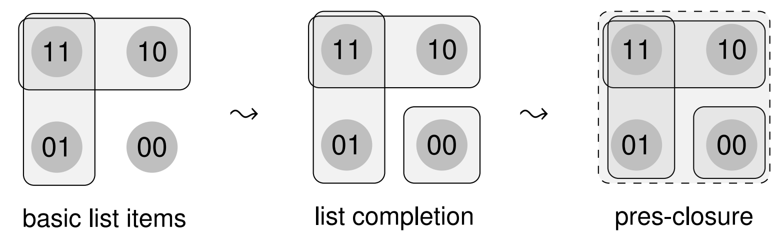
(27) Is he going to Spain↑, or to Italy↓?



Empirical coverage: interrogatives

Open interrogative with multiple items

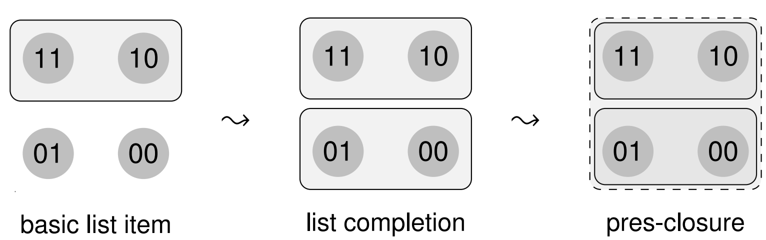
(28) Is he going to Spain↑, or to Italy↑?



Empirical coverage: interrogatives

Open interrogative with single item, simple case

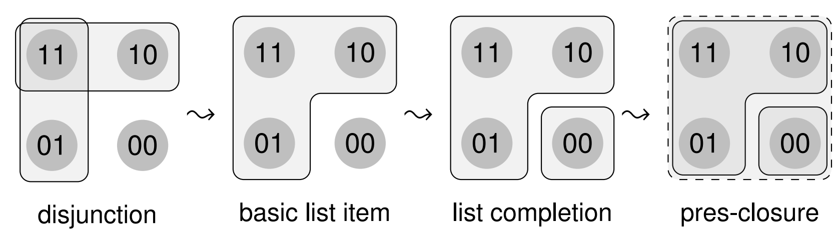
(29) Is he going to Spain↑?



Empirical coverage: interrogatives

Open interrogative with single item, complex case

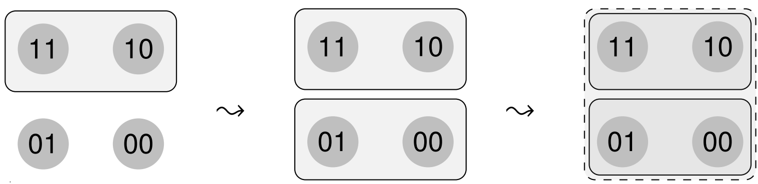
(30) Is he going to Spain-or-Italy↑?



Empirical coverage: interrogatives

Closed interrogative with single item

(31) Is he going to Spain↓?

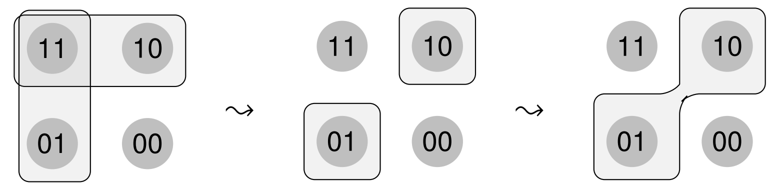


basic list item ⤳ list completion ⤳ pres-closure

Empirical coverage: declaratives

Closed declarative with multiple items

(32) He is going to Spain↑ or to Italy↓.

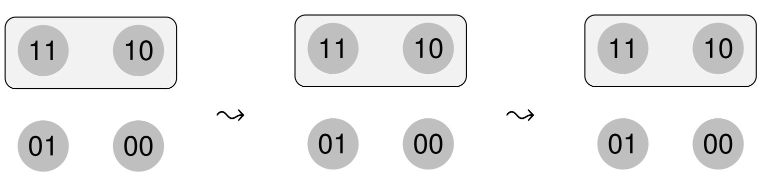


basic list items ⤳ ex-strengthening ⤳ non-inq closure

Empirical coverage: declaratives

Closed declarative with single item, simple case

(33) He is going to Spain↓.

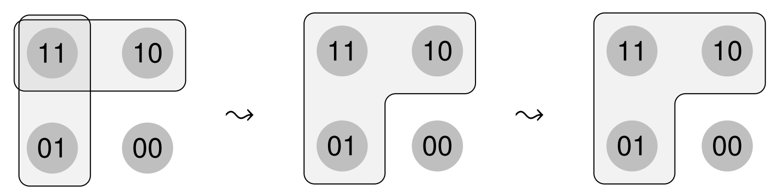


basic list items ⤳ ex-strengthening ⤳ non-inq closure

Empirical coverage: declaratives

Closed declarative with single item, complex case

(34) He is going to Spain-or-Italy↓.



disjunction ⤳ basic list item ⤳ non-inq closure

Empirical coverage: declaratives

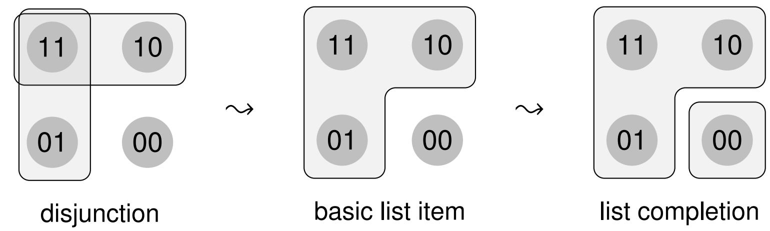
Open declarative with single item, simple case

(35) He is going to Spain↑.

Empirical coverage: declaratives

Open declarative with single item, complex case

(36) He is going to Spain-or-Italy↑.



Empirical coverage: declaratives

Open declarative with multiple items

(37) He is going to Spain↑, or to Italy↑.

A special case

Closed disjunctive interrogative without phrase break

(38) Is he going to Spain-or-Italy↓?

Two strategies to ensure inquisitiveness:

1. Treat the disjuncts as separate list items,
   even though no prosodic phrase break was perceived
2. Treat the disjunction as a single list item,
   and invoke list completion to generate a second alternative

Experimental results show that the first strategy is preferred (82%)

(Pruitt and Roelofsen '13)

Summing up

- Wide coverage of disjunctive lists, across clause types
- Of course the analysis could be further refined and extended
  - Examine the relevant intonation patterns in more detail
    (Hedberg & Sosa '11, Truckenbrodt '12, Pruitt & Roelofsen '13)
  - Account for the special effect of rising declaratives
    (Gunlogson '01, Malamud & Stephenson '11, Farkas & Roelofsen '12)
  - Account for polarity particle responses
    (Pope '76, Kramer & Rawlins '09, Farkas & Roelofsen '12, Krifka '13)
  - ...

Summing up

- Explain distributional restrictions on exclusive strengthening
  (Pruitt & Roelofsen '11)
- Consider disjunctive lists cross-linguistically
  (Alonso-Ovalle '06, Haspelmath '07, Winans '12)
- Consider embedded disjunctive lists
  (Ciardelli et.al. '09, Uegaki '12, Aher '12)

Crucial point

A uniform account of disjunctive lists does not get off the ground without a notion of meaning that captures both informative and inquisitive content in an integrated way

Conclusion

An inquisitive perspective on meaning:

- Sheds new light on some fundamental issues in semantics
- Yields a principled treatment of the basic connectives
- Gives rise to semantic operations like exclusive strengthening, list completion, and non-inquisitive closure, which seem to play a pervasive role in natural language
- Makes it possible to formulate a uniform, perspicuous account of disjunctive (and non-disjunctive) declaratives and interrogatives with different intonation patterns

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