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(joint work with Floris Roelofsen & Maria Aloni)

PREDICTING THE DISTRIBUTION OF EXHAUSTIVE READINGS FOR *KNOW*

InqBnB Workshop
Broek in Waterland
27 June 2017

Preview

PART 1

Intermediate exhaustive readings

Are these readings available for *know*?

→ G&S: no; C&C: yes.

PART 2

Semantic approach: resolution introspection

Pragmatic approach: implicatures

PART 3

Experiments

PART 1

Intermediate exhaustivity

Traditional readings of embedded questions

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Intermediate exhaustive (IE) reading

- x knows of everyone who passed that they did,
- but doesn't believe of anyone who didn't pass that they did.

But is the IE reading available for *know*?

According to Groenendijk and Stokhof (1982, p.180), it's not:

> *"Suppose that John knows of everyone who walks that he/she does; that of no one who doesn't walk, he believes that he/she does; but that of some individual that actually doesn't walk, he doubts whether he/she walks or not.*
>
> *In such a situation,* ***John would not say of himself that he knows who walks. We see no reason to override his judgement*** *and to claim that in this situation, John does know who walks."*

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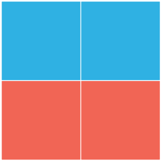
However, recent experiments (Cremers and Chemla, 2016) provide evidence that *know* licenses IE readings.



The card that
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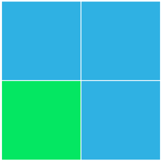
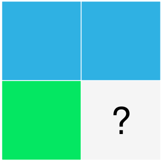


John's beliefs
in scenario A



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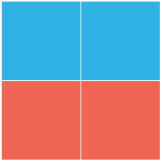

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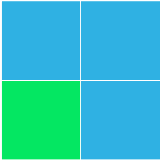

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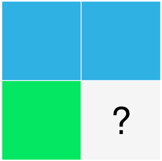

John's beliefs
in scenario B

(3) John knew which squares were blue.

- saliently judged **false** in scenario A $\rightsquigarrow$ **stronger than WE**
- saliently judged **true** in scenario B $\rightsquigarrow$ **weaker than SE**

Two reactions

Semantic approach:

Assume that *know* is **ambiguous**:

- **introspective reading** (G&S, responsible for SE)
- **non-introspective reading** (C&C, responsible for IE)

Pragmatic approach:

Assume that *know-wh* expresses WE knowledge and **derive IE/SE readings** as implicatures (à la Klinedinst and Rothschild).

PART 2

Two approaches to IE and SE readings

Formal preliminaries

We work in a **typed inquisitive semantics**: the meaning of a sentence is construed as the **set of resolutions** of the issue raised by the sentence (type $\langle\langle s,t\rangle,t\rangle =: T$).

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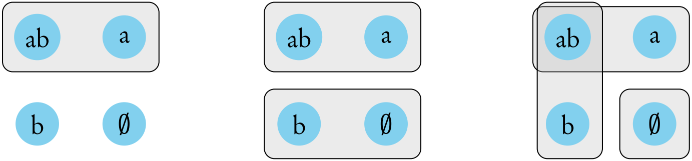

Ann passed. Did Ann pass? Who passed?

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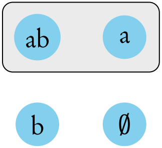

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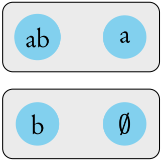

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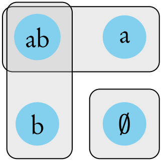

Who passed?

Differences from Hamblin-style alternative semantics:

- sentence meanings are **downward-closed**
- standard, **non-pointwise** composition

Formal preliminaries

- For example, we take the meaning of Ann won to be the set of resolutions of the trivial issue that Ann won.
- This is the set of propositions p such that Ann won in every world $w \in p$:

$$[\![\text{Ann won}]\!] = \lambda p_{\langle s,t \rangle}.\forall w \in p : W(a)(w)$$

$$[\![\text{won}]\!] = \lambda x_e.\lambda p_{\langle s,t \rangle}.\forall w \in p : W(x)(w)$$

Semantic approach to IE: truthful resolutions

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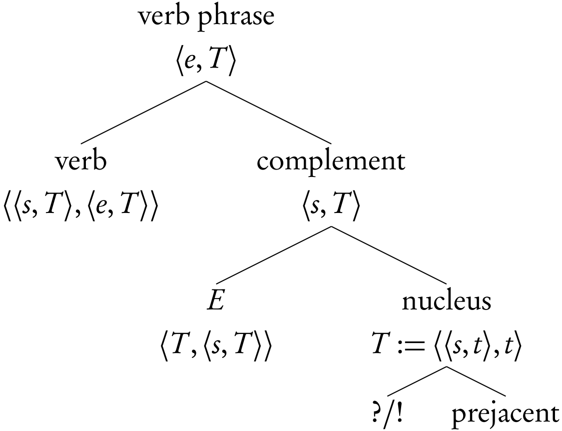
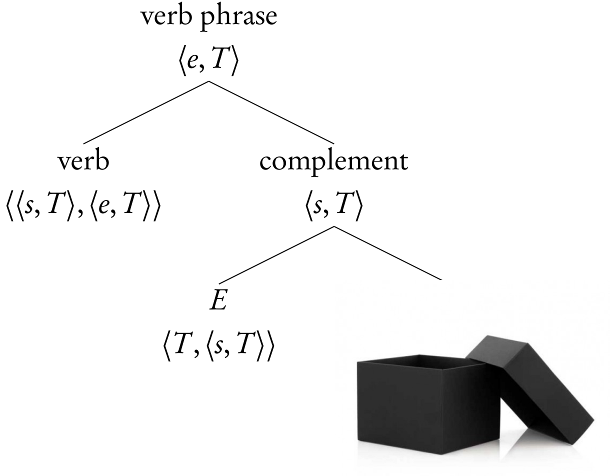
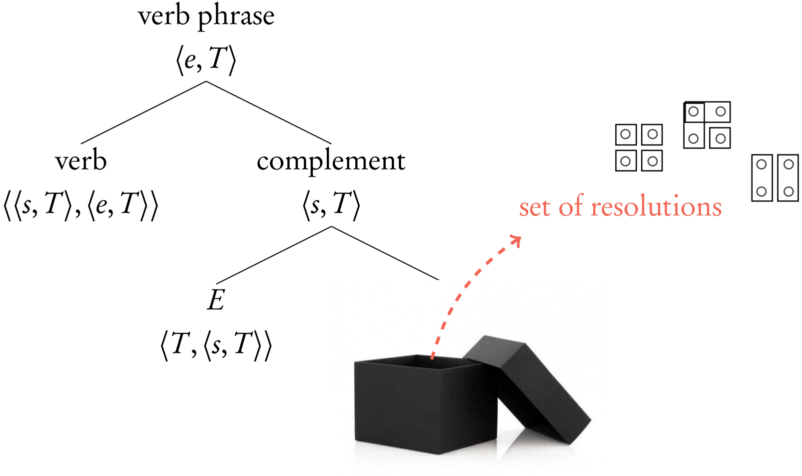

verb phrase
⟨e, T⟩
verb
⟨⟨s, T⟩, ⟨e, T⟩⟩
complement
⟨s, T⟩
E
⟨T, ⟨s, T⟩⟩
nucleus
T := ⟨⟨s, t⟩, t⟩
?/!
prejacent


verb phrase
$\langle e, T \rangle$
verb
$\langle \langle s, T \rangle, \langle e, T \rangle \rangle$
complement
$\langle s, T \rangle$
E
$\langle T, \langle s, T \rangle \rangle$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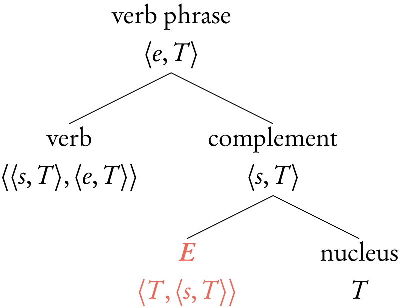
set of resolutions

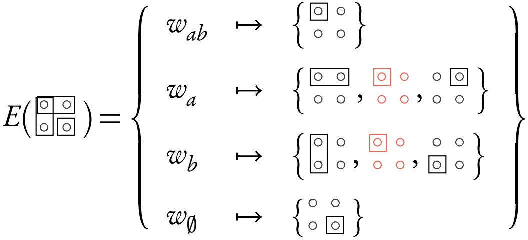


$$E_{[+cmp]} := \lambda P_T.\lambda w.\lambda p.\left(\begin{array}{l} p \in P \wedge p \neq \emptyset \wedge \\ \forall q \in \text{ALT}_w(P) : p \subseteq q \wedge \\ \neg\exists q \in \text{ALT}^*_w(P) : p \subseteq q \end{array}\right)$$

$\text{ALT}_w(P) := \{p \in \text{ALT}(P) \mid w \in p\}$ true alternatives

$\text{ALT}^*_w(P) := \{\bigcup Q \mid Q \subseteq \text{ALT}(P) \text{ and } w \notin \bigcup Q\}$ false partial answers

Truthful resolutions



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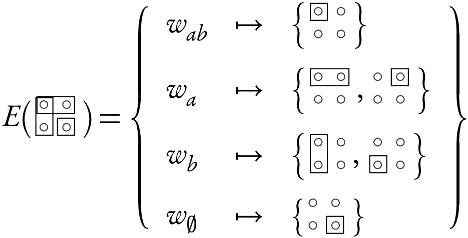
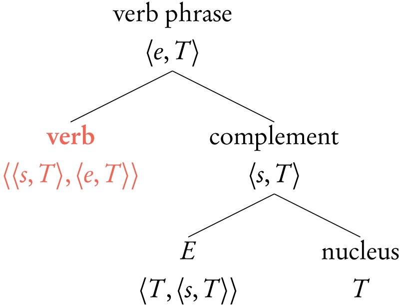


Basic lexical entry for *know*



$$[\![\text{know}]\!] := \lambda f_{\langle s,T\rangle}.\lambda x.\lambda p.\forall w \in p:\ \boldsymbol{\sigma}_x^w \in f(w)$$

Intermediate exhaustive reading

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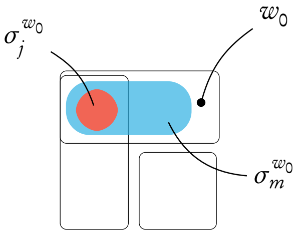

Here, Mary's but not John's information state is a truthful resolution.

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- Requires a strong form of **introspection**: the subject must be sure she has the correct answer to the question.
- **No uncertainty allowed** $\rightsquigarrow$ **SE**

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- Whether the subject would self-ascribe the knowledge isn't relevant.
- Rather, it matters whether an omniscient **external observer** thinks that there is a **sufficient match** between the subject's beliefs and actuality.
- uncertainty on part of the subject permitted $\leadsto$ IE available

Internal and external reading of *know*

- We'd like to be able to **capture both readings**.
- The entry we already have corresponds to the **external perspective**.

$$[\![\text{know}]\!] = \lambda f_{\langle s,\langle st,t\rangle\rangle}.\lambda x.\lambda p.\forall w \in p : \sigma_x^w \in f(w)$$

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- In order to also capture the internal perspective, we will add an **introspection condition:** resolution introspection.

Resolution introspection goes beyond standard introspection in epistemic logic, which is only concerned with declarative knowledge:

Introspection condition		Introspection principles
$\forall v \in \sigma_x^w : \sigma_x^v = \sigma_x^w$	$\rightsquigarrow$	$K\varphi_{\text{decl}} \rightarrow KK\varphi_{\text{decl}}$
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What we want to capture though: awareness of *interrogative* knowledge, so that we get a unified introspection principle that applies to both declaratives and interrogatives.

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$+$

Resolution introspection

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Unified introspection principles

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Resolution introspection

Internal *know*:

$$[\![\textsf{know}_{\text{int}}]\!] := \lambda f_{\langle s,T\rangle}.\lambda x.\lambda p.\forall w \in p : (\sigma_x^w \in f(w) \wedge \underbrace{\forall v \in \sigma_x^w : \sigma_x^v \in f(v)}_{\text{resolution introspection}})$$

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  - So, you know answer2$(Q)(w)$ iff you know what answer1$(Q)(w)$ is.
- We can formulate an introspection condition along these lines:

Heim introspection:

The subject has to be aware what the truthful resolutions are in w:

$$[\![\text{know}_{\text{Heim}}]\!] = \lambda f.\lambda x.\lambda p.\forall w \in p : (\sigma_x^w \in f(w) \wedge \underbrace{\forall v \in \sigma_x^w : f(v) = f(w)}_{\text{Heim introspection}})$$

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facts	✓	✗
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(5) Janna knows where one can buy an Italian newspaper.

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facts	✓	✗
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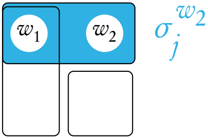
We think (5) should come out true under an internal interpretation and an MS reading.

(6) Janna knows where one can buy an Italian newspaper.



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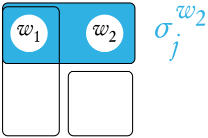
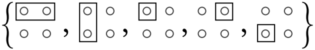
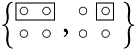


- We get the following sets of truthful resolutions:

$f(w_1) =$ 

$f(w_2) =$ .

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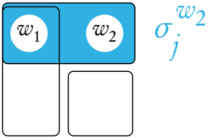

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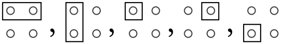
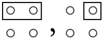
  $f(w_1) = \{$  $\}$

  $f(w_2) = \{$  $\}$.

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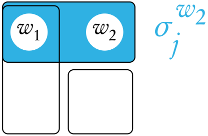

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- **Heim introspection:** $\forall v \in \sigma_j^{w_2} : f(v) = f(w_2)$ ✗
  since $f(w_1) \neq f(w_2)$

Interaction between MS/IE/SE and internal/external

	ext	**int**
MS	r_1	r_2
IE	r_3	r_4
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If the verb receives an internal interpretation, then IE and SE interpretation of the complement yield exactly the same reading for the sentence as a whole.

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- But this is just resolution introspection! Hence, SE.

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- **G&S's claim** that *know* doesn't allow for an IE reading is **salvaged**, though only under an internal interpretation of the verb—the interpretation they seem to have had in mind.
- On the other hand, under an external interpretation, IE readings exist independently of SE ones.
- This accounts for **C&C's findings**, whose experiments seem to have made the external interpretation especially salient.

Predictions:

- **First-person** ascriptions are always **SE** (unless MS).
- **Third-person** ascriptions are **SE** if the internal perspective is relevant, **IE** otherwise.

PRAGMATIC APPROACH

Pragmatic approach: IE as implicature

Klinedinst and Rothschild (2011), building on an idea by Berman:

- Knowledge-*wh* is essentially **WE knowledge**
- Stronger exhaustivity is the result of **implicatures** due to alternative false answers
- Additional hypothesis (Cremers, 2017):
  ⟨know, believe⟩ form a **scale**

Pragmatic approach: IE as an implicature

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Pragmatic approach: SE as a local implicature

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If the interrogative complement itself is exhaustified, we derive an SE interpretation:

$$K_m(Exh_{\{a,b,c\}}(a \wedge b)) = K_m(a \wedge b \wedge \neg c)$$

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Alternatively, the SE reading can be derived by strengthening the IE interpretation with an excluded-middle presupposition (Uegaki 2015, see also Russel 2006).

Pragmatic approach: Conclusion

- **IE reading** = "global" implicature (matrix exhaustification)
- **SE reading** = exhaustification of the embedded interrogative
- No clear prediction on the **distribution** of IE and SE (see debates in the literature on local implicatures)

PART 3

Revisiting Cremers & Chemla

A version of C&C with internal readings?

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  - stays very close to that of C&C,
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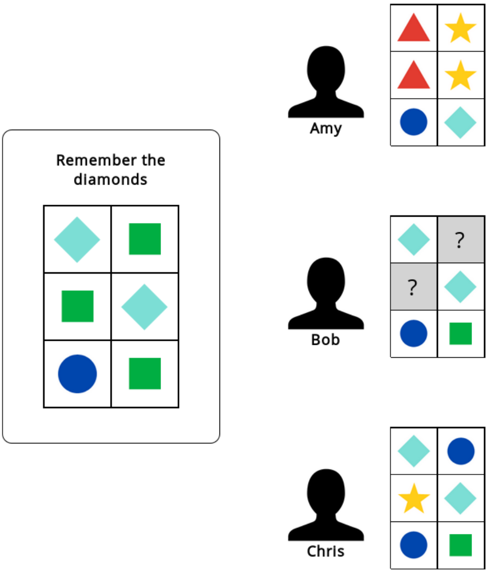
A version of C&C with internal readings?

- What if we conduct an experiment that:
  - stays very close to that of C&C,
  - but makes the internal reading more salient?
- **Similar design:** card game in which players have to remember the symbols on a card.
- **Now however:** multi-player game, win $5 for correct answer, lose $10 for wrong answer, option to withdraw



Who knows which of the shapes are diamonds?

☐ Amy ☐ Bob ☐ Chris

Instructions

Amy, Bob and Chris are playing a memory game with cards. Each round, they get to see a different card, but only for a few seconds. All cards consist of six cells, and each cell can contain one of various symbols

The aim is to remember where certain symbols appeared on the card. Which symbols need to be remembered varies from round to round and is indicated on the card. If a player manages to recall the position of the relevant symbols correctly, she gets 5 dollars. If she makes any mistakes, she loses 10 dollars.

Each round, players also have the option to **withdraw**. If they withdraw, they won't win anything, but they won't lose anything either. When they are unsure about too many symbols, players tend to withdraw since the risk of losing 10 dollars may outweigh the chance of winning 5 dollars.

What you will see are the actual cards, and how Amy, Bob and Chris remember them. Using this information, you will have to answer various questions about Amy, Bob and Chris.

Idea: with withdrawal option, the players' decisions on how to proceed depend on whether they'd say of themselves that they know an answer to the given question.

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More SE readings in version A.

What we found:

The opposite. If anything, more SE readings in version B.

	A	**B**
IE	21	10
SE	15	21
other	9	12
total	45	43

(p=.07 if we keep others, .06 if not)

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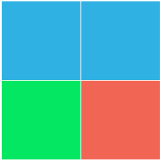
This seems to be a possible explanation for the results we got, but there's no obvious fix: if your knowledge state matters to the game, one of the readings will be favored over the other independently of introspection.

Idea for a different design

Alternative idea for making intropection salient: rather than giving a **graphical** representation, let the agent **describe** her beliefs herself.



Mary: “I remember that block 1 and 2 are blue, and that block 3 is green. But I am unsure about block 4: it might be red or blue.”

Mary knows which squares are blue.

○ true ○ false

THANK YOU!

Suggestions? Questions?

References

Cremers, A. and Chemla, E. (2016). A psycholinguistic study of the exhaustive readings of embedded questions. *Journal of Semantics*, **33**(1), 49–85.

Groenendijk, J. and Stokhof, M. (1982). Semantic analysis of wh-complements. *Linguistics and Philosophy*, **5**(2), 175–233.

Heim, I. (1994). Interrogative semantics and Karttunen's semantics for *know*. In R. Buchalla and A. Mittwoch, editors, *The Proceedings of the Ninth Annual Conference and the Worshop on Discourse of the Israel Association for Theoretical Linguistics*. Academon, Jerusalem.

Klinedinst, N. and Rothschild, D. (2011). Exhaustivity in questions with non-factives. *Semantics and Pragmatics*, **4**(2), 1–23.