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RESOLUTION INTROSPECTION

Reconciling Groenendijk & Stokhof with Cremers & Chemla

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Preview

PART 1

This is what intermediate exhaustive readings are and how we capture them.

PART 2

Are these readings available for *know*?

G&S said: no. C&C found: yes.

These positions can be reconciled. We'll do that.

PART 3

We conducted an experiment, but got unexpected results.

PART 1

Intermediate exhaustivity

Recap: levels of exhaustivity

- We'll focus on the case of ***know***:

  (1) John knows who called.

- Suppose Ann and Bob called while Carol didn't.
- Two prominent **proposals** for the meaning of a sentence like (1):

Weak exhaustivity
(Karttunen, 1977)
John knows the true complete answer, i.e., he knows that Ann and Bob called.

Strong exhaustivity
(Groenendijk & Stokhof, 1984)
John knows the true strongly-exhaustive answer, i.e., he knows that **only** Ann and Bob called.

Recap: levels of exhaustivity

Both WE/SE

John knows who called.
Mary called.
∴ John knows that Mary called.

Only SE

John knows who called.
Mary **didn't** call.
∴ John knows that Mary didn't call.

But even if we don't think the SE inference should be licensed, WE readings are still **too weak** for certain verbs (Spector, 2005; Klinedinst and Rothschild, 2011).

Strengthening WE: intermediate exhaustivity

- WE readings ignore **false answers**:

	Ann passed	Bob passed	Carol passed
facts	✓	✓	✗
Mary	✓	✓	?
John	✓	✓	✓

- In this scenario, (2-a) is judged true, while (2-b) is judged false.

(2) a. Mary knows who passed the exam.
    b. John knows who passed the exam.

- This is unexpected on both WE and SE reading: WE predicts both sentences to be true, SE predicts both to be false.

Strengthening WE: intermediate exhaustivity

What we need instead:

Intermediate exhaustive (IE) reading

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

- Roughly, we will build this **false-answer sensitivity** into our notion of "true answers".

Strengthening WE: intermediate exhaustivity

We call a proposition that entails all true answers and doesn't entail any (partial) false answers a complete **truthful resolution**.

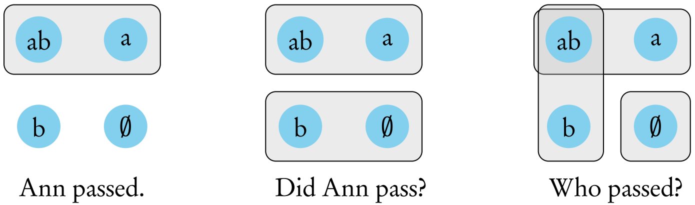
- ⟦Ann and Bob passed⟧ is a truthful resolution.
- ⟦Ann, Bob and Carol passed⟧ is **not**.
- ⟦Ann and Bob passed, effortlessly, without even studying⟧ is a truthful resolution—even if, in fact, Ann and Bob spent months before the exam revising.

For x to *know* a question, σ_x^w has to match a truthful resolution:

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

Formal preliminaries

We work in a **typed inquisitive semantics**, which is essentially an **alternative semantics**: the meaning of a sentence is construed as a **set of propositions** (type $\langle\langle s,t\rangle,t\rangle =: T$).



Two differences from Hamblin-style alternative semantics:

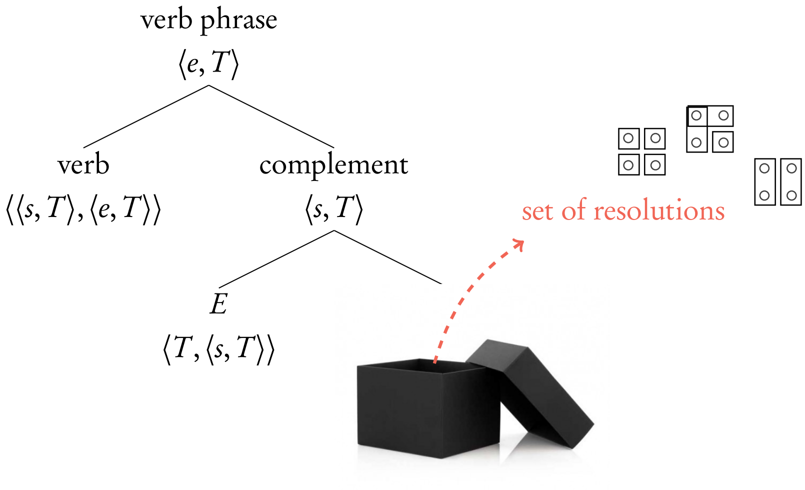
- sentence meanings are **downward-closed**
- standard, **non-pointwise** composition

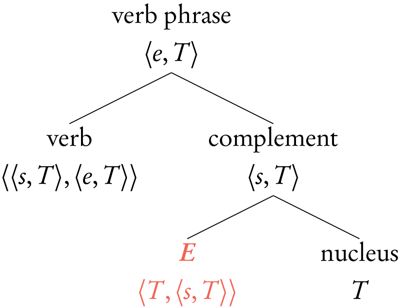
Formal preliminaries

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

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

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


verb phrase
⟨e, T⟩
verb
⟨⟨s, T⟩, ⟨e, T⟩⟩
complement
⟨s, T⟩
E
⟨T, ⟨s, T⟩⟩
set of resolutions

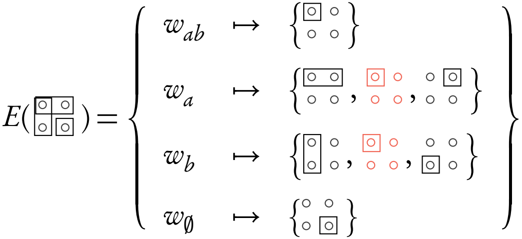


$$E_{[+cmp]} := \lambda P_T.\lambda w.\lambda p. \left(\begin{array}{l} p \in P \wedge p \neq \emptyset \wedge \\ \forall q \in \text{ALT}_w(P) : p \subseteq q \wedge \\ \neg \exists q \in \text{ALT}^*_w(P) : p \subseteq q \end{array} \right)$$

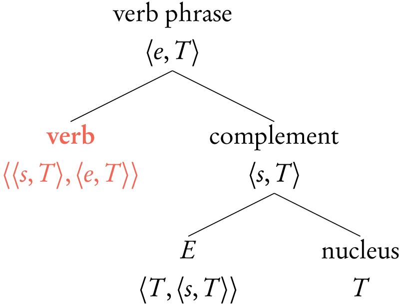
$\text{ALT}_w(P) := \{p \in \text{ALT}(P) \mid w \in p\}$ true alternatives

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

Truthful resolutions



A lexical entry for *know*



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

PART 2

Internal and external reading

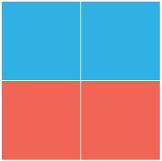
Is the IE reading available for *know*?

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

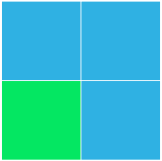
> *"Suppose that John knows of everyone who walks that he/she does; that of no one who doesn't walk, he believes that he/she does; but that of some individual that actually doesn't walk, he doubts whether he/she walks or not.*
>
> *In such a situation, **John would not say of himself that he knows who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

Is the IE reading available for *know*?

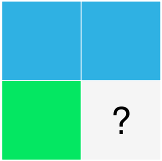
However, recent experiments (Cremers and Chemla, 2016) seem to show that *know* licenses IE readings.



The card that John looked at



John's beliefs in scenario A



John's beliefs in scenario B

(3) John knew which squares were blue.

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

Internal and external reading of *know*

Our proposal: knowledge ascriptions are **multiply ambiguous**

- **exhaustive strength** of the interrogative complement
- different interpretations of *know* itself: ***internal* and *external***

G&S's perspective: internal

- Truth of knowledge-ascription depends on whether the subject would **self-ascribe** the knowledge.
- Requires a strong form of **introspection**: the subject must be sure she has the correct answer to the question.
- **No uncertainty allowed** $\rightsquigarrow$ **SE**

Internal and external reading of *know*

Perspective most salient in C&C's experiment: external

- 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 $\rightsquigarrow$ 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.

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

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

Resolution introspection

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

Introspection condition $\forall v \in \sigma_x^w : \sigma_x^v = \sigma_x^w$ $\rightsquigarrow$ **Introspection principle** $K\varphi_{\text{decl}} \to KK\varphi_{\text{decl}}$

- 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.

Introspection condition $\forall v \in \sigma_x^w : \sigma_x^v = \sigma_x^w$
$+$
Resolution introspection

$\rightsquigarrow$ **Unified introspection principle** $K\varphi \to KK\varphi$

Resolution introspection

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

It's not enough if x's information state just *happens* to coincide with a truthful resolution in the world of evaluation—x also has to be aware of this match.

Alternative implementation: Heim introspection

- Recall: Heim (1994) derives SE answers from WE answers:
  - answer1$(Q)(w)$ is the true WE answer of Q in w.
  - answer2$(Q)(w)$ is the set of all worlds v such that answer1$(Q)(v)$ is the same as answer1$(Q)(w)$.
  - 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:

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

Why not use Heim introspection?

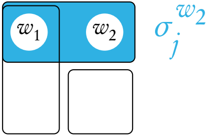
know$_{\text{Heim}}$ and *know*$_{\text{int}}$ come apart their empirical predictions for mention-some readings.

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

	Newstopia	Paperworld
facts	✓	✗
Janna	✓	?

We think (4) should come out true under an internal interpretation and an MS reading.

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



- We get the following sets of truthful resolutions:

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

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

- **Resolution introspection:** $\forall v \in \sigma_j^{w_2} : \sigma_j^{w_2} \in f(v)$ ✓

  since  $\in f(w_1)$ and  $\in f(w_2)$

- **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
			$\parallel$
SE	r_5	$=$	r_6

If the complement receives an MS or an SE interpretation, then external and internal interpretation yield exactly the same reading for the sentence as a whole.

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.

Self-ascriptions

Additional prediction:
With knowledge **self-ascriptions, IE = SE**, even under an external interpretation.

(6) I know who called.

- Assume external interpretation and IE reading.

⇒ (6) is true in w iff $\sigma_x^w \in f_{\text{IE}}(w)$.

- Assume the speaker is complying with the Gricean maxims, in particular with **Quality**.

⇒ She must believe what she just said, i.e., $\forall v \in \sigma_x^w : \sigma_x^v \in f_{\text{IE}}(v)$.

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

be certain

We assume that *be certain* only has an internal interpretation.

$$[\![\text{be certain}]\!]$$

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

$$= \lambda f_{\langle s,T\rangle}.\lambda x.\lambda p.\forall w \in p : \forall v \in \sigma_x^w : \sigma_x^w \in f(v)$$

- **Prediction:** *be certain* only allows SE readings.
- In line with Uegaki (2015).

Interim conclusion

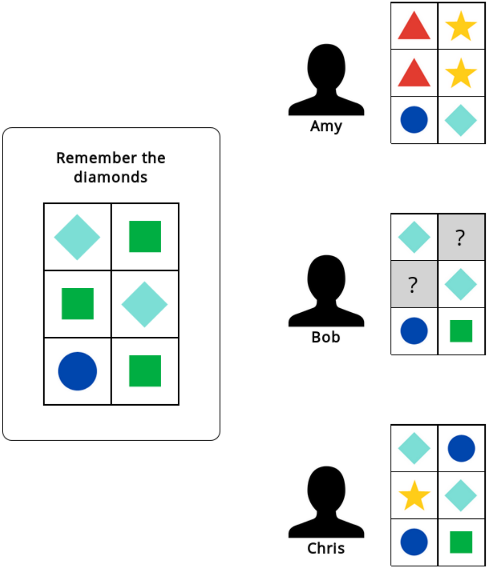
- **G&S's claim** that *know* doesn't allow for an IE reading is **salvaged**, though only under an internal interpretation of the verb—the interpretation that they seem to have had in mind.
- On the other hand, under an external interpretation, IE readings exist independently of SE ones.
- This accounts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

PART 3

Revisiting Cremers & Chemla

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?
- **Again:** 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.

Two versions:

- **A** Every round, players have the option to withdraw.
- **B** No withdrawal option. Players have to play in every round.

What we predicted:

More SE readings in version A.

What we found:

The opposite. Significantly 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)

Conjecture at what happened here

- **In version B**, you are forced to make a guess about *every* symbol on the card.
- So, to avoid losses, you need SE knowledge!
- **In version A**, on the other hand, there's an easy strategy for avoiding losses: play only when you are sure. If you only have IE knowledge, then withdraw.
- In this sense, IE knowledge is sufficient for success in version A.

This seems to be a possible explanation for the results we got.
But there's no obvious fix.

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