

# On the monotonicity of attitudes: Clausal embedding and NPI licensing

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## 1. Introduction

- This talk is concerned with the question of **modeling monotonicity in attitude reports**: how should our semantics capture the entailments like in (1)?
- (1)    a.    Katya believes that Anton snowboarded last Friday.  
      b.     $\rightsquigarrow$  Katya believes that Anton snowboarded.
- We will use Negative Polarity Items (NPIs) to probe this question.
  - NPIs are sensitive to monotonicity<sup>1</sup>: they are licensed in Strawson Downward-Entailing (SDE) but not in Strawson Upward-Entailing (SUE) environments:
- (2)    a.    \*Katya believes [that Anton has **ever** snowboarded].  
      b.    Katya doesn't believe [that Anton has **ever** snowboarded].
- A note of caution: *believe* typically licenses a NEG-raising inference, i.e., from *x doesn't believe that p* to *x believes that not p*. Non-NEG-raising doxastics show us that NEG-raising isn't necessary for licensing weak NPIs:
- (3)    Katya isn't certain [that Anton has **ever** snowboarded].

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<sup>1</sup>See Fauconnier 1975, 1979, Ladusaw 1979, 1980a,b, Hoeksema 1986, Kadmon & Landman 1993, von Stechow 1993, a.m.o.

- Our empirical focus is the contrast in (4), first noticed by Sharvit (2023): in negated belief reports, NPIS cannot be licensed in *relative* clauses modifying objects like *the rumor*, (4a), but they are licensed in *complement* clauses composing with such noun phrases, (4b).<sup>2</sup>

(4) **Sharvit’s Puzzle**

- a. \*Katya doesn’t believe [the rumor [that Anton has **ever** spread]].
- b. Katya doesn’t believe [the rumor [that Anton has **ever** snowboarded]].

- Impossibility of the NPI in (4a) is expected:  
The presupposition introduced by the singular definite description in (4a) makes the context SUE, and thus anti-licenses the NPI.

- (5)
- a. Katya doesn’t believe the rumor that Anton spread last Friday.
  - b. There is a unique rumor that Anton spread.
  - c.  $\leadsto$  Katya doesn’t believe the rumor that Anton spread.

- But if singular definite descriptions create SUE environments and bleed NPI licensing, we should see that in (4b) as well, contrary to fact.

★ **Questions:**

- What explains the contrast between (4a) and (4b), and what does it tell us about monotonicity in attitude reports?
- How do different theories of clausal embedding fare with respect to Sharvit’s puzzle — can they be made to account for this data?

★ **This talk:**

- Certain approaches to clausal embedding make bad predictions (Sharvit 2023).
- Proposal: modeling monotonicity with the help of *incrementality* (Krifka 1998).
- Solving the puzzle: *Equality Semantics* of CP embedding (Moulton 2009, Elliott 2017, Bondarenko 2022) + *Incrementality* (Krifka 1998).
- **Implication:** attitude reports don’t inherently involve universal quantification.

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<sup>2</sup>The main contention of Sharvit 2023 is that this paradigm cannot be captured by (a particular rendering of) the Kratzerian approach to verbs like *believe*. One of our goals is to argue against Sharvit by providing such a theory. See appendix A for discussion of Sharvit’s proposal.

## 2. Semantics of Clausal Embedding

### 2.1. The Neo-Davidsonian Perspective & Attitude Reports

- Since Hintikka 1962, 1969, *believe* and other doxastic verbs have been modeled as universal models; they establish a subset relationship between the doxastic set of the attitude holder and the embedded proposition:

$$(6) \quad \llbracket \text{believe} \rrbracket^w = \lambda p_{st} . \lambda x_e . \text{DOX}_w(x) \subseteq p$$

- (6) captures clause-embedding properties of the verb well, but ignores its event-related properties. Yet *believe* describes eventualities:

- (7)    a.    Alice believed in ghosts *for two weeks*.  
           b.    When I saw this, I *suddenly/immediately/quickly* believed in ghosts.

- Instead, our starting point will be an event-based treatment of attitude verbs — specifically, we adopt *Neo-Davidsonian* Logical Forms whereby arguments are introduced via *thematic functions*<sup>3</sup> (Castañeda 1967). Then the Logical Form for (7a) might be something like in (8).

$$(8) \quad \exists e \left[ \begin{array}{l} \text{believe}_w(e) \wedge \text{HOLDER}_w(e) = \mathbf{Alice} \\ \wedge \text{OBJ}_w(e) = \mathbf{Ghosts} \wedge \text{DUR}_w(e) = \mathbf{2weeks} \end{array} \right]$$

- Once we make this move, we need to re-evaluate our analysis of clausal embedding: how does the verb combine with the CP in examples like (9a)?
- What is the semantic contribution of *that*-clauses? Can we have a uniform semantics for the CPs in (9a), (9b) and (9c)?

- (9)    a.    Alice believes [that there are ghosts].  
           b.    The belief [that there are ghosts] is wrong.  
           c.    The belief was [that there are ghosts].

- **Kratzer’s insight:** clauses can be modeled as predicates of individuals/events (Kratzer 2006, 2013, 2016).
- In the following, we will argue against Kratzer’s (2006) original implementation of this view — *subset semantics* — and in favor of an alternative — *equality semantics*.

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<sup>3</sup>The literature often treats thematic roles as relations, guaranteeing functionality via a distinct ‘thematic uniqueness’ postulate.

## 2.2. Subset Semantics

- We can marry event semantics with modal semantics by assuming that the modal base is determined by particulars—individuals and events (Kratzer 2013):<sup>4</sup>
- (10) **The Modal Anchor Hypothesis**  
 Modal domains are projected from particulars:  
 events or individuals, the “modal anchors”.
- **Decomposing attitudes** (Kratzer 2006, 2013, 2016):  
 Certain particulars are associated with a unique *propositional content*.  
 This propositional content can be retrieved via CONT: a partial function from eventualities/individuals to propositions.
  - **Ontological assumption:**  
 The domain of individuals  $D_e$  includes familiar concrete objects, but also Davidsonian *eventualities*, and more abstract entities such as *ideas*, *stories*, and *dreams*.
- (11) Elements in  $D_e$ :
- a. **Mitya, Anton**
  - b. **the unique fact that the earth is round**
  - c. **Mitya’s dream (Oct 10 2023, 10:03-10:47) that Anton is skiing**
  - d. **Anton’s playing of the harp (Aug 3 2022, 14:05-14:32)**
- If we treat embedded clauses as predicates of contentful particulars, then given their meanings, they can combine both with verbs, (14), and with nouns, (15), given the following ingredients.
- (12) Verbs, like nouns, are just *predicates* (neo-Davidsonianism)
- a.  $\llbracket \text{believe} \rrbracket^w = \lambda e . \text{believe}_w(e)$
  - b.  $\llbracket \text{belief} \rrbracket^w = \lambda x . \text{belief}_w(x)$

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<sup>4</sup>This idea has proven useful for treating modals of various kinds:

- modal verbs (Hacquard 2006, 2010, Arregui 2010);
- counterfactuals (Arregui 2007, 2009);
- modal indefinites (Alonso-Ovalle & Menéndez-Benito 2018);
- mood (Kratzer 2016, Portner & Rubinstein 2020, Alonso-Ovalle, Menéndez-Benito & Rubinstein 2022);
- imperfective morphology (Arregui, Rivero & Salanova 2014).

- (13) An embedded clause denotation after Kratzer:  
 $\llbracket \text{that there are ghosts} \rrbracket^w = \lambda x . \text{CONT}_w(x) \subseteq \{ w' \mid \text{there are ghosts in } w' \}$
- (14) Modifying the event argument of the verb (Elliott 2017):  
 $\llbracket \text{Alice believes that there are ghosts} \rrbracket^w$   
 $= \exists e \left[ \text{believe}_w(e) \wedge \text{HOLDER}_w(e) = \mathbf{Alice} \right.$   
 $\left. \wedge \text{CONT}_w(e) \subseteq \{ w' \mid \text{there are ghosts in } w' \} \right]$
- (15) Modifying the individual argument of the noun (Kratzer 2006, Moulton 2009):  
 $\llbracket \text{the belief that there are ghosts} \rrbracket^w$   
 $= \iota x (\text{belief}_w(x) \wedge \text{CONT}_w(x) \subseteq \{ w' \mid \text{there are ghosts in } w' \})$
- **Virtue:** There is no need to postulate lexical ambiguity—treating clauses as predicates of contentful entities allows us to give a unified account of clauses that combine with verbs and clauses that combine with nouns. Hintikka’s insight that attitude reports are modal is maintained.
  - We will call Kratzer’s proposal *Subset Semantics*:
- (16) **Subset Semantics:**  
 $\llbracket \text{that } p \rrbracket^w = \lambda x . \text{CONT}_w(x) \subseteq p$
- We choose to use this version of the modal analysis for Sharvit’s puzzle because the puzzle requires us to have a theory of how nouns compose with clauses, and Kratzer’s theory provides a straightforward way of doing that without positing ambiguity (cf. Sharvit 2023).
  - This proposal immediately captures that clauses that combine with nouns are never obligatory—*Katya believes the claim (that Anton snowboarded)*, and also existence of embedded clauses that are clearly unselected, (17).
- (17) Ralph **seufzte**, dass er betrogen worden sei.  
 Ralph **sighed** that he betrayed been was.SUBJ  
 ‘Ralph sighed that he had been betrayed.’ (Kratzer 2013: 29)

## 2.3. Equality Semantics

- Putting aside some immediate concerns, another option we might consider is *Equality Semantics*:

(18) **Equality Semantics**

$$\llbracket \text{that } p \rrbracket^w = \lambda x . \text{CONT}_w(x) = p$$

- On this view (Moulton 2009, 2015, Elliott 2016, 2017, 2020, Bassi & Bondarenko 2021, Bondarenko 2022), the set of worlds that the  $\text{CONT}$  function returns is *equated* with the embedded proposition.

(19)  $\llbracket \text{that there are ghosts} \rrbracket^w = \lambda x . \text{CONT}_w(x) = \{ w' \mid \text{there are ghosts in } w' \}$

- As with Kratzer’s subset semantics, CPs are predicates of contentful events and individuals, and can compose with both verbs and nouns via Predicate Modification (Elliott 2017):

(20)  $\llbracket \text{Alice believes that there are ghosts} \rrbracket^w =$   
 $\exists e [\text{believe}_w(e) \wedge \text{EXP}(e) = \mathbf{Alice} \wedge \text{CONT}_w(e) = \{ w' \mid \text{there are ghosts in } w' \}]$

(21)  $\llbracket \text{the belief that there are ghosts} \rrbracket^w =$   
 $\iota x (\text{belief}_w(x) \wedge \text{CONT}_w(x) = \{ w' \mid \text{there are ghosts in } w' \})$

- In this approach, embedded clauses are treated on par with nominal arguments in neo-Davidsonian representations: they are linked to the verb via its event argument with the help of a function.<sup>5</sup>

### 2.3.1. Monotonicity in Subset Semantics vs. Equality Semantics

- An immediate drawback of equality semantics is that it fails to capture entailments like (1), repeated below as (22).

- (22) a. Katya believes that Anton snowboarded last Friday.  
b.  $\rightsquigarrow$  Katya believes that Anton snowboarded.

(23) *Equality Semantics*: ✗ (22) not captured

- a.  $\llbracket \text{Katya believes that Anton snowboarded last Friday} \rrbracket^w =$   
 $\exists e \left[ \begin{array}{l} \text{believe}_w(e) \wedge \text{EXP}(e) = \mathbf{Katya} \\ \wedge \text{CONT}_w(e) = \{ w' \mid \text{Anton snowboarded last Friday in } w' \} \end{array} \right]$
- b.  $\llbracket \text{Katya believes that Anton snowboarded} \rrbracket^w =$   
 $\exists e \left[ \begin{array}{l} \text{believe}_w(e) \wedge \text{EXP}(e) = \mathbf{Katya} \\ \wedge \text{CONT}_w(e) = \{ w' \mid \text{Anton snowboarded in } w' \} \end{array} \right]$

<sup>5</sup>But note that there is a significant difference between the two: nominal arguments don’t themselves contribute thematic functions, whereas embedded clauses do contribute the  $\text{CONT}(\text{ENT})$  function. This is the difference between arguments and modifiers on this view.

- Subset Semantics, on the other hand, of course captures the entailment in (22) just as Hintikka semantics did.
- **Equality Semantics is inherently non-monotonic:** without additional assumptions, existence of an entity with content  $q$  does not tell us anything about existence of an entity of the same sort with content  $p$ , even if  $q \subseteq p$ .<sup>6</sup>

### 2.3.2. Motivation for Equality Semantics

- Equality Semantics can't capture simple entailments like in (22), why pursue it?
- **Motivations for Equality Semantics:**
  - impossibility of clause stacking (Moulton 2009);
  - interaction with definiteness (Elliott 2017, 2020);

#### ★ Impossibility of clause stacking

- Embedded clauses, unlike relative clauses, cannot be stacked (Moulton 2009):

- (24) a. \*The rumor that Fred was happy, that he was in Paris,  
that he could see ghosts.  
b. The rumor that Fred made, that Jill believed,  
that Bill spread to his friends...  
(Moulton 2009: 29)

- If clauses are *predicates* that modify event and individual arguments, we need to explain why they, unlike other modifiers, cannot be stacked.
- Contradictory properties can't be ascribed to eventualities and individuals:

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<sup>6</sup>It's worth noting that not all clause-embedding verbs are monotonic. For example, many emotive verbs are non-monotonic, and for them  $V(+N) + q$  does not entail  $V(+N) + p$  when  $q \subseteq p$ :

- (i) Ja ne udivilas' (zajavleniju,) što kto-to polučil nagradu, no ja udivilas'  
I NEG surprised (claim) COMP someone got award but I surprised  
(zajavleniju,) što Svuna polučila nagradu.  
(claim) COMP Swuna got award  
'I'm not surprised (by a claim) that someone got an award, but I am surprised (by a claim) that Swuna got an award.'

So, in a sense, Equality Semantics generalizes “to the worst case”, assuming that attitude and speech reports are all underlyingly non-monotonic, whereas Subset Semantics takes the monotonic cases to be at the core of attitude and speech reports.

- (25) a. \*Jones buttered the toast at 3pm at 1am.  
       cf. *I buttered the toast at 3pm on Sunday.*  
       b. \*I met a girl with blue eyes with green eyes.  
       cf. *I met a girl with blue eyes with blonde hair.*

- Stacking embedded clauses results in contradictory meaning on Equality Semantics, but not necessarily so on Subset Semantics:<sup>7</sup>

- (26) *Equality Semantics: stacking leads to deviant meaning*  
 $\llbracket \text{Katya believes that } p \text{ that } q \rrbracket^w$   
 $= \exists e[\text{believe}_w(e) \wedge \text{EXP}(e) = \mathbf{Katya} \wedge \text{CONT}(e) = p \wedge \text{CONT}(e) = q]$   
**always false** (for any  $w$ , and distinct propositions  $p, q$ )
- (27) *Subset Semantics: stacking does not lead to a deviant meaning*  
 $\llbracket \text{Katya believes that } p \text{ that } q \rrbracket^w$   
 $= \exists e[\text{believe}_w(e) \wedge \text{EXP}(e) = \mathbf{Katya} \wedge \text{CONT}_w(e) \subseteq p \wedge \text{CONT}_w(e) \subseteq q]$   
**Can be true** (for some  $w$ , distinct propositions  $p, q$ )

### ★ Interaction with definiteness

- Subset semantics in tandem with definiteness predicts intuitively strange presuppositions:

- (28)  $\llbracket \text{The fact that it's raining} \rrbracket^w$   
*Presupposes:*  $\exists! x[\text{fact}_w(x) \wedge \text{CONT}_w(x) \subseteq \{w' \mid \text{it's raining in } w'\}]$

- To see this, note that (28) can be deployed in a context where, e.g., it's raining heavily.

- (29) Context: *it's raining heavily.*  
       The fact that it's raining doesn't bother me.

- Why should this make us suspicious? Let's think again about exactly what constraints the presupposition in (28) places on the common ground:

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<sup>7</sup>A proviso: when the embedded clauses pick out *the same proposition*, the result is not contradictory, but stacking is nevertheless ruled out. We assume that sentences like (ia) are ruled out by some suitably articulated notion of redundancy, which is independently needed, (ib).

- (i) a. \*I heard the rumor [that Vincent doesn't have a spouse] [that Vincent isn't married].  
       b. \*I left [when Vincent's spouse arrived] [when the person that Vincent is married to arrived].



- *There’s a unique fact whose content entails that it’s raining.*
- Importantly, both **fact**<sub>1</sub>, and **fact**<sub>2</sub> are such facts:
  - $\text{CONT}_w(\mathbf{fact}_1) = \{ w' \mid \text{it's raining in } w' \}$
  - $\text{CONT}_w(\mathbf{fact}_2) = \{ w' \mid \text{it's raining heavily in } w' \}$
- For the presupposition in (28) to be satisfied, *fact*<sub>1</sub> and *fact*<sub>2</sub> can’t both exist, as this violates uniqueness.
- This seems odd, but perhaps not fatal. Maybe, in a case like (29), we can say that either only **fact**<sub>1</sub> exists, or only **fact**<sub>2</sub> exists.<sup>8</sup>
- There is a serious problem with this view however. Consider the following:

(30) Context: *it’s raining heavily.*

The **fact that it’s raining** doesn’t bother me,  
but **the fact that it’s raining heavily** really does.

- The presupposition predicted by subset semantics predicts that *both definite descriptions must pick out the same fact* — **fact**<sub>2</sub> — since the content *it’s raining heavily* entails both *that it’s raining heavily*, and *that it’s raining*.
- However! In (30), this would mean that we were ascribing contradictory properties to the self-same fact!
- Note that equality semantics doesn’t face this problem at all, and delivers intuitively plausible results. The facts picked out by (31a) and (31b) can quite happily co-exist.
- More generally, equality semantics is compatible with the view that every true proposition *p* corresponds to an abstract **fact** entity (which has *p* as its content).

- (31) a.  $\llbracket \text{The fact that it's raining} \rrbracket^w$   
           *Presupposes:*  $\exists! x [\text{fact}_w(x) \wedge \text{CONT}_w(x) = \{ w' \mid \text{it's raining in } w' \}]$
- b.  $\llbracket \text{The fact that it's raining heavily} \rrbracket^w$   
           *Presupposes:*  
            $\exists! x [\text{fact}_w(x) \wedge \text{CONT}_w(x) = \{ w' \mid \text{it's raining heavily in } w' \}]$

- A related phenomena, noticed by Elliott (2017, 2020): with *fact* specifically, whether or not a Noun Phrase can be constructed using an indefinite article seems to be conditioned on the absence of an embedded clause.

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<sup>8</sup>Nevertheless, this would require us to abandon the (eminently plausible) idea that there is an abstract *fact* entity corresponding to every true proposition in a given world.

- (32) a. Josie mentioned the fact (that it's raining).  
 b. Josie mentioned a fact (\*that it's raining)  
 cf. *Josie mentioned a fact that everyone knows.*  
 cf. *Josie mentioned a rumor that it's raining.*

- The paradigm in (32) is highly reminiscent of paradigm noticed by Heim 1991:

- (33) a. The/\*a weight of our tent is under 4lb.  
 b. I interviewed the/\*a biological father of the victim.

- Heim's explanation for the infelicity of the indefinite article in (33) is that using the indefinite article gives rise to an *obligatory* non-uniqueness inference, which gives rise to oddness in cases where uniqueness is contextually entailed.
- The constraint can be stated as follows (see Heim 1991 for a much more general formulation — *Maximize Presupposition!*):

- (34) In utterance situations where the presupposition of [*the*  $\phi$ ]  $\psi$  is already known to be satisfied, it is not permitted to utter [*a*  $\phi$ ]  $\psi$ .

- How does equality (but not subset) semantics explain the paradigm in (32)?
  - *facts* are (abstract) entities, and there can be many such abstract entities, which readily explains the possibility of talking about *a fact*, or *a fact that everyone knows*.
  - According to equality semantics, when *fact* composes with an embedded clause  $p$ , it describes a property of *facts* whose content is  $p$ .
  - If we make the (very reasonable) assumption that facts are only individuated on the basis of their content, for any given (true) proposition  $p$ , there can only ever be a single *fact that p*.
  - This explains the infelicity of the indefinite article — once *fact* composes with an embedded clause, a unique satisfier is contextually entailed. This clashes with the constraint imposed by (34).
- In this particular case, *Josie mentioned a fact that it's raining* can't be asserted because the presupposition of *Josie mentioned the fact that it's raining* (there's a unique fact with content *that it's raining*) is already known to be satisfied.
- In subset semantics however, there can be many different *facts that p*:

- (35)  $\llbracket \text{fact that it's raining} \rrbracket^w$   
 $\lambda x . \text{fact}_w(x) \wedge \text{CONT}_w(x) \subseteq \{ w' \mid \text{it's raining in } w' \}$

- Any fact whose content entails *that it's raining* will satisfy (35).
- There will always be many such true propositions corresponding to facts, so there is no expectation that “a fact that it's raining” should be deviant, and furthermore, the presupposition of the definite article will not be actually met.

### 3. Incorrect Predictions of Existing Theories

- In sum, we have two theories of the semantics of clausal embedding, both of which:
  - make some good predictions (monotonicity for Subset Semantics, lack of stacking and interaction with definiteness for Equality Semantics);
  - make some bad predictions (monotonicity for Equality Semantics, lack of stacking and interaction with definiteness for Subset Semantics).

(36) <b>Subset Semantics</b> $\llbracket \text{that } p \rrbracket^w = \lambda x. \text{CONT}_w(x) \subseteq p.$	(37) <b>Equality Semantics</b> $\llbracket \text{that } p \rrbracket^w = \lambda x. \text{CONT}_w(x) = p.$
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- Let us now get back to Sharvit's puzzle, and see how the two theories fare.
- **Desideratum:** explain the contrast between (38) and (39).

- (38)    *NPIs within Complement Clauses*
- a. \*Katya believes [the rumor [that Anton has ever snowboarded]].
  - b. Katya doesn't believe [the rumor [that Anton has ever snowboarded]].

- (39)    *NPIs within Relative Clauses*
- a. \*Katya believes [the rumor [that Anton ever spread]].
  - b. \*Katya doesn't believe [the rumor [that Anton ever spread]].

- Table 1 summarizes the predictions of the two theories for complement clauses compared to the desired predictions.

	POS (39a)	NEG (39b)
Subset Semantics	✓ SUE, ✓ SDE   *	✓ SUE, ✓ SDE   *
Equality Semantics	✗ SUE, ✗ SDE   *	✗ SUE, ✗ SDE   *
Desideratum	✓ SUE, ✗ SDE   *	✗ SUE, ✓ SDE   OK

Table 1: Predictions of theories for complement clauses within definite DPs

- Let us first establish why the relative clauses are predicted to be ✓ *SUE*, ✓ *SDE*, and thus why (39a)–(39b) is an expected pattern.

- (40) **Strawson Entailment** ( $\Rightarrow_s$ )  
(von Fintel 1999, here via Crnič 2019: p.2, (2))
- For any  $p, q$  of type  $t$ :  $p \Rightarrow_s q$  iff  $p = 0$  or  $q = 1$ .
  - For any  $f, g$  of type  $(\sigma\tau)$ ,  $f \Rightarrow_s g$  iff for every  $x$  of type  $\sigma$  such that  $g(x)$  is defined,  $f(x) \Rightarrow_s g(x)$ .
- (41) **Strawson Downward-Entailing (SDE)** (from Crnič 2019: p.4, (7))<sup>9</sup>  
A Constituent  $S$  is *Strawson Downward-Entailing* with respect to a subconstituent  $X$  iff for every  $X'$  such that  $\llbracket X' \rrbracket \Rightarrow_s \llbracket X \rrbracket$ , it holds that  $\llbracket S \rrbracket \Rightarrow_s \llbracket S[X/X'] \rrbracket$  (where  $S[X/X']$  is identical to  $S$  except that  $X'$  replaces  $X$ ).
- (42) **Strawson Upward-Entailing (SUE)**  
A Constituent  $S$  is *Strawson Upward-Entailing* with respect to a subconstituent  $X$  iff for every  $X'$  such that  $\llbracket X' \rrbracket \Rightarrow_s \llbracket X \rrbracket$ , it holds that  $\llbracket S[X/X'] \rrbracket \Rightarrow_s \llbracket S \rrbracket$  (where  $S[X/X']$  is identical to  $S$  except that  $X'$  replaces  $X$ ).
- (43) **Condition for licensing weak NPIs**  
A weak NPI is an indefinite that is acceptable only if it is dominated by a constituent that is Strawson Downward Entailing (SDE) and not Strawson Upward Entailing (SUE) with respect to its restrictor.
- Here is how this approach to NPIs explains the ungrammaticality of (39b): the presupposition of the definite determiner makes the sentence under negation a SUE environment, and thus the condition for licensing NPIs is not met.
- (44)  $P = \text{Katya doesn't believe the rumor that Anton spread last Friday,}$   
 $Q = \text{Katya doesn't believe the rumor that Anton spread.}$
- $P$  is true:  $\exists!x[\text{rumor}_w(x) \wedge \text{Anton spread } x \text{ last Friday in } w]$   
 $\neg \exists e \left[ \begin{array}{l} \text{believe}_w(e) \wedge \text{HOLDER}_w(e) = \mathbf{Katya} \wedge \text{THEME}_w(e) \\ = (\iota x[\text{rumor}_w(x) \wedge \text{Anton spread } x \text{ last Friday in } w]) \end{array} \right]$
  - $Q$ 's presupp. is true:  $\exists!x[\text{rumor}_w(x) \wedge \text{Anton spread } x \text{ in } w]$
  - Assume that  $Q$  is false, then the following is true:  
 $\exists e[\text{believe}_w(e) \wedge \text{HOLDER}(e) = \mathbf{Katya} \wedge \text{THEME}(e) = (\iota x[\text{rumor}_w(x) \wedge \text{Anton spread } x \text{ in } w])]$
  - We have arrived at a contradiction:  
Because *the rumor that Anton spread* and *the rumor that Anton spread last Friday* must be the same rumor.  
Hence,  $Q$  must be true, and  $P \Rightarrow_s Q$ .

<sup>9</sup>Crnič calls this property *Strawson Entailment-Reversing*, but here we keep the ‘downward entailing’ in the name, as we will not be looking at any contexts of reversal from a downward-entailing environment to an upward-entailing environment.

- Under the Subset Semantics, the same logic extends to complement clauses (details elided):

- (45)  $P = \text{Katya doesn't believe the rumor that Anton snowboarded last Friday,}$   
 $Q = \text{Katya doesn't believe the rumor that Anton snowboarded,}$   
 $p = \{ w' \mid \text{Anton snowboarded last Friday in } w' \},$   
 $q = \{ w' \mid \text{Anton snowboarded in } w' \}$
- $\underline{P \text{ is true: } \exists!x[\text{rumor}_w(x) \wedge \text{CONT}_w(x) \subseteq p]}$
  - $\underline{Q's \text{ presupp. is true: } \exists!x[\text{rumor}_w(x) \wedge \text{CONT}_w(x) \subseteq q]}$
  - $\underline{\text{Because the rumor that Anton snowboarded last Friday and the rumor that Anton snowboarded must be the same rumor, the logic is the same as before.}}$   
 $P \Rightarrow_s Q.$

- **Note why this entailment holds:**

It holds because if there is a unique individual whose content *entails*  $p$ , and  $p$  entails  $q$ , then that very same individual will be the individual whose content entails  $q$ . I.e.,  $P$  and  $Q$  have the same assertion.

- Equality Semantics also makes bad predictions, but for the opposite reason: it predicts the environment to be neither SUE nor SDE. Let us illustrate the lack of SDE-ness with the sentence under negation.

- (46)  $P = \text{Katya doesn't believe the rumor that Anton snowboarded,}$   
 $Q = \text{Katya doesn't believe the rumor that Anton snowboarded last Friday,}$   
 $p = \{ w' \mid \text{Anton snowboarded in } w' \},$   
 $q = \{ w' \mid \text{Anton snowboarded last Friday in } w' \}$
- $\underline{P \text{ is true: } \exists!x[\text{rumor}_w(x) \wedge \text{CONT}_w(x) = p]}$   
 $\neg\exists e[\text{belief}_w(e) \wedge \text{HOLDER}(e) = \mathbf{Katya} \wedge \text{THEME}(e) = (\iota x[\text{rumor}_w(x) \wedge \text{CONT}_w(x) = p])]$
  - $\underline{Q's \text{ presupp. is true: } \exists!x[\text{rumor}_w(x) \wedge \text{CONT}_w(x) = q]}$
  - $\underline{\text{This is compatible with } Q \text{ being false:}}$   
 $\exists e[\text{belief}_w(e) \wedge \text{HOLDER}(e) = \mathbf{Katya} \wedge \text{THEME}(e) = (\iota x[\text{rumor}_w(x) \wedge \text{CONT}_w(x) = q])]$

- Since Equality Semantics doesn't account for monotonicity, *the rumor that Anton snowboarded* doesn't have to be the same entity as *the rumor that Anton snowboarded last Friday*. And so the truth of  $P$  and  $Q$  are independent.

### ★ Summing up:

- Both theories make bad predictions—they cannot capture the monotonicity of the environment that is empirically observed.

- Subset Semantics wrongly predicts that the context is both SUE and SDE.
- Equality Semantics wrongly predicts that the context is neither SUE nor SDE.

## 4. Monotonicity and Incrementality of Content

- Despite its inability to capture certain uncontroversial entailments, **equality semantics** has many advantages over subset semantics.
- **Our proposal:** monotonicity can be grafted onto an equality semantics via a property that certain attitudinal eventualities may have: *incrementality of Content* (by analogy with incrementality of Themes and Paths Krifka 1998).
- Importantly, our proposal imposes monotonicity via the verbal semantics, rather than directly building it into the meaning of the declarative complementizer.
- This means we will not lose our account of the data that motivated the equality semantics approach to begin with, these results will be maintained.
- Finally, we'll show that a resolution to *Sharvit's puzzle* is achieved via *incrementality of content*, once we assume that predicates like *believe* require Content-matching between events and their Themes.

### 4.1. Incrementality

- Our proposal will relate to the fact that contentful entities (including eventualities and individuals) have a *rich mereological structure*.
- (47)    a. Part of what Tanya believes is that Anton can ski.  
           b. Part of Tanya's belief is that Anton can ski.
- A natural question that arises: how does the part-whole structure of contentful entities relate to the part-whole structure of their *contents*?
  - For verbs that combine with Theme arguments with propositional content (e.g. *believe the rumor that p*), there are additional questions:
    - how does the part-whole structure of events relate to the part-whole structure of their contentful Themes?
    - how does the content of the eventuality relate to the content of its Theme?

- Here, borrowing ideas from Krifka’s (1998) work on incrementality, we propose that certain functions exhibit properties that we will call *Mapping-to-Subparts-of-the-Inputs* (MSI) and *Mapping-to-Subparts-of-the-Outputs* (MSO):<sup>10</sup>

(48) **Mapping-to-Subparts-of-the-Inputs (MSI)**

A function  $f : D \rightarrow D'$  satisfies Mapping-to-Subparts-of-the-Inputs iff:

$$(f(x) = y \wedge y' < y) \rightarrow \exists x' \in D[x' < x \wedge f(x') = y'] \quad \forall x \in D, \forall y, y' \in D'$$

(49) **Mapping-to-Subparts-of-the-Outputs (MSO)**

A function  $f : D \rightarrow D'$  satisfies Mapping-to-Subparts-of-the-Outputs iff:

$$(f(x) = y \wedge x' < x) \rightarrow \exists y' \in D'[y' < y \wedge f(x') = y'] \quad \forall x, x' \in D, \forall y \in D'$$

- Whether a certain *thematic function* exhibits MSI and MSO properties depends on the *kind of entities* the relation combines with. Consider Themes:

(50) a. **Incremental Theme:** *Julia ate the apple.*

→ Every proper part of the apple corresponds to some proper subevent of the eating, and every proper subevent of eating corresponds to a proper subpart of the apple.

b. **Not an Incremental Theme:** *Julia saw the apple.*

↯ Every proper subevent of seeing corresponds to a proper subpart of the apple (i.e., Mapping-to-Subparts-of-the-Outputs is not met).

- Our proposal about verbs like *believe* then amounts to the following: their Content exhibits MSI, and their Theme exhibits MSO.

## 4.2. Content and MSI

- Our contention: the CONT function exhibits MSI for *believing*-eventualities, and more generally for any attitudes that exhibit monotonicity, as well as certain content nouns such as *belief*, *rumor*, *claim*, etc.
- **The idea informally:** *If there’s a believing e with content q, and part of what q conveys is that p, then there’s a part of e which conveys p.*
- Let’s say that it’s true that “Tanya believes that Anton can ski, and Mitya can snowboard”. Since *part of* the conjunctive proposition is that *Anton can ski*, then there’s a sub-part of Tanya’s belief which conveys this as its content.

<sup>10</sup>Krifka (1998) proposes principles that are exactly the same. The only difference is that Krifka’s definitions are specific to thematic relations holding between individuals and events, whereas we provide generalized definitions.

(51) **MSI of Content**

$$\text{CONT}(y) = q \wedge p < q \rightarrow \exists x \in D_e[x < y \wedge \text{CONT}(x) = p] \quad \forall y \in D_e, \forall q, p \in D_{st}$$

- We need to specify what *parthood* means with respect to propositions. In order to hew as closely as possible to the predictions of a Hintikkan semantics, we'll adopt the notion of parthood based on classical entailment.<sup>11,12</sup>

(52) Parthood for propositions (entailment-based):

$$p \leq q := p \supseteq q$$

( $p$  is a part of  $q$  iff  $p$  is entailed by  $q$ )

- Let's see how this captures monotonicity for simple attitude-reports.

(53) Patrick believes that it's raining heavily.

$$\exists e \left[ \text{HOLDER}(e) = \mathbf{Patrick} \right. \\ \left. \wedge \text{believe}_w(e) \wedge \text{CONT}_w(e) = \{ w' \mid \text{it's raining heavily in } w' \} \right]$$

- In order for this existential statement to be true, it must have a *verifier*, let's call this eventuality **b**.

(54)  $\text{CONT}_w(\mathbf{b}) = \{ w' \mid \text{it's raining heavily in } w' \}$

- Since *Content* of *believing*-eventualities satisfies MSI, then for every proper part  $p$  of the proposition  $q = \text{it's raining heavily}$  (i.e., for every *superset* of  $q$ ), there must be a corresponding proper part of **b** with content  $p$ .
- This guarantees the existence of, e.g., the following sub-believings of Patrick:<sup>13</sup>

(55) a.  $\text{CONT}_w(\mathbf{b}') = \{ w \mid \text{it's raining in } w \}$   
b.  $\text{CONT}_w(\mathbf{b}'') = \{ w \mid \text{it's raining or snowing in } w \}$   
c.  $\text{CONT}_w(\mathbf{b}''') = \{ w \mid \text{it's raining or not raining in } w \}$

- Each of these sub-believings verifies a corresponding belief-report, where the content of Patrick's belief is entailed by *it's raining heavily*, e.g., (55a) verifies:

(56) Patrick believes it's raining.

$$\exists e' \left[ \text{HOLDER}(e') = \mathbf{Patrick} \right. \\ \left. \wedge \text{believe}_w(e') \wedge \text{CONT}_w(e') = \{ w' \mid \text{it's raining in } w' \} \right]$$

<sup>11</sup>It can easily be verified that the *superset* relation satisfies the requirements of a mereological parthood relation, namely, it's *reflexive*, *transitive*, and *anti-symmetric*.

<sup>12</sup>See appendix B for discussion of potential problems with this notion of parthood.

<sup>13</sup>We importantly assume that every part of a *believing-of-Patrick* eventuality is also a *believing-of-Patrick* eventuality.



- It's easy to see that imposing MSI on the CONTENT of *believe* renders *believe* monotonic, since for any *believing* eventuality with content  $q$ , there's guaranteed to be a sub-*believing* with content  $p$ , where  $q$  classically-entails  $p$ .
- The corollary is that a *negated* belief-report creates a downward-entailing environment, thus accounting for NPIs. This should be straightforward to see:

(57) Patrick doesn't believe that it's raining.

$$\neg \exists e \left[ \text{HOLDER}(e) = \mathbf{Patrick} \right. \\ \left. \wedge \text{believe}_w(e) \wedge \text{CONT}_w(e) = \{ w' \mid \text{it's raining in } w' \} \right]$$

- The existence of a verifier for *Patrick believes that it's raining heavily* would falsify (57), since thanks to the guarantees imposed by MSI of Content, it would entail the existence of a verifier for *Patrick believes that it's raining*.
- As well as responding to one of the main objections to equality semantics, this handily accounts for the possibility of NPIs in negated belief-reports:

(58) Mitya doesn't believe that Anton has ever snowboarded.

- While MSI of Content gives us monotonicity of *believe* with embedded clauses, it is insufficient for solving Sharvit's puzzle, as the puzzle involves verbs like *believe* composing with THEME arguments.

### 4.3. Theme and MSO

- MSO-exhibiting THEME relation holds for *believing*-eventualities:  
*If there's a believing  $e$  whose THEME is the rumor  $y$ , then for any subevent of  $e$  there is a sub-rumor of  $y$  that is its THEME.*

(59) **MSO of Theme**

$$\text{THEME}(e') = y \wedge e < e' \rightarrow \exists x \in D_e [x < y \wedge \text{THEME}(e) = x] \\ \forall e, e' \in D_e, \forall y \in D'$$

- *If Katya believes the rumor that Anton snowboarded on Friday, then all of the sub-beliefs of this believing event have subparts of the rumor that Anton snowboarded on Friday as their THEMES.*
- **NB:** We do NOT assume that part-whole structure of believing events is isomorphic with their *durations*—proper parts of beliefs can have the same duration as the belief (*we can have many related beliefs at any given time interval!*).

- Expressions like *partially*, (60), suggest that this is on the right track: e.g., (60) can be true if Mary believes  $p$  but not  $q$ , but it cannot imply that Mary is temporally part way through a  $p$ -and- $q$ -believe state.

- (60) Mary partially believes  $p$  and  $q$ .  
 $\neq$  Mary is part way through a duration of a believing event  
 with content  $p$  and  $q$ .

#### 4.4. Theme-Event Content Matching

- Our final piece for solving the puzzle is the observation that verbs like *believe* involve a special relation between the propositional content of the THEME and the propositional content of the believing eventuality: from the sentence with the DP we can infer that the sentence with the CP is true, (61a)-(61b).
- This is not true of all verbs: e.g. cf. *imagine* in (62a)-(62b).<sup>14</sup>

- (61) a. Katya believes the rumor that Anton snowboarded.  
 b.  $\rightsquigarrow$  Katya believes that Anton snowboarded.

- (62) a. Katya imagines the rumor that Anton snowboarded.  
 b.  $\nrightarrow$  Katya imagines that Anton snowboarded.

- We suggest that this entailment arises from the *Theme-Event Content Matching* restriction, (63), that some verbs place on their internal arguments: some verbs that combine with contentful entities require that their content be the same as the content of the eventuality whose THEME they are.

- (63) THEME-EVENT CONTENT MATCHING (TECM)  
 Theme-Event Content Matching holds for a predicate of contentful events  $P$   
 iff:  
 $\forall x, e \in \mathbf{Dom}(\mathbf{CONT}), (P(e) \wedge \mathbf{THEME}(e) = x) \rightarrow \mathbf{CONT}(e) = \mathbf{CONT}(x)$

---

<sup>14</sup>Uegaki (2016) lists the following verbs that do and do not allow such entailment:

- |     |  |      |   |
|-----|--|------|---|
| (i) | DP $\Rightarrow$ CP<br>believe, accept, trust, deny,<br>(dis)prove, validate | (ii) | DP $\nRightarrow$ CP<br>know, discover, report, predict |
|-----|--|------|---|

## 4.5. Resolving Sharvit's puzzle

- Now we have all the ingredients to solve Sharvit's puzzle: TECM, (63), MSI of CONTENT, (64), MSO of THEME, (65). As a reminder:

(64) **MSI of Content**

$$\text{CONT}(y) = q \wedge p < q \rightarrow \exists x \in D_e[x < y \wedge \text{CONT}(x) = p] \quad \forall y \in D_e, \forall q, p \in D_{st}$$

(65) **MSO of Theme**

$$\text{THEME}(e') = y \wedge e < e' \rightarrow \exists x \in D_e[x < y \wedge \text{THEME}(e) = x] \quad \forall e, e' \in D_e, \forall y \in D'$$

- Let us first see how we capture Strawson Upward Entailingness of (66).

- (66) a. Katya believes the rumor that Anton snowboarded last Friday.  
b.  $\rightsquigarrow$  Katya believes the rumor that Anton snowboarded.

- (67)  $Q = \text{Katya believes the rumor that Anton snowboarded last Friday,}$   
 $P = \text{Katya believes the rumor that Anton snowboarded,}$

$$q = \{w' \mid \text{Anton snowboarded last Friday in } w'\},$$

$$p = \{w' \mid \text{Anton snowboarded in } w'\}$$

- a.  $Q$  is true:

$$\text{Let } r_q = \iota y[\text{rumor}_w(y) \wedge \text{CONT}_w(y) = q]$$

$$\exists e'[\text{believe}_w(e') \wedge \text{HOLDER}(e') = \text{Katya} \wedge \text{THEME}(e') = r_q]$$

- b.  $P$  is true

$$\text{Let } r_p = \iota x[\text{rumor}_w(x) \wedge \text{CONT}_w(x) = p]$$

- c. Instantiate  $e'$  in (67a) as  $b_q$ ; By TECM:

$$\text{CONT}_w(b_q) = q$$

- d. By MSI of Content from (67c), given that  $p < q$ :

$$\exists e[e < b_q \wedge \text{HOLDER}(e) = \text{Katya} \wedge \text{CONT}_w(e) = p]$$

- e. instantiate  $e$  as  $b_p$ ; by MSO of Theme from (67a) and (67d):

$$\exists r[r < r_q \wedge \text{THEME}(b_p) = r]$$

- f. instantiate  $r$  as  $r_p$ ; by TECM from (67e):

$$\text{CONT}_w(r_p) = p$$

- g. By the presupposition of  $P$  (67b), existential generalization:

$$\exists e[\text{belief}_w(e) \wedge \text{HOLDER}(e) = \text{Katya} \wedge \text{THEME}(e) = r_p]$$

- Since there is an event  $e'$  that verifies the statement *Katya believes the rumor that Anton snowboarded last Friday*, by TECM this event, let's call it  $b_q$ , has Content *Anton snowboarded last Friday*, (67c).
- Due to MSI, and because *Anton snowboarded last Friday* entails *Anton snowboarded*, there has to exist a subevent of  $b_q$ , let's call it  $b_p$ , whose content is *Anton snowboarded*, (67d).
- Now since the THEME of  $b_q$  is *the rumor that Anton snowboarded last Friday*, and  $b_p$  is part of  $b_q$ , by MSO we can conclude that there is a subpart of this rumor, let's call it  $r_p$  (itself a rumor) that is the THEME or the subevent  $b_p$ .
- By TECM then, because the content of  $b_p$  is  $p$ , its THEME  $r_p$  will have the same content—and so (67f) must hold.
- Finally, due to P's presupposition that there is a unique rumor with content  $p$ , we reach the conclusion that Katya believes the rumor with content  $p$ .
- Thus,  $\mathbf{Q} \Rightarrow \mathbf{P}$ , and we correctly predict  $\checkmark$ SUE.
- Now let's see what happens under negation. We want the sentence to be SDE and not SUE in order to explain why the NPI is licensed:

- (68) a. Katya doesn't believe the rumor that Anton snowboarded.  
b.  $\neg$  Katya doesn't believe the rumor that Anton snowboarded last Friday.

- (69) a. Katya doesn't believe the rumor that Anton snowboarded last Friday.  
b.  $\nrightarrow$  Katya doesn't believe the rumor that Anton snowboarded.

- As (70) illustrates, we correctly predict the environment to be SDE: if we assume that  $P$  is true (*Katya doesn't believe the rumor that Anton snowboarded*), but  $Q$  is false (*Katya believes the rumor that Anton snowboarded last Friday*, then by exactly the same logic as in (67) we will reach the conclusion that Katya must have a belief whose THEME is the rumor that Anton snowboarded, (70h).
- But that violates our assumption that  $P$  is true — i.e., that Katya does not believe this rumor. Hence, the environment is SDE.

- (70)  $P = \text{Katya doesn't believe the rumor that Anton snowboarded,}$   
 $Q = \text{Katya doesn't believe the rumor that Anton snowboarded last Friday,}$   
 $p = \{ w' \mid \text{Anton snowboarded in } w' \}$   
 $q = \{ w' \mid \text{Anton snowboarded last Friday in } w' \}$   
a.  $P$  is true: Let  $r_p = \iota x[\text{rumor}_w(x) \wedge \text{CONT}_w(x) = p]$   
 $\neg \exists e[\text{Believe}_w(e) \wedge \text{HOLDER}(e) = \text{Katya} \wedge \text{THEME}(e) = r_p]$

- b. *Q's presupp. is true:* Let  $r_q = \iota y[\text{rumor}_w(y) \wedge \text{CONT}_w(y) = q]$
- c. *Assume that Q is false. Then the following holds:*  
 $\exists e'[\text{believe}_w(e') \wedge \text{HOLDER}_w(e') = \text{Katya} \wedge \text{THEME}_w(e') = r_q]$
- d. *Instantiate  $e'$  in (70c) as  $b_q$ ; By TECM:*  
 $\text{CONT}_w(b_q) = q$
- e. *By MSI of Content from (70d), given that  $p < q$ :*  
 $\exists e[e < b_q \wedge \text{Holder}(e) = \text{Katya} \wedge \text{CONT}_w(e) = p]$
- f. *instantiate  $e$  as  $b_p$ ; by MSO of Theme from (70e) and (67d):*  
 $\exists r[r < r_q \wedge \text{Theme}(b_p) = r]$
- g. *instantiate  $r$  as  $r_p$ ; by TECM from (70f):*  
 $\text{CONT}_w(r_p) = p$
- h. *By the presupposition of Q (70a), existential generalization:*  
 $\exists e[\text{belief}_w(e) \wedge \text{HOLDER}(e) = \text{Katya} \wedge \text{THEME}(e) = r_p]$
- i. We have arrived at a contradiction: (70a) contradicts (70h).  
Thus,  $Q$  cannot be false, and  $\mathbf{P} \Rightarrow \mathbf{Q}$ . We correctly predict  $\checkmark$  SDE.

- Importantly, we do not predict the environment to be SUE: Katya having a rumor whose content *equals* the proposition  $p = \{w' \mid \text{Anton snowboarded in } w'\}$  is totally compatible with Katya not believing the rumor whose content *equals* the proposition  $q = \{w' \mid \text{Anton snowboarded last Friday in } w'\}$ .

- (71)  $P = \text{Katya doesn't believe the rumor that Anton snowboarded,}$   
 $Q = \text{Katya doesn't believe the rumor that Anton snowboarded last Friday,}$   
 $p = \{w' \mid \text{Anton snowboarded in } w'\},$   
 $q = \{w' \mid \text{Anton snowboarded last Friday in } w'\}$
- a. *Q is true:*  
Let  $r_q = \iota y[\text{rumor}_w(y) \wedge \text{CONT}_w(y) = q]$   
 $\neg \exists e'[\text{believe}_w(e') \wedge \text{HOLDER}(e') = \text{Katya} \wedge \text{THEME}(e') = r_q]$
  - b. *Presupp. P is true*  
Let  $r_p = \iota x[\text{rumor}_w(x) \wedge \text{CONT}_w(x) = p]$
  - c. *If P is false, then:*  
 $\exists e[\text{belief}_w(e) \wedge \text{HOLDER}(e) = \text{Katya} \wedge \text{THEME}(e) = r_p]$
  - d. *Instantiate  $e$  as  $b_p$ ; by TECM from (71c):*  $\text{Cont}_w(b_p) = p$
  - e. *(71d) does NOT allow us to infer that Katya has a belief with Content  $q$ :*  
MSI of Content doesn't tell us anything about super-parts of individuals with Content—from existence of a belief with Content  $p$  it does not follow that there would be a bigger belief whose Content is a subset of  $p$ .  
Thus,  $\mathbf{Q} \not\Rightarrow \mathbf{P}$ , and we correctly predict  $\times$  SUE.

- Note that adopting Theme-Event Content Matching (or any other way of deriving the entailment in (72a)-(72b)) does not help the Subset Semantics to account for the Sharvit’s puzzle: it still predicts the environment in to be SUE.

- (72) a. Katya believes the rumor that Anton snowboarded.  
b.  $\rightsquigarrow$  Katya believes that Anton snowboarded.

- Its problem is that if there is a unique *rumor that Anton snowboarded last Friday* and a unique *rumor that Anton snowboarded*, due to the property in (73), they must be the same rumor, and this is why Katya doesn’t believe *the rumor that Anton has ever snowboarded* is SUE on this approach.
- Equality semantics avoids this issue because for it no rumor that  $q$  is a rumor that  $p$ , (74).

$$(73) \quad \forall w, \forall x, \forall p \supset q [Cont_w(x) \subseteq q \rightarrow Cont_w(x) \subseteq p]$$

$$(74) \quad \forall w, \forall x, \forall p \supset q [Cont_w(x) = q \rightarrow Cont_w(x) \neq p]$$

## 5. Conclusion

- To sum up, our account has the following ingredients:
  1. *Mereological properties*:
    - their CONTENT exhibits Mapping-to-Subparts-of-Inputs;
    - their THEME exhibits Mapping-to-Subparts-of-Outputs;
  2. *Theme-Event Content-Matching*.
- We conjectured that *believing* eventualities satisfy the aforementioned mereological properties, and observe TECM.
- MSI of CONTENT gave us an account of monotonicity of clause-embedding verbs.
- MSO of THEME and *Theme-Event Content-Matching* allowed us to capture how the contentful internal arguments of verbs like *believe* are related to the event argument of *believe*, and thus explain entailment patterns in complement clauses of THEME of *believe*, and provide a solution to Sharvit’s puzzle.
- **One of our next questions:** What predictions do we make beyond *believe*?

- **Prediction about NPI licensing in Sharvit’s configuration:**

If for a certain type of contentful events CONTENT exhibits MSI and they also have a THEME argument such that TECM holds, then CPs combining with nouns in the following configuration should be able to contain NPIs once the sentence is embedded under some operator that makes it SDE but not SUE:

*S V the N CP.*

- Here are verbs for which this prediction is borne out: *accept* and *trust*.<sup>15</sup>

- (75) a. John **accepts** that it’s raining heavily,  
#but he doesn’t accept that it’s raining.  
b. John **trusts** that it’s raining heavily,  
#but he doesn’t trust that it’s raining.
- (76) a. John **accepts** the claim that it’s raining.  
↗ John **accepts** that it’s raining.  
b. John **trusts** the claim that it’s raining.  
↗ John **trusts** that it’s raining.
- (77) a. Mitya doesn’t **accept** the rumor that Anton has ever been skiing.  
b. Mitya doesn’t **trust** the rumor that Anton has ever been skiing.

- We also expect that if verbs denote predicates of events whose CONTENT exhibits MSI, but whose THEME arguments do not have the same CONTENT as they do, then NPIs shouldn’t be licensed in the Sharvit’s configuration.

- Two verbs potentially displaying this pattern:

- (78) a. John **remembers** that it’s raining heavily,  
#but he doesn’t **remember** that it’s raining.

---

<sup>15</sup>There are also verbs that contain inherent negation and are thus SDE, (i). If such verbs exhibit TECM, (ii), then NPIs are licensed in the Sharvit’s configurations for such verbs too, (iii).

- (i) a. John **denies** that it’s raining,  
#but he doesn’t deny that it’s raining heavily.  
b. John **disproved** that it’s raining,  
#but he didn’t disprove that it’s raining heavily.
- (ii) a. John **denies** the claim that it’s raining.  
↗ John **denies** that it’s raining.  
b. John **disproves** the claim that it’s raining.  
↗ John **disproves** that it’s raining.
- (iii) a. Mitya **denies** the rumor that Anton has ever been skiing.  
b. Mitya **disproves** the rumor that Anton has ever been skiing.

- b. John is **imagining** that it's raining heavily,  
#but he isn't **imagining** that it's raining.
- (79)
  - a. John **remembers** the claim that it's raining.  
↗ John **remembers** that it's raining.
  - b. John is **imagining** the claim that it's raining.  
↗ John is **imagining** that it was raining.
- (80) \*John doesn't remember the claim that Anton has ever been snowboarding.
- (81) \*John isn't imagining the claim that Anton has ever been snowboarding.

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## A. Comparison with Sharvit 2023

- Sharvit demonstrates that a Kratzerian theory of clausal embedding, without more being said, is incompatible with a monotonicity-based account of NPI licensing.
- **Her proposal** (as far as we understood it): *lexical ambiguity + equality semantics* for clauses that combine with nouns.
- Here are the two lexical entries for *believe* she suggests (we are simplifying them here by omitting the presuppositional component of the lexical entries, and adapting them to the notation used in this handout):

$$(82) \quad \llbracket \text{believe}_{DP} \rrbracket^w = \lambda x. \lambda y. \lambda e. \text{BEL}_w(y)(e) \subseteq \{ w' \mid \text{CONT}_w(x)(w') = 1 \}$$

$$(83) \quad \llbracket \text{believe}_{CP} \rrbracket^w = \lambda p. \lambda y. \lambda e. \text{BEL}_w(y)(e) \subseteq \{ w' \mid p(w') = 1 \} \\ \text{where } \text{BEL}_w(y)(e) = \\ \{ w' \mid w' \text{ is compatible with what } y \text{ believes in } w \text{ in } e \}$$

- *Believe* on this view has the semantics of a universal modal.
- Because embedded clauses with nouns like *claim* are optional, we need to postulate lexical ambiguity for all such clause-taking nouns:

$$(84) \quad \llbracket \text{claim}_{+CP} \rrbracket^w = \lambda p. \lambda x. \text{claim}_w(x) \wedge \text{CONT}_w(x) = p$$

$$(85) \quad \llbracket \text{claim}_{-CP} \rrbracket^w = \lambda x. \text{claim}_w(x)$$

- Note that (84) uses *equality semantics*: content of a claim is *equated* with the embedded proposition, it does not *entail* embedded proposition.
- This is the key to accounting for the puzzle. *Believe<sub>DP</sub>* extracts the meaning of the proposition from its internal argument: it gets the proposition that equals the Content of the claim.
- Hence, for any  $p, q$  such that  $p \supset q$ , we will get (86) entail (87), correctly predicting the environment to be SDE.

$$(86) \quad \llbracket \text{Katya doesn't believe}_{DP} \text{ the claim that } p \rrbracket^w = 1 \text{ iff} \\ \neg[\text{BEL}_w(\mathbf{Katya})(e) \\ \subseteq \{ w' \mid \text{CONT}_w(\iota x(\text{claim}_w(x) \wedge \text{CONT}_w(x) = p))(w') = 1 \}] \\ = 1 \text{ iff: } \neg[\text{BEL}_w(\mathbf{Katya})(e) \subseteq p]$$

$$(87) \quad \llbracket \text{Katya doesn't believe}_{DP} \text{ the claim that } q \rrbracket^w = 1 \text{ iff} \\ \neg[\text{BEL}_w(\mathbf{Katya})(e) \\ \subseteq \{ w' \mid \text{CONT}_w(\iota x(\text{claim}_w(x) \wedge \text{CONT}_w(x) = q))(w') = 1 \}] \\ = 1 \text{ iff: } \neg[\text{BEL}_w(\mathbf{Katya})(e) \subseteq q]$$

- Note that we do not in this case predict the environment to be SUE: (87) can be true even if (86) is false. This is due to *equality semantics*.
- If we assumed the denotation in (88) instead, then whenever the presupposition of the article was met, the claim that  $q$  and the claim that  $p$  would pick out the same claim, and we would then predict that whenever (90) is true, (89) should be true as well, making the environment SUE.

$$(88) \quad \llbracket \text{claim}_{+CP} \rrbracket^w = \lambda p. \lambda x. \text{claim}_w(x) \wedge \text{CONT}_w(x) \subseteq p$$

- (89)  $\llbracket \text{Katya doesn't believe}_{DP} \text{ the claim that } p \rrbracket^w = 1$  iff  
 $\neg[\text{BEL}_w(\mathbf{Katya})(e)$   
 $\subseteq \{ w' \mid \text{CONT}_w(\iota x(\text{claim}_w(x) \wedge \text{CONT}_w(x) \subseteq p))(w') = 1 \}]$
- (90)  $\llbracket \text{Katya doesn't believe}_{DP} \text{ the claim that } q \rrbracket^w = 1$  iff  
 $\neg[\text{BEL}_w(\mathbf{Katya})(e)$   
 $\subseteq \{ w' \mid \text{CONT}_w(\iota x(\text{claim}_w(x) \wedge \text{CONT}_w(x) \subseteq q))(w') = 1 \}]$

Here, we think, are some advantages of our proposal:

- unlike Sharvit, we do not need to postulate *lexical ambiguity* of verbs and nouns, which seems like virtue in light of the fact that it's not only *believe* and *claim* that display this behavior, but classes of verbs and nouns;
- our proposal allow for a uniform treatment of the semantics of clausal embedding: for us it does not matter whether it is a verb or a noun that combines with an embedded clause, the displacement always involves *equality semantics*, and it is always contributed by the complementizer;
- in Sharvit's account, as far as we see, the content DP is not treated as a THEME argument of the verb (instead, it's basically shifted to a proposition)—this might be problematic, as it predicts that *Katya believes the claim that Anton snow-boarded* could be true even if Katya has never interacted with this claim, i.e. there is no requirement that the claim ever be an object of Katya's believing.

## B. Content and Conjunctive Parthood

- The notion of parthood we adopted for propositions, repeated below, is based on *classical entailment*:

- (91) Parthood for propositions (entailment-based):  
 $p \leq q := p \supseteq q$   
 $(p \text{ is a part of } q \text{ iff } p \text{ is entailed by } q)$

- Although orthogonal to our main point, we're interested in the extent to which (91) is really adequate.
- By design, it inherits the problem of logical omniscience (Stalnaker 1991, etc.) from the Hintikka semantics for attitude reports.
- We can see manifestations of this problem when we explicitly query the mereological part-whole structure of the content of *believing* eventualities.

- An entailment-based view of parthood for propositions correctly predicts that (92a) and (92b) should be true in the context provided, but it also erroneously predicts that (92c) should be true.

(92) Context: *Mitya is planning a bank robbery. Mitya believes that there are 5 security cameras, and that there are 3 security guards.*

- a. Part of what Mitya believes is that there are 5 security cameras.
- b. Part of what Mitya believes is that there are security cameras.
- c. #Part of what Mitya believes is that either there are security cameras, or there are no security guards.

- This problem is mirrored by the familiar problem of logical omniscience in belief reports, specifically disjunction introduction:

(93) Mitya believes that there are 5 security cameras.

?  $\Rightarrow$  Mitya believes that there are 5 security cameras or no security guards.

- This general issue can be localized in the notion of parthood (and concomitantly the notion of content), that we adopt.
- It's of course widely appreciated that the putative entailment in (93) is extremely difficult to block, assuming a classical notion of content and entailment (but see, e.g., Yalcin 2018 that maintains a classical notion of content).
- One salient possibility is to shift to a richer notion of content in which a notion of *conjunctive parthood* can be stated, such as truthmaker semantics (Yablo 2014, Fine 2017c,a,b). Essentially, we'd like  $p$  to count as *part of*  $p \wedge q$ , without  $p \vee q$  counting as part of  $p$ .
- Here, we'll sketch how Kit Fine does it, purely as a proof of concept.
- Fine's truthmaker semantics is *state-based* — a sentence  $\phi$  is verified/falsified by a *state*, which can be thought of as a situations with just enough information to make  $\phi$  true/false.
- Sentences can thereby be associated with sets of verifiers/falsifiers. The state-space itself has a mereological part-whole structure, and is closed under mereological fusion  $\sqcup$ .
- The propositional fragment is quite straightforward; the semantics is fundamentally bilateral, so each sentence is mapped to a set of verifiers by  $\llbracket \cdot \rrbracket^+$ , and a set of falsifiers by  $\llbracket \cdot \rrbracket^-$ .

(94) Atomic sentences

- a.  $\llbracket p \rrbracket^+ = I^+(p)$
- b.  $\llbracket p \rrbracket^- = I^-(p)$

(95) Negated sentences

- a.  $\llbracket \neg \phi \rrbracket^+ = \llbracket \phi \rrbracket^-$
- b.  $\llbracket \neg \phi \rrbracket^- = \llbracket \phi \rrbracket^+$

- For our purposes, the definitions for verifiers of complex sentences are worth paying attention to:
  - The verifiers of a conjunctive sentence are the *pointwise fusion* of the verifiers of each conjunct.
  - The verifiers of a disjunctive sentence are simply the union of the verifiers of each disjunct.
  - We provide the falsifier clauses for completeness, although they won't be directly relevant to the following discussion.

(96) Conjunctive sentences

- a.  $\llbracket \phi \wedge \psi \rrbracket^+ = \{ t \sqcup u \mid t \in \llbracket \phi \rrbracket^+, u \in \llbracket \psi \rrbracket^+ \}$
- b.  $\llbracket \phi \wedge \psi \rrbracket^- = \llbracket \phi \rrbracket^- \cup \llbracket \psi \rrbracket^-$

(97) Disjunctive sentences

- a.  $\llbracket \phi \vee \psi \rrbracket^+ = \llbracket \phi \rrbracket^+ \cup \llbracket \psi \rrbracket^+$
- b.  $\llbracket \phi \vee \psi \rrbracket^- = \{ t \sqcup u \mid t \in \llbracket \phi \rrbracket^-, u \in \llbracket \psi \rrbracket^- \}$

- Fine goes on to define a notion of *conjunctive parthood*, which we'll exploit for a revised notion of parthood for content:

(98) **Conjunctive parthood:**

given two sentences  $\phi, \psi$ ,  $\psi$  is a conjunctive part of  $\phi$  iff:

- a.  $\forall s' \in \llbracket \psi \rrbracket^+, \exists s \in \llbracket \phi \rrbracket^+ [s' \sqsubseteq s]$
- b.  $\forall s \in \llbracket \phi \rrbracket^+, \exists s' \in \llbracket \psi \rrbracket^+ [s' \sqsubseteq s]$

- It follows from this definition that  $p$  is a conjunctive part of  $p \wedge q$ , but  $p \vee q$  is *not* a conjunctive part of  $p$ . Let's see how this works:

$$(99) \quad \llbracket \text{it's raining} \rrbracket^+ = \{ r_1, r_2 \}, \quad \llbracket \text{it's cold} \rrbracket^+ = \{ c_1, c_2 \}$$

$$(100) \quad \begin{aligned} \text{a. } & \llbracket \text{it's raining and cold} \rrbracket^+ = \{ r_1 \sqcup c_1, r_1 \sqcup c_2, r_2 \sqcup c_1, r_2 \sqcup c_2 \} \\ \text{b. } & \llbracket \text{it's raining or cold} \rrbracket^+ = \{ r_1, r_2, c_1, c_2 \} \end{aligned}$$

- It follows that *it's raining* is a conjunctive part of *it's raining and cold*, since for every verifier  $r$  of *it's raining*, we can find a verifier  $s$  for *it's raining and cold*, such that  $r \sqsubseteq s$ , and for every verifier  $s$  of *it's raining and cold*, we can find a verifier  $r$  of *it's raining*, such that  $r \sqsubseteq s$ .
- It's easy to see that *it's raining or cold* is **not** a conjunctive part of *it's raining*, since there's a verifier of *it's raining or cold* — e.g.,  $c_1$  — that is not part of a verifier of *it's raining*.
- Combining truth-maker semantics with a neo-Davidsonian semantics for attitudes of course requires some care, but as a first step we can think of  $\text{CONT}$  as a function from an eventuality/individual to a set of states.
- Embedded clauses might have the following semantics; *that*  $p$  denotes a predicate of individuals that have as their content the set of states that verify  $p$ .

$$(101) \quad \llbracket \text{that it's raining} \rrbracket = \lambda x . \text{CONT}(x) = \llbracket \text{it's raining} \rrbracket^+$$

- Finally, we replace our notion of parthood for propositions with *conjunctive parthood*:

$$(102) \quad \begin{array}{l} \text{Conjunctive parthood for state-based content:} \\ Q \sqsubseteq_{\text{Conj}} P \iff \forall s' \in Q, \exists s \in P [s' \sqsubseteq s] \\ \qquad \qquad \qquad \forall s \in P, \exists s' \in Q [s' \sqsubseteq s] \end{array}$$

- By exploiting *Mapping-to-Subparts-of-Inputs*, we can now account for the fact that  $x$  *believes that*  $p \wedge q$  entails that  $x$  *believes that*  $p$ , but  $x$  *believes that*  $p$  doesn't entail that  $x$  *believes that*  $p \vee q$ .
- We leave a more thorough exploration of conjunctive parthood in the domain of content to future work.