Negation, modality, events, and truthmaker semantics

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Overview of the course

- Day 1: Davidsonian event semantics, problems with negation.
- Day 2: Situation semantics, negation as a modality.
- Day 3: Negative events in compositional semantics.
- Day 4: Event semantics as exact truthmaker semantics.
- Day 5: Propositions as sets of events, and negative individuals.

Day 1

Today's contents

- Negation in classical logic.
- Background on action sentences and event semantics.
- Generalization to states.
- The Davidsonian and Neo-Davidsonian approaches.
- The standard analysis of negation in event semantics.
- The puzzle surrounding negative perception reports.
- A scope paradox surrounding negation and the event quantifier.
- Maximal events and Krifka's negation.

Notation and terminology

- Terminology:
  - Sentence: a linguistic expression
  - Proposition: a (metaphysical) bearer of truth
- A sentence denotes a proposition in a natural language.
- Denotation of a phrase: $[\![\_]\!]$
  (e.g., $[\![$There is a red bike$]\!] = \exists x.\ \mathit{red}(x) \wedge \mathit{bike}(x)$)
- Truth and falsity: T, F
- Logical symbols: $\wedge$, $\vee$, $\neg$, $\forall$, $\exists$
- Basic types: t (truth values), e (individuals), v (events), s (worlds)
- Functional types: $\langle \alpha, \beta \rangle$
  (e.g., $\langle e, t \rangle$, $\langle \langle v, t \rangle, \langle v, t \rangle \rangle$)

Negation in classical logic

Two properties of classical logic

1. any proposition is either true or false, and never both;
2. the negation of a true sentence is false, and vice versa.

- Truth table of negation:

ϕ	$\neg\phi$
T	F
F	T

(1) In event-less first-order logic:

a. $[\![$Mary is running$]\!] = sleep(Mary)$

b. $[\![$Mary is not running$]\!] = \neg sleep(Mary)$

De Morgan's laws and double negation elimination

- De Morgan's laws are valid in classical logic:

(2) a. $\neg(\phi \wedge \psi) \equiv (\neg\phi) \vee (\neg\psi)$
b. It's not (both raining and windy). $\equiv$ It's either not raining or not windy.

(3) a. $\neg(\phi \vee \psi) \equiv (\neg\phi) \wedge (\neg\psi)$
b. It's not (either raining or windy). $\equiv$ It's neither raining nor windy.

- Double negation elimination is also valid:

(4) a. $\neg(\neg\phi) \equiv \phi$
b. It's not (not raining). $\equiv$ It's raining.

Natural language and classical logic

- Classical $\wedge$, $\vee$ and $\neg$ are usually taken to be at the core of the semantics of *and*, *or* and *not*.
- In this course, we work with *event semantics* and will study nonstandard interpretations of *not*.

The syntax of verbs: obligatory arguments

- Verbs are sometimes categorized according to their obligatory syntactic arguments.
  - Intransitive verbs:

    (5) a. Mary is running.
        b. $\textit{run}(\textit{Mary})$

  - Transitive verbs:

    (6) a. Mary is buttering a toast.
        b. $\exists x.\ \textit{toast}(x) \wedge \textit{butter}(\textit{Mary}, x)$

  - etc.

The syntax of verbs: optional modifiers

- In addition to a finite number of grammatically expected arguments, verbs can be modified by any number of modifiers:

(7) Jones buttered the toast in the bathroom with a knife at midnight.

- "most philosophers today would, as a start, analyze this sentence as containing a five-place predicate" (Davidson 1967b):

(8) $\exists x.\ \mathit{knife}(x) \wedge \mathit{butter}(\mathit{Jones}, \iota \mathit{toast}, \iota \mathit{bathroom}, x, \mathit{0{:}00})$

- Can you see any difficulties for this approach? `(Hint: Think about entailments.)`

The semantics of verbs: entailment patterns

(Davidson 1967b)

"If we go on to analyze 'Jones buttered the toast' as containing a two-place predicate, 'Jones buttered the toast in the bathroom' as containing a three-place predicate, and so forth, we obliterate the logical relations between these sentences"

Jones buttered the toast in the bathroom with a knife

↙ ↘

Jones buttered the toast in the bathroom | Jones buttered the toast with a knife

↘ ↙

Jones buttered the toast

The semantics of verbs: an additional implicit argument

- How could one design a system in which the corresponding entailments are guaranteed (and simple)?
- Davidson's solution:
  - Actions are first class citizens of the semantics;
  - Action verbs (e.g., *to butter*) lexicalize predicates that have an implicit argument denoting an action in addition to their traditional ones (subject, etc.);
  - Verbal modifiers (at least some of them; e.g., *in the kitchen*, *at midnight*) lexicalize predicates of actions.

Davidsonian event semantics

- Notation: e, e_1, e_2, etc., for events.

(9) a. Jones buttered the toast in the bathroom with a knife at midnight. (= (7))

b. $\exists e.\ \mathit{butter}(e, \mathit{Jones}, \iota \mathit{toast}) \wedge \mathit{in}(e, \iota \mathit{bathroom}) \wedge \exists x.\ \mathit{knife}(x) \wedge \mathit{with}(e, x) \wedge \mathit{at}(e, \mathit{0{:}00})$

- Entailments are given by conjunction elimination (e.g., $\phi \wedge \psi \vdash \phi$).

(10) a. Jones buttered the toast in the bathroom with a knife.

b. $\exists e.\ \mathit{butter}(e, \mathit{Jones}, \iota \mathit{toast}) \wedge \mathit{in}(e, \iota \mathit{bathroom}) \wedge \exists x.\ \mathit{knife}(x) \wedge \mathit{with}(e, x)$

(11) a. Jones buttered the toast in the bathroom at midnight.

b. $\exists e.\ \mathit{butter}(e, \mathit{Jones}, \iota \mathit{toast}) \wedge \mathit{in}(e, \iota \mathit{bathroom}) \wedge \mathit{at}(e, \mathit{0{:}00})$

Events in linguistic analysis

- There is further empirical motivation for the introduction of events in linguistic analysis.
- Causation (a la Davidson 1967a):

(12) a. Mary fell because she slipped on a banana peel.
b. $\exists e_1.\ \mathit{fall}(e_1, \mathit{Mary}) \wedge \exists x.\ \mathit{banana\_peel}(x) \wedge \exists e_2.\ \mathit{slip\_on}(e_2, \mathit{Mary}, x) \wedge \mathit{cause}(e_2, e_1)$

- Event anaphora (de Swart 1996):

(13) Mary won$_{e_1}$ the game. This$_{e_1}$ occurred on a Friday.

- Perception reports (Higginbotham 1983):

(14) a. John saw Mary leave.
b. $\exists e_1.\ \mathit{leave}(e_1, \mathit{Mary}) \wedge \exists e_2.\ \mathit{see}(e_2, \mathit{John}, e_1)$

Generalization to states

- Davidson (1967b) limited his analysis to actions.
- Since: generalization to *eventualities* (Bach 1986).
- In particular, to states (Parsons 1990):

(15) a. Mary is happy.
b. $\exists e.\ happy(e, Mary)$

- In this course, we use "event" in a very general sense.

The Neo-Davidsonian approach

- Arity of a verbal predicate:
  - according to Davidson (1967b): $1 + \#\{\text{syn. args}\}$
  - according to Parsons (1990): 1

Syntactic arguments are treated similarly to optional verbal modifiers and are related to the event via *thematic roles* ("θ-roles").

(16) a. $[\text{Mary}]_{ag}$ buttered $[\text{a toast}]_{th}$.

b. $\exists e.\ \mathit{butter}(e) \wedge \mathit{ag}(e) = \mathit{Mary} \wedge \exists x.\ \mathit{toast}(x) \wedge \mathit{th}(e) = x$

Thematic roles

- Thematic roles (Fillmore 1968, Jackendoff 1972): intuitively, semantic counterparts of the syntactic roles.
- The two notions are logically independent.
- Unergative verb:

(17) a. $[\text{Mary}]^{\text{subj.}}_{ag}$ talked.
b. $\exists e.\ talk(e) \wedge ag(e) = Mary$

- Unaccusative verb:

(18) a. $[\text{The letter}]^{\text{subj.}}_{th}$ arrived.
b. $\exists e.\ arrive(e) \wedge th(e) = \iota letter$

Thematic roles

- Active-passive alternation:

(19) a. (i) $[\text{John}]^{\text{subj.}}_{ag}$ broke $[\text{the window}]^{\text{obj.}}_{th}$.
(ii) $\exists e.\ break(e) \wedge ag(e) = John \wedge th(e) = \iota window$
b. (i) $[\text{The window}]^{\text{subj.}}_{th}$ was broken by $[\text{John}]^{\text{obj.}}_{ag}$.
(ii) $\exists e.\ break(e) \wedge ag(e) = John \wedge th(e) = \iota window$

- Causative-inchoactive alternation:

(20) a. (i) $[\text{John}]^{\text{subj.}}_{ag}$ broke $[\text{the window}]^{\text{obj.}}_{th}$.
(ii) $\exists e.\ break(e) \wedge ag(e) = John \wedge th(e) = \iota window$
b. (i) $[\text{The window}]^{\text{subj.}}_{th}$ broke.
(ii) $\exists e.\ break(e) \wedge th(e) = \iota window$

The standard analysis of negation in event semantics

(21) a. It is raining.
b. $\exists e.\ rain(e)$

(22) a. It is not raining.
b. $*_{\text{(too weak)}}\ \exists e.\ \neg rain(e)$
c. $\neg\exists e.\ rain(e)$

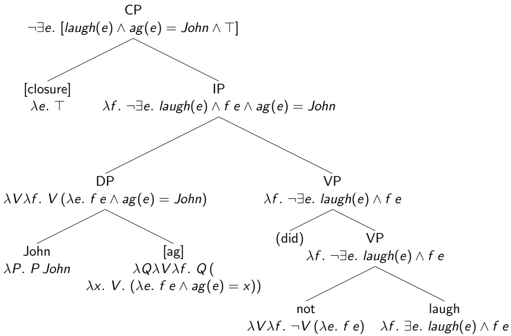
- Analysis: In a simple negated sentence, the negation outscopes the quantifier over events; no event is introduced.
- From a compositional point of view, this is not as simple as it might look.

Implementations of the standard analysis

- Kamp & Reyle (1993) work in Discourse Representation Theory (DRT);
  - the syntactic tree is processed (roughly) from top to bottom and turned into a DR Structure;
  - the conversion rules and the fact that the negation scopes over the VP ensures that $\neg$ scopes over the event quantifier.
- de Groote & Winter (2015) work with Abstract Categorial Grammars (ACG);
  - two categories for verbal projections, a higher one and a lower one;
  - the quantifier over event is introduced by a covert operator, the *existential closure*, which is necessary to bridge the gap between the two categories;
  - negation applies to the higher category and thus scopes over the event quantifier.

Implementations of the standard analysis

- Champollion (2015) works with a more standard syntax-semantics interface;
  - the lexical entries of verbs include an event quantifier;
  - verbs and VPs denote generalized quantifier over events and their argument is used to send semantic material within the scope of the event quantifier.



First puzzle: negation and nonfinite perception reports

- Higginbotham (1983): How to interpret the negation in (24a)?

(23) a. John sees Mary leave.

b. $\exists e_2.\ leave(e_2) \wedge ag(e) = Mary \wedge \exists e_1.\ see(e_1) \wedge exp(e_1) = John \wedge th(e_1) = e_2$

(24) a. John sees Mary not leave.

b. $*_{\text{(too weak)}}\ \exists e_2.\ \neg leave(e_2) \wedge ag(e_2) = Mary \wedge \exists e_1.\ see(e_1) \wedge exp(e_1) = John \wedge th(e_1) = e_2$

c. $*_{\text{(too weak)}}\ \exists e_2.\ \neg[leave(e_2) \wedge ag(e_2) = Mary] \wedge \exists e_1.\ see(e_1) \wedge exp(e_1) = John \wedge th(e_1) = e_2$

d. $*_{(e_2\ \text{free})}\ \neg[\exists e_2.\ leave(e_2) \wedge ag(e_2) = Mary] \wedge \exists e_1.\ see(e_1) \wedge exp(e_1) = John \wedge th(e_1) = e_2$

- Answering this question is one of our goals.

For-adverbials and negation: the ambiguity

- Scope ambiguity between negation and *for*-adverbials:

(25) John didn't laugh for two hours. (Krifka 1989)
  a. It is not the case that John laughed for two hours.
  b. For two hours, John didn't laugh.

- *For*-adverbials check for *atelicity*. (*In*-adverbials check for *telicity*)

Atelicity: two views

The ontological view (e.g., Moens & Steedman 1988)

- Different kinds of sentences introduce intrinsically different kinds of entities (e.g., proper events, states, processes);
- sensibility to (a)telicity is sensibility to this ontology.

The algebraic view (e.g., Krifka 1989)

- The events introduced are taken from sets with different algebraic properties;
- sensibility to (a)telicity is sensibility to these properties.

For-adverbials and negation: a problem?

(26) John didn't laugh for two hours. (=(25))

a. It is not the case that John laughed for two hours.

b. For two hours, John didn't laugh.

- (26a) is not particularly challenging. But what about (26b)?
- Standard analysis:
  $[\![\text{John didn't laugh}]\!] = \neg\exists e.\ \mathit{laugh}(e) \wedge \mathit{ag}(e) = \mathit{John}$
- In (26b),
  - (ontological view) what eventuality is checked for atelicity?
  - (algebraic view) what set is checked for atelicity?

Krifka's maximal events

- Krifka (1989) defends an algebraic view of (a)telicity.
- $\leq$ denotes parthood between events (a partial order).
- For any set of events S, $\sqcup S$ is the least upper bound of S.

The *maximal event* at time t

$$\mathrm{MXT}(t) = \sqcup\{e \mid \tau(e) \subseteq t\}$$

Krifka's solution to the problem: a nonstandard negation

- $[\![\text{not}]\!]_{\text{Krifka}} = \lambda P \lambda e.\ \exists t.\ e = \text{MXT}(t) \wedge \neg\exists e'.\ [e' \leq e \wedge P\, e']$
- $[\![\text{John (did) not laugh}]\!] =$
  $\lambda e.\ \exists t.\ e = \text{MXT}(t) \wedge \neg\exists e'.\ [e' \leq e \wedge \mathit{laugh}(e') \wedge \mathit{ag}(e') = \mathit{John}]$
- This is the set that is checked for atelicity by the *for*-adverbial in (27) when negation is in low position.

(27) John didn't laugh for two hours. (=(25))

Negation in nonfinite perception reports: paradox still unsolved

- Back to our first puzzle:

(28) John sees Mary not leave. (=(24a))

- With Kifka's negation?

(29) a. John sees an event that satisfies $[\![\text{not}]\!]_{\text{Krifka}}[\![\text{Mary leaves}]\!]$

b. $\exists e_1.\ \exists e_2.\ \exists t.\ e_2 = \text{MXT}(t) \wedge$
$\neg\exists e_3.\ [e_3 \leq e_2 \wedge \mathit{leave}(e_3) \wedge \mathit{ag}(e_3) = \mathit{Mary}]$
$\wedge \mathit{see}(e_1) \wedge \mathit{ag}(e_1) = \mathit{John} \wedge \mathit{th}(e_1) = e_2$

- This translation is inappropriate: it leads to incorrect entailment patterns. Can you find one?

Maximal events do not help with perception reports

- Assume the formula is true:

(30) $$\exists e_1.\ \exists e_2.\ \exists t.\ e_2 = \mathrm{MXT}(t) \wedge \\ \neg\exists e_3.\ [e_3 \leq e_2 \wedge \mathit{leave}(e_3) \wedge \mathit{ag}(e_3) = \mathit{Mary}] \\ \wedge \mathit{see}(e_1) \wedge \mathit{ag}(e_1) = \mathit{John} \wedge \mathit{th}(e_1) = e_2$$

- Assume that William does not sleep during t.
- Then, the following formula is also true!

(31) $$\exists e_1.\ \exists e_2.\ \exists t.\ e_2 = \mathrm{MXT}(t) \wedge \\ \neg\exists e_3.\ [e_3 \leq e_2 \wedge \mathit{sleep}(e_3) \wedge \mathit{ag}(e_3) = \mathit{William}] \\ \wedge \mathit{see}(e_1) \wedge \mathit{ag}(e_1) = \mathit{John} \wedge \mathit{th}(e_1) = e_2$$

- This formula would be the translation of *John sees William not sleep*.
- In fact, while Krifka's negation introduces events, they have little to do with the negated predicates.

Day 1: Summary

- In traditional event semantics, sentences existentially quantify over events.
- This has been generalized from action sentences to other natural language constructions.
- *John saw Mary leave*:
  $\exists e_1 \exists e_2.\ see(John, e_1, e_2) \wedge leave(e_2, Mary)$
- According to the standard analysis, the event quantifier takes scope below classical negation.
- This leaves little room for negated event descriptions such as *John saw Mary not leave*.
- Krifka (1989) introduced a nonstandard negation to deal with some temporal modifiers, but this does not really help with perception reports.

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