Lecture 10
Intensional semantics

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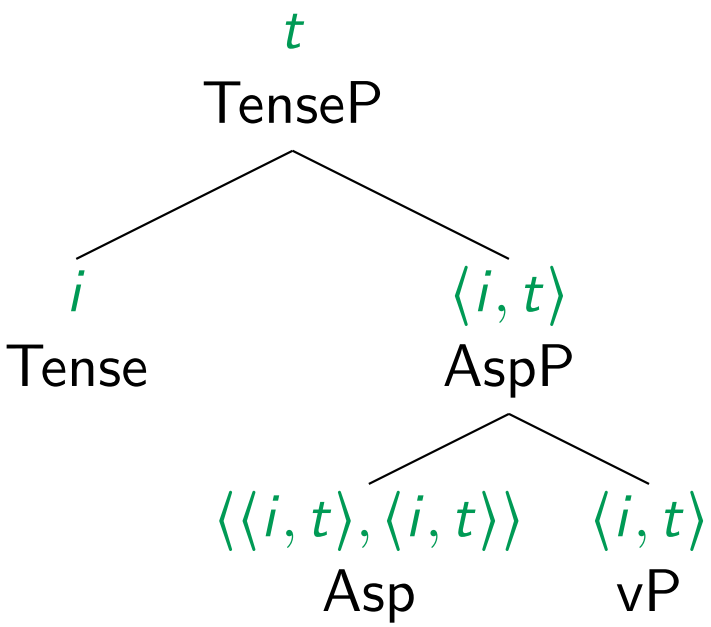
Introduction to Semantics · EGG 2019

Outline

Tense and aspect

- Tense relates reference time R and speech time S
- Grammatical aspect relates reference time R and event time E

Syntax/semantics mapping:



An incorrect theory of present tense

(1) PRESENT $\rightsquigarrow$ now

Present tense $\neq$ *now* (Kamp, 1971):

(2) a. Someday Susan will marry a man she loves.
b. Someday Susan will marry a man she loves now.

Present tense can be bound:

(3) Whenever he sneezes, I laugh.

Simple present has habitual interpretation with non-statives:

(4) a. I {?laugh,am laughing} at this headline. [non-stative]
b. I {live,am living} in Amsterdam. [stative]

Future of the past

(5) (In 1981, Dave's marriage was very stable.)
However, he **would** later learn (in 1987) that his wife was cheating on him.

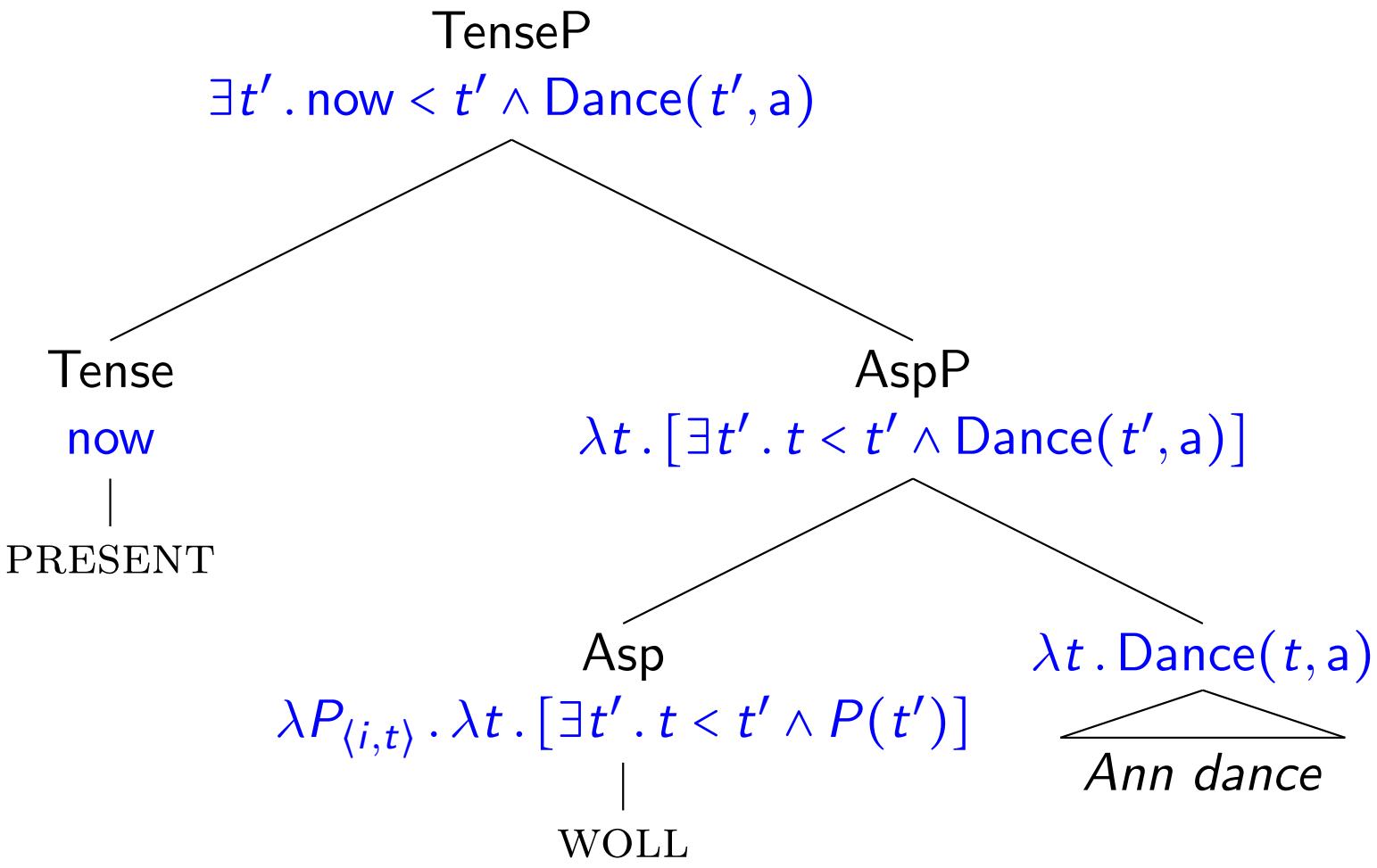
Future as an aspect

(6) WOLL $\rightsquigarrow \lambda P_{\langle i,t \rangle} . \lambda t . [\exists t' . t < t' \wedge P(t')]$

- In present → future
- In past → future of the past

(Cable, 2008; Matthewson, 2006).

Derivation for *Ann will dance*



Lexicon

Verbal predicates:

(7) *dance* $\rightsquigarrow \lambda x \,.\, \lambda t \,.\, \mathsf{Dance}(t, x)$

Aspectual markers:

(8) $\textsc{perf} \rightsquigarrow \lambda P_{\langle i,t \rangle} \,.\, \lambda t \,.\, \exists t' \,.\, [t' \subseteq t \wedge P(t')]$

(9) $\textsc{imp} \rightsquigarrow \lambda P_{\langle i,t \rangle} \,.\, \lambda t \,.\, \exists t' \,.\, [t \subseteq t' \wedge P(t')]$

(10) $\textsc{woll} \rightsquigarrow \lambda P_{\langle i,t \rangle} \,.\, \lambda t \,.\, [\exists t' \,.\, t < t' \wedge P(t')]$

Tense markers:

(11) $\textsc{past}_n \rightsquigarrow \iota t \,.\, [t = t_n \wedge t_n < \mathsf{now}]$

(12) $\textsc{present}_n \rightsquigarrow \mathsf{now}$

Types

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- t is a type (truth values)

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- Nothing else is a type.

Models

$$M = \langle D, I, T, <, \subseteq \rangle$$

where

- D is the domain of individuals D
- I is an interpretation function assigning semantic values to each of the non-logical constants in the language
- T is a set of times
- $<$ is a precedence relation among times
- $\subseteq$ is a containment relation among times

Outline

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(13) Scott Pruitt is the head of the Environmental Protection Agency (EPA).

(14) Scott Pruitt is a climate change denier.

(15) Therefore, the head of the EPA is a climate change denier.

When Leibniz's law doesn't hold

(16) Necessarily, the head of the EPA is the head of the EPA.

(17) Necessarily, Scott Pruitt is the head of the EPA.

When Leibniz's law doesn't hold

(18) Ed knows that the head of the EPA is the head of the EPA.

(19) Ed knows that Scott Pruitt is the head of the EPA.

Referential opacity

Contexts where Leibniz's law does not hold are also **referentially opaque**. Example:

(20) Jane is seeking a unicorn.

Does not imply that a unicorn exists $\Rightarrow$ referentially opaque.

Indefinites in opaque contexts

Indefinites can be interpreted either inside or outside an opaque context (Quine, 1956).

(21) Mary believes that a Republican will win.

- **de re**
  There is a Republican x such that: Mary believes x will win. (Mary might not even know x is a Republican.)
- **de dicto**
  Mary's belief holds in any world where there is a Republican who wins, no matter which one.

de dicto vs. *de re* in the media

Actual headline:

(22) Lindsey Graham wants a ‘race-baiting, xenophobic kook’ to be president.

(He had indeed called Trump a ‘race-baiting, xenophobic kook’, and he did indeed support Trump for president.)

de dicto vs. *de re* in the law

It is a federal crime to:

"knowingly ... corruptly persuade another ... with intent to ... induce any person to ... withhold a record, document, or other object, from an official proceeding."

Enron case

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Shortly later, the SEC began an official investigation.

They stopped shredding immediately after SEC's subpoena.

Supreme court ruling

The statute again:

"knowingly ... corruptly persuade another ... with intent to ... induce any person to ... withhold a record, document, or other object, from an official proceeding."

The Supreme Court held that, if in its frenzy of paper shredding the defendant firm was not specific about the particular official proceeding to be obstructed, the statute could not have been violated.

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(Anderson, 2014)

Returning to Leibniz's law

(23) Necessarily, the head of the EPA is the head of the EPA.

(24) Necessarily, Scott Pruitt is the head of the EPA.

Why doesn't Leibniz's law hold in opaque contexts?

- Identity between Scott Pruitt and the head of the EPA holds in *this* world, but not every world; it is **contingent**.
- The identity between the head of the EPA and the head of the EPA holds in every world; it is **necessary**.
- So the two sentences express different propositions; one contingent, one necessary.
- Necessity and belief say something about the proposition expressed by a sentence; they are not truth-functional.

Intension vs. extension (Carnap)

- The **extension** at a world w of an expression is its denotation at w.
  - For names: individuals
  - For unary predicates: sets
  - For formulas: truth values
- The **intension** of an expression is a function from possible worlds w to its extension at w.

Intension vs. extension of formulas

The **extension of a formula** (at a world) is a truth value.

The **intension of a formula** is a function from possible worlds to truth values, i.e., a **proposition** (cf. Kaplan's **content**).

Opaque contexts involve intensionality

- 'Necessarily ϕ' says that ϕ is true at every possible world.
- 'Ed believes that ϕ' says that all of the worlds that are epistemically accessible to Ed are worlds where ϕ holds.

Both require access to the intension of ϕ.

Note: Hyperintensionality

Mere intensionality will not solve everything:

(25) a. Sandhya believes that $2 + 2 = 4$.
b. Sandhya believes that Toida's conjecture is true.

(26) a. Sandhya believes that the cat is in if the dog is out.
b. Sandhya believes that the dog is in if the cat is out.

Problem of logical omniscience: We don't know all of the logical consequences of what we believe.

Modal logic

$\Box\phi$: 'It is necessary that ϕ'

$\Diamond\phi$: 'It is possible that ϕ'

Intensional models (cf. 'Kripke frames')

$$M = \langle D, W, I \rangle$$

where:

- D is a set of individuals
- W is a set of worlds
- I is an interpretation function that maps $\langle$ constant, world $\rangle$ pairs to their extensions at the world.

Interpretations in intensional models

Let $D = \{a, b, c\}$.

$I(w_1, \text{john}) = b$	$I(w_2, \text{john}) = b$	$I(w_3, \text{john}) = b$
$I(w_1, \text{mary}) = a$	$I(w_2, \text{mary}) = a$	$I(w_3, \text{mary}) = a$
$I(w_1, \text{Happy}) = \{a, b, c\}$	$I(w_2, \text{Happy}) = \{a, b\}$	$I(w_3, \text{Happy}) = \{c\}$

A syncategorematic semantics for the modal operators

Semantic rule: Necessity ($\Box$)

$[\![\Box\phi]\!]^{M,g,w} = 1$ iff $[\![\phi]\!]^{M,g,w'} = 1$ for all $w' \in W$

Semantic rule: Possibility ($\Diamond$)

$[\![\Diamond\phi]\!]^{M,g,w} = 1$ iff $[\![\phi]\!]^{M,g,w'} = 1$ for some $w' \in W$

Facts

$\Box$ and $\Diamond$ are **duals** of each other:

- $\Box\phi \equiv \neg \Diamond \neg\phi$
- $\neg \Box \neg\phi \equiv \Diamond\phi$

(The same is true for $\forall$ and $\exists$)

What does *necessarily* mean?

First attempt:

necessarily $\rightsquigarrow \lambda p_t \,.\, \Box\, p$

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Problem: p denotes a truth value. We need the intension.

What does *necessarily* mean?

Second attempt:

necessarily $\rightsquigarrow \lambda p_{\langle s,t \rangle} \,.\, \Box\, p$
where $\langle s, t \rangle$ is the type of propositions (functions from worlds to truth values)

Problem: $\Box$ combines with an expression of type t.

What does *necessarily* mean?

Third attempt:

necessarily $\rightsquigarrow \lambda p_{\langle s,t \rangle} . \mathrm{Nec}(p)$
where

- $\langle s, t \rangle$ is the type of propositions (functions from worlds to truth values)
- Nec denotes a function from propositions to truth values: $[\![\mathrm{Nec}]\!]^{M,g,w}$ = that function f such that $f(p) = 1$ iff $p \subseteq W$.

Getting ahold of the intension

How to compositionally derive:

(27) Necessarily, Scott Pruitt is Scott Pruitt.

Semantic rule: Monague's hat operator

$[\![\hat{}\alpha]\!]^{M,g,w}$ = that function h such that for all $w \in W$: $h(w) = [\![\alpha]\!]^{M,g,w}$.

(28) Nec(^(s = s))

Representing *de dicto* vs. *de re*

(29) Lindsey Graham wants a "race-baiting, xenophobic kook" to be president.

de dicto reading:

$$\mathsf{Want}(\mathsf{lg}, {}^\wedge\exists x[\mathsf{POTUS}(x) \wedge \mathsf{RXK}(x)])$$

de re reading:

$$\exists x[\mathsf{RXK}(x) \wedge \mathsf{Want}(\mathsf{lg}, {}^\wedge\mathsf{POTUS}(x))$$

Types in Montague's Intensional Logic

The types are defined recursively as follows:

- t is a type, the type of truth values
- e is a type, the type of individuals
- i is a type, the type of times
- If σ and τ are types, then so is $\langle \sigma, \tau \rangle$
- If τ is any type, then $\langle s, \tau \rangle$ is a type, the type of functions from possible worlds to D_τ.
- Nothing else is a type

Explicit quantification over worlds

Instead of:

$$\hat{}\mathsf{Bald}(\mathsf{m})$$

we have:

$$\lambda w \,.\, \mathsf{Bald}_w(\mathsf{m})$$

as in Gallin's (1975) Ty_2, which has two types other than t, namely e and s.

Type system with worlds as first-class citizens

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- e is a type, the type of individuals
- i is a type, the type of times
- s is a type, the type of worlds
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Representing *de dicto* vs. *de re*

(30) Lindsey Graham wants a "race-baiting, xenophobic kook" to be president.

de dicto reading:

$$\lambda w\,.\,\mathsf{Want}_w(\mathsf{lg}, \lambda w' \exists x[\mathsf{POTUS}_{w'}(x) \wedge \mathsf{RXK}_{w'}(x)])$$

de re reading:

$$\lambda w\,.\,\exists x[\mathsf{RXK}_w(x) \wedge \mathsf{Want}(\mathsf{lg}, \lambda w'\,.\,\mathsf{POTUS}_{w'}(x))$$

Outline

Example for discussion

George, in the movie *It's a Wonderful Life*:

(31) I wish I did not exist.

What he wishes for is not impossible. In other words:

(32) I don't necessarily exist.

Yet it seems impossible for this to be true:

(33) I do not exist.

How is this possible?

Outline

Want more?

Apply to BU!
`http://ling.bu.edu/grad/degrees/ling-phd`

The deadline for application for PhD students who will be entering the program in Fall of 2020 is January 6, 2020.

Or read my textbook!

Currently known as *Formal Semantics Boot Camp*, co-authored with Lucas Champollion.

Stay tuned for updates!

Stay in touch, in any case!

Thank you!

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