Introducing dynamics

Semantics II

April 2 & 4, 2018

Dynamic exceptional scope

Famously, indefinites can antecede pronouns they don't (can't) scope over:[1]

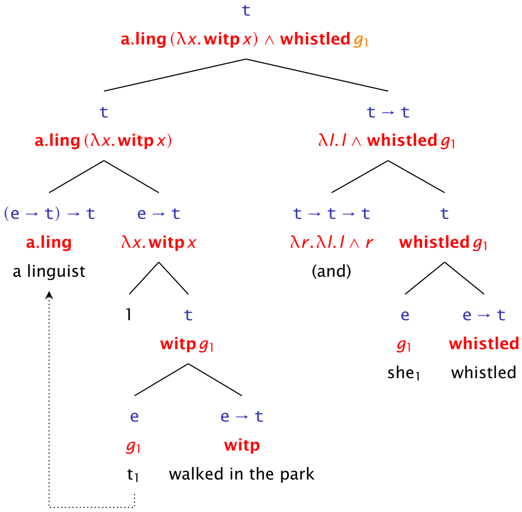
1. {A, *Every} linguist$_i$ walked in the park. She$_i$ whistled.
2. If {a, *every} man$_i$ is from Omaha, he$_i$ isn't from Lincoln.

If indefinites are quantifiers, this behavior is puzzling.

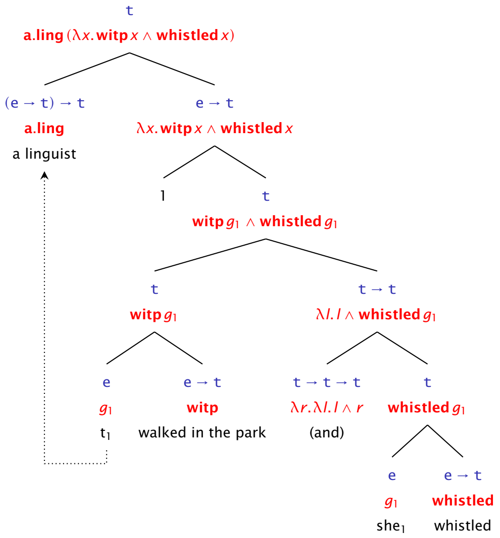
Alternative: indefinites *aren't* quantifiers, but fuzzy analogs of singular terms. A proper name refers to a concrete entity, and an indefinite "refers" to a fuzzy entity.

[1] Geach (1962), Lewis (1975), Karttunen (1976), Heim (1982, 1983), many more.

An LF dramatizing the challenge



Another possibility?



Some questions about scoping

The analysis on the last slide moves an indefinite out of a coordinate structure, perhaps even to a position of *discourse-level scope*! Why can't *all* quantifiers do this? Is this just another sign that indefinites have super-duper scope properties?

What does this predict about cases like the following? Is the meaning acceptable?

3. Exactly one linguist$_i$ walked in the park. She$_i$ whistled.
   $\rightsquigarrow$ $\mathbf{ex1.ling}\,(\lambda x.\,\mathbf{witp}\,x \wedge \mathbf{whistled}\,x)$

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It is not. Unlike the sentence, the derived meaning is consistent with many linguists walking in the park, so long as just one of those people whistled.

On donkeys

Furthermore, it does not seem that the scoping solution can account for *donkey anaphora*, cases where there is exceptional anaphora to an indefinite that cannot be accounted for simply by scoping the indefinite all the way up:

4. If a man_i is from Omaha, he_i's from Nebraska.
5. Every person with a son_i teaches him_i to drive.

These sentences have salient binding readings that keep the indefinite within the scope of *if* and *every*. So simply QRing the indefinite seems insufficient.

On the other hand, we might consider *decomposing if* into negation and conjunction, and then allowing indefinites (but nothing else) to take scope in the middle of *if*:[2]

$$\neg(\exists x \in \mathbf{man} : \mathbf{from}\,\mathbf{o}\,x \wedge \neg\mathbf{from}\,\mathbf{n}\,x)$$

[2] See Barker & Shan (2008) for this strategy.

File change semantics

The file metaphor

A discourse is a file (cabinet?): a set of file cards, each of them about some *discourse referent* (dref), with information about that dref.

Declarative discourse involves (at least) taking a file cabinet with a bunch of existing information about various drefs, and adding information to it, with different kinds of expressions associated with different kinds of updates:

- Indefinites: introduce a new file card
- Definites (including pronouns): update an old file card

An example

Repeating our example from the first slide:

6. A linguist_1 t_1 walked in the park. She_1 whistled.

Let's informally walk through how the file cabinet gets updated as we process this:

- We meet an indefinite with index 1. Introduce a new file card for 1.
- We meet a trace with index 1. Update the card for 1: 1 walked in the park.
- We meet a pronoun with index 1. Update the card for 1: 1 whistled.

Working towards formalization

What is a file? It's associated with some numbers (its domain), and some conditions those numbers have to satisfy.

With a wee shift in perspective, we can think of a file as a *set of assignments*:

$$\{g \mid \mathbf{ling}\, g_1, \mathbf{witp}\, g_1, \mathbf{whistled}\, g_1\}$$

To hew closely to Heim (1982, 1983), we will think of these as *partial* assignments (strictly speaking, this is not necessary).

An illustration[3]

$$\{\emptyset\}$$

$$\downarrow$$

$$\{\emptyset \cup (1, x) \mid \textbf{ling}\, x\}$$

$$\downarrow$$

$$\{\emptyset \cup (1, x) \mid \textbf{ling}\, x, \textbf{witp}\, x\}$$

$$\downarrow$$

$$\{\emptyset \cup (1, x) \mid \textbf{ling}\, x, \textbf{witp}\, x, \textbf{whistled}\, x\}$$

$$\downarrow$$

$$\{\emptyset \cup (1, x) \cup (2, y) \mid \textbf{ling}\, x, \textbf{witp}\, x, \textbf{whistled}\, x, \textbf{phil}\, y\}$$

$$\downarrow$$

$$\vdots$$

[3] Note that I'm writing '$F \cup (n, a)$' to mean '$F \cup \{(n, a)\}$'.

Recalling a simple dynamic system

A dynamic semantics for $\phi ::= \texttt{Atom} \mid \phi \wedge \phi \mid \neg\phi$:

$$\begin{aligned} s[p] &= \{w \in s : w\,p\} \\ s[\phi \wedge \psi] &= s[\phi][\psi] \\ s[\neg\phi] &= s \setminus s[\phi] \end{aligned}$$

(Thus, for example, $[p] = \lambda s.\{w \in s : w\,p\}$.)

Conjunction amounts to function composition:

$$\begin{aligned} [\phi \wedge \psi] &= \lambda s.[\psi]([\phi]\,s) \\ &= [\psi] \circ [\phi] \\ &= [\phi] \mathbin{;} [\psi] \end{aligned}$$

Updating our language

We'll make our language a simple first-order one, in the usual way:

$$\texttt{Atom} ::= R x_1 \ldots x_n \qquad \phi ::= \texttt{Atom} \mid \phi \wedge \phi \mid \neg\phi \mid \exists^i$$

This language has a standard model $(\llbracket\cdot\rrbracket, D, G)$: $\llbracket\cdot\rrbracket$ associates n-ary predicates R with relations (sets of tuples): $\llbracket R\rrbracket^g \subseteq D_1 \times \cdots \times D_n$ (where $g \in G$).

$$\begin{aligned} s[R x_1 \ldots x_n] &= \{g \in s \mid (\llbracket x_1\rrbracket^g, \ldots, \llbracket x_n\rrbracket^g) \in \llbracket R\rrbracket^g\} \\ s[\phi \wedge \psi] &= s[\phi][\psi] \\ s[\exists^i] &= \{g \cup (i, x) \mid g \in s, x \in D\} \end{aligned}$$

The dynamic existential quantifier $\exists^i$ *expands* the incoming assignment functions, effectively introducing a new file card.

Illustration

Suppose our domain has 3 individuals, $D = \{\mathbf{a}, \mathbf{b}, \mathbf{c}\}$, and that **a** and **c** are French, and only **a** is a linguist. Then we may observe the following succession of updates:[4]

$$
\begin{array}{c}
\{\emptyset\} \\
\Big\downarrow {\scriptstyle \exists^1} \\
\{[1 \to \mathbf{a}], [1 \to \mathbf{b}], [1 \to \mathbf{c}]\} \\
\Big\downarrow {\scriptstyle \mathbf{french}\, x_1} \\
\{[1 \to \mathbf{a}], [1 \to \mathbf{c}]\} \\
\Big\downarrow {\scriptstyle \mathbf{ling}\, x_1} \\
\{[1 \to \mathbf{a}]\} \\
\Big\downarrow {\scriptstyle \exists^2} \\
\{[1 \to \mathbf{a}, 2 \to \mathbf{a}], [1 \to \mathbf{a}, 2 \to \mathbf{b}], [1 \to \mathbf{a}, 2 \to \mathbf{c}]\} \\
\vdots
\end{array}
$$

[4] E.g., $[1 \to \mathbf{a}]$ is the very partial assignment $\{(1, \mathbf{a})\}$ that maps 1 to **a**, and does nothing else.

What if i isn't novel?

Suppose i isn't novel in the input state s. What happens if we try to re-introduce i?

$$\{[1 \rightarrow \mathbf{a}]\} \xrightarrow{\exists^1 \wedge x_1 = \mathbf{b}} \{[1 \rightarrow \mathbf{a}, 1 \rightarrow \mathbf{b}]\}$$

The result here is a state that contains a single assignment. However, this assignment does not know what to do with the index 1! It is no longer an assignment function, but an assignment *relation*.

Thus, if we tried to continue with, say, **french** x_1, the result would not be defined:

$$\begin{aligned} [\![x_1]\!]^{[1 \rightarrow \mathbf{a}, 1 \rightarrow \mathbf{b}]} &= [1 \rightarrow \mathbf{a}, 1 \rightarrow \mathbf{b}]_1 \\ &= ??? \end{aligned}$$

Implementing novelty

So what should we do? One option is simply to presuppose novelty in $s[\exists^i]$:

$$s[\exists^i] = \begin{cases} \{g \cup (i, x) \mid g \in s, x \in D\} & \text{if } i \notin \operatorname{Dom} s \\ \text{undefined} & \text{otherwise} \end{cases}$$

Where $\operatorname{Dom} s$ is the indices that are already assigned values in s:

$$\operatorname{Dom} s = \{i \mid g \in s, (i, \_) \in g\}$$

On the other hand, it is not actually clear that we need to hard-wire this constraint. We could just say that if we don't choose our indices carefully, we might end up in a state that can't value certain variables. Maybe this is enough.[5]

[5] The system of Heim (1982, 1983) actually *does* need to hard-wire novelty into the system, because of certain technical choices: specifically, Heim uses total assignment functions, and then keeps track separately of which variables are "active" in s. Heim implements novelty as a constraint on *LFs*.

True dynamicity

A system is *irreducibly* dynamic (i.e., not a reformulation of a static/intersective system) when it has updates which are non-distributive, or non-eliminative:[6]

$$\underbrace{s[\phi] = \bigcup_{g \in s} \{g\}[\phi]}_{\phi \text{ is distributive}} \qquad \underbrace{s[\phi] \subseteq s}_{\phi \text{ is eliminative}}$$

Our dynamic system *has non-eliminative updates*. Why?

[6] van Benthem (1989), Groenendijk & Stokhof (1991), Rothschild & Yalcin (2015), Charlow (2016).

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Our dynamic system *has non-eliminative updates*. Why? In general, $s[\exists^i]$ is not a subset of s, since the g's in s can be *modified* in the output.

On the other hand, the system is distributive since none of our updates ever needs to see the entire incoming state s. Notice in particular:

$$\left.\begin{array}{ll} s[R x_1 \ldots x_n] & = \{g \in s \mid ([\![x_1]\!]^g, \ldots, [\![x_n]\!]^g) \in [\![R]\!]^g\} \\ s[\exists^i] & = \{g \cup (i, x) \mid g \in s, x \in D\} \end{array}\right\} \text{processing } s \text{ point-wise}$$

[6] van Benthem (1989), Groenendijk & Stokhof (1991), Rothschild & Yalcin (2015), Charlow (2016).

On negation

We observe the following properties:

7. Mary doesn't own a car$_i$. *It$_i$'s parked outside.
8. Everyone who owns a car$_i$ washes it$_i$. *It$_i$'s parked outside.

This tells us something important about the function of negation. Negation *wipes out* any drefs/binding information generated in its scope. The parallel behavior of universals means we should consider defining them in terms of negation.

Here is the entry for negation from our propositional language:

$$s[\neg\phi] = s - s[\phi]$$

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Will this work for us? No, precisely because ϕ might be non-eliminative, e.g., $\exists^i$.

An entry for negation

Intuitively, $\neg\phi$ should toss out all the assignments in the input state that lead to a successful update with ϕ. But because the system is non-eliminative, success cannot be identified with "support".[7]

On the other hand, the following notion will do:

$$s[\neg\phi] = \{g \in s \mid \underbrace{\{g\}[\phi] = \emptyset}_{\text{updating } \{g\} \text{ with } \phi \text{ fails, } \textit{not } \{g\} \text{ supports } \phi}\}$$

An important feature of this semantics is that, even if ϕ expands the domain to include new discourse referents, the assignments returned by $\neg\phi$ are only ever ones drawn from the input state s. Any new binding info in ϕ is discarded.

[7] State s supports ϕ iff $s[\phi] = s$.

Illustrating negation

Suppose our domain has 3 individuals, $D = \{\mathbf{a}, \mathbf{b}, \mathbf{c}\}$, and that **a** and **c** are French, and only **a** is a linguist. Then we may observe the following updates:

$$
\begin{tikzcd}
\{\emptyset\} \arrow[d, dotted, "\exists^1"] \\
\{[1 \to \mathbf{a}], [1 \to \mathbf{b}], [1 \to \mathbf{c}]\} \arrow[d, dotted, "\mathbf{french}\, x_1"] \\
\{[1 \to \mathbf{a}], [1 \to \mathbf{c}]\} \arrow[d, dotted, "\mathbf{ling}\, x_1"] \\
\{[1 \to \mathbf{a}]\}
\end{tikzcd}
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\{[1 \to \mathbf{a}], [1 \to \mathbf{c}]\} \arrow[d, dotted, "\neg\mathbf{ling}\, x_1"] \\
\{[1 \to \mathbf{c}]\}
\end{tikzcd}
\qquad
\begin{tikzcd}
\{\emptyset\} \arrow[d, dotted, "\exists^1 \wedge \mathbf{french}\, x_1 \wedge \mathbf{ling}\, x_1"] \\
\{[1 \to \mathbf{a}]\} \arrow[d, dotted, "\neg(\exists^2 \wedge \mathbf{italian}\, x_2 \wedge \mathbf{ling}\, x_2)"] \\
\{[1 \to \mathbf{a}]\} \arrow[d, dotted, "\exists^2 \wedge \neg\mathbf{french}\, x_2"] \\
\{[1 \to \mathbf{a}, 2 \to \mathbf{b}]\}
\end{tikzcd}
$$

Donkeys

We can treat the conditional operator $\rightsquigarrow$ as an abbreviation in the usual way:

$$\begin{aligned} s[\phi \rightsquigarrow \psi] &= s[\neg(\phi \wedge \neg\psi)] \\ &= \{g \in s \mid \{g\}[\phi \wedge \neg\psi] = \emptyset\} \end{aligned}$$

This correctly allows binding in *if someone$_i$'s Omahan, they$_i$'re Nebraskan*:

$$\begin{aligned} s[(\exists^1 \wedge \mathbf{o}\, x_1) \rightsquigarrow \mathbf{n}\, x_1] &= s[\neg((\exists^1 \wedge \mathbf{o}\, x_1) \wedge \neg\mathbf{n}\, x_1)] \\ &= \{g \in s \mid \{g\}[(\exists^1 \wedge \mathbf{o}\, x_1) \wedge \neg\mathbf{n}\, x_1] = \emptyset\} \\ &= \{g \in s \mid \{g\}[\exists^1][\mathbf{o}\, x_1][\neg\mathbf{n}\, x_1] = \emptyset\} \\ &= \{g \in s \mid \neg(\exists x \in \mathbf{o} : \neg\mathbf{n}\, x)\} \\ &= \{g \in s \mid \forall x \in \mathbf{o} : \mathbf{n}\, x\} \end{aligned}$$

If we can find any Omahans who aren't Nebraskan, there will be no g's left over (the update fails). If all Omahans are Nebraskan, we'll just get back s. So binding succeeds, but the binding info contributed by $\exists^1$ does not outlast the conditional.

Universals

We can make exactly the same move for universal quantifiers:

$$s[\forall^i(\phi, \psi)] = s[\neg(\exists^i \wedge \phi \wedge \neg\psi)]$$

As with the conditional, the fact that conjunction is dynamic guarantees that *n* will be "active" when both ϕ and ψ are interpreted!

For conditionals/universals, we predict something generally known as the "strong" reading: *if someone's Omahan, they're Nebraskan* means *every* Omahan is Nebraskan. *Every farmer who owns a donkey beats it* means every farmer beats *every* donkey s/he owns. But "weak" readings are often observed:[8]

9. If I have a quarter$_i$, I'll throw it in the parking meter.
10. Every farmer who owns a donkey$_i$ will ride it$_i$ to town tomorrow.

[8] E.g., Schubert & Pelletier (1989), Kanazawa (1994), Chierchia (1995), Brasoveanu (2007), many more.

Dekker (1994)

The system of Predicate Logic with Anaphora is closely related to the version of File Change Semantics that we have given here.

PLA treats conversational states as sets of *sequences of individuals*. Supposing our domain has 3 individuals, $D = \{\mathbf{a}, \mathbf{b}, \mathbf{c}\}$, and that **a** and **c** are French:

$$\begin{tikzcd}
\{\emptyset\} \arrow[d, dotted, "\exists"] \\
\{\mathbf{a}, \mathbf{b}, \mathbf{c}\} \arrow[d, dotted, "\mathbf{french}\, x_1"] \\
\{\mathbf{a}, \mathbf{c}\} \arrow[d, dotted, "\exists"] \\
\{\mathbf{aa}, \mathbf{ab}, \mathbf{ac}, \mathbf{ca}, \mathbf{cb}, \mathbf{cc}\}
\end{tikzcd}$$

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