Binding *ex post facto*

Patrick D. Elliott\(^x\)    Yasu Sudo\(^y\)

November 12, 2018 – LENLS, Keio University

Leibniz-Center for General Linguistics\(^x\) and University College London\(^y\)
This is joint work with Yasu Sudo (University College London).
In this talk, we focus on apparent cases of **cataphora** from the perspective of **dynamic semantics** – a framework in which the *left-to-right* nature of anaphora resolution is baked into semantic composition.

We’ll argue that genuine *right-to-left binding* exists, and that dynamic frameworks can be extended in a natural way to account for just those cases in which it’s allowed.
Concretely, we will argue for the following putative generalization:

**The binding-presupposition generalization**
Presupposition projection, but not scope, may feed binding.

We will present a refinement of orthodox dynamic theories, from which this generalization falls out.
Roadmap

- Theoretical background: a primer in Dynamic Predicate Logic.
- Evidence for backwards binding: cataphoric sloppy donkeys.
- Analysis: binding by presupposition.
Dynamic primer
Classical dynamic semantics (Heim 1982, Kamp 1981, etc.) is primarily a theory of *anaphora with indefinite antecedents*. Famously, it accounts for the truth-conditions of sentences involving *cross-sentential* anaphora (1), and *donkey* anaphora (2).

(1) A woman$^x$ walked in. She$_x$ sat down.

(2) Every farmer who owns a donkey$^x$ loves it$_x$. 
Dynamic semantics is also tailored to account for the *left-to-right* nature of anaphora resolution; cataphora with indefinite antecedents, as in (3) and (4), is markedly worse.

(3) #She\(_x\) sat down. A woman\(_x\) walked in.

(4) #Every farmer who owns it\(_x\) loves a donkey\(_x\).
Other achievements of dynamic semantics.

- Presupposition projection (Heim 1992, Beaver 2001 etc.)
- Discourse plurals (van den Berg 1996, Nouwen 2003 etc.).
- Weak island and intervention effects (Honcoop 1996, Haida 2007 etc.).
- Epistemic modality (Veltman 1996 etc.).

We’ll put aside the possibility of right-to-left dependencies in the above phenomena in this talk, although this is something we’d like to look at in the future.
The framework: Dynamic Predicate Logic

• We’ll briefly present Dynamic Predicate Logic (DPL; Groenendijk & Stokhof 1991) as a representative dynamic framework, primarily for its simplicity.

• As far as we can tell, the choice of dynamic framework will not be important for the core properties of our analysis.
• DPL is easy to work with, since the syntax of DPL is identical to the syntax of First-Order Logic – a wff of FOL is a well-formed formula of DPL.

• We can think of a wff of FOL as denoting a set of information states, represented by the assignments the formula is true with respect to.

• A wff of DPL denotes a relation between two information states.
• Just as in FOL, information states are represented as assignments.
• A model for DPL is just a first-order model $M = \langle D, I \rangle$.
• The semantics of constants and variables is first-order.

$$[t]_M^f = \begin{cases} I(t) & \text{if } t \text{ is a constant} \\ f(t) & \text{if } t \text{ is a variable} \end{cases}$$
Atomic wff are tests – they take an input information state \( f \) and return that same information state iff the wff is true wrt \( f \).

\[
f[[P x_1 \ldots x_n]]_M g \iff f = g \text{ and } \langle [x_1]^f_M, \ldots, [x_n]^f_M \rangle \in I(P)
\]

Negation and equality statements also induce tests.

\[
f[[\neg \phi]]_M g \iff f = g \text{ and } f[[\phi]]_M h \text{ for no } h
\]

\[
f[[x = y]]_M g \iff f = g \text{ and } [x]^f_M = [y]^f_M
\]
We can define truth simpliciter in DPL by existentially closing the output assignment:

\[(5) \text{ A DPL formula } \phi \text{ is true with respect to } f \text{ iff there is } g \text{ such that } f [\phi] \models g.\]

N.b. we suppress the model parameter from now on.
What we’ve seen so far amounts to a static first-order fragment embedded in a dynamic setting. With existentials and conjunction, things get more interesting.

Indefinites are translated into existential quantifiers, which trigger random assignment.

\[ f \models \exists x [\varphi] \iff \text{there is } h \text{ such that } f \approx_x h \text{ and } h \models [\varphi] \]

\[ f \approx_x h \text{ means assignments } f \text{ and } h \text{ are different at most in the value they assign to } x \]
In order to account for donkey anaphora, dynamic semantics makes composition sensitive to linear order. In DPL, this is cashed out in the semantic rule for conjunction.

\( \land \) is order-sensitive in that \((\phi \land \psi)\) and \((\psi \land \phi)\) are not always equivalent.

\[
\begin{align*}
f[(\phi \land \psi)] & \iff f[\phi]_M h \text{ and } h[\psi]_M g \text{ for some } h
\end{align*}
\]

Conjunction takes an input information state \(f\) feeds it into \(\phi\), and feeds the output \(h\) into the second conjunct \(\psi\), returning \(g\).
Random assignment and dynamic conjunction interact in order to license cross-sentential anaphora.

(6)  a. A man\(^x\) walked in. He\(_x\) sat down

\[
\leadsto (\exists x [\text{man } x \land \text{walkedIn } x] \land \text{satDown } x)
\]

b. \(f[(\exists x [\text{man } x \land \text{walkedIn } x] \land \text{satDown } x)] \ g\)

\[
\iff f \approx_x g \text{ and } g(x) \in I(\text{man}) \text{ and } g(x) \in I(\text{walkedIn})
\text{ and } g(x) \in I(\text{satDown})
\]

The modified assignment yielded by random assignment in the first conjunct is fed in as input to the second conjunct, catching the pronoun.
Due to the definition of dynamic conjunction, the output of the first conjunct feeds the input of the second conjunct, but not vice versa.

(7)  a. He\textsubscript{a} sat down. A\textsuperscript{a} man walked in.
    \[ \leadsto (\text{satDown} x \land \exists x [\text{man } x \land \text{walkedIn } x]) \]

    b. \[ f [[(\text{satDown} x \land \exists x [\text{man } x \land \text{walkedIn } x])] g \]
    \[ \Leftrightarrow x \in \text{dom}(f) \text{ and } f(x) \in I(\text{satDown}) \text{ and } f \approx_x g \]
    \[ \text{and } g(x) \in I(\text{man}) \text{ and } g(x) \in I(\text{walkedIn}) \]

This successfully ensures that dynamic binding always proceeds from left-to-right – cataphora is predicted to be impossible.
Cataphoric sloppy donkeys
There is a basic asymmetry between indefinites and definites wrt to the availability of a “bound” reading, where the bound expression precedes the binder.

(8) Every professor who wants to read it\textsubscript{a} bought \{ # a\textsuperscript{a} | the\textsuperscript{a} \} new book by Chomsky.

We put bound in scare quotes here, as there are a couple of straightforward ways to account for the acceptability of (8) without invoking genuine cataphoric binding.
For the dynamic semanticist, there are two analytical possibilities:

- Blame apparent cataphora on coreference; the bound expression and the binder just happen to pick out the same individual.
- Blame apparent cataphora on crossover; exceptionally, the cataphoric binder takes scope over the bound expression.

We’ll consider each of these two possibilities in the following section, and dismiss them both for conceptual and empirical reasons.
Sag (1976) famously observed that elliptical sentences with pronouns are ambiguous, as in (10) (see also Williams 1977).

(9) Ivan met his student, and Jorge did

\[
\begin{cases}
\langle \text{meet Ivan’s student} \rangle & \text{strict} \\
\langle \text{meet Jorge’s student} \rangle & \text{sloppy}
\end{cases}
\]

too

For expository purposes, we adopt a deletion view on ellipsis and indicate the elided material as \( \langle \text{ellipsis} \rangle \).
The Sag-Williams generalization

sloppy identity requires binding in the antecedent (see Tomioka 1999, Charlow 2012 for discussion).

(10)   Ivan\textsuperscript{x} met his\textsubscript{x/y} student,
       and Jorge\textsuperscript{z} did \langle \text{meet his\textsubscript{z} student} \rangle too.

Without binding in the antecedent, there is no way that the elided constituent can satisfy the identity condition on ellipsis.
Evidence for the Sag-Williams generalization

The unavailability of sloppy readings in *rebinding configurations* bear out the Sag-Williams generalization (although see Fox & Takahashi 2005 for a refinement).

(11) *Ivan\(^x\) said that Tanya met his\(_x\) student,
and she said that Jorge did \(\langle\text{meet Jorge’s student}\rangle\) too.

Even more straightforward evidence:

(12) *Ivan met Ivan’s student,
and Jorge did \(\langle\text{meet Jorge’s student}\rangle\) too.
Crucially for our purposes, *dynamic* binding licenses sloppy readings.

(13) Every farmer who owns a donkey\(_x\) loves it\(_x\), and every farmer who owns a mule\(_y\) does \langle loves it\(_y\) \rangle too.

The claim that licensing of sloppy identity is a property of anaphora in general, including dynamic anaphora, is due to Hardt (1999).
Now that we have a robust diagnostic for genuine binding, we can apply it to the case we’re interested in – namely, apparent cataphora with definite antecedents.

**Disclaimer**

From here on out, the judgements get extremely tricky. We’ve checked the English facts with around 10 expert informants, but there is still more empirical work to be done.
The datapoint in (14) addresses the dynamic semanticist’s first objection to the reality of cataphoric binding.

(14) Every linguistics professor who wanted to read $\text{it}_a$ bought Chomsky’s book$^a$, and every philosophy professor who did ⟨want to read $\text{it}_b$⟩ bought Yablo’s book$^b$.

Since cataphora licenses sloppy readings, it must involve genuine binding and cannot involve accidental co-reference. Otherwise, only the strict reading is predicted to be available.
We’ve dealt with the possibility that apparent cataphora with definite antecedents merely involves coreference.

There’s another analytical possibility of course - apparent cataphora is actually *anaphora* fed by exceptional scope, as schematized in (15).

\[(15) \quad \langle \text{Chomsky’s book}\rangle \quad [\text{Every linguistics professor who wanted to read it bought Chomsky’s book}]\]
Dynamic semantics must rule out crossover configurations independency, otherwise they risk subverting the dynamic explanation for the left-to-right nature of anaphora resolution with indefinite antecedents.

\[(16)\quad *\langle A \text{ woman}^a \rangle [she^a \text{ walked in and a woman}^a \text{ sat down}]\]

Since indefinites can take exceptional scope, if we allow crossover configurations we risk letting in cataphora with indefinite antecedents.
Crossover won’t help with (17) – the definite binder must be able to stay in the scope of the subject NP under the relevant reading, due to the bound pronoun.

(17) [Every professor who wanted KRISZTA to read $\text{it}_a$]$_x$ printed out [$\text{His}_x\ \text{Dissertation}^a$], and [every professor who wanted ROBYN to ⟨read $\text{it}_b$⟩]$_x$ printed out [$\text{His}_x\ \text{first Journal Article}^b$].
Analysis
• How do we account for the ability of definites to bind to their left without dispensing with the core results of dynamic semantics in the domain of anaphora with indefinite antecedents?

• Our claim: unlike orthodox dynamic binding of a definite by an indefinite, *cataphora* involves binding by a *presupposition*.

• We can’t make sense of this in orthodox dynamic theories, so we provide an extension of DPL in which we can cash this out.
From now on, English sentences are translated into a pair of DPL statements.

In $\frac{\phi}{\psi}$, $\phi$ represents the presupposition and $\psi$ the at-issue meaning.

$\frac{\phi}{\psi}$ is a partial function over information states whose domain is $\{i \mid i \models \phi \text{ for some } j\}$. 
The definite description *the new book* is translated as in (19). Note the existential statement in the presupposition, and contrast with orthodox dynamic theories in which definites just denote (possibly restricted) variables.

(18) \text{The}^a_x \text{ new book is sold out.} \\

(19) \begin{array}{l}
\exists! a \left[ \text{newBook} \ a \right] \land x = a \\
\text{soldOut} \ x
\end{array}

Auxiliary definition:

(20) \exists! x[\phi] := \exists x[\phi \land \neg \exists y[\phi[x/y] \land x \neq y]] \text{ where } \phi \text{ is free for } y
Similarly, we assume that other definite phrases such as proper names and pronominals can also in principle have existential presuppositions.

\[(21) \quad \begin{align*}
a. \quad & \text{Paul}_x^a \text{ sat down} \quad \leadsto \quad \exists! a [x = a] \land x = \text{Paul} \\
& \quad \text{satDown} x
\end{align*}

\begin{align*}
b. \quad & \text{He}_x^a \text{ sat down} \quad \leadsto \quad \exists! a [x = a] \\
& \quad \text{satDown} x
\end{align*}\]
We define an accommodation operator $\mathbb{A}$ that takes a partial DPL statement $\frac{\phi}{\psi}$ and returns a total one by sequencing the presupposition with the assertion. There is a trivial identity test, i.e. $i[T]j : \iff i = j$.

\begin{equation}
\mathbb{A} \left( \frac{\phi}{\psi} \right) := \frac{T}{\phi \land \psi}
\end{equation}

In what follows, we omit the presupposition whenever it is trivial. Thus, we will simply write $\phi \land \psi$ for the above.
Accounting for cataphora

We now have everything we need to account for cross-sentential cataphora.

(23) He$_a$ sat down. The new arrival$_a$ yawned.

What happens to the presuppositions of the individual conjuncts? We assume that they project, i.e., the presupposition of the first conjunct is sequenced with the presupposition of the second.

(24) $\frac{\pi \land \psi}{\alpha \land \beta} := \frac{\pi \land \psi}{\alpha \land \beta}$
Accounting for cataphora ii

Post-accommodation, the existential presupposition introduced by *the new arrival* binds the variable introduced by *he* in the assertive dimension.

(25)  a. $\text{he}_a \text{ sat down} \rightsquigarrow \text{satDown } a$

b. $\text{the new arrival}_x^a \text{ yawned} \rightsquigarrow \exists!a[\text{newArrival } a] \land x = a$

$\text{yawned } x$

c. $\text{He}_a \text{ sat down. The new arrival}_x^a \text{ yawned.} \rightsquigarrow$

$$\begin{align*}
\forall (\exists!a[\text{newArrival } a] \land x = a) \\
\land \text{satDown } a \land \text{yawned } x \\
\exists!a[\text{newArrival } a] \land x = a \land \text{satDown } a \land \text{yawned } x
\end{align*}$$
Conclusion and open issues
We predict – correctly in the majority of cases – that cataphora with indefinite antecedents is disallowed in the majority of cases.

(26)  

(a) If a farmer\textsuperscript{x} owns a donkey\textsuperscript{y}, he\textsubscript{x} beats it\textsubscript{y}.

(b) *? If he\textsubscript{x} owns it\textsubscript{y}, a farmer\textsuperscript{x} beats a donkey\textsuperscript{y}.
Chierchia (1995: p. 192) observed that cataphora with indefinite antecedents is surprisingly good in certain cases (see also Barker & Shan 2008).

(27) If John overcooks it\textsubscript{a}, a hamburger\textsubscript{a} usually tastes bad.
We think that there is something different going on here. Notice that cataphora with indefinite antecedents becomes bad in an episodic version of the sentence in (27).

(28) *If John, overcooks it$_a$, a hamburger$^a$ tastes bad.

We suspect that it’s not a coincidence that apparent cataphora with indefinite antecedents seem to be licensed wherever the indefinite antecedent can receive a generic reading.

We think that this case involves a reading of a hamburger under which it is essentially a definite picking out a kind, although this is still a matter for future research.
• Empirically, cataphoric sloppy donkeys provided evidence for genuine cataphoric binding.
• There is a natural tension with arguably the most successful theory of anaphora – dynamic semantics – which is tailored to block genuine semantic binding that proceeds right-to-left.
• Our goal was to account for cataphora without jettisoning the results of dynamic semantics in the domain of anaphora.
• Our hunch was that apparent cataphora with definite antecedents involves anaphora to the *presupposition* introduced by the definite.

• In order to cash out this intuition, we sketched a presuppositional variant of DPL, according to which presuppositions themselves are fully dynamic statements, and therefore can give rise to genuine dynamic binding.

• There are surely further ramifications to making presuppositions dynamic in the way we suggest here. The consequences of this move are the subject of future work.
Thanks for listening!

We’d like to thank Simon Charlow, Ezra Keshet, and reviewers for LENLS 2018 for valuable comments and feedback.

If you have follow-up questions, you can email us at:

- y.sudo@ucl.ac.uk
- elliott@leibniz-zas.de
We predict that in cases where the existential presupposition associated with a definite antecedent can be locally satisfied (Stalnaker 1976, Schlenker 2009, and others), it fails to license cataphora.

First, observe that in a conditional statement, when the presupposition of the consequent is contextually entailed by the presupposition of the antecedent, the conditional statement is globally presuppositionless

(29) If Chomsky is active, then the new Chomsky book is sold out.
We predict therefore that cataphora should be impossible in the following sentence.

(30) Every student who pre-ordered it_α knows that [if Chomsky is active, then his new book_α is sold out].

We’re not sure yet about the empirical facts, so this is a matter for future research.
References


