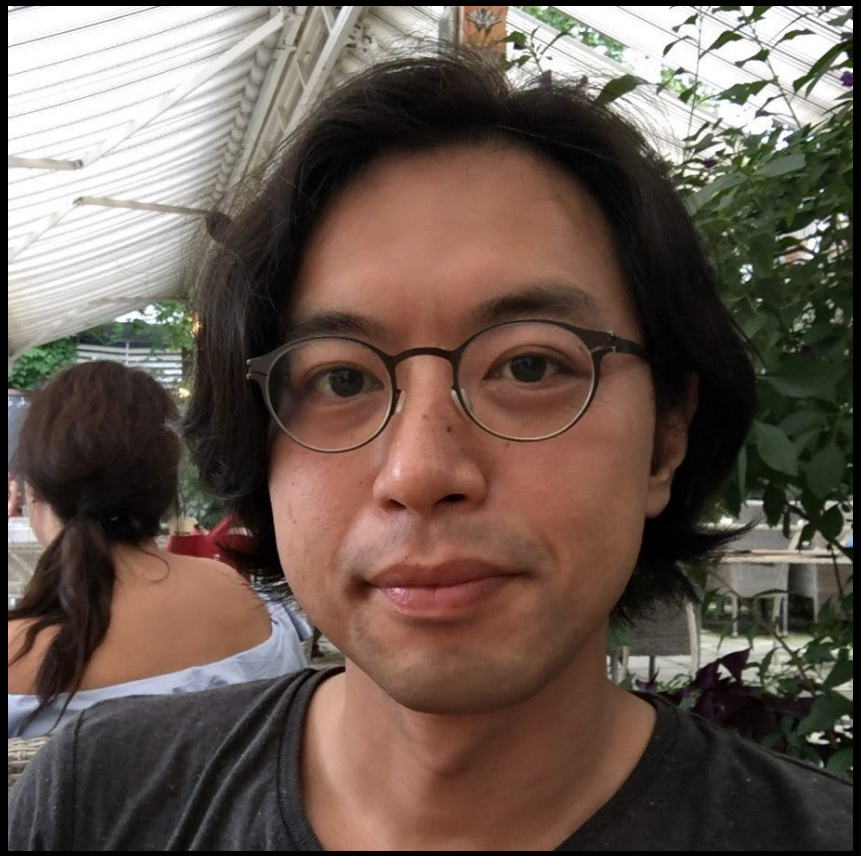
Binding *ex post facto*

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).



Overview i

- 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.

Overview ii

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

The empirical purview of Dynamic Semantics i

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$_{x}$.

The empirical purview of Dynamic Semantics ii

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.

The empirical purview of dynamic semantics iii

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 i

- 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*.

DPL ii

- 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.

$$[t]^f_M = \begin{cases} I(t) & \text{if } t \text{ is a constant} \\ f(t) & \text{if } t \text{ is a variable} \end{cases}$$

DPL iii

Atomic wff are tests – they take an input information state f and return that same information state iff the wff is true wrt f.

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

Negation and equality statements also induce tests.

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

$$f [\![x = y]\!]_M g \Leftrightarrow f = g \text{ and } [x]^f_M = [y]^f_M$$

Recovering truth in DPL

We can define truth simpliciter in DPL by existentially closing the output assignment:

(5) A DPL formula ϕ is true with respect to f iff there is g such that $f [\![\phi]\!] g$.

N.b. we suppress the model parameter from now on.

DPL v

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.

$$f [\![\exists x[\varphi]]\!] g \Leftrightarrow \text{there is } h \text{ such that } f \approx_x h \text{ and } h [\![\varphi]\!] g$$

$f \approx_x h$ means assignments f and h are different at most in the value they assign to x

DPL vi

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.

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

$$f [\![(\phi \wedge \psi)]\!] g \Leftrightarrow f [\![\phi]\!]_M h \text{ and } h [\![\psi]\!]_M g \text{ for some } h$$

Conjunction takes an input information state f feeds it into ϕ, and feeds the output h into the second conjunct ψ, returning g.

Cross-sentential anaphora in DPL

Random assignment and dynamic conjunction interact in order to license cross-sentential anaphora.

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

$\rightsquigarrow (\exists x[\text{man}\, x \wedge \text{walkedIn}\, x] \wedge \text{satDown}\, x)$

b. $f [\![(\exists x[\text{man}\, x \wedge \text{walkedIn}\, x] \wedge \text{satDown}\, x)]\!] g$

$\Leftrightarrow$ $f \approx_x g$ and $g(x) \in I(\text{man})$ and $g(x) \in I(\text{walkedIn})$ 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.

Blocking cataphora

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$_a$ sat down. A^a man walked in.

$\rightsquigarrow (\text{satDown}\, x \wedge \exists x[\text{man}\, x \wedge \text{walkedIn}\, x])$

b. $f [\![(\text{satDown}\, x \wedge \exists x[\text{man}\, x \wedge \text{walkedIn}\, x])]\!] g$

$\Leftrightarrow$ $x \in \text{dom}(f)$ and $f(x) \in I(\text{satDown})$ and $f \approx_x g$ and $g(x) \in I(\text{man})$ 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

Apparent cataphora with definite antecedents

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$_a$
bought $\{$ # a^a | the^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.

Apparent cataphora with definite antecedents ii

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.

Background on the strict-sloppy ambiguity

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
$\left\{\begin{array}{ll}\langle\text{meet Ivan's student}\rangle & \text{strict}\\ \langle\text{meet Jorge's student}\rangle & \text{sloppy}\end{array}\right.$
too

For expository purposes, we adopt a deletion view on ellipsis and indicate the elided material as ⟨ellipsis⟩.

Background on the strict-sloppy ambiguity ii

The Sag-Williams generalization

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

(10) Ivan^{x} met his$_{x/*y}$ student,
and Jorge^{z} did ⟨meet his$_{z}$ student⟩ 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 $\overbrace{\text{Tanya met his}_{x}\text{ student}}^{\text{no binding in the antecedent}}$,
and SHE said that JORGE did ⟨meet Jorge's student⟩ too.

Even more straightforward evidence:

(12) * Ivan met Ivan's student,
and Jorge did ⟨meet Jorge's student⟩ too.

Sloppy donkeys

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 ⟨loves it$_{y}$⟩ too.

The claim that licensing of sloppy identity is a property of anaphora in general, including dynamic anaphora, is due to Hardt (1999).

Cataphora licenses sloppy identity i

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.

Cataphora licenses sloppy identity ii

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 it$_a$
bought CHOMSKY's book^a,
and every PHILOSOPHY professor who did
⟨want to read 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.

Crossover i

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) ⟨Chomsky's book^{a}⟩ [Every linguistics professor who wanted to read it$_{a}$ bought Chomsky's book$_{a}$]

Conceptual objection

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) $^{*}\langle$A woman$^{a}\rangle$ [she$_{a}$ walked in and a woman$_{a}$ sat down]

Since indefinites can take exceptional scope, if we allow crossover configurations we risk letting in cataphora with indefinite antecedents.

Empirical objection

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 it_a]^x printed out [his_x dissertation]^a, and [every professor who wanted Robyn to ⟨read it_b⟩]^x printed out [his_x first journal article]^b.

Analysis

Overview i

- 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.

Presuppositional DPL i

- From now on, English sentences are translated into a pair of DPL statements.
- In $\frac{\phi}{\psi}$, ϕ represents the presupposition and ψ the at-issue meaning.
- $\frac{\phi}{\psi}$ is a partial function over information states whose domain is $\{ i \mid i [\![\phi]\!] j \text{ for some } j \}$.

Presuppositional DPL ii

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) The$^{a}_{x}$ new book is sold out.

(19) $$\frac{\exists!a[\text{newBook}\,a] \wedge x = a}{\text{soldOut}\,x}$$

Auxiliary definition:

(20) $\exists!x[\phi] \coloneqq \exists x[\phi \wedge \neg\exists y[\phi[x/y] \wedge x \neq y]]$ where ϕ is free for y

Presuppositional DPL iii

Similarly, we assume that other definite phrases such as proper names and pronominals can also in principle have existential presuppositions.

(21) a. Paul^{a}_{x} sat down $\rightsquigarrow \dfrac{\exists! a[x = a] \wedge x = \text{Paul}}{\text{satDown}\, x}$

b. He^{a}_{x} sat down $\rightsquigarrow \dfrac{\exists! a[x = a]}{\text{satDown}\, x}$

Presuppositional DPL iv

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. T here is a trivial identity test, i.e. $i[\mathsf{T}]j :\Leftrightarrow i = j$.

(22) $$\mathbb{A}\left(\frac{\phi}{\psi}\right) := \frac{\mathsf{T}}{\phi \wedge \psi}$$

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

Accounting for cataphora i

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) $$\frac{\pi}{\alpha} \wedge \frac{\psi}{\beta} := \frac{\pi \wedge \psi}{\alpha \wedge \beta}$$

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. he_a sat down $\rightsquigarrow$ satDown a

b. the new arrival^a_x yawned $\rightsquigarrow$ $\dfrac{\exists! a[\text{newArrival}\, a] \wedge x = a}{\text{yawned}\, x}$

c. He_a sat down. The new arrival^a_x yawned. $\rightsquigarrow$

$$\mathbb{A}\left(\frac{\exists! a[\text{newArrival}\, a] \wedge x = a}{\text{satDown}\, a \wedge \text{yawned}\, x}\right)$$
$$= \exists! a[\text{newArrival}\, a] \wedge x = a \wedge \text{satDown}\, a \wedge \text{yawned}\, x$$

Conclusion and open issues

Cataphora with indefinite antecedents i

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^{x} owns a donkey^{y}, he$_{x}$ beats it$_{y}$.

b. *? If he$_{x}$ owns it$_{y}$, a farmer^{x} beats a donkey^{y}.

Cataphora with indefinite antecedents ii

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$_a$, a hamburger^a usually tastes bad.

Cataphora with indefinite antecedents iii

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.

Summing up i

- 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*.

Summing up ii

- 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.

Acknowledgements and thanks

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

Prediction: local satisfaction bleeds cataphora

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_a knows that
[if Chomsky is active, then his new book_x^a is sold out].

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

References

Barker, Chris & Chung-chieh Shan. 2008. Donkey anaphora is in-scope binding. *Semantics and Pragmatics* 1.

Beaver, David I. 2001. *Presupposition and assertion in dynamic semantics.* (Studies in logic, language, and information). Stanford, California: CSLI. 314 pp.

Charlow, Simon. 2012. Cross-categorial donkeys. In Maria Aloni et al. (eds.), *Logic, language and meaning* (Lecture Notes in Computer Science), 261–270. Springer Berlin Heidelberg.

Chierchia, Gennaro. 1995. *Dynamics of meaning: Anaphora, presupposition, and the theory of grammar*. Chicago: University of Chicago Press. 270 pp.

Fox, Danny & Shoichi Takahashi. 2005. Proceedings of SALT 15. 223–240.

Groenendijk, Jeroen & Martin Stokhof. 1991. Dynamic predicate logic. *Linguistics and Philosophy* 14(1). 39–100.

Hardt, Daniel. 1999. Dynamic interpretation of verb phrase ellipsis. *Linguistics and Philosophy* 22(2). 185–219.

- Heim, Irene. 1982. *The semantics of definite and indefinite noun phrases*. 2011 edition - typesetting by Anders J. Schoubye and Ephraim Glick. University of Massachusetts - Amherst dissertation.
- Heim, Irene. 1992. Presupposition projection and the semantics of attitude verbs. *Journal of Semantics* 9(3). 183–221.
- Kamp, Hans. 1981. A theory of truth and semantic representation. In Paul Portner & Barbara H. Partee (eds.), *Formal semantics: The essential readings*, 189–222. Blackwell.
- Sag, Ivan. 1976. *Deletion and logical form*. Massachussetts Institute of Technology dissertation.
- Schlenker, Philippe. 2009. Local contexts. *Semantics and Pragmatics* 2.
- Stalnaker, Robert. 1976. Propositions. In A. F. MacKay & D. D. Merrill (eds.), *Issues in the philosophy of language*, 79–91. New Haven: Yale University Press.
- Tomioka, Satoshi. 1999. A sloppy identity puzzle. *Natural Language Semantics* 7(2). 217–241.


Williams, Edwin S. 1977. Discourse and logical form. *Linguistic Inquiry* 8(1). 101–139.