Scope parallelism in coordination in Dependent Type Semantics

Yusuke Kubota[1] and Robert Levine[2]

[1] University of Tsukuba, Ohio State University
<kubota.yusuke.fn@u.tsukuba.ac.jp>
[2] Ohio State University <levine@ling.ohio-state.edu>

Abstract. The scope parallelism in the so-called Geach sentences in right-node raising (*Every boy admires, and every girl detests, some saxophonist*) poses a difficult challenge to many analyses of right-node raising, including ones formulated in the type-logical variants of categorial grammar (e.g. Kubota and Levine (2015)). In this paper, we first discuss Steedman's (2012) solution to this problem in Combinatory Categorial Grammar, and point out some empirical problems for it. We then propose a novel analysis of the Geach problem within Hybrid Type-Logical Categorial Grammar (Kubota and Levine 2015), by incorporating Dependent Type Semantics (Bekki 2014) as the semantic component of the theory. The key solution for the puzzle consists in linking quantifiers to the argument positions that they correspond to via an anaphoric process. Independently motivated mechanisms for anaphora resolution in DTS then automatically predicts the scope parallelism in Geach sentences as a consequence of binding parallelism independently observed in right-node raising sentences.

Keywords: scope parallelism, coordination, right-node raising, Hybrid Type-Logical Categorial Grammar, Dependent Type Semantics

1 Scope parallelism in coordination and Type-Logical Categorial Grammar

In his recent book, Steedman (2012) offers what at first sight appears to be an elegant account of the scope parallelism in examples like (1), first noted by Geach (1972):

(1) Every boy admires, and every girl detests, some saxophonist.
$(\forall > \exists \wedge \forall > \exists; \exists > \forall \wedge \exists > \forall)$

(1) has only the two readings shown above, and crucially, lacks readings in which the right-node raised (RNR'ed) existential scopes above the universal in one conjunct but below it in the other conjunct.

Steedman's own account of this problem hinges on his treatment of indefinites as underspecified Skolem functions. In Steedman's approach, indefinites are translated as Skolem functions whose values can be fixed via an operation called 'Skolem specification' at different points in the derivation, potentially affecting their interpretations. For example, in a simple non-RNR sentence like (2), we obtain different interpretations based on whether Skolem specification takes place at ♣ or ♠.

(2)

$$\dfrac{\dfrac{\dfrac{\dfrac{\text{Every farmer}}{S/(NP\backslash S)} \quad \dfrac{\text{owns}}{(NP\backslash S)/NP}}{\begin{array}{cc}: \lambda p.\forall y[farmer'y \rightarrow py] & : \lambda x.\lambda y.own'xy\end{array}}}{S/NP : \lambda x.\forall y[farmer'y \rightarrow own'xy]}{>}\mathrm{B} \quad \dfrac{\text{a donkey}}{(S/NP)\backslash S}\clubsuit \;\; : \lambda q.q(skolem'donkey')}{\dfrac{S : \forall y[farmer'y \rightarrow own'(skolem'donkey')y]}{S : \forall y[farmer'y \rightarrow own'sk^{(y)}_{donkey'}y]}\spadesuit}<$$

In the derivation illustrated in (2), Skolem specification takes place at ♠. This has the effect that the interpretation of the Skolem function depends on the value of the variable bound by the outscoping universal (as indicated by the superscript y). This yields the $\forall > \exists$ reading, where there can be different donkeys corresponding to different farmers. In an alternative derivation in which Skolem specification takes place at an earlier point in the derivation ♣, the Skolem function is not under the scope of the universal. In this case the Skolem function is assigned a constant value, corresponding to wide scope for the existential.

In the case of a more complex derivation involving RNR, the same early specification of the Skolem function has the effect of giving the existential interpretation associated with the resulting skolem constant wide scope over the entire conjunction within which the universal quantifiers take scope. As a result, the existential inevitably winds up outscoping these universals—a possibility illustrated in the following derivation (Steedman 2012: 166):

(3)

$$\dfrac{\dfrac{\text{Every boy admires and every girl detests}}{\begin{array}{c}S/NP\\ : \lambda x.\forall y.[boy'y \rightarrow admires'xy] \wedge \forall z[girl'z \rightarrow detests'xz]\end{array}} \quad \dfrac{\text{some saxophonist}}{\begin{array}{c}S\backslash(S/NP)\\ : \lambda q.q(skolem'sax')\\ \cdots\cdots\cdots\\ : \lambda q.q(sk_{sax'})\end{array}}}{S : \forall y.[boy'y \rightarrow admires'sk_{sax'}y] \wedge \forall z[girl'z \rightarrow detests'sk_{sax'}z]}<$$

The identical Skolem constant $sk_{sax'}$ appearing in each conjunct entails the existence of a single constant saxophonist that is the target of admiration in the first conjunct and detestation in the second, and hence corresponds to an existential scoping widely over the conjunction. For an RNR sentence, another possibility is to wait to state the Skolem specification till after the RNRed existential is β-converted into the position of the x variable in each conjunct. At that point, the Skolem term is under the scope of the universal in each conjunct, and hence receives an interpretation dependent on the universally bound y and z variables, corresponding to the $\forall > \exists$ reading in both conjuncts.

The CCG analysis of RNR thus ensures that the source of scope ambiguity in RNR sentences is exactly the same as in simpler sentences like (2) (with positions in the derivation corresponding to ♣ and ♠ yielding two distinct readings).

Crucially, there is no way to 'split' the derivational step at which Skolem specification takes place in the two conjuncts in an RNR sentence. It then follows that 'mixed scope' readings are ruled out automatically.

However, a closer look suggests that the same aspects of Steedman's approach which blocks the mixed-scope reading in Geach sentences lead to some serious undergeneration problems. As already noted, in Steedman's analysis, there are only two possibilities: either Skolem specification occurs after the Skolem function combines with (and falls under the scope of) the universal quantifier, or it occurs at an earlier step, in which case we obtain the wide-scope reading for the existential along the lines illustrated in (3). In other words, the only way for the Skolem function to distribute over the conjunction—i.e., for the latter to outscope it—is for the function to be specified after it falls under the scope of the universal in both conjuncts, in which case the universal will always outscope it.

But it is not difficult to find instances of RNR with a reading in which the conjunction outscopes the Skolem function but where the latter takes wide scope over the universal in each conjunct. Consider the example in (4).

(4) Every American respects, and every Japanese admires, some novelist—namely, their respective most recent Nobel Prize winner.

The relevant reading can be paraphrased as 'There is some American novelist such that every American respects that novelist and there is some Japanese novelist such that every Japanese respects that novelist'. The existential distributes over the conjunction, but within each conjunct it takes widest scope.

The Skolem function analysis of existentials cannot capture the salient reading of (4). CCG could perhaps be extended to license cases such as (4) by taking existentials to have lexical entries not only as Skolem functions but as standard generalized quantifiers, and assuming a higher-order polymorphic category for RNR (e.g., conjunction of $S/((S/NP)\backslash S)$). However, at least the first of these assumptions is severely at odds with the core premises of Steedman's own analysis of indefinites.

Another problem comes from examples such as (5):

(5) Every boy in that prep school started going out steadily with, and every one of his relatives ended up having serious reservations about his marrying, some totally unsophisticated rural girl.

This sentence is most naturally understood on the $\forall_{\mathbf{boy}} > \exists_{\mathbf{girl}} > \forall_{\mathbf{relative}}$ reading, which requires having the universal quantifier in the first conjunct scope over the whole coordinate structure, thereby binding the pronoun in the restriction of the universal in the second conjunct. But since in typical cases universals scope only within their conjuncts, Steedman (2012) builds supposedly syntactic island restrictions including the Coordinate Structure Constraint into his combinatorics for quantifier interpretation. This prevents quantifiers from scoping out of the conjuncts they occur in. A reading of this sentence in which the quantifier in the first conjunct scopes over the whole coordinate structure is therefore underivable.[3]

Unlike CCG, Type-Logical Categorial Grammar (TLCG) does not suffer from undergeneration, but it suffers from overgeneration. Specifically, in TLCG, without constraining quantifier scope relations, the mixed readings are licensed. Here, we illustrate this problem with the treatment of quantifier/RNR interactions in Hybrid TLCG (Kubota and Levine 2015; K&L). In what follows, we assume basic familiarity with Hybrid TLCG. For further details, see Kubota and Levine (2015).

The overgeneration issue becomes clear once we see how the existential narrow scope reading is obtained in K&L's fragment. This part of their proof rests on the 'slanting' lemma, from which type specifications for quantifiers involving directional (i.e. forward and backward) slashes—including those separately

---

[3] In connection to this point, note that Steedman (2012) cites the following example from Fox (2000: 51–54):

(i) Some student likes every professor and hates her assistant.

which (apparently) has a reading in which *her* is bound by *every professor*. Steedman suggests that this may not be a real instance of bound anaphora and that perhaps 'something other than compositional semantics is at work' (Steedman 2012: 173) here, since the possessive can be replaced with an epithet such as *the old dear's* (which according to Steedman (2012) normally resists bound variable constuals) with the same reading preserved. If compositional semantics is not responsible for the relevant interpretation of (i), it is not clear what else is, and Steedman (2012) does not elaborate on this point any further anywhere in the whole book.

Moreover, the assumption that epithets in general cannot support real bound anaphoric interpretation seems questionable, even though such a claim is pervasive in the literature, based on the alleged evidence that such construals are unavailable in c-commanded positions in examples such as the following (see, for example, Déchaine and Wiltschko (2014)):

(ii) *Every woman$_i$ was outraged that the bitch$_i$ was underpaid.

But note that the following example is fine on the bound variable construal even with the epithet in a clearly c-commanded position:

(iii) Every [two-bit drug dealer we pull in]$_i$ is going to hear it from me that [the son-of-a-bitch]$_i$ is going to prison when this is all over.

We take it that the contrast between (iii) and (ii) should be explained in terms of difference in perspectives and that the unacceptability of (ii) does not provide any evidence for the assumption that epithets are different from pronouns in their ability to induce bound variable readings.

In any event, Steedman's (2012) account of (i), whatever one makes of it, does not seem to extend to the case of (5) in any event, since at least for the second author of the present paper, replacing *his relatives* with *the lad's relatives* in (5) does not preserve the bound-variable reading.

listed in the lexicon in CCG—all follow. For example, we can derive a directionally slashed version for an object quantified NP in English as follows:

(6)

$$\dfrac{\lambda\sigma.\sigma(\mathsf{someone});\ \mathbf{\exists_{person}};\ S{\upharpoonright}(S{\upharpoonright}NP) \quad \dfrac{\dfrac{[\varphi_2; P; S/NP]^2 \quad [\varphi_1; x; NP]^1}{\varphi_2 \circ \varphi_1;\ P(x);\ S}\backslash E}{\lambda\varphi_1.\varphi_2 \circ \varphi_1;\ \lambda x.P(x);\ S{\upharpoonright}NP}{\upharpoonright}I^1}{\dfrac{\varphi_2 \circ \mathsf{someone};\ \mathbf{\exists_{person}}(\lambda x.P(x));\ S}{\mathsf{someone};\ \lambda P.\mathbf{\exists_{person}}(\lambda x.P(x));\ (S/NP)\backslash S}\backslash I^2}{\upharpoonright}E$$

The last line is identical to the lexical entry that Steedman posits for a quantifier in direct object position, but which, in Hybrid TLCG, is simply a consequence of the S↾(S↾NP) type under the inference rules of the hybrid calculus.

We can then derive an expression subcategorizing for a 'slanted' quantifier (e.g. (6)) in the object position:

(7)

$$\dfrac{\dfrac{\dfrac{\dfrac{\begin{matrix}\vdots & \vdots\\ \varphi_2 \circ \mathsf{admires};\ \lambda w.\mathbf{admire}(w)(v);\ S/NP\end{matrix} \quad [\varphi_1; cV; (S/NP)\backslash S]^1}{\varphi_2 \circ \mathsf{admires} \circ \varphi_1;\ \mathscr{V}(\lambda w.\mathbf{admire}(w)(v));\ S}}{\lambda\varphi_2.\varphi_2 \circ \mathsf{admires} \circ \varphi_1;\ \lambda v.\mathscr{V}(\lambda w.\mathbf{admire}(w)(v));\ S{\upharpoonright}NP} \quad \begin{matrix}\lambda\sigma_1.\sigma_1(\mathsf{every} \circ \mathsf{boy});\\ \mathbf{\forall_{boy}};\ S{\upharpoonright}(S{\upharpoonright}NP)\end{matrix}}{\mathsf{every} \circ \mathsf{boy} \circ \mathsf{admires} \circ \varphi_1;\ \mathbf{\forall_{boy}}(\lambda v.\mathscr{V}(\lambda w.\mathbf{admire}(w)(v)));\ S}}{\mathsf{every} \circ \mathsf{boy} \circ \mathsf{admires};\ \lambda\mathscr{V}.\mathbf{\forall_{boy}}(\lambda v.\mathscr{V}(\lambda w.\mathbf{admire}(w)(v)));\ S/((S/NP)\backslash S)}$$

Two or more such signs can be conjoined to produce functor of the same type, which will take the directionally slashed quantifier term as its argument, as for example in (8):

(8) $\mathbf{\forall_{boy}}(\lambda z.\mathbf{\exists_{saxist}}(\lambda x.\mathbf{admire}(x)(z))) \wedge \mathbf{\forall_{girl}}(\lambda z.\mathbf{\exists_{saxist}}(\lambda x.\mathbf{detest}(x)(z)))$

However, this analysis also overgenerates the mixed readings since the type S/((S/NP)\S) sign for the conjunct can be associated with a different scoping relation between the two quantifiers:

(9)

$$\dfrac{\dfrac{\dfrac{\begin{matrix}\vdots & \vdots\\ \mathsf{every} \circ \mathsf{girl} \circ \mathsf{detests} \circ \varphi_1;\ \mathbf{\forall_{girl}}(\lambda y.\mathbf{detest}(u)(y));\ S\end{matrix}}{\mathsf{every} \circ \mathsf{girl} \circ \mathsf{detests};\ \lambda u.\mathbf{\forall_{girl}}(\lambda y.\mathbf{detest}(u)(y));\ S/NP} \quad [\varphi_2; \mathscr{U}; (S/NP)\backslash S]^1}{\mathsf{every} \circ \mathsf{girl} \circ \mathsf{detests} \circ \varphi_2;\ \mathscr{U}(\lambda u.\mathbf{\forall_{girl}}(\lambda y.\mathbf{detest}(u)(y)));\ S}}{\mathsf{every} \circ \mathsf{girl} \circ \mathsf{detests};\ \lambda\mathscr{U}.\mathscr{U}(\lambda u.\mathbf{\forall_{girl}}(\lambda y.\mathbf{detest}(u)(y)));\ S/((S/NP)\backslash S)}$$

Conjoining (9) and (7) yields a functor taking (6) as an argument to give rise to a mixed reading.

We are thus left in the unsatisfactory situation of either blocking mixed readings for Geach sentences but undergenerating (4) and (5) via the CCG analysis, or licensing (4) and (5) while overgenerating the mixed Geach reading via Hybrid TLCG. In the latter case, the source of the problem is that in its current formulation, Hybrid TLCG has no way to ensure that the bound higher order variables in each conjunct, corresponding to the RNR'ed generalized quantifier argument of the conjunction, have parallel scope with regard to the other quantifier term in their respective conjunct. As things stand, given the inherent lack of correlation between how hypothetical reasoning is carried out in two different parts of a proof, it is difficult to see how this parallelism could be enforced. In the following section, therefore, we argue for an analysis of quantifier interpretation which is quite different from the standard assumptions common across the various different versions of TLCG.

2 Scope parallelism as binding parallelism in Dependent Type Semantics

We adopt Dependent Type Semantics (DTS; Bekki (2014)) as the compositional semantic theory for Hybrid TLCG to solve the overgeneration problem. DTS is a proof-theoretic compositional dynamic semantics based on Dependent Type Theory (Martin-Löf 1984).

2.1 Anaphora in DTS

We start by illustrating the analysis of anaphora resolution in DTS with (10):

(10) A man entered. He sat down.

DTS assigns the following semantic translation for the above mini-discourse:

(11)
$$\lambda c. \begin{bmatrix} v : \begin{bmatrix} u : \begin{bmatrix} x : \mathbf{Ent} \\ \mathbf{Man}(x) \end{bmatrix} \\ \mathbf{Enter}(\pi_1 u) \end{bmatrix} \\ \mathbf{Sit\text{-}down}(@_1(c, v)) \end{bmatrix}$$

Here u is a proof term of the dependent sum type $\begin{bmatrix} x : \mathbf{Ent} \\ \mathbf{Man}(x) \end{bmatrix}$ (roughly corresponding to the existential quantification $\exists x.\mathbf{Man}(x)$; we sometimes abbreviate this as $[(x : \mathbf{Ent}) \times \mathbf{Man}(x)]$ below). The existence of this proof term means that there is a proof that x is of type **Ent** (entity) and that x is a man. Unlike existential quantification, since u is technically just a pair, its components can be referenced by projection functions. Thus, $\pi_1 u$ corresponds to the variable x, and this means that v is (roughly) a proof that the proposition $\exists x.[\mathbf{Man}(x) \wedge \mathbf{Enter}(x)]$ is true. Finally, pronouns encode underspecified proof terms with the @ operator (which comes with indices to impose certain identity conditions; see below for its use). Resolving this underspecification amounts to resolving anaphora. In (11), a context (formally modelled as a pair) consisting of the previous discourse context c and the whole proof term for the immediately preceding sentence (v) is passed on to $@_1$ as an argument. By instantiating this underspecified term as $@_1 = \lambda c.\pi_1\pi_1\pi_2 c$, we obtain the intended reading for (10), where the individual that sat down is the man who entered (note that with this resolution, $@_1(c, v)$ corresponds to x).

2.2 Mixed binding problem solved

DTS solves an important overgeneration issue in a previous approach to anaphora resolution in a proof theoretic setup by Krahmer and Piwek (Krahmer and Piwek 1999, Piwek and Krahmer 2000), which incorrectly licenses the mixed binding reading ('John loves his own father and Bill loves somebody else's father') for the following example:

(12) Each of John and Bill loves his father.

Specifically, the following representation is assigned as the meaning for (12) in Bekki's (2014) approach:

(13)
$$\lambda c.\mathbf{L}(\mathbf{j}, \pi_1((@_1 : \gamma_1 \to \begin{bmatrix} x : \mathbf{Ent} \\ \mathbf{FatherOf}(x, (@_0 : \gamma_0 \to e)(c, \mathbf{j})) \end{bmatrix})(c, \mathbf{j})))$$
$$\wedge\mathbf{L}(\mathbf{b}, \pi_1((@_1 : \gamma_1 \to \begin{bmatrix} x : \mathbf{Ent} \\ \mathbf{FatherOf}(x, (@_0 : \gamma_0 \to e)(c, \mathbf{b})) \end{bmatrix})(c, \mathbf{b})))$$

The crucial assumption here is that the $@_0$ operator corresponding to the pronoun *his* is resolved in the same way. By resolving it as $@_0 = \pi_2$ we obtain the parallel sloppy reading. If, by contrast, $@_0$ is resolved in some other way to pick up some antecedent from the discourse (represented by the context variable c), then a parallel strict reading is obtained. Crucially, because of the coindexing (by the subscript 0) of the $@_0$ operator, $@_0$ is to be instantiated in exactly the same way in its two occurrences in the two conjuncts. Thus, mixed binding readings are ruled out.

As we show below, our own solution for the Geach problem below crucially relies on DTS's solution for the mixed binding problem.

2.3 HTLCG+DTS

We now present a fragment adopting DTS as the dynamic compositional semantics theory for Hybrid TLCG (HTLCG+DTS). HTLCG+DTS is modelled after Bekki's (2014) fragment combining CCG and DTS (CCG+DTS) and mostly involves straightforward translation of Bekki's CCG lexicon to Hybrid TLCG. The only major difference is that the lexical assignments of quantifiers and pronouns with directional slashes are replaced by ones with the vertical slash (of type $S{\upharpoonright}(S{\upharpoonright}NP)$):

(14) a. $\lambda\varphi\lambda\sigma.\sigma(\mathsf{every} \circ \varphi)$; $\lambda P\lambda Q\lambda c.(u : [(x : \mathbf{Ent}) \times Pxc]) \to Q(\pi_1 u)(c, u)$; $S{\upharpoonright}(S{\upharpoonright}NP){\upharpoonright}N$

b. $\lambda\varphi\lambda\sigma.\sigma(\mathsf{some} \circ \varphi)$; $\lambda P\lambda Q\lambda c.\begin{bmatrix} u : [(x : \mathbf{Ent}) \times Pxc] \\ Q(\pi_1 u)(c, u) \end{bmatrix}$; $S{\upharpoonright}(S{\upharpoonright}NP){\upharpoonright}N$

c. $\lambda\sigma.\sigma(\mathsf{it})$; $\lambda P\lambda c.P(@_1 c)(c, @_1 c)$; $S{\upharpoonright}(S{\upharpoonright}NP)$

We can now analyze the donkey sentence *Every farmer who owns a donkey beats it* as in (15), which yields exactly the same translation as Bekki's CCG+DTS fragment.

(15)

$$\dfrac{\lambda\varphi\lambda\sigma.\sigma(\mathsf{every}\circ\varphi);\ \lambda P\lambda Q\lambda c.\left(v:\begin{bmatrix}x:\mathbf{Ent}\\ Pxc\end{bmatrix}\right)\to Q(\pi_1 v)(c,v);\ \mathrm{S}\upharpoonright(\mathrm{S}\upharpoonright\mathrm{NP})\upharpoonright\mathrm{N} \qquad \dfrac{\mathsf{farmer};\ \lambda x\lambda c.\mathbf{F}x;\ \mathrm{N} \qquad \dfrac{\lambda\sigma.\mathsf{who}\circ\sigma(\varepsilon);\ \lambda P\lambda Q\lambda x\lambda c.Qxc\wedge Pxc;\ (\mathrm{N}\backslash\mathrm{N})\upharpoonright(\mathrm{S}\upharpoonright\mathrm{NP}) \qquad \dfrac{\dfrac{\begin{matrix}\vdots\ \vdots\\ \lambda\sigma.\sigma(\mathsf{a}\circ\mathsf{donkey});\ \lambda Q\lambda c.\begin{bmatrix}u:\begin{bmatrix}y:\mathbf{Ent}\\ \mathbf{D}y\end{bmatrix}\\ Q(\pi_1 u)(c,u)\end{bmatrix};\ \mathrm{S}\upharpoonright(\mathrm{S}\upharpoonright\mathrm{NP})\end{matrix} \qquad \dfrac{\begin{bmatrix}\varphi_1;\\ x;\\ \mathrm{NP}\end{bmatrix}^1 \ \begin{bmatrix}\varphi_2;\\ y;\\ \mathrm{NP}\end{bmatrix}^2\\ \vdots\ \vdots\ \vdots\ \vdots}{\lambda\varphi_2.\varphi_1\circ\mathsf{owns}\circ\varphi_2;\ \lambda y\lambda c.\mathbf{O}(x,y);\ \mathrm{S}\upharpoonright\mathrm{NP}}}{\varphi_1\circ\mathsf{owns}\circ\mathsf{a}\circ\mathsf{donkey};\ \lambda c.\begin{bmatrix}u:[(y:\mathbf{Ent})\times\mathbf{D}y]\\ \mathbf{O}(x,\pi_1 u)\end{bmatrix};\ \mathrm{S}}}{\lambda\varphi_1.\varphi_1\circ\mathsf{owns}\circ\mathsf{a}\circ\mathsf{donkey};\ \lambda x\lambda c.\begin{bmatrix}u:[(y:\mathbf{Ent})\times\mathbf{D}y]\\ \mathbf{O}(x,\pi_1 u)\end{bmatrix};\ \mathrm{S}\upharpoonright\mathrm{NP}}}{\mathsf{who}\circ\mathsf{owns}\circ\mathsf{a}\circ\mathsf{donkey};\ \lambda Q\lambda x\lambda c.Qxc\wedge\begin{bmatrix}u:[(y:\mathbf{Ent})\times\mathbf{D}y]\\ \mathbf{O}(x,\pi_1 u)\end{bmatrix};\ \mathrm{N}\backslash\mathrm{N}}}{\mathsf{farmer}\circ\mathsf{who}\circ\mathsf{owns}\circ\mathsf{a}\circ\mathsf{donkey};\ \lambda x\lambda c.\mathbf{F}x\wedge\begin{bmatrix}u:[(y:\mathbf{Ent})\times\mathbf{D}y]\\ \mathbf{O}(x,\pi_1 u)\end{bmatrix};\ \mathrm{N}}}{\lambda\sigma.\sigma(\mathsf{every}\circ\mathsf{farmer}\circ\mathsf{who}\circ\mathsf{owns}\circ\mathsf{a}\circ\mathsf{donkey});\ \lambda Q\lambda c.\left(v:\begin{bmatrix}x:\mathbf{Ent}\\ \mathbf{F}x\wedge\begin{bmatrix}u:[(y:\mathbf{Ent})\times\mathbf{D}y]\\ \mathbf{O}(x,\pi_1 u)\end{bmatrix}\end{bmatrix}\right)\to Q(\pi_1 v)(c,v);\ \mathrm{S}\upharpoonright(\mathrm{S}\upharpoonright\mathrm{NP})}$$

$$\dfrac{\begin{matrix}\vdots\ \vdots\\ \lambda\sigma.\sigma(\mathsf{every}\circ\mathsf{farmer}\circ\mathsf{who}\circ\mathsf{owns}\circ\mathsf{a}\circ\mathsf{donkey});\\ \lambda Q\lambda c.\left(v:\begin{bmatrix}x:\mathbf{Ent}\\ \mathbf{F}x\wedge\begin{bmatrix}u:[(y:\mathbf{Ent})\times\mathbf{D}y]\\ \mathbf{O}(x,\pi_1 u)\end{bmatrix}\end{bmatrix}\right)\to Q(\pi_1 v)(c,v);\ \mathrm{S}\upharpoonright(\mathrm{S}\upharpoonright\mathrm{NP})\end{matrix} \qquad \dfrac{\dfrac{\lambda\sigma.\sigma(\mathsf{it});\ \lambda P\lambda c.P(@_1 c)(c,@_1 c);\ \mathrm{S}\upharpoonright(\mathrm{S}\upharpoonright\mathrm{NP}) \qquad \dfrac{\begin{bmatrix}\varphi_3;\\ z;\mathrm{NP}\end{bmatrix}^3\ \begin{bmatrix}\varphi_4;\\ w;\mathrm{NP}\end{bmatrix}^4\\ \vdots\ \vdots\ \vdots\ \vdots}{\lambda\varphi_4.\varphi_3\circ\mathsf{beats}\circ\varphi_4;\ \lambda w\lambda c.\mathbf{B}(z,w);\ \mathrm{S}\upharpoonright\mathrm{NP}}}{\varphi_3\circ\mathsf{beats}\circ\mathsf{it};\ \lambda c.\mathbf{B}(z,@_1 c);\ \mathrm{S}}}{\lambda\varphi_3.\varphi_3\circ\mathsf{beats}\circ\mathsf{it};\ \lambda z\lambda c.\mathbf{B}(z,@_1 c);\ \mathrm{S}\upharpoonright\mathrm{NP}}}{\mathsf{every}\circ\mathsf{farmer}\circ\mathsf{who}\circ\mathsf{owns}\circ\mathsf{a}\circ\mathsf{donkey}\circ\mathsf{beats}\circ\mathsf{it};\ \lambda c.\left(v:\begin{bmatrix}x:\mathbf{Ent}\\ \mathbf{F}x\wedge\begin{bmatrix}u:[(y:\mathbf{Ent})\times\mathbf{D}y]\\ \mathbf{O}(x,\pi_1 u)\end{bmatrix}\end{bmatrix}\right)\to\mathbf{B}(\pi_1 v,@_1(c,v));\ \mathrm{S}}$$

As in Bekki's (2014) analysis, by instantiating the $@_1$ operator as $@_1 = \lambda c.\pi_1\pi_1\pi_2\pi_2\pi_2 c$, we obtain the reading in which the pronoun refers to the donkey.

2.4 Geach problem solved

The intuition behind our analysis of Geach sentences is that the derivation for the mixed reading for (1) fails for the same reason that mixed readings for pronouns is ruled out in coordination contexts, as illustrated above for the case of ordinary constituent coordination. This was in fact one of the key motivations for the use of the @ operator for anaphora resolution in DTS. The same binding parallelism extends to RNR contexts, as noted by Jacobson (1999):

(16) Every Englishman respects, and every American loves, his mother.

The following translation is assigned to (16) by assuming the direct constituent coordination analysis of RNR standard in many variants of CG:

(17)
$$\lambda c.(u : \begin{bmatrix} x : \mathbf{Ent} \\ \mathbf{E}(x) \end{bmatrix}) \to \mathbf{R}(\pi_1 u, \pi_1((@_1 : \gamma_1 \to \begin{bmatrix} y : \mathbf{Ent} \\ \mathbf{M}(y, (@_0 : \gamma_0 \to e)(c, u)) \end{bmatrix})(c, u)))$$
$$\wedge (u : \begin{bmatrix} x : \mathbf{Ent} \\ \mathbf{A}(x) \end{bmatrix}) \to \mathbf{L}(\pi_1 u, \pi_1((@_1 : \gamma_1 \to \begin{bmatrix} y : \mathbf{Ent} \\ \mathbf{M}(y, (@_0 : \gamma_0 \to e)(c, u)) \end{bmatrix})(c, u)))$$

The situation is completely parallel to the binding parallelism in ordinary constituent coordination. If the $@_0$ operator is instantiated as $@_0 = \lambda c.\pi_1\pi_2 c$, then we obtain the parallel sloppy reading and if it is instantiated to pick some other individual available in the context c, then the parallel strict reading is obtained. Since these are the only two possibilities for instantiating $@_0$, mixed readings are correctly blocked.

To capture the parallel behavior of pronominal binding and quantificational scope in Geach sentences, we take quantifiers to leave an 'invisible pronoun' in the trace position. The intuition behind this proposal is that sentences like (1) receive interpretations that can roughly be paraphrased as follows:

(18) Every boy$_i$ is such that there is a saxophonist$_j$ such that he$_i$ admires him$_j$, and every girl$_k$ is such that there is a saxophonist$_l$ such that she$_k$ admires him$_l$. (on the $\forall > \exists \wedge \forall > \exists$ reading)

The problem of mixed scope readings for quantifiers then reduces to the problem of mixed binding readings, since the mixed scope readings for (1) require the 'hidden pronoun' corresponding to the shared object quantifier to resolve anaphora differently in the two conjuncts. To put it informally, although the antecedent existential quantifier is 'visible' as antecedent to the pronoun in the trace position in both scope configurations, the relative scope between the subject and object quantifiers differ in the two clauses in the mixed reading cases since the 'target' antecedent quantifier is located in different positions in the context passed to the @ operator, thus making the mixed construal unavailable.

Below, we formalize an analysis that implements the above analytic idea in HTLCG+DTS and show how it solves the problem of mixed scope readings in Geach sentences. Since the 'hidden pronoun' that is involved in the interpretation of quantifiers plays a nontrivial role only for the shared object quantifier in RNR sentences like (1), for ease of exposition, we illustrate the analysis with a simplified translation that involves a hidden pronoun only for the object quantifier. To simplify the analysis further, we treat pronouns in syntactic category NP_p as in (19a), and assume that verbs can undergo lexical operations to take pronouns in any argument position, as in (19b):

(19) a. it; $\lambda c.@_i c$; NP_p

b. admires; $\lambda f \lambda x \lambda c.\mathbf{A}(x, fc)$; $(\mathrm{NP}\backslash\mathrm{S})/\mathrm{NP}_p$

A quantifier entry that introduces a hidden pronoun in the trace position can then be written as follows:[4]

(20) $$\lambda\varphi\lambda\sigma.\sigma(\mathsf{some} \circ \varphi);\ \lambda P\lambda Q\lambda c.\begin{bmatrix} u : [(x : \mathbf{Ent}) \times Pxc] \\ Q(\lambda d.@_1^{\pi_1 u} d)(c, u) \end{bmatrix};\ \mathrm{S}{\upharpoonright}(\mathrm{S}{\upharpoonright}\mathrm{NP}_p){\upharpoonright}\mathrm{N}$$

Here, $@_1^{\pi_1 u}$ is an abbreviation of a *constrained* @ operator such that, for any c, $@_1^{\pi_1 u} c$ is well-defined only if $@_1^{\pi_1 u} c = \pi_1 u$.

With the entry for the existential quantifier in (20), we obtain the following analysis for the surface scope reading of the sentence *Every boy admires some saxophonist*:

(21)
$$\dfrac{\begin{array}{l} \vdots \quad \vdots \\ \lambda\varphi\lambda\sigma.\sigma(\mathsf{every} \circ \mathsf{boy}); \\ \lambda Q\lambda c.(v : [(x : \mathbf{Ent}) \times \mathbf{B}x]) \\ \quad \to Q(\pi_1 v)(c, v); \\ \mathrm{S}{\upharpoonright}(\mathrm{S}{\upharpoonright}\mathrm{NP}) \end{array} \quad \dfrac{\dfrac{\begin{array}{l} \vdots \quad \vdots \\ \lambda\sigma.\sigma(\mathsf{some} \circ \mathsf{saxophonist}); \\ \lambda Q\lambda c.\begin{bmatrix} u : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ Q(\lambda d.@_1^{\pi_1 u} d)(c, u) \end{bmatrix}; \\ \mathrm{S}{\upharpoonright}(\mathrm{S}{\upharpoonright}\mathrm{NP}_p) \end{array} \quad \dfrac{\begin{array}{cc} \begin{bmatrix} \varphi_1; \\ z; \mathrm{NP} \end{bmatrix}^1 & \begin{bmatrix} \varphi_2; \\ f; \mathrm{NP}_p \end{bmatrix}^2 \\ \vdots \quad \vdots & \vdots \quad \vdots \end{array}}{\begin{array}{l} \lambda\varphi_2.\varphi_1 \circ \mathsf{admires} \circ \varphi_2; \\ \lambda f\lambda c.\mathbf{A}(z, fc); \mathrm{S}{\upharpoonright}\mathrm{NP}_p \end{array}}}{\begin{array}{c} \varphi_1 \circ \mathsf{admires} \circ \mathsf{some} \circ \mathsf{saxophonist}; \\ \lambda c.\begin{bmatrix} u : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ \mathbf{A}(z, @_1^{\pi_1 u}(c, u)) \end{bmatrix}; \mathrm{S} \end{array}}}{\begin{array}{c} \lambda\varphi_1.\varphi_1 \circ \mathsf{admires} \circ \mathsf{some} \circ \mathsf{saxophonist}; \\ \lambda z\lambda c.\begin{bmatrix} u : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ \mathbf{A}(z, @_1^{\pi_1 u}(c, u)) \end{bmatrix}; \mathrm{S}{\upharpoonright}\mathrm{NP} \end{array}}}{\begin{array}{c} \mathsf{every} \circ \mathsf{boy} \circ \mathsf{admires} \circ \mathsf{some} \circ \mathsf{saxophonist}; \\ \lambda c.(v : [(x : \mathbf{Ent}) \times \mathbf{B}x]) \to \begin{bmatrix} u : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ \mathbf{A}(\pi_1 v, @_1^{\pi_1 u}((c, v), u)) \end{bmatrix}; \mathrm{S} \end{array}}$$

The $@_1^{\pi_1 u}$ operator is constrained to be well-defined only if it returns the term $\pi_1 u$ for any given c as an argument. Thus, the only possible instantiation that yields an interpretable result for (21) is $@_1^{\pi_1 u} = \lambda c.\pi_1\pi_2 c$. With this instantiation of $@_1^{\pi_1 u}$, we obtain the following as the final translation of (21) after anaphora resolution has taken place:

(22) $$\lambda c.(v : [(x : \mathbf{Ent}) \times \mathbf{B}x]) \to \begin{bmatrix} u : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ \mathbf{A}(\pi_1 v, \pi_1 u) \end{bmatrix}$$

Moving on to the Geach sentences, corresponding to (7) and (9), we now obtain the following signs:

(23) $\mathsf{every} \circ \mathsf{boy} \circ \mathsf{admires};\ \lambda \mathscr{P}\lambda c.(w : [(x : \mathbf{Ent}) \times \mathbf{B}x]) \to \mathscr{P}(\lambda f\lambda c.\mathbf{A}(\pi_1 w, fc))(c, w);$ $\mathrm{S}/((\mathrm{S}/\mathrm{NP}_p)\backslash\mathrm{S})$

(24) $\mathsf{every} \circ \mathsf{girl} \circ \mathsf{detests};\ \lambda \mathscr{P}.\mathscr{P}(\lambda f\lambda c.(w : [(x : \mathbf{Ent}) \times \mathbf{G}x]) \to \mathbf{D}(\pi_1 w, f(c, w)));$ $\mathrm{S}/((\mathrm{S}/\mathrm{NP}_p)\backslash\mathrm{S})$

[4] The idea that 'traces' of movement contain more contentful material than just bound variables seems to have something in common with various proposals made in the minimalist literature in the context of the so-called 'copy theory' of movement (cf., e.g., Fox (1999, 2002)).

By conjoining two conjuncts of the form in (24) via dynamic generalized conjunction and giving a slanted existential (which has the same semantic translation as (20)) as an argument to that functor, we obtain the following translation for the whole sentence:

(25)
$$\lambda c.\begin{bmatrix} t : \begin{bmatrix} w : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ (u : [(x : \mathbf{Ent}) \times \mathbf{B}x]) \to \mathbf{A}(@_1^{\pi_1 w}((c, w), u)) \end{bmatrix} \\ \begin{bmatrix} s : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ (v : [(x : \mathbf{Ent}) \times \mathbf{G}x]) \to \mathbf{D}(@_1^{\pi_1 s}(((c, t), s), v)) \end{bmatrix} \end{bmatrix}$$

By resolving the $@_1$ operator as $@_1 = \lambda c.\pi_1\pi_2\pi_1 c$, we obtain a parallel wide scope interpretation for the existential suitable for examples like (4).

Conjoining (23) and (24) and feeding the slanted existential to it yields the following translation:

(26)
$$\lambda c.\begin{bmatrix} t : \left((w : [(x : \mathbf{Ent}) \times \mathbf{B}x]) \to \begin{bmatrix} u : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ \mathbf{A}(@_1^{\pi_1 u}((c, w), u)) \end{bmatrix} \right) \\ \begin{bmatrix} s : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ (v : [(x : \mathbf{Ent}) \times \mathbf{G}x]) \to \mathbf{D}(\pi_1 v, (@_1^{\pi_1 s}(((c, t), s), v)) \end{bmatrix} \end{bmatrix}$$

But this does not correspond to any coherent interpretation of the sentence since there is no coherent way to instantiate the $@_1$ operator. Thus, the mixed readings are correctly ruled out.

(5), which was problematic for Steedman's (2012) account, can be dealt with easily in the present approach. For expository convenience, we analyze a slightly different example (27), which exhibits essentially the same scopal relation between the two subject quantifiers and the RNR'ed quantifier:

(27) A famous professor$_i$ in our department agreed to fix, and (therefore) a student of his$_i$ will wind up eliminating, every remaining problem in Taking Scope.

To derive the relevant reading ($\exists_{\mathbf{prof}} > \forall_{\mathbf{problem}} > \exists_{\mathbf{student}}$) for this example, we need the following pronominalization operator that turns a missing NP into a pronominal one:

(28) $\lambda\sigma.\sigma$; $\lambda P \lambda f \lambda c.P(fc)c$; $(\mathrm{S}{\upharpoonright}\mathrm{NP}_p){\upharpoonright}(\mathrm{S}{\upharpoonright}\mathrm{NP})$

The derivation then goes as follows (here, we simplify the meaning of the existential quantifier instead of the universal quantifier; the last step which introduces the subject quantifier for the first conjunct is omitted):

(29)

$$\dfrac{\begin{array}{l}\lambda\sigma.\sigma(\mathsf{a} \circ \mathsf{student});\\ \lambda Q\lambda c.\begin{bmatrix} u : \begin{bmatrix} y : \mathbf{Ent} \\ \mathbf{S}y \end{bmatrix} \\ Q(\pi_1 u)(c,u) \end{bmatrix};\\ \mathrm{S}{\upharpoonright}(\mathrm{S}{\upharpoonright}\mathrm{NP})\end{array} \quad \dfrac{\dfrac{\begin{bmatrix}\varphi_3;\\ z;\\ \mathrm{NP}\end{bmatrix}^3 \quad \dfrac{\begin{array}{c}[\varphi_1; x; \mathrm{NP}]^1 \quad [\varphi_2; y; \mathrm{NP}]^2\\ \vdots \quad \vdots \qquad \vdots \quad \vdots\end{array}}{\begin{array}{l}\varphi_1 \circ \mathsf{agreed} \circ \mathsf{to} \circ \mathsf{fix} \circ \mathsf{and} \circ \varphi_2 \circ \mathsf{eliminates};\\ \lambda z\lambda c.[(\mathbf{F}(x,z)) \times \mathbf{E}(y,z)]; \mathrm{S/NP}\end{array}}}{\begin{array}{l}\varphi_1 \circ \mathsf{agreed} \circ \mathsf{to} \circ \mathsf{fix} \circ \mathsf{and} \circ \varphi_2 \circ \mathsf{eliminates} \circ \varphi_3;\\ \lambda c.[(\mathbf{F}(x,z)) \times \mathbf{E}(y,z)]; \mathrm{S}\end{array}}}{\begin{array}{l}\lambda\varphi_2.\varphi_1 \circ \mathsf{agreed} \circ \mathsf{to} \circ \mathsf{fix} \circ \mathsf{and} \circ \varphi_2 \circ \mathsf{eliminates} \circ \varphi_3;\\ \lambda y\lambda c.[(\mathbf{F}(x,z)) \times \mathbf{E}(y,z)]; \mathrm{S}{\upharpoonright}\mathrm{NP}\end{array}}}{\dfrac{\begin{array}{l}\varphi_1 \circ \mathsf{agreed} \circ \mathsf{to} \circ \mathsf{fix} \circ \mathsf{and} \circ \mathsf{a} \circ \mathsf{student} \circ \mathsf{eliminates} \circ \varphi_3;\\ \lambda c.\begin{bmatrix} u : [(y : \mathbf{Ent}) \times \mathbf{S}y] \\ [(\mathbf{F}(x,z)) \times \mathbf{E}(\pi_1 u, z)] \end{bmatrix}; \mathrm{S}\end{array}}{\begin{array}{l}\lambda\varphi_3.\varphi_1 \circ \mathsf{agreed} \circ \mathsf{to} \circ \mathsf{fix} \circ \mathsf{and} \circ \mathsf{a} \circ \mathsf{student} \circ \mathsf{eliminates} \circ \varphi_3;\\ \lambda z\lambda c.\begin{bmatrix} u : [(y : \mathbf{Ent}) \times \mathbf{S}y] \\ [(\mathbf{F}(x,z)) \times \mathbf{E}(\pi_1 u, z)] \end{bmatrix}; \mathrm{S}{\upharpoonright}\mathrm{NP}\end{array}}}$$

$$\dfrac{\begin{array}{l}\quad\vdots \quad \vdots\\ \lambda\varphi\lambda\sigma.\sigma(\mathsf{every} \circ \mathsf{problem});\\ \lambda Q\lambda c.(v : [(x : \mathbf{Ent}) \times \mathbf{B}x])\\ \quad \to Q(\lambda d.@_1^{\pi_1 v} d)(c,v);\\ \mathrm{S}{\upharpoonright}(\mathrm{S}{\upharpoonright}\mathrm{NP}_p)\end{array} \quad \dfrac{\begin{array}{l}\lambda\sigma.\sigma;\\ \lambda P\lambda f\lambda c.P(fc)c;\\ (\mathrm{S}{\upharpoonright}\mathrm{NP}_p){\upharpoonright}(\mathrm{S}{\upharpoonright}\mathrm{NP})\end{array} \quad \begin{array}{l}\quad\vdots \quad \vdots\\ \lambda\varphi_3.\varphi_1 \circ \mathsf{agreed} \circ \mathsf{to} \circ \mathsf{fix} \circ\\ \quad \mathsf{and} \circ \mathsf{a} \circ \mathsf{student} \circ \mathsf{eliminates} \circ \varphi_3;\\ \lambda z\lambda c.\begin{bmatrix} u : [(y : \mathbf{Ent}) \times \mathbf{S}y] \\ [(\mathbf{F}(x,z)) \times \mathbf{E}(\pi_1 u, z)] \end{bmatrix}; \mathrm{S}{\upharpoonright}\mathrm{NP}\end{array}}{\begin{array}{l}\lambda\varphi_3.\varphi_1 \circ \mathsf{agreed} \circ \mathsf{to} \circ \mathsf{fix} \circ\\ \quad \mathsf{and} \circ \mathsf{a} \circ \mathsf{student} \circ \mathsf{eliminates} \circ \varphi_3;\\ \lambda f\lambda c.\begin{bmatrix} u : [(y : \mathbf{Ent}) \times \mathbf{S}y] \\ [(\mathbf{F}(x,fc)) \times \mathbf{E}(\pi_1 u, fc)] \end{bmatrix}; \mathrm{S}{\upharpoonright}\mathrm{NP}_p\end{array}}}{\begin{array}{l}\varphi_1 \circ \mathsf{agreed} \circ \mathsf{to} \circ \mathsf{fix} \circ \mathsf{and} \circ \mathsf{a} \circ \mathsf{student} \circ \mathsf{eliminates} \circ \mathsf{every} \circ \mathsf{problem};\\ \lambda c.(v : [(x : \mathbf{Ent}) \times \mathbf{B}x]) \to \begin{bmatrix} u : [(y : \mathbf{Ent}) \times \mathbf{S}y] \\ [(\mathbf{F}(x, @_1^{\pi_1 v}(c,v))) \times \mathbf{E}(\pi_1 u, @_1^{\pi_1 v}(c,v))] \end{bmatrix}; \mathrm{S}\end{array}}$$

The point here is that the parallel scope requirement for the right node-raised quantifier is lifted since the anaphora resolution process for the hidden pronoun corresponding to the quantifier takes place outside of the conjunction. Thus, an asymmetrical $\exists_{\mathbf{prof}} > \forall_{\mathbf{problem}} > \exists_{\mathbf{student}}$ reading does not pose any problem as long as the right node-raised quantifier takes scope outside of the conjunction.

3 Open questions

A reviewer for the present paper notes that the constraint we impose on anaphora resolution for the covert pronoun in the interpretation of quantifiers may be too strong. In this section, we discuss some examples which may turn out to be problematic for the current formulation of our account for this reason. The key readings of the relevant examples are somewhat complex, and it is difficult to determine whether they are available readings. For this reason, we leave it as an open issue to decide whether these examples ultimately provide counterexamples for our approach.

The first type of potential problem for the present approach comes from examples such as the following:

(30) John admires, and every girl detests, some saxophonist.

The $\forall > \exists$ reading for the second conjunct is unproblematic, since in that case, the existential is the outermost 'discourse referent' in the context passed on to the hidden pronoun in the two conjuncts. Thus, $@_1 = \lambda c.\pi_1\pi_2 c$ suffices to resolve the anaphoric reference correctly. The reading in which the existential outscopes the whole conjunction is similarly unproblematic. In this case, just as in (27), the hidden pronoun itself scopes over the conjunction, and thus, the index on the @ operator does not introduce any further constraint on its interpretation. However, the present approach does not license the reading in which the existential scopes over the universal but *within* the second conjunct, unless proper names such as *John* are treated on a par with quantifiers. To see this, note that our analysis assigns the following representation for the relevant reading of the sentence:

(31)
$$\lambda c.\begin{bmatrix} t : \begin{bmatrix} u : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ \mathbf{A}(\mathbf{j}, @_1^{\pi_1 u}(c, t)) \end{bmatrix} \\ \begin{bmatrix} s : [(x : \mathbf{Ent}) \times \mathbf{S}x] \\ (v : [(x : \mathbf{Ent}) \times \mathbf{G}x]) \to \mathbf{D}(\pi_1 v, (@_1^{\pi_1 s}(((c, t), s), v)) \end{bmatrix} \end{bmatrix}$$

Just as in (27), there is no way of instantiating the @ operator so that it yields a coherent interpretation.

It is currently unclear to us whether (30) has the relevant reading. (For the second author of the present paper, that reading does not seem to be available.) Obviously, more work needs to be done to first clarify the empirical issue, and then, to make any necessary theoretical adjustments, but we have to leave this task for future study.

More generally, when different numbers of quantifiers are present in the two conjuncts, a parallel in-conjunct wide scope reading is blocked on the present account. Thus, the following example is predicted to lack the reading parallel to (4) where the right node-raised existential scopes above the subject universal separately in the two conjuncts:

(32) Every American detests, and every Japanese has some serious reservations for, some Nobel Prize winner—namely, their respective most recent Literature Prize winners.

Again, it is difficult to tell whether the intended reading is available for this sentence.

Acknowledgments. We thank two anonymous reviewers for LENLS 12 for their insightful comments. Discussions with Daisuke Bekki and Koji Mineshima have also been very useful. The first author acknowledges the financial support from the Japan Society for the Promotion of Science (KAKENHI; Grant number 15K16732).

References

Bekki, Daisuke. 2014. Representing anaphora with dependent types. In N. Asher and S. Soloviev, eds., *Logical Aspects of Computational Linguistics 2014*, 14–29. Heidelberg: Springer.

Déchaine, Rose-Marie and Martina Wiltschko. 2014. Bound variable anaphora. MS. available at http://ling.auf.net/lingbuzz/002280.

Fox, Danny. 1999. Reconstruction, binding theory, and the interpretation of chains. *Linguistic Inquiry* 30:157–196.

Fox, Danny. 2000. *Economy and Semantic Interpretation*. Cambridge, Mass.: MIT Press.

Fox, Danny. 2002. Antecedent-contained deletion and the copy theory of movement. *Linguistic Inquiry* 33(1):63–96.

Jacobson, Pauline. 1999. Towards a variable-free semantics. *Linguistics and Philosophy* 22(2):117–184.

Krahmer, Emiel and Paul Piwek. 1999. Presupposition projection as proof construction. In H. Bunt and R. Muskens, eds., *Computing Meaning*, vol. 1, 281–300. Dordrecht: Kluwer.

Kubota, Yusuke and Robert Levine. 2015. Against ellipsis: Arguments for the direct licensing of 'non-canonical' coordinations. To appear in *Linguistics and Philosophy*, MS., University of Tsukuba and Ohio State University, available at http://ling.auf.net/lingbuzz/002214.

Martin-Löf, Per. 1984. *Intuitionistic Type Theory*. Bibliopolis.

Piwek, Paul and Emiel Krahmer. 2000. Presuppositions in context: Constructing bridges. In P. Bonzon, M. Cavalcanti, and R. Nossum, eds., *Formal Aspects of Context*, 85–106. Dordrecht: Kluwer.

Steedman, Mark. 2012. *Taking Scope*. Cambridge, Mass.: MIT Press.