Retrieving Antecedents in Processing: Binder Indices and ϕ-Features

Keir Moulton

1. The processor and the grammar

What is the relation between the syntactic processor and the grammar? Lewis & Phillips (2015) suggest, as have others before, that the relation is one of identity: the processor *is* the grammar. I take this to mean that there are no linguistically-specific processing routines separate from the grammar, once you factor out general cognitive processes related to memory storage and retrieval, computational complexity and the like. At the same time, however, one detects a note of skepticism in Lewis & Phillips (2015) as to whether psycholinguist results can bear on traditionally theoretical questions. The skepticism is well-placed: theories rarely make clear timing predictions that could be investigated by online results. But if the processor *is* the grammar, and we have processing results that cannot be explained by appeals to non-linguistic factors, isn't it possible that processing results could be profitably explained by aspects of what we traditionally call *the grammar*?

In this short note I want to meditate on how a set of processing results, reported by Moulton & Han (to appear), can be understood in light of two theoretical ideas about pronouns. The first is that some pronouns are disguised definite descriptions, specifically D-type pronouns (Elbourne, 2005). The second is a theory how ϕ-features are encoded on semantic binders in the syntax, building on work by Sudo (2012).

2. Moulton and Han: C-command not just scope

In recent psycholinguistic work, Kush et al. (2015) and Cunnings et al. (2015) have argued that the processing of bound variable pronouns is sensitive to a structural constraint like c-command (Reinhart, 1983).[1] Cunnings et al. 2015 tested sentences like those in Table 1, in which c-command was manipulated. Their design employed a Gender Mismatch paradigm (Garnham, 2001; van Gompel & Liversedge, 2003; Sturt, 2003). It has been established that pronouns that mismatch the gender of an available antecedent show processing difficulty—a Gender Mismatch Effect (GMME) (van Gompel & Liversedge, 2003; Garnham, 2001). Crucially, it has been shown that what counts as an available antecedent for the processor is guided by, in some cases, the Binding Theory (BT) (Sturt, 2003; Kazanina et al., 2007). For instance, Sturt (2003) tested reflexive anaphors as in (1). In (1a), the BT-compliant antecedent for *himself* (*the surgeon*) matches in gender, while the BT-noncompliant DP (*Jennifer*) does not match in gender. This sentence poses no difficulty for the processor at the anaphor. In contrast, in (1b) the only BT-compliant antecedent for *herself* (*the surgeon*) does mismatch in gender and this results in processing difficulty—a GMME.

(1) a. The surgeon [who treated Jennifer] had pricked himself. — no GMME
b. The surgeon [who treated Jennifer] had pricked herself. — GMME!

* Simon Fraser University, kmoulton@sfu.ca. I would like to thank Chung-hye Han and members of the XSyn Lab at SFU: Tanie Cheng, Queenie Chan, Holly Gendron, Trevor Block, Sara Williamson and Kyeong-min Kim. I would also like to thank Ivona Kučerová, Elsi Kaiser, Dave Kush, Brian Dillon, Lyn Frazier, Luka Crnič, Yosef Grodzinsky and members of the Neurolinguistics Lab at the Hebrew University of Jerusalem. Thanks most of all to the wonderful organizers of WCCFL 35! This work is supported by SSHRC Insight Development Grant 430-2014-01034 "Experiment and Theory at the Syntax-Semantics Interface" to the author.

[1] In truth, nothing of what Kush et al., Cunning's et al. or Moulton and Han do distinguishes c-command from *precede and command* (Langacker, 1969; Bruening, 2014). But I will stick to using *c-command* following the experimental work.

 Proceedings of the 35th West Coast Conference on Formal Linguistics, ed. Wm. G. Bennett et al., 30-40. Somerville, MA: Cascadilla Proceedings Project.

The processor, at least in initial stages, simply does not entertain *Jennifer* as an antecedent in (1a) because it is not in a position compliant with Principle A. The processor accesses only the BT-compliant antecedent and in (1b) and this produces a GMME.

Cunnings et al. (2015) used this design to probe whether bound variable pronouns only access c-commanding antecedents. They tested QPs in positions that c-command the pronouns *he/se* (the CC sentences) and QPs in positions that do not c-command those pronouns (the NoCC conditions). In the NoCC cases, the QP is embedded in a relative clause, and so does not c-command the pronoun. This factor manipulation was crossed with whether the pronoun was Match or Mismatch:

CC	Match	The surgeon saw that **every old man** on the emergency ward silently wished that **he** could go a little bit faster.
	Mismatch	The surgeon saw that **every old woman** on the emergency ward silently wished that **he** could go a little bit faster.
NoCC	Match	The surgeon who **every old man** on the emergency ward saw silently wished that **he** could go a little bit faster.
	Mismatch	The surgeon who **every old woman** on the emergency ward saw silently wished that **he** could go a little bit faster.

Table 1: *Cunnings et al.'s (2015) stimuli, Experiment 2*

In their analysis of eye-movements, Cunnings et al. (2015) found an interaction such that there was a GMME in the CC-Mismatch sentences, but not in the NoCC-Mismatch sentences. This suggests that the processor accesses c-commanding QP antecedents at very early points in processing, but not NoCC antecedents. This, in turn, illustrates that the processor is sensitive to—or implements—grammatical knowledge quickly in online processing.[2] Relatedly, Kush et al. (2015) found processing difficulty for pronouns whose QP antecedent was non-c-commanding in comparison those whose antecedent did c-command.

There is a problem, however, in taking Kush et al.'s and Cunnings et al.'s results as showing that c-command is the relevant factor at work in triggering GMMEs. That's becuase in both the Cunnings et al. and Kush et al. stimuli, the QP fails to put the pronoun in its semantic scope. Semantic scope is a necessary condition for bound variable pronouns.[3] In fact, Barker (2012) has argued that it is also a sufficient condition for bound variable pronouns and that we should dispense with a c-command requirement altogether. He points out that the number of cases of bound variable interpretations without c-command is so large that a structural requirement like c-command is untenable. Some illustrative examples below.

(2) a. One page [in *every book*] had something written on *it*.
b. We [will sell *no wine*] before *its* time.
c. . . . [after seeing *each animal*] but before categorizing *it* on the computer or recording *it* on their response sheet.
d. . . . [after fetching *each pointer*], but before dereferencing *it* . . .
e. The grade [that *each student* receives] is recorded in *his* file.
(Barker, 2012)

In each case, the QP puts the pronoun in its semantic scope but does not c-command it. As you can see in the experimental stimuli of Cunnings et al., 2015 in (2), the QP is buried within a relative clause. That is not normally a position that a quantifier can scope from into the matrix clause.[4] We can verify this by replacing the pronoun with an indefinite quantifier, as in (3):

[2] On the view that the processor *is* the grammar (Lewis & Phillips, 2015), I suppose there isn't any sense to the notion of "implementing" or being "sensitive to" the grammar.

[3] What allows a quantifier to take semantic scope over a position is due to a number of factors—the type of quantifier, the syntactic environment, etc.

[4] Aside from cases of functional relatives (Sharvit, 1999), but these are not such cases.

(3) The surgeon who *every old man* on the emergency ward saw silently wished that *an operation* could go a little bit faster. $*\forall > \exists$

There is no interpretation of this sentence in which the existentially quantified *operation* can scope under the universal.[5] The results so far, then, tell us nothing about c-command, but—if Barker is correct that only semantic scope is required for bound variables—that semantically illegitimate QP binders are not accessed by the processor.

Moulton & Han (to appear) controlled for the scope confound by testing stimuli in which the QP semantically scopes over a pronoun but does not c-command it. We call these scope complaint, NoCC configurations. The sentences were modelled after cases like (2c) from Barker (2012) in which the QP was embedded in a sentence-initial temporal adjunct clause, as in the NoCC example in Table 2.

CC	It seems **each boy** brought fresh water from the kitchen quickly right before **he** went on an early break.
NoCC	After **each boy** brought fresh water from the kitchen quickly it seems that **he** went on an early break.

Table 2: *Moulton & Han's (to appear) stimuli, Experiment 1*

The QP *each* is notorious for taking wide scope (Vendler, 1962; Kroch, 1974; Ioup, 1975; Beghelli & Stowell, 1997; Tunstall, 1998; Brasoveanu & Dotlačil, 2015, among many others), even from temporal adjunct clauses (see Artstein, 2005 and references therein). Moulton and Han determined that from this position *each* readily binds a bound variable pronoun in the matrix clause. We tested these sentences offline in a forced-choice comprehension task and found that participants got a bound variable reading as readily as the CC sentences as the NoCC sentences.[6] In contrast, however, we *did* find an effect of c-command in the online record. Using a GMM paradigm with self-paced reading, we tested the NoCC vs. CC sentences in Table 3 and manipulated whether the pronoun Matched or Mismatched in gender.

CC	Match	It seems **each boy** brought fresh water from the kitchen quickly right before **he** went on an early break.
	Mismatch	It seems **each boy** brought fresh water from the kitchen quickly right before **she** went on an early break.
NoCC	Match	After **each boy** brought fresh water from the kitchen quickly it seems that **he** went on an early break.
	Mismatch	After **each boy** brought fresh water from the kitchen quickly it seems that **she** went on an early break.

Table 3: *Moulton & Han's (to appear) stimuli, Experiment 2*

At the region of the pronoun, a significant interaction was found such that reading times at a mismatch pronoun were elevated only the CC conditions. There was no difference in reading times between

[5] Kush et al.'s stimuli are likewise confounded: the QP they used was an NPI that cannot scope over the position in which they placed the pronoun. They did this intentionally, and for good reason, becuase they wanted to block telescoping. I return to telescoping below.

[6] Participants were asked to answer the question:

(i) Who went on an early break?
  a. One person.
  b. Each of the boys.

In addition, Kush et al.'s comprehension stimuli we replicated, showing that the NoCC cases they tested did not give rise to bound variable readings compared to their CC sentences.

the two NoCC conditions. So even though the (matched) NoCC pronoun can be interpreted as bound (as shown in the offline record), it does not produce a GMME. In a third self-paced reading study, Moulton and Han compared referential (Ref.) vs. quantificational (Quant.) antecedents, both in NoCC positions, using the same GMM design as above (see Table 4). Since referential antecedents are not subject to a c-command requirement, we *do* expect a GMME in those cases (slow reading times at the pronoun in the Ref.-Mismatch condition) but no difference between the Quant. conditions (as in our Experiment 2).

Ref.	Match	After **the boy** brought fresh water from the kitchen quickly it seems that **he** went on an early break.
	Mismatch	After **the boy** brought fresh water from the kitchen quickly it seems that **she** went on an early break.
Quant.	Match	After **each boy** brought fresh water from the kitchen quickly it seems that **he** went on an early break.
	Mismatch	After **each boy** brought fresh water from the kitchen quickly it seems that **she** went on an early break.

Table 4: *Moulton & Han's (to appear) stimuli, Experiment 3*

An interaction was found, such that there was a GMME in the Ref.-Mismatch conditions but not in the quantificational cases. So the processor *does* access non-c-commanding referential antecedents, producing a GMME. The conclusion in Moulton & Han (to appear) is that c-command, over and above semantic scope, influences the online processing of bound variable pronouns.

3. Psycholinguistic approaches to antecedent retrieval

GMMEs arise when the antecedent retrieval process accesses a mismatched antecedent. This requires a theory of antecedent retrieval. Lewis et al. (2006) argue that antecedent retrieval relies on a *content addressable memory*. In such a cue-based architecture, accessible antecedents are tagged, or cued, with features like gender or number. Retrieval of an antecedent at a pronoun involves the search for (partially) matching antecedents. When a mismatched antecedent is accessed, processing is disrupted.

We also want to model how the processor selectively targets c-commanding quantifiers for antecedents but not non-c-commanding quantifiers. Recall that the presence of GMME only QP antecedents that c-command suggests that non-c-commanding QPs are not among the antecedents that are accessible in memory. As Kush (2013) stresses, it is difficult to encode relational constraints (like semantic scope or c-command) in a content addressable memory. Unlike features such as gender and number, whether a QP c-commands or scopes over a pronoun cannot be registered "once and for all" as a cue on an antecedent. Whereas the gender or number of an antecedent is constant, whether a QP c-commands a pronoun is dependent on the structural relation between the QP and that pronoun. Kush et al. (2015) develop an approach to this problem. They suggest that *all* antecedents bear a feature ACCESSIBLE, which is used as a retrieval cue in memory. Referential DPs always bear ACCESSIBLE whereas "QPs, on the other hand, bear an ACCESSIBLE feature that lasts only as long as the parser is elaborating their scope domain" (Kush et al., 2015:36). Now, given the results in Moulton & Han (to appear), we should amend this so that the feature ACCESSIBLE lasts only as long as the parser is elaborating the c-command domain of the QP. So a pronoun will access a c-commanding mismatched antecedent but not a non-c-commanding one.

The question arises, however, as to how the NoCC-Matched conditions are processed. In the Kush et al. architecture, even the matching NoCC QP is not accessible and must be retrieved differently, perhaps later. We might expect, then, that such pronouns would be difficult to process, since they would in essence be unheralded pronouns (Filik et al., 2008). And, indeed, Kush et al. found elevated reading times for NoCC-Match pronouns. (Kush et al. 2015 also have suggestive evidence for the (weak) possibility of late retrieval of NoCC-QP antecedents. I do not know whether the Match-NoCC pronouns in Cunnings et al.'s experiments showed the expected processing difficulty or not.)

In Experiments 2 and 3 in Moulton & Han (to appear), however, we did not find processing difficulty for the Match-NoCC pronouns. For instance, in Experiment 3 there was no significant difference between Quant-Match and Ref-Match (p>.2). Of course, unlike Kush et al., these were self-paced reading studies and so perhaps the effect was not detected. But there is another possibility: pronouns that fall in the semantic scope of a QP but not the c-command domain are processed rapidly and easily but nonetheless do not exhibit GMME. In fact,

There is independent evidence that scope compliant, NoCC antecedents are readily processed. Carminati et al. (2002) compared bound variable pronouns under c-command with cross-clausal, NoCC antecedents as in Table 5 (alongside sentences with referential antecedents).

CC	Quant.	**Every British soldier** thought that **he** killed an enemy soldier.
	Ref.	**The British soldier** thought that **he** killed an enemy soldier.
NoCC	Quant.	**Every British soldier** aimed and then **he** killed an enemy soldier.
	Ref.	**The British soldier** aimed and then **he** killed an enemy soldier.

Table 5: *Carminati et al.'s (2002) stimuli*

Their eye-movement data showed no difference between CC and NoCC conditions. There were only re-reading differences between quantified and referential conditions, with the former taking longer. The lack of any penalty for bound NoCC pronouns suggested to Carminati et al. (2002) that such interpretations are readily available. The NoCC configurations that Carminati et al. employed are instances of *telescoping* (Roberts, 1987; Poesio & Zucchi, 1992). Telescoping is the name for phenomena that involve binding across a sentence boundary. In recent work, Anderssen (2011) has argued that telescoping involves D-type pronouns. Of course, D-type analyses have most famously been applied to donkey pronouns (Cooper, 1979; Evans, 1980) like (4):

(4) Every farmer who owns *a donkey* beats it.

The D-type approach developed by Elbourne (2005) treats the pronoun as the spell-out of a definite determiner whose NP complement has been elided (Postal, 1969).

(5) Every farmer who own *a donkey* beats *it* ~~donkey~~. it $\rightsquigarrow$ the donkey

The definite co-varies because it is interpreted with respect to a situation variable which is bound by *every*, which quantifies over individual-situation pairs (Berman, 1987). Restrictions on the size of the situation satisfies the uniqueness requirements of the definite (Heim, 1990). More specifically, interpreting the pronoun as a definite involves 'extended' situations in the nuclear scope of the quantifier.[7]

(6) For every x, s_b such that s_b is a minimal situation in which a farmer x owns a donkey, there is an extended situation s_e, $s_b \leq s_e$ such that x beats in s_e **the donkey in s_e**.
(adapted from Büring, 2004:29: (39))

The reason a D-type analysis is suited to telescoping, as Anderssen (2011) shows experimentally, is that the availability of telescoping is sensitive to situation semantics. He provides a worked-out D-type account where the situation variable in the D-type pronoun is bound by a generic GEN operator.[8]

(7) *Every British soldier* aimed...
and then **he** killed an enemy soldier
$\approx$ GEN$_s$ ... [he$_s$ killed an enemy soldier]
he$_s$ = the British soldier in s

[7] The extended situation will not include donkeys other than the unique one in the base situation. The following formula is different from that in Büring, 2004, and like that in Elbourne, 2005 in terms of which situation (s_e or s_b) the definite is evaluated in.

[8] To get the right meaning, Anderssen shows how the restrictor of GEN smuggles in material from the first conjunct.

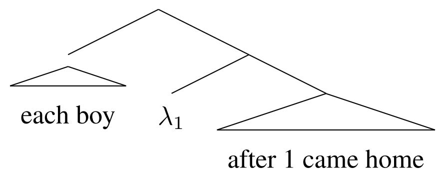
A situation-based D-type approach naturally extends to the NoCC configurations with temporal adjunct clauses tested in Moulton & Han. A definite description is certainly a possible paraphrase for the bound pronouns:

(8) After *each boy* came home, it seems that *the boy* practiced piano.

We need an analysis of temporal adjunct clauses and how quantifiers within them can semantically bind into the matrix clause. Artstein (2005) argues that the adjunct is a temporal quantifier which quantifies over the matrix clause. I will deviate from Artstein's implementation in a number of ways (such as replacing times with situations) but I believe this doesn't do too much injustice to his account. The denotation of the adjunct clause is shown in (9). The QP *each boy* QRs just to edge of the adjunct, not outside of it (since QR is finite clause bound).[9]

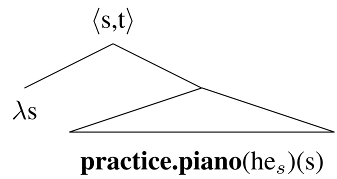
(9) $[\![$ **after each boy came home** $]\!]$ =

$$\lambda P_{\langle s,t\rangle}.\forall x[\mathbf{boy}(x) \rightarrow \exists s[\mathbf{came.home}(x)(s)\ \&\ \exists s'[P(s')\ \&\ \mathbf{after}(s)(s')]]]$$



The crucial thing to note is that the adjunct clause introduces existential quantification over situations in which P is true—these will be the situations described by the matrix clause after function application. This also puts the matrix clause below the scope of the QP *each boy*. The denotation of the matrix clause is given in (10), where the D-type pronoun is bound by a situation binder λs:

(10) $[\![$ **he practiced piano** $]\!]$ =



The adjunct clause in (9) then takes the matrix clause in (10) as its argument:

(11) $[\![$ **after each boy came home** $]\!]$ ($[\![$ **he practiced piano** $]\!]$) =

$$\forall x[\mathbf{boy}(x) \rightarrow \exists s[\mathbf{came.home}(x)(s)\ \&\ \exists s'[\mathbf{practice}(\ he_{s'})(s')\ \&\ \mathbf{after}(s)(s')]]]$$

We need to be careful, though, to ensure situations of the right size to license D-type pronouns. I suspect we need a *matching function M* (Rothstein, 1995; Schwarz, 2009):

(12) $\forall \mathbf{x}[\mathbf{boy}(x) \rightarrow \exists s[\mathbf{came.home}(x)(s)\ \&\ \exists s'[\mathbf{practice}(he_{s'})(s')\ \&\ \mathbf{after}(s)(s')\ \&\ \underline{M}(\mathbf{x})(s')]]]$

The idea is that the situations in which $he_{s'}$ (the boy in s′) practices are matched to each of the boys being quantified (and those situations are ones that contain only one boy each). The hope is that this, if the right matching function is provided by the context, will ensure that for every boy x, s' is a situation that contains x and no other boys (see Schwarz, 2009 for details). In addition to irresponsibly glossing over important aspects of situation semantics that make this all work (such as *exemplification*, Kratzer, 2007; Schwarz, 2009), I also do not know how to get the matching function into (12) compositionally.

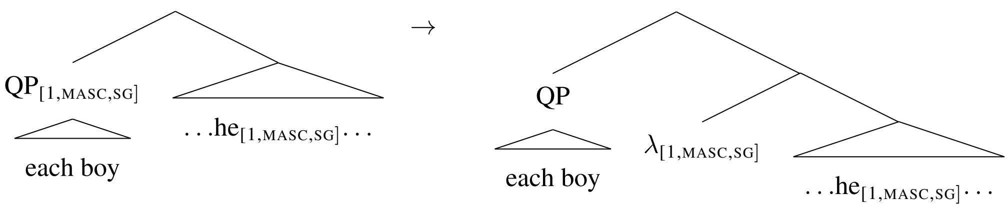
[9] See Kusumoto 2008 for an alternative that *does* involve QR from the finite clause.

Nevertheless, here I want to make the speculation that this approach is relevant to the processing data we have seen. Recall that pronouns anteceded by scope compliant NoCC quantifiers do not show GMMEs. Given previous results, this seems to suggest that the processor does not access such antecedents, i.e they lack the feature ACCESSIBLE à la Kush et al. (2015). At the same time, however, we saw no evidence in Moulton & Han (to appear) that the Matched pronouns that are bound by scope compliant quantifiers pose any processing difficulty, suggesting that they *are* somehow accessed easily (perhaps rapidly) by the processor (and this is corroborated by the results in Carminati et al., 2002). How do we resolve this tension? Suppose that what the processor is looking for is a semantic binder—a lambda—in the case of bound pronouns. But see that on the D-type analysis, the semantic binding is just of situations, not individuals. In the next section, I am going to spell out an approach to pronoun binding that contrasts situation variable binding with individual variable binding, wherein the former but not the latter involves ϕ-features, and hence capture their differing sensitivities to gender mismatch.

4. Gender mismatch from the grammar of binding

To begin, I want to lay out how non-D-type bound variables are represented. As we know, quantifiers do not bind pronouns, but rather their associated indices do (Heim & Kratzer, 1998). I take standard (non-D-type) pronouns to be individual-denoting index features, bundled with ϕ-features (which perhaps place presuppositions on the referent). Indices on QPs are converted to *binder indices* housed in separate functional heads on the clausal spine (13) (Adger & Ramchand, 2005; Kratzer, 2009). The crucial piece here is that the binder index carries ϕ-features as well, following Sudo (2012).[10]

(13) *Predicate Abstraction*



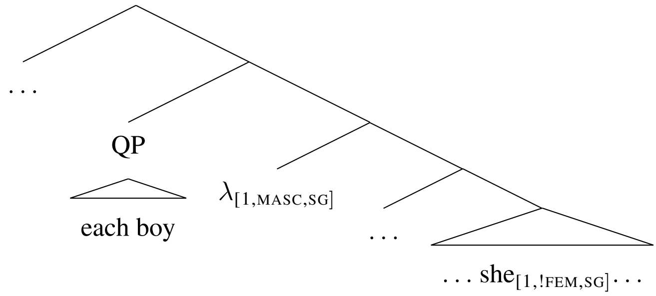
Variable binding requires non-conflicting features on binder indices and bound indices (which are spelled out as pronouns). Following and modifying Kush et al. (2015), I suggest that features on binder indices are ϕ-ACCESSIBLE only over a specified span of syntactic structure (we return to referential DPs below).

(14) ϕ-ACCESSIBILITY *(to be revised)*
ϕ-features bundled with a binder index *n* on the verbal spine of the smallest clause C_a containing *n* are not ACCESSIBLE after C_a is closed.

The guiding intuition is that the heads that support binder indices are part of the verbal spine, much like agreement heads. And, in a way that mirrors morpho-syntactic agreement, the contents of these heads are not accessible outside of their c-command domain. Let's walk through some cases, starting with a c-commanding quantifier binding a pronoun (QP-CC) in (15):

[10] What I do below does not honor particularly well the sophistication of the proposals in Sudo (2012).

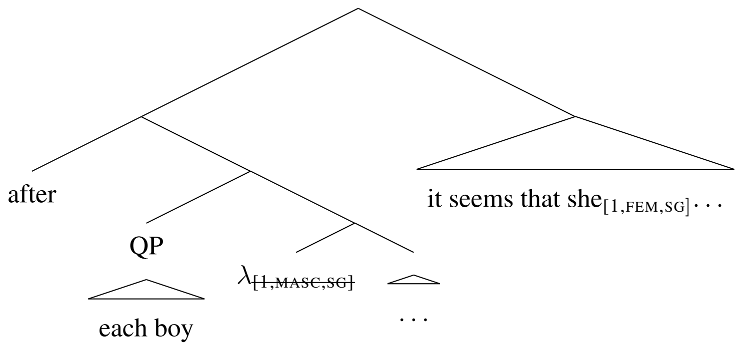
(15) *QP-CC*
It seems that *each boy* went on an early break after *she*...



The feminine gender feature on the pronoun mismatches with an ACCESSIBLE binder, giving rise to a GMME, indicated as !FEM.

In a NoCC configuration (16), the binder's ϕ-features are no longer accessible once its minimal clause is closed (indicated by strikeout), hence there is no GMME when a mismatched pronoun is encountered:

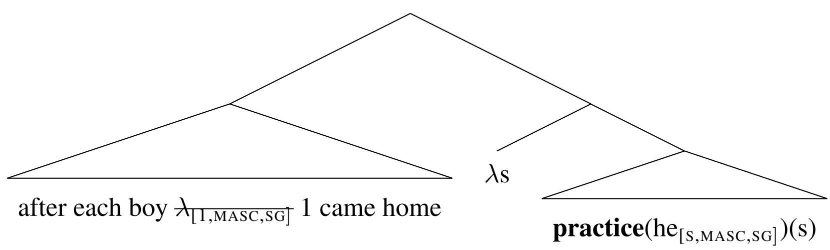
(16) *QP-NoCC-Mismatch*
After *each boy* went on an early break, it seems that *she*...



There may be an unheralded pronoun effect here since there is no available antecedent. And we did find a strong numerical trend in Moulton & Han (to appear) suggesting that compared to NoCC-Match, NoCC-Mismatch pronouns were read more slowly.

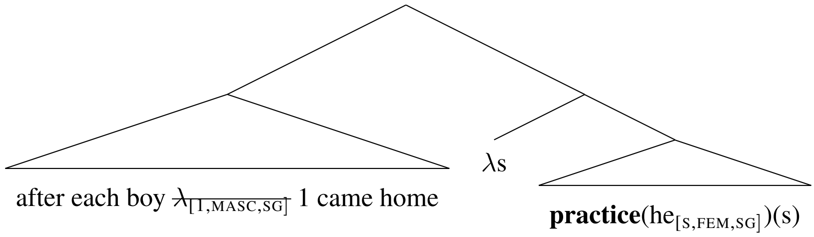
Now what if a D-type strategy is employed in the NoCC cases. The representation is in (17), where the ϕ-features are inaccessible on QP binder after the adjunct CP is closed following (14). But the pronoun can still be interpreted because of the D-type option. A D-type pronoun is bound by a situation binder easy and available (hence no delay in processing):

(17) *QP-NoCC-Match* (D-type strategy)
After *each boy* came home, *he* practiced...



Here's the crucial piece: a mismatched D-type pronoun's ϕ-features will not clash with an ACCESSIBLE binder because situation binders don't have ϕ-features:

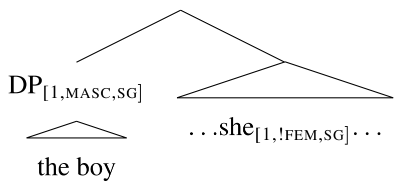
(18) *QP-NoCC-Mismatch* (D-type strategy)
After *each boy* came home, *she* practiced. . .



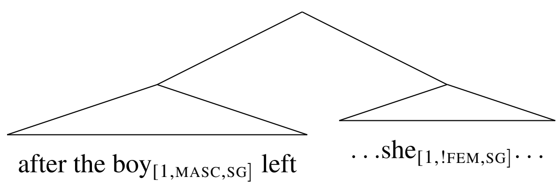
Again, the only problem here would be accommodating a new referent (recall that we saw trends of a weak unheralded pronoun effect here in our experiments, but not a GMME). Clearly even D-type pronouns must 'match' their antecedents, perhaps by finding a NP antecedent for ellipsis. My claim is that this process, when it fails, does not cause the kinds of disruptions that register as GMMEs. GMMEs are responses to mismatches with ACCESSIBLE semantic binders that bear ϕ-features. In the case of D-type pronouns, the semantic binder is not the element that bears a ϕ-feature.[11]

Now to address referential antecedents. Recall that referential DPs induce GMMEs regardless of c-command. The idea presented above for QPs is that the higher index, bundled with ϕ-features, gets somehow transferred to a separate verbal projection—which is rendered inaccessible after the clause is closed. We want referential DPs to retain their ϕ-features regardless of c-command:

(19) *CC-Ref.-Mismatch: GMME*

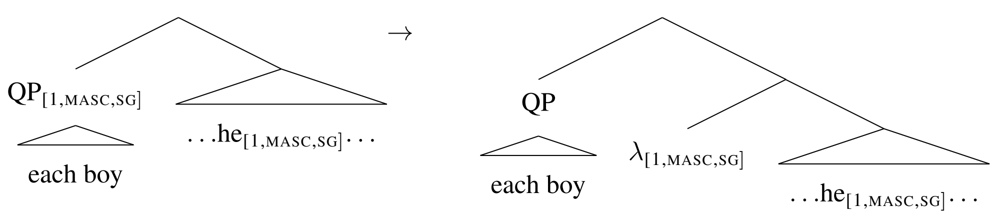


(20) *NoCC-Ref.-Mismatch: also GMME*



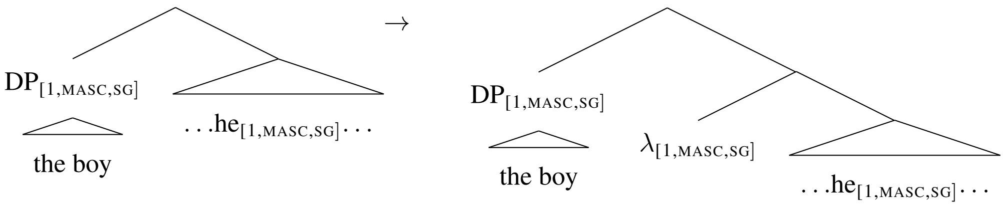
Now certainly referential DPs can (and perhaps very often do) move and create a lambda-abstract, which can co-bind a trace and a pronoun. (Think A-movement and antecedents for sloppy ellipsis: *Fred* λ1. 1 *loves his*$_1$ *mother* and Ed does ~~λ1. 1 *loves his*$_1$ *mother*~~ *too*.) So we need to invoke a difference between QPs and DPs. Suppose that unlike QPs—where the index, along with the ϕ-features, are transferred to a separate head as in (21) (repeated from (13))—referential DPs keep a copy of their index-ϕ bundle after the creation of a binder (22):

(21) *QP Predicate Abstraction*



[11] We also need to consider the derivation in which a D-type strategy is used in a c-command environment, which is certainly possible. I suspect that even if the pronoun is D-type and bound by a ϕ-less λ_s, we could insist that the QP still generate a binder index of the individual sort. This deserves more attention.

(22) *Referential DP Predicate Abstraction* (copying)



But an index on a DP, rather than that on clausal spine, survives the closure of the clause—its existence is not regulated by c-command. We add this to the formulation of ϕ-ACCESSIBILITY:

(23) ϕ-ACCESSIBILITY *(final)*
 (i) ϕ-features bundled with a binder index *n* on the verbal spine of the smallest clause C_a containing *n* are not ACCESSIBLE after C_a is closed.
 (ii) ϕ-features bundled with a referential index *n* on a DP remain ACCESSIBLE after C_a is closed.

This seems like a reasonable thing to say, given that referential DPs refer but quantifier phrases do not. Referential indices last through the discourse. (The foregoing may be related to Heim's (1998) distinction between *inner* vs. *outer* indices.)

5. Conclusion

Have we made any progress with Kush et al.'s (2015) formulation of ACCESSIBLE? Well, for Kush et al.—or a version of their proposal that explicitly mentions c-command—the difference between QP and DP was stated mostly in terms of the effect we see: QPs are not accessible outside their c-command domain. My hope is to get the effect from some deeper differences about the way DPs' and QPs' indices—and therefore bundled ϕ-features—persist depending on whether the index is a binder (a verbal functional head, which can be rendered inaccessible) or a referential index (something that persists, like a discourse referent perhaps). The story is also an attempt to reconcile the fact that pronouns are readily interpreted in scope-compliant, NoCC configurations but do not induce GMMEs. A D-type strategy seems well suited to these cases: the binder index in this case, while a c-commanding one, does not bear ϕ-features.

References

Adger, David & Gillian Ramchand (2005). Merge and move: *Wh*-dependencies revisited. *Linguistic Inquiry* 36:2, 161–193.

Anderssen, Jan (2011). *Qauntification, Misc.* Ph.D. thesis, University of Massachusetts, Amherst.

Artstein, Ron (2005). Quantificational arguments in temporal adjunct clauses. *Linguistics and Philosophy* 28:5, 541–597.

Barker, Chris (2012). Quantificational binding does not require c-command. *Linguistic Inquiry* 4, 614–633.

Beghelli, Filippo & Tim Stowell (1997). Distributivity and negation: The syntax of *each* and *every*. Szabolcsi, Anna (ed.), *Ways of Scope Taking*, Kluwer Academic Publishers, Dordrecht, 71–108.

Berman, Stephen (1987). Situation-based semantics for adverbs of quantification. Blevins, Jim & Ann Vainikka (eds.), *University of Massachusetts Occasional Papers Vol. 12*, GLSA, Amherst, MA, 8–23.

Brasoveanu, Adrian & Jakub Dotlačil (2015). Strategies for scope taking. *Natural Language Semantics* 23:1, 1–19.

Bruening, Benjamin (2014). Precede-and-command revisited. *Language* 90:2, 342–388.

Büring, Daniel (2004). Crossover situations. *Natural Language Semantics* 12:1, 23–62.

Carminati, Maria Nella, Lyn Frazier & Keith Rayner (2002). Bound Variables and C-Command. *Journal of Semantics* 19:1–34.

Cooper, Robin (1979). The Interpretation of Pronouns. Heny, F. & H. Schnelle (eds.), *Syntax and Semantics 10: Selections from the Third Groningen Round Table*, Academic Press, New York, 61–92.

Cunnings, Ian, Clare Patterson & Claudia Felser (2015). Structural constraints on pronoun binding and coreference: evidence from eye movements during reading. *Frontiers in Psychology* 6.

Elbourne, Paul D. (2005). *Situations and Individuals*. MIT Press, Cambridge, MA.

Evans, Gareth (1980). Pronouns. *Linguistic Inquiry* 11:2, 337–362.

Filik, Ruth, Anthony J. Sandford & H. Leuthold (2008). Processing pronouns without antecedents. *Journal of Cognitive Neuroscience* 20, 1315–1326.

Garnham, Alan (2001). *Mental models and the interpretation of anaphora*. Psychology Press, Philadelphia, PA.

van Gompel, R.P.G & Simon P. Liversedge (2003). The influence of morphological information on cataphoric pronoun assignment. *Journal of Experimental Psychology: Learning, Memory and Cognition* 1, 128–139.

Heim, Irene (1990). E-type pronouns and donkey anaphora. *Linguistics and Philosophy* 13:2, 137–178.

Heim, Irene (1998). Anaphora and semantic interpretation: A reinterpretation of Reinhart's approach. Percus, Orin & Uli Sauerland (eds.), *The Interpretive Tract (MITWPL 25)*, MIT, Cambridge, Massachusetts, 205–246.

Heim, Irene & Angelika Kratzer (1998). *Semantics in Generative Grammar*. Blackwell, Malden, MA.

Ioup, Georgia (1975). Some universals for quantifier scope. Kimball, John (ed.), *Syntax and Semantics*, Academic Press, New York, vol. 4, 37–58.

Kazanina, Nina, M. Lieberman, M. Yoshida & C. and Phillips (2007). The effect of Syntactic Constraints on the Processing of Backwards Anaphora. *Journal of Memory and Language* 56, 384–409.

Kratzer, Angelika (2007). Situations in Natural Language Semantics. Edward N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy*.

Kratzer, Angelika (2009). Making a pronoun: Fake indexicals as windows into the properties of pronouns. *Linguistic Inquiry* 40:2, 187–237.

Kroch, Anthony (1974). *The semantics of scope in English*. Ph.D. thesis, MIT.

Kush, Dave (2013). *Respecting relations: memory access and retrieval in incremental sentence processing*. Ph.D. thesis, University of Maryland.

Kush, Dave, Jeffrey Lidz & Colin Phillips (2015). Relation-sensitive retrieval: evidence from bound variable pronouns. *Journal of Memory and Language* 82, 18–40.

Kusumoto, Kiyomi (2008). Dependencies in Temporal Adjunct Clauses. Friedemann, T. & S. Ito (eds.), *SALT XVIII*, Cornell University, Ithaca, NY.

Langacker, Ronald W. (1969). On pronominalization and the chain of command. Reibel, David A. & Sandford A. Schane (eds.), *Modern Studies in English*, Prentice Hall, 160–186.

Lewis, David, Shravan Vasishth & J Van Dyke (2006). Computation principles of working memory in sentence comprehension. *Trends in Cognitive Science* 10, 447–454.

Lewis, Shevaun & Colin Phillips (2015). Aligning grammatical theories and language processing models. *Journal of Psycholinguistic Research* 44:1, 27–46.

Moulton, Keir & Chung-Hye Han (to appear). C-Command vs. Scope: An Experimental Assessment of Bound Variable Pronouns. *Language*.

Poesio, Massimo & Alessandro Zucchi (1992). On telescoping. Barker, Chris & David Dowty (eds.), *Proceedings of Semantics and Linguistic Theory II*, OSU Working Papers in Linguistics, Columbus, Ohio, 347–366.

Postal, Paul M. (1969). On so-called 'pronouns' in English. Reibel, D. & Sandford Schane (eds.), *Modern Studies in English*, Prentice-Hall, Englewood Cliffs, New Jersey, 201–244.

Reinhart, Tanya (1983). *Anaphora and Semantic Interpretation*. University of Chicago Press, Chicago, Illinois.

Roberts, Craige (1987). *Modal Subordination, Anaphora and Distributivity*. Ph.D. thesis, University of Massachusetts, Amherst.

Rothstein, Susan (1995). Small clauses and copular constructions. Cardinaletti, Anna & Maria Teresa Guasti (eds.), *Small Clauses(28)*, Academic Press, San Diego, California, 27–48.

Schwarz, Florian (2009). *Two types of definites in natural language*. Ph.D. thesis, University of Massachusetts at Amherst.

Sharvit, Yael (1999). Connectivity in specificational sentences. *Natural Language Semantics* 7:3, 299–339.

Sturt, Patrick (2003). The time-course of the application of binding constraints in reference resolution. *Journal of Memory and Language* 48:3, 542–562.

Sudo, Yasutada (2012). *On the Semantics of Phi Features on Pronouns*. Ph.D. thesis, MIT.

Tunstall, Susanne Lynn (1998). *The Interpretation of Quantifiers: Semantics and Processing*. Ph.D. thesis, University of Massachusetts Amherst.

Vendler, Zeno (1962). Each and every, any and all. *Mind* 71:282, 145–160.

Proceedings of the 35th West Coast Conference on Formal Linguistics

edited by Wm. G. Bennett, Lindsay Hracs, and Dennis Ryan Storoshenko

Cascadilla Proceedings Project Somerville, MA 2018

Copyright information

ISBN 978-1-57473-472-0 library binding

Ordering information

Orders for the library binding edition are handled by Cascadilla Press.
To place an order, go to www.lingref.com or contact:

Cascadilla Press, P.O. Box 440355, Somerville, MA 02144, USA
phone: 1-617-776-2370, fax: 1-617-776-2271, sales@cascadilla.com

Web access and citation information

This entire proceedings can also be viewed on the web at www.lingref.com. Each paper has a unique document # which can be added to citations to facilitate access. The document # should not replace the full citation.

This paper can be cited as:

Moulton, Keir. 2018. Retrieving Antecedents in Processing: Binder Indices and ϕ-Features. In *Proceedings of the 35th West Coast Conference on Formal Linguistics*, ed. Wm. G. Bennett et al., 30-40. Somerville, MA: Cascadilla Proceedings Project. www.lingref.com, document #3372.