1 Binding in the LF-based theory

For non-reflexive pronouns, no additional apparatus is needed beyond what we developed for relative clauses and quantifier scope.

Bound reading:

```
  S
 /\  
QP  \  
  /  \  
\ λ3 \  
  Q NP
  /\  
 every3 boy
```

Free reading:

```
  S
 /\  
QP  \  
  /  \  
\ λ3 \  
  Q NP
  /\  
 every3 boy
```

1
This leads us to expect:

Generalization: A QP cannot bind a pronoun unless it takes (semantic!) scope over it.

Support: quantificational binding is sensitive to restrictions on scope.

(1) a. The man who works for himi despises Sigfriedi. (coreferential rdg OK)
b. The man who works for himi despises someisi of the managers. (*binding)
c. The man who works for every foremanji despises someisi of the managers. (*everyi>somei)

But linear order is not the key determinant:

(2) a. In heri bed Zeldai spent heri sweetest hours.
b. *? In Zeldai’s bed shei spent heri sweetest hours.

Crossover indicates that the scope generalization is necessary but not sufficient.

(3) a. Someone loves every boy. (every boy can scope over a subject)
b. SCO: Hesi loves everyi boy. (object Q can’t bind a subject pronoun)
c. WCO: Hisisi mother loves everyi boy. (can’t bind a pronoun inside a subject)

Reinhart (1983): Strengthen the requirement to

A QP cannot bind a pronoun unless it takes scope over it and c-commands it.

Definition 1. (C-command) \( \alpha \) c-commands \( \beta \) iff the first branching node dominating \( \alpha \) also dominates \( \beta \).

Note that surface c-command is what’s needed here: c-command at LF would hold in SCO and WCO contexts, and it would also fail to account for “reconstruction” examples like (7) below.

The c-command restriction is widely assumed in work on the syntax-semantics interface, but it’s also pretty clearly false (see Barker 2012 for more exx. and discussion).

(4) a. [Noi one’s mother] thinks hei is a fool. (possessives)
b. [Someone from everyi city] hates iti. (‘inverse linking’)
c. This shows that [the fate of everyi individual] is decided by hisi inner ego. (N complement)
d. [The cost of eachi item] is marked on itsi label. (N adjunct)
e. She [copied eachi book] without hurting iti. (binding from VP into adjunct)

Even worse for the c-command requirement, each — which can take scope out of a tensed clause, violating claimed restrictions — can also bind a pronoun out of a tensed clause. (From our own Lauri Karttunen, via Barker.)

(5) The grade that eachi student received was celebrated with an enormous party. (ok with one party per student: each scopes over indefinite, out of tensed clause)
(6) The grade that each student received was recorded in his file. (binding out of tensed clause)

“Reconstruction” creates additional problems: we need to amend the c-command requirement to apply to a level prior to surface structure.

(7) a. [Which of his relatives] does everyone love t_j?
   b. * [Which of his relatives] t_i loves everyone_j?
   c. Name something in their house that almost everyone wishes were bigger. (http://www.familyfeudinfo.com/question.php?id=361)
   d. Once in his life, every man is entitled to fall madly in love with a gorgeous redhead. (Reconstruction?? — quote from Lucille Ball)

On (7b), note however that (8) is much improved:

(8) [Which of its properties] t_i best defines every_j object?

This is interesting; what’s the source of this distinction? Is animacy relevant? What if WCO isn’t a grammatical phenomenon at all, but rather a processing constraint?

What remains? Barker advocates an approach based on ‘evaluation order’. We’ll talk more about this idea when we read Barker & Shan 2014 in a few weeks.

2 Directly compositional account

We add superscripted categories to record the presence of a bindable pronoun (inter al.).

For any categories A and B, $A^B$ is also a category. Its semantic type is the type of functions from B-category meanings to A-category meanings.

- The sentence He left is a $S[V]^{NP}$, with semantic type $\langle e, t \rangle$ — waiting to return a truth-value once we tell it what entity he refers to.
- $NP^{NP}$ is the category of a pronoun like he, she, it, him, her, with semantic type $\langle e, e \rangle$.

We continue to ignore gender and number, and assume that pronouns denote identity functions. Recall the Geach rule(s):

**G-R**: If $\alpha = ([\alpha], A/_{RB}, [\alpha])$, there is a $\gamma = ([\alpha], (A/_{RC})/_{L}(B/_{RC}), \lambda P \lambda x.[\alpha](P(x)))$.

**G-L**: If $\alpha = ([\alpha], A/_{LB}, [\alpha])$, there is a $\gamma = ([\alpha], (A/_{LC})/_{L}(B/_{LC}), \lambda P \lambda x.[\alpha](P(x)))$.

We introduce a modification which differs only syntactically, with the function of passing up category superscripts.
**Geach-superscript (g-sup)**: If \( \alpha = ([\alpha], A/B, [\alpha]) \), then for any category \( C \) there is a \( \beta = ([\alpha], A^C/B^C, \lambda P \lambda x. [\alpha](P(x))) \).

The key difference between **g-sup** and **Geach-Right/-Left** will be in how the category behaves in the overall grammar. *Mary saw* is not a complete sentence, but can form a constituent that is part of a gapping or relative clause construction. We want *Mary saw him* to have the same denotation, but to act like an \( S \) in the syntax. We will formulate rules that allow us to make this purely syntactic distinction. Compare the two trees on the next page.

Returning:

We can use **g-sup** to pass variables up a tree, but we also need a way of capturing them when we want to bind them.

\[ z: \text{If } \alpha = ([\alpha], (A/NP)/B, [\alpha]), \text{then there is a } \beta = ([\alpha], (A/NP)/B^{NP}, \lambda P \lambda x.P([\alpha](x))(x)). \]

Syntactically, \( z \) captures a bindable pronoun. Semantically, \( z \) is a duplicator which applies its second argument to its first, as J describes:

Consider *Every third grade boy loves his mother*. *His mother* is a function mapping each individual to his mother; call this the-mother-of function. Now take *love*. Its type is \( (e, (e, t)) \), and so cannot combine directly with *his mother* which is of type \( (e, e) \). The bound reading results from mapping to \( z(\text{love}) \), whose meaning is of type \( ((e, e), (e, t)) \). It is easiest to get the intuition of the semantics of \( z \) informally. To \( z \)-love some function \( f \) of type \( (e, e) \) is to be an \( x \) who \( z \)-loves the-mother-of \( x \). So in this case \( z \)-love combines with the-mother-of function, and to be an \( x \) who \( z \)-loves the-mother-of function is to be an \( x \) who \( z \)-loves the-mother-of \( x \). In function terms, the meaning of the VP is \( \lambda x. \text{love} (\text{the} - \text{mother} - \text{of}(x))(x) \); in set terms it is the set of self’s mother-lovers. And the full meaning ... is derived by taking this as argument of the GQ subject. The whole \( S \), then, is true just in case the set of self’s mother-lovers has the third-grade-boy set as a subset.

Consider at this point the trees on pp.6-7.
FREE READING:

\[
\begin{align*}
&\text{S}[V]^{NP} \\
&\quad \lambda z \forall x. \text{thinks}(x)(\text{left}(z)) \\
&\quad \text{g-sup} \\
&\quad \text{S}[V]/_R(\text{S}[V]/_L\text{NP})^{NP} \\
&\quad \lambda R \lambda z. [\lambda P \forall x. P(x)](R(z)) \\
&\quad \text{g-sup} \\
&\quad \text{everyone} \\
&\quad (\text{S}[V]/_L\text{NP})^{NP}/_R \text{CP}^{NP} \\
&\quad \lambda P \forall x. \text{thinks}(P(x)) \\
&\quad \text{g-sup} \\
&\quad \text{thinks} \\
&\quad \text{CP}/_R \text{S}[V]^{NP} \\
&\quad \lambda P \forall x'. [\lambda z'. z'](P(x')) \\
&\quad = \lambda P \forall x'. P(x') \\
&\quad \text{g-sup} \\
&\quad \text{thinks} \\
&\quad \text{NP}^{NP}/_L \text{NP}^{NP} \\
&\quad \lambda z. z' \\
&\quad \text{g-sup} \\
&\quad \text{that} \\
&\quad \text{S}[V]/_L\text{NP} \\
&\quad \text{left} \\
&\quad \text{he} \\
&\quad \text{left} \\
\end{align*}
\]
BOUND READING:

\[ \forall x'. \text{thinks}(\text{left}(x'))(x') \]

\[ S[V]/R(S[V]/LN) \lambda P \forall x'. P(x') \]

\[ \text{everyone} \]

\[ (S[V]/LN)/_R\text{CP}^NP \lambda P\forall x. \text{thinks}(P(x))(x) \]

\[ \text{g-sup} \]

\[ \text{thinks} \]

\[ \text{g-sup} \]

\[ \text{that} \]

\[ \text{he} \]

\[ \text{left} \]
Using just these combinators it’s impossible to generate crossover violations — but you also can’t deal with legitimate cases of binding out of NP that we saw above, such as *Everyone’s mother loves him*. Jacobson (1999); Barker (2005) discuss the possibility of dealing with this problem by adding a new type-shifter that transmits binding potential upward.

$s$: If $\alpha = ([\alpha], (A/B)/NP, [\alpha])$, then there is a $\beta = ([\alpha], (A/B^{NP})/NP, \lambda y \lambda f.[\alpha](y)(f(x)))$.

As Barker shows in detail, this combines neatly with Hendriks’ flexible types to get the correct result — but also makes it possible to get binding in *His, mother loves everyone!*

Jacobson (1999); Jacobson (2014: 236) rejects $s$ as a result, but doesn’t say how she proposes to deal with binding out of NP, from main clauses into adjuncts, and reconstruction. (See Jacobson 2002 for some suggestions.)

Barker (2005) suggests an enriched system of syntactic marking that would prevent crossover violations by tying them to left-right order. (This would seem to rule out backwards binding cases like the 3 examples in (7), though.) The later developments mentioned earlier, where linear order is replaced by evaluation order, are probably a further improvement—but this summary of the LF-based/variable-free dialectic is still useful (pp.22-23).

So what makes a variable-free semantics worth pursuing? Should we be surprised or impressed to learn that it is possible to build a descriptively adequate semantics that does not make essential use of variables? Not very: it is well-known that variable-free systems exist that have an expressive power exactly equivalent to the pure untyped lambda calculus. The prime example is Combinatory Logic, due separately to Schönfinkel and Curry (see, e.g., Barendregt (1984: chapter 7) for a standard reference establishing this equivalence). It follows that any semantics that can be rendered in a lambda calculus has an equivalent variable-free version, so adopting a variable-free approach is no restriction at all from the point of view of expressive power.

What is not obvious is that it is possible to construct a variable-free semantics that satisfies various compositionality constraints. In fact, Jacobson advocates a radically strict compositional discipline that she calls direct compositionality: the idea is that each syntactic constituent has a well-formed and complete denotation that does not depend on any linguistic element external to that expression. On Jacobson’s view, taking direct compositionality seriously has consequences for expressions that contain pronouns. In the standard treatment, pronouns translate as variables, and the denotation of an expression that contains a pronoun depends on an external assignment function. But if variables are prohibited, then of course assignment functions cannot be used (since they are functions from variables to individuals), and the denotation of the expression itself must provide explicit semantic access to the argument position occupied by the pronoun. For instance, we saw above that if loves Mary denotes a function from individuals to truth values, then loves him denotes something more complicated, namely, a function from individuals to a function from
individuals to truth values.

Consequently, variable-free direct compositionality entails that an expression that contains a bindable pronoun will have a syntactic category that is different from an expression that is otherwise identical but that contains a proper name in the place of the pronoun. The implicit prediction is that expressions that contain bindable pronouns could have a restricted syntactic distribution, and the existence of weak crossover confirms this prediction. In other words, even though weak crossover does not “fall out” for free in the variable-free approach, the possibility that a constraint like weak crossover might exist does fall out. In most other theories I am aware of, no matter how easy it might be to state a constraint prohibiting weak crossover, the existence of such a constraint always comes as an unpleasant surprise.

References