Crossover ii[1]

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[1] 24.979: Topics in semantics
Getting high: Scope, projection, and evaluation order

Some reminders

If you're a **registered student**, please send us your project proposal by the end of the week.

1 From continuation semantics to dynamic semantics

1.1 Barker & Shan: WCO as a reflex of evaluation order

At the beginning of the semester, we learned about a theory of scope-taking with a built-in left-to-right bias – *continuation semantics*.

Concretely, due to the way that the composition rule Scopal Function Application (SFA) was defined, evaluation of quantificational effects *mirrors* linear order.[2]

As we saw in the last class, an appealing consequence of this linear bias was a natural account of Weak Crossover (WCO) in terms of evaluation order.[3]

Recall, a simplified version of the WCO paradigm: scope can feed binding (1), unless the binder doesn't precede the bound expression (2).

(1) [Everyone^x's mother] bought them$_x$ a bicycle.

(2) Their$_x$ mother showered everyone^x with gifts.
cf. a different person showered everyone with gifts.

The idea, briefly, was to generalize our notion of a scope-taker to make sense of the idea that pronouns also *scope*.

In Barker & Shan's system, pronouns take scope in the following way: they expect *a proposition*, and they return an *open proposition*.[4]

In order for a Quantificational Phrase (QP) to bind a pronoun, it must first be

[2] To cash this out, we needed to say something concrete about the syntax-semantics interface – concretely, we committed to the ideas that (a) the basic combinatoric operation MERGE is asymmetric, and (b) the syntactic and semantic composition proceed in lockstep (direct compositionality).

[3] See especially Shan & Barker 2006 and Barker & Shan 2014: chapters 2 and 4.

[4] We can helpfully think of an open proposition in this framework as a proposition with anaphoric effects (i.e., environment sensitivity).

bind-shifted. A bind-shifted QP expects an open proposition, and returns a proposition. Successful binding is illustrated in figure 1.

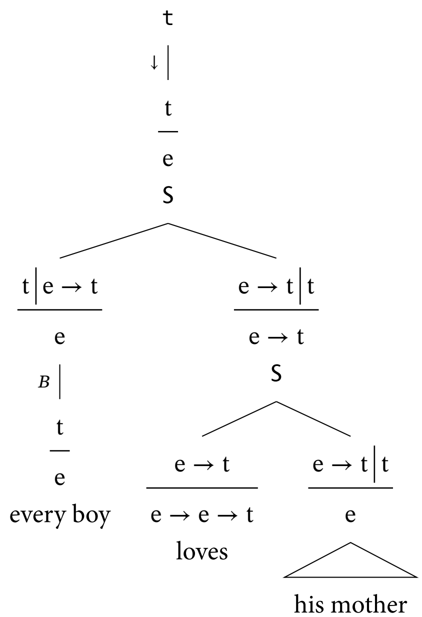

Figure 1: Successful binding

Putting mechanisms for inverse scope to one side, WCO follows straightforwardly from this system. Since both pronouns and bind-shifted QPs are scope-takers, for the pronoun to be bound, the QP has to be evaluated first. Scope can feed binding, but the QP must precede the pronoun, since *evaluation order mirrors linear order*.[5]

[5] One of the virtues of continuation semantics is that it straightforwardly accounts for scope out of Quantificational Phrase (DP) without requiring *movement* out of DP.

Continuation semantics includes mechanisms for subverting the linear bias (namely, higher-order continuations), in order to account for inverse scope.

With mechanisms for inverse scope in the picture, things become a little less neat. Barker & Shan (2014) must stipulate that *lower* – the operation via which continuized meaning are collapsed into ordinary meanings – is rigidly typed. If we assume that *internal lower* is derived as lifted *lower*, this also has consequences for its type:

(3) a. $\downarrow : \dfrac{a \mid t}{t} \to a$

b. $\Downarrow : \dfrac{b}{\dfrac{a \mid t}{t}} \to \dfrac{b}{a}$

This move basically guarantees, via a syntactic stipulation, that in order for a bind-shifted QP to bind a pronoun, it must take scope at the same tower-story as the pronoun. If it takes scope on a high level, then the resulting meaning cannot ultimately be lowered by a rigidly typed *lower*.

An unsuccessful attempt at getting internal lift to feed binding is illustrated in figure 2.

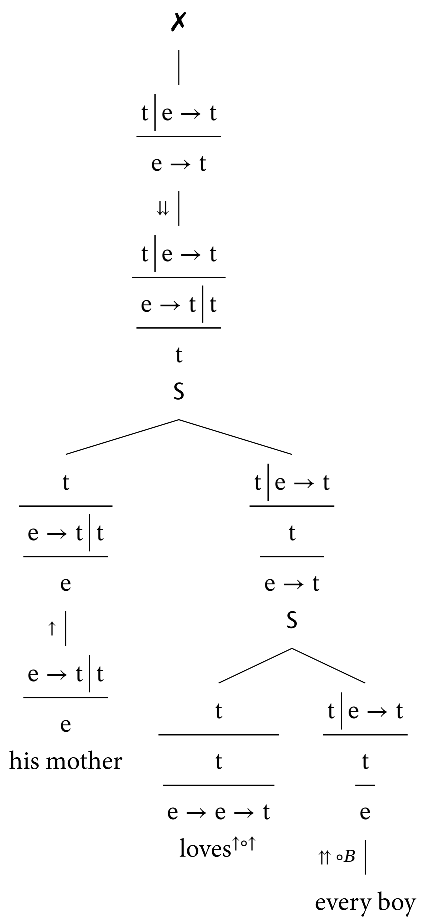

Figure 2: Unsuccessful binding (wco)

What's crucial here is that both lower and internal lower are rigidly typed.

Just how satisfying is this as an explanation though? If we look at what lower actually *does*, there's no intrinsic reason why it should be so rigidly typed.

As shown in (4), all that lower does is feed its sole argument the identity function. On a maximally polymorphic definition, therefore, the argument need only be of type $(\mathsf{a} \rightarrow \mathsf{a}) \rightarrow \mathsf{b}$.

(4) Lower (maximally polymorphic ver.)
$m^{\downarrow} := m\ id$

A maximally polymorphic lower could save the WCO-violating derivation in figure 2.

Based on what lower *does*, there's no strong *semantic* motivation for making it rigidly typed. Therefore, despite the initial conceptual appeal of Barker & Shan's system, its success ultimately rests on what looks like a syntactic stipulation.

1.2 Chierchia: WCO as a reflex of the dynamics of anaphora

Chierchia (2020) develops a theory of WCO based on *dynamic semantics*.

Much like continuation semantics, dynamic semantics is a semantic theory with a "built-in" left-to-right bias.

2 Dynamic Semantics

2.1 A Heimian fragment

In dynamic semantics (Heim 1982, Groenendijk & Stokhof 1991, Chierchia 1995) sentences denote *relations between assignments* (equivalently: functions from assignments, to sets of assignments).

DPs introduce Discourse Referents (DRs), modeled as variables; indefinites, unlike definites induce *indeterminacy*, concerning the identity of the DR. This is illustrated schematically in figure **??**.

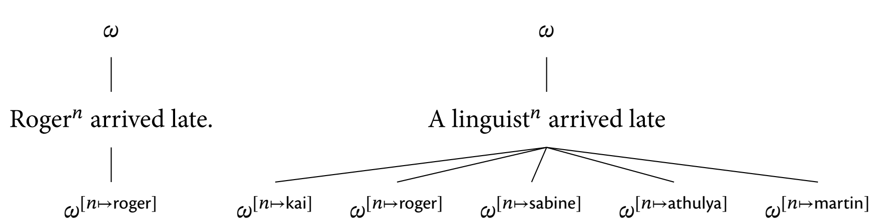

Figure 3: Relations between assignments

Assignments are functions from variables to individuals; as is standard, we'll represent the set of variables as $\mathbb{N}$:

(5) Type of assignments
$\mathsf{o} \coloneqq \mathsf{n} \to \mathsf{e}$

Chierchia assumes that assignments are *partial* functions.[6] That is to say, an assignment may only be defined for certain indices. The following are all valid assignments:

$$[1 \mapsto \mathsf{roger}] \qquad \begin{bmatrix} 1 \mapsto \mathsf{roger} \\ 3 \mapsto \mathsf{martin} \end{bmatrix} \qquad \begin{bmatrix} 4 \mapsto \mathsf{kai} \\ 5 \mapsto \mathsf{athulya} \\ 7 \mapsto \mathsf{sabine} \end{bmatrix}$$

[6] See also Rothschild & Mandelkern (2017) for a dynamic semantics using partial assignments.

In order to characterize a dynamic sentential meaning, we define a type constructor $\mathtt{T}$ to abbreviate relations between assignments:

(6) Type of Context Change Potentials (CCPs)
$\mathtt{T} \coloneqq \mathtt{o} \to \mathtt{o} \to \mathtt{t}$

Add some example sentential meanings here

We can get back an "ordinary" sentential meaning from a CCP by existentially closing the output assignment, as defined in (7).

(7) Dynamic closure (def.)
$m^{\downarrow} \coloneqq \lambda\omega \,.\, \exists\omega'[m\ \omega\ \omega']$ $\qquad \downarrow : \mathtt{T} \to \mathtt{t}$

How do we build up CCPs compositionally? Chierchia assumes that predicates are fundamentally Montagovian (i.e., functions of type $\mathtt{e} \to \mathtt{t}$):

(8) $[\![\text{swim}]\!] \coloneqq \lambda x \,.\, \mathsf{swim}\ x$ $\qquad \mathtt{e} \to \mathtt{t}$

Predicates are lifted into a dynamic setting by a type-shifter *dynamic lift*; d-lift takes a function from an individual to a truth-value, and shifts it into a function from an individual to a CCP – specifically, a dynamic *test*.

(9) Dynamic lift (def.)
$f^{\Delta} \coloneqq \lambda x \,.\, \lambda\omega \,.\, \lambda\omega' \,.\, \omega = \omega' \wedge f\ x$ $\qquad \Delta : (\mathtt{e} \to \mathtt{t}) \to \mathtt{e} \to \mathtt{T}$

Tests don't do anything interesting to input contexts. In orthodox dynamic fragments, all of the interesting dynamic action is triggered by arguments – specifically, pronouns and indefinites.

A pronoun indexed n expects a dynamic predicate k as its input, and returns a CCP – a function from an input assignment ω to the result of feeding ω_n into k, *re*-saturated with ω.[7]

[7] The type signature of a pronoun betrays the fact that, in this dynamic grammar, pronouns are *scope-takers*, and in fact, we can abbreviate a pronominal meaning using tower notation:

(10) Pronouns (tower def.)
$$\mathsf{pro}_n \coloneqq \frac{\lambda\omega \,.\, ([\,]\ \omega)}{\omega_n}$$

(13) Pronouns (def.)

$$\mathsf{pro}_n := \lambda k \,.\, \lambda\omega \,.\, k\ \omega_n\ \omega^{8} \qquad \mathsf{pro}_n : (\mathsf{e} \to \mathsf{T}) \to \mathsf{T}$$

Pronouns now may compose with d-lifted predicates via Function Application (FA), as illustrated in figure 4:

$$\lambda\omega\omega' \,.\, \omega = \omega' \wedge \mathsf{swim}\ \omega_3$$

$$\lambda k \,.\, \lambda\omega \,.\, k\ \omega_3\ \omega \qquad \lambda x \,.\, \lambda\omega\omega' \,.\, \omega = \omega' \wedge \mathsf{swim}\ x$$

he_n $\qquad$ Δ swim

Figure 4: Pronouns in a dynamic fragment
"He_3 swims"

The result is a dynamic *test*, that saturates the argument of *swim* with whatever the input assignment ω maps to pronominal index 3 to.

In an orthodox dynamic fragment (Heim 1982, Groenendijk & Stokhof 1991), indefinites introduce DRS.[9,10]

(14) Indefinites (Heimian def.)

$$\mathsf{someone}_n := \lambda k \,.\, \lambda\omega\omega' \,.\, \exists x, w''[\omega \overset{n/x}{=} \omega'' \wedge k\ x\ \omega''\omega']$$

$$\mathsf{someone}_n\ (\mathsf{e} \to \mathsf{T}) \to \mathsf{T}$$

In figure 5, we show how a Heimian indefinite composes in a dynamic fragment. The result maps each input assignment ω to (the characteristic function of) a *set* of assignments ω', s.t., ω'_n is a swimmer.

$$\lambda\omega\omega' \,.\, \exists x[\omega \overset{7/x}{=} \omega' \wedge \mathsf{swim}\ x]$$

equiv

$$\lambda\omega\omega' \,.\, \exists x, w''[\omega \overset{7/x}{=} \omega'' \wedge \omega'' = \omega' \wedge \mathsf{swim}\ x]$$

$$\lambda k \,.\, \lambda\omega\omega' \,.\, \exists x, w''[\omega \overset{7/x}{=} \omega'' \wedge k\ x\ \omega''\omega'] \qquad \lambda x \,.\, \lambda\omega\omega' \,.\, \omega = \omega' \wedge \mathsf{swim}\ x$$

someone_7 $\qquad$ Δ swim

Figure 5: Heimian indefinites in a dynamic fragment
"Someone_7 swims"

Chierchia's innovation is to posit a second way of lifting predicates into a dynamic setting: DR *introduction*.

(15) Discourse referent introduction (def.)

$$f^{\Delta_n} := \lambda x \,.\, \lambda\omega \,.\, \lambda\omega'\omega \overset{n/x}{=} \omega' \wedge f\ x \qquad \Delta_n : (\mathsf{e} \to \mathsf{t}) \to \mathsf{e} \to \mathsf{T}$$

In dynamic semantics, the connectives manipulate CCPS directly. At the heart

[8] Chierchia actually posits a syncategorematic rule for composing pronouns and dynamic predicates – instead, I've built what Chierchia's rule does into the meaning of the pronoun.

[9] Chierchia will ultimately reject this assumption, but it will be useful to consider his claims in light of the standard theory.

[10] $\omega \overset{n/x}{=} \omega'$ is defined iff ω_n is *un*defined, and is true just in case ω' differs from ω at most in what n is mapped to.

Heim's *novelty condition* is essentially built into the rule for DR introduction.

of the system is the entry for dynamic sequencing/conjunction, given in (16).

(16) Dynamic sequencing (def.)
$m\,;n := \lambda\omega\,.\,\lambda\omega'\,.\exists\omega''[m\;\omega\;\omega'' \wedge n\;\omega''\;\omega']$ $\qquad (;) : \mathtt{T} \to \mathtt{T} \to \mathtt{T}$

(17) Dynamic negation (def.)
$\neg\, m := \lambda\omega\,.\,\lambda\omega'\,.\,\omega = \omega' \wedge m^{\downarrow}\;\omega$ $\qquad \neg : \mathtt{T} \to \mathtt{T}$

(18) Dynamic lift (def.)
$P^{\Delta} := \lambda x\,.\,\lambda\omega\,.\,\lambda\omega'\,.\,\omega = \omega' \wedge p\;x$ $\qquad \Delta : (\mathtt{e} \to \mathtt{t}) \to \mathtt{e} \to \mathtt{T}$

(19) Discourse referent introduction (def.)
$P^{\Delta n} := \lambda x\,.\,\lambda\omega\,.\,\lambda\omega'\omega \overset{n/x}{=} \omega' \wedge P\;x$ $\qquad \Delta n : (\mathtt{e} \to \mathtt{t}) \to \mathtt{e} \to \mathtt{T}$

Remember to say something about how sneaky Chierchia is about variables.

(20) Someone (def.)
$\mathsf{someone}_n\; m := \lambda\omega\,.\,\lambda\omega'\,.\,\exists x[m\;\omega\;\omega']$ $\qquad \mathsf{someone}_n : \mathtt{T} \to \mathtt{T}$

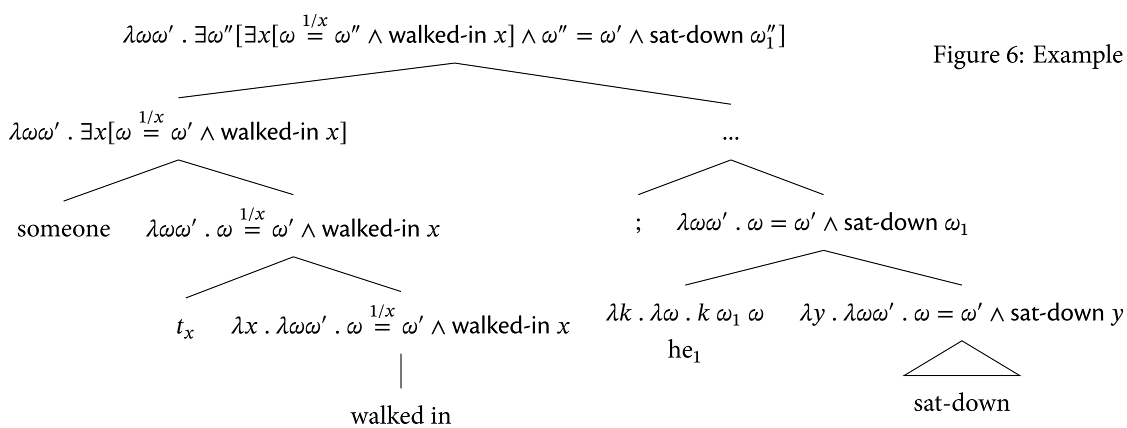

Figure 6: Example derivation

2.2 *Accessibility*

2.3 *From dynamic semantics to event semantics*

Traditions in event semantics:

Neo-Davidsonian (Castañeda 1967, Parsons 1990):

(21) $[\![\text{love}]\!] \coloneqq \lambda e\,.\,\mathsf{love}\ e$ $\qquad \mathtt{v} \to \mathtt{t}$

Thematic role functions (see also Elliott 2017):

(22) $\mathsf{THEME} \coloneqq \lambda f\,.\,\lambda x\,.\,\lambda e\,.\,\mathsf{theme}\ e = x \wedge f\ e$ $\qquad (\mathtt{v} \to \mathtt{t}) \to \mathtt{e} \to \mathtt{v} \to \mathtt{t}$

3 *The problem of existentials*

4 *Rethinking the system*

Conceptual issues:

- Much like, e.g., Dynamic Montague Grammar (DMG), Chierchia's system implicitly makes a syntactic distinction between two different kinds of variables.[11] Can we do better? Continuations provide a way of doing scope-taking without any need for traces, so this issue should (hopefully) dissolve if we shift to a continuation-based theory.

[11] See Barker & Shan's (2008) criticism of DMG for related discussion.

4.1 A more general dynamic system

Charlow (2019) (see also Charlow 2014) generalizes orthodox dynamic semantics. We'll adopt his system here.

Dynamic as are functions from an input assignment g, to a set of as paired with output assignments g'.

(23) $\mathtt{D\ a} \coloneqq g \to \{\,(a, g)\,\}$

(24) Unit (def.)
$a^{\eta} \coloneqq \lambda g\,.\,\{\,(a, g)\,\}$

Redo definition of bind

(25) Bind (def.)
$m^{\star} \coloneqq \lambda k\,.\,\lambda g\,.\,\bigcup_{(x,h)\in m\ g} \{\,k\ x\ h\,\}$ $\qquad \star : \mathtt{D\ a} \to (\mathtt{a} \to \mathtt{D\ b}) \to \mathtt{D\ b}$

(26) $\text{pro}_n \coloneqq \lambda g \,.\, \{\,(g_n, g)\,\}$ $\qquad$ D e

(27) $\text{some boy}_n \coloneqq \lambda g \,.\, \{\,(x, g) \mid \text{boy}\ x\,\}$ $\qquad$ D e

(28) $m^{\Delta_n} \coloneqq \lambda g \,.\, \bigcup_{(x,h)\in m\, g} \{\,(x, h^{[n\to x]})\,\}$ $\qquad$ D e → D e

(29) $\text{Q} \coloneqq \lambda k \,.\, \lambda g \,.\, \{\,(Q\ (\lambda x \,.\, (k\ x)^{\downarrow g})), g)\,\}$ $\qquad$ everyone : $\dfrac{\text{D t}}{\text{e}}$

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