Crossover ii[1]

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

1 From continuations to dynamics

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

bind-shifted. A bind-shifted QP expects an open proposition, and returns a proposition. Successful binding is illustrated in figure 1.
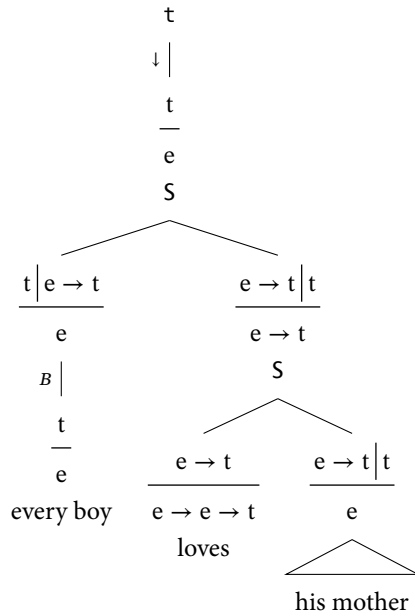
Putting mechanisms for inverse scope to one side, WCO follows straightforwardly from this system. Since both pronouns and bind-shifted QPS are scopetakers, for the pronoun to be bound, the QP has to be evaluated first. Scope can feed binding, but the QP must precede the pronoun, since *evaluation order mirrors linear order.*[5]

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:

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

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

(4) $\Downarrow: \dfrac{b}{\dfrac{a \mid t}{t}} \to \dfrac{b}{a}$

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*.

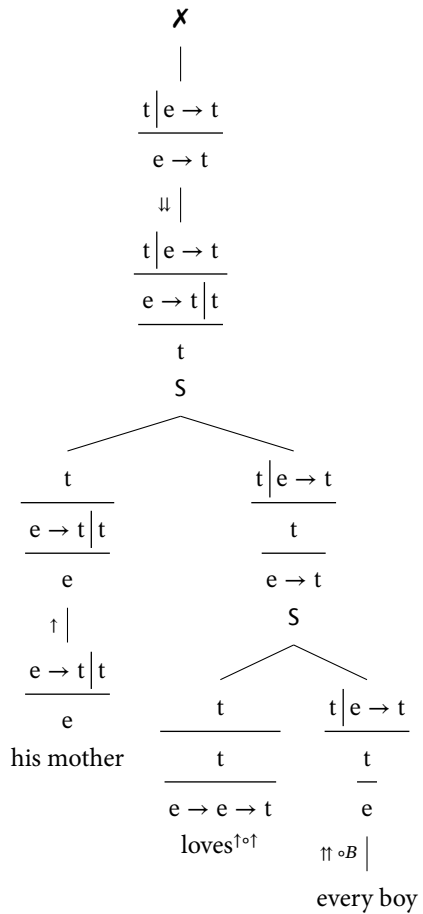An unsuccessful attempt at getting internal lift to feed binding is illustrated in figure 2.

$$
\begin{array}{c}
\textbf{✗} \\
| \\
\underline{t \mid e \rightarrow t} \\
e \rightarrow t \\
\Downarrow \mid \\
\underline{t \mid e \rightarrow t} \\
\underline{e \rightarrow t \mid t} \\
t \\
S
\end{array}
$$

t
$\dfrac{e \rightarrow t \mid t}{e}$
$\uparrow \mid$
$\dfrac{e \rightarrow t \mid t}{e}$
his mother

$t \mid e \rightarrow t$
$\dfrac{t}{e \rightarrow t}$
S

$\dfrac{t}{t}$
$e \rightarrow e \rightarrow t$
$loves^{\uparrow \circ \uparrow}$

$t \mid e \rightarrow t$
$\dfrac{t}{e}$
$\Uparrow \circ B \mid$

every boy

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 (5), 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 $(a \rightarrow a) \rightarrow b$.

(5)   Lower (maximally polymorphic ver.)
    $m^{\downarrow} \coloneqq m \; id$

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 (ds) is a semantic theory with a "built-in" left-to-right bias.

2   *Dynamic semantics*

> Add more references below

ds is one of the most empirically successful theories of anaphora (Heim 1982, Groenendijk & Stokhof 1991, Dekker 1994, a.o.) and presupposition projection (Heim 1983, Beaver 2001, a.o.). It has also been extended to a variety of other phenomena, including epistemic modality, exhaustification (Elliott 2019), and more.

Crowning achievements of ds include analyses of the following phenomena:[6]

- Cross-sentential anaphora.

(6)   a.   A man^1 walked in. He$_1$ sat down.
      b. *He$_1$ sat down. A man$_1$ walked in.

- Donkey anaphora.

(7)   a.   Every farmer who owns a donkey^3 treasures it$_3$.
      b.   ?Every farmer who owns it$_3$ treasures a donkey^3.

- Presupposition projection.

(8)   a.   [Ka visited Rome last summer]$^\alpha$,
          and [she visited Rome again]$_\alpha$ this summer.
      b.   #[Ka visited Rome again]$_\alpha$,
          and [she visited Rome last summer]$^\alpha$.

[6] The (b) examples are included to briefly show that the phenomena under consideration exhibit a *left-to-right asymmetry*, thus motivating a dynamic treatment.

2.1   A Heimian fragment

In DS ([Heim 1982](), [Groenendijk & Stokhof 1991](), [Chierchia 1995]()) sentences de-note *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 3.[7]

[7] One way of thinking about this: definites induce a *functional* relation between assignments – every input assignment is mapped to a unique output assignment, whereas indefinites induce a *non-functional* relation between assignments – each input assignment can mapped to one or more output assignments.

Figure 3: Relations between assignments
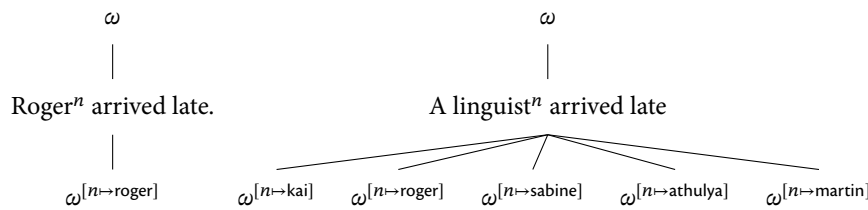
Assignments are functions from variables to individuals; as is standard, we'll represent the set of variables as $\mathbb{N}$:[8]

[8] We'll use o as the type of assignments to distinguish between assignments used in a static setting.

(9)   Type of assignments

$$o := n \rightarrow e$$

[Chierchia]() assumes that assignments are *partial* functions.[9] That is to say, an assignment may only be defined for certain indices. The following are all valid assignments:

[9] See also [Rothschild & Mandelkern (2017)]() for a DS using partial assignments.

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

In order to characterize a dynamic sentential meaning, we define a type con-structor T to abbreviate relations between assignments:

(10)   Type of Context Change Potentials (CCPS)

$$T := o \rightarrow o \rightarrow t$$

> 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 (11).

(11)   Dynamic closure (def.)
$$m^\downarrow := \lambda\omega \,.\, \exists\omega'[m\,\omega\,\omega']$$ $\downarrow : T \to t$

How do we build up ccps compositionally? Chierchia assumes that predicates are fundamentally Montagovian (i.e., functions of type e → t):

(12) $[\![\text{swim}]\!] := \lambda x \,.\, \text{swim } x$ e → 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*.

(13)   Dynamic lift (def.)
$$f^\Delta := \lambda x \,.\, \lambda\omega \,.\, \lambda\omega' \,.\, \omega = \omega' \wedge f\,x$$ $\Delta : (e \to t) \to e \to T$

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.[10]

(17)   Pronouns (def.)
$$\text{pro}_n := \lambda k \,.\, \lambda\omega \,.\, k\,\omega_n\,\omega^{11}$$ $\text{pro}_n : (e \to T) \to T$

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

Figure 4: Pronouns in a dynamic fragment
He₃ swims
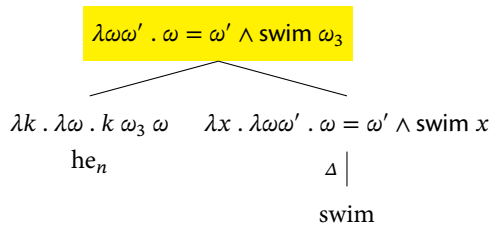
The result is a dynamic *test*, that saturates the argument of *swim* with whatever the input assignment ω maps to pronominal index 3 to.

In an orthodox dynamic fragment (Heim 1982, Groenendijk & Stokhof 1991), indefinites introduce drs.[12,13]

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[10] 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:

(14)   Pronouns (tower def.)
$$\text{pro}_n := \frac{\lambda\omega \,.\, ([]\,\omega)}{\omega_n}$$

Interestingly, this is what we get if we apply the *bind* of the Reader monad to the static entry for a pronoun.

(15)   Pronoun (static def.)
$$\text{pro}_n := \lambda\omega \,.\, \omega_n$$
                                                          o → e

(16)   Bind of Reader (def.)
$$m^\star := \lambda k \,.\, \lambda\omega \,.\, k\,(m\,\omega)\,\omega$$
$$(o \to a) \to (a \to o \to b) \to o \to b$$

[11] 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.

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

[13] $\omega \overset{n/x}{=} \omega'$ 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.

(18) Indefinites (Heimian def.)

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

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

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.

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

equiv

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

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

$$\text{someone}_7 \qquad\qquad \Delta$$
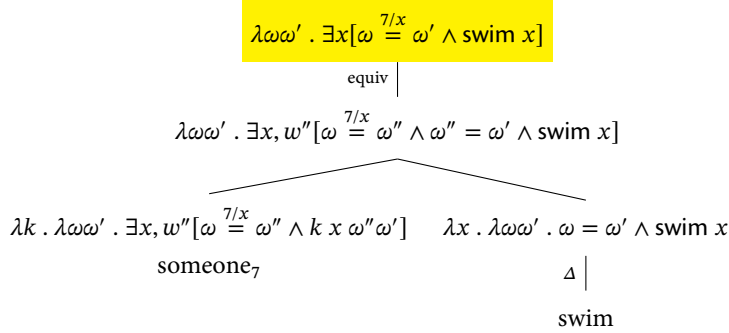
$$\text{swim}$$

Figure 5: Heimian indefinites in a dynamic fragment
"Someone$_7$ swims"

A famous design feature of DS is an account of cross-sentential binding, as in the following famous examples:

(19) a. Someone[1] walked in and he$_1$ sat down.
      b. Someone[1] walked in. he$_1$ sat down.

In DS, conjunction – as in (19a) – is treated as a special case of *discourse sequencing* (19b).

Discourse sequencing is an operation on CCPS:

(20) Dynamic sequencing (def.)

$m\ ; n := \lambda\omega . \lambda\omega' . \exists\omega''[m\ \omega\ \omega'' \wedge n\ \omega''\ \omega'] \qquad\qquad (;) : T \to T \to T$

An illustration of how cross-sentential anaphora works in a Heimian fragment is given in figure 6: sequencing the CCPS gives rise to a CCP that relates ω and ω' just in case ω_4 is undefined and and ω'_4 walked in and sat down.

Why is DS promising as a starting point for a theory of WCO? Consider the contrast below, reminiscent of WCO:

(21) a. Someone[4] walked in and he sat down.
      b. *He$_4$ walked in and someone[4] sat down.

Just so long as *someone* takes scope within its containing sentence, DS cap-
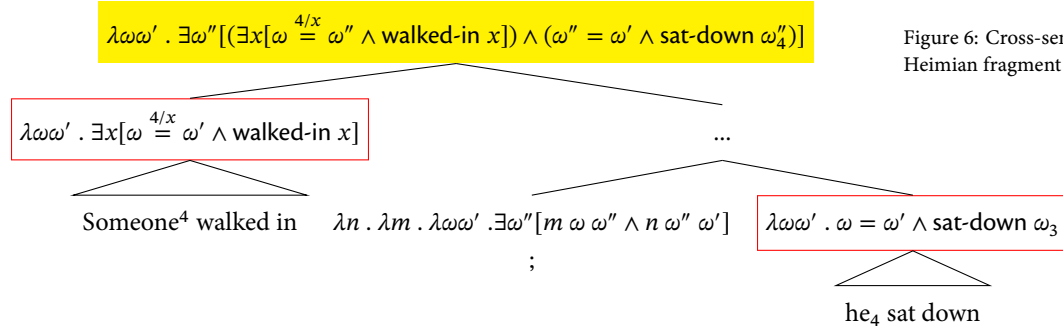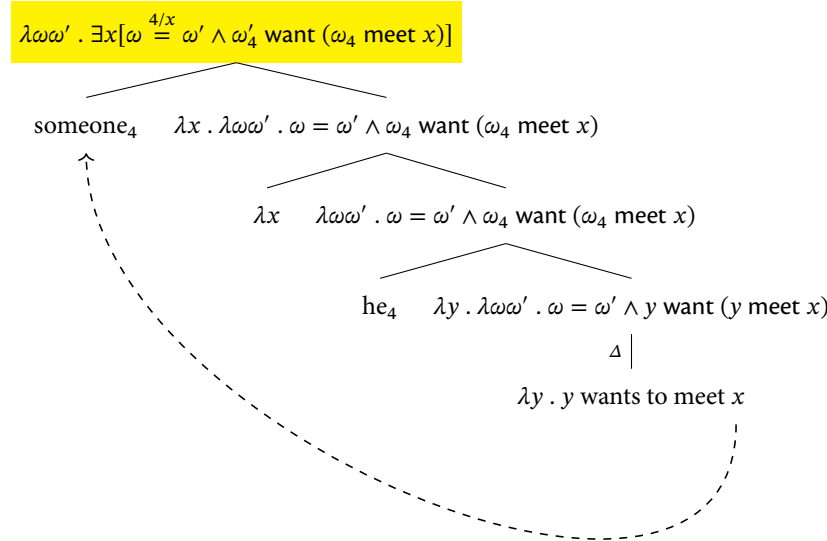
$$\lambda\omega\omega' \, . \, \exists\omega''[(\exists x[\omega \overset{4/x}{=} \omega'' \wedge \text{walked-in } x]) \wedge (\omega'' = \omega' \wedge \text{sat-down } \omega''_4)]$$

Figure 6: Cross-sentential anaphora in a Heimian fragment

$$\lambda\omega\omega' \, . \, \exists x[\omega \overset{4/x}{=} \omega' \wedge \text{walked-in } x]$$

...

Someone^4 walked in $\lambda n \, . \, \lambda m \, . \, \lambda\omega\omega' \, . \exists\omega''[m \, \omega \, \omega'' \wedge n \, \omega'' \, \omega']$ $\lambda\omega\omega' \, . \, \omega = \omega' \wedge \text{sat-down } \omega_3$

;

he$_4$ sat down

tures this contrast, by virtue of the left-to-right bias built into the definition of discourse sequencing.

If we try to compute the ccp for (21b), the result is guaranteed to be undefined. This is because, if the input assignment ω is defined for 4, it can't also be *undefined* for 4, as is required by the meaning contributed by the indefinite.

(22) $\lambda\omega\omega' \, . \, \exists\omega''[\omega = \omega'' \wedge \text{sat-down } \omega_4 \wedge (\exists x[\omega'' \overset{4/x}{=} \omega' \wedge \text{walked-in } x])]$

DS doesn't by itself however capture wco – this is because, independently, we need a mechanism that allows indefinites to *take scope*; indefinites introduce discourse referents at their scope site. We can therefore compute a bound reading for the following example, by scoping the indefinite over the pronoun:[14]

$$\lambda\omega\omega' \, . \, \exists x[\omega \overset{4/x}{=} \omega' \wedge \omega'_4 \text{ want } (\omega_4 \text{ meet } x)]$$

someone$_4$ $\lambda x \, . \, \lambda\omega\omega' \, . \, \omega = \omega' \wedge \omega_4 \text{ want } (\omega_4 \text{ meet } x)$

λx $\lambda\omega\omega' \, . \, \omega = \omega' \wedge \omega_4 \text{ want } (\omega_4 \text{ meet } x)$

he$_4$ $\lambda y \, . \, \lambda\omega\omega' \, . \, \omega = \omega' \wedge y \text{ want } (y \text{ meet } x)$

Δ

$\lambda y \, . \, y \text{ wants to meet } x$

[14] For reasons that will become clear here, we're being a bit sneaky concerning how the scoped indefinite binds its trace.

Figure 7: Violating wco in a Heimian fragment
"He$_4$ wants to meet someone^4"

Intuitively, a problematic feature of DS in this regard is that it ties together DR

introduction with quantificational scope.

2.2   The Dynamic Prediction Principle

At the heart of Chierchia account of wco is an apparently minor modification to orthodox dynamics, with far reaching consequences: the Dynamic Predication Principle (DPP), stated in (23).

(23)   The Dynamic Predication Principle (DPP)
DRS can only be introduced by predicates.   (Chierchia 2020: p. 32)

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

(24)   Discourse referent introduction (def.)
$f^{\Delta_n} := \lambda x \,.\, \lambda \omega \,.\, \lambda \omega' \omega \overset{n/x}{=} \omega' \wedge f\, x$ $\Delta_n : (e \rightarrow t) \rightarrow e \rightarrow T$

In dynamic semantics, the connectives manipulate CCPS directly. At the heart of the system is the entry for dynamic sequencing/conjunction, given in (20).

(25)   Dynamic negation (def.)
$\neg\, m := \lambda \omega \,.\, \lambda \omega' \,.\, \omega = \omega' \wedge m^{\downarrow}\, \omega$ $\neg : T \rightarrow T$

(26)   Dynamic lift (def.)
$P^{\Delta} := \lambda x \,.\, \lambda \omega \,.\, \lambda \omega' \,.\, \omega = \omega' \wedge p\, x$ $\Delta : (e \rightarrow t) \rightarrow e \rightarrow T$

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

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

(28)   Someone (def.)
$\text{someone}_n\, m := \lambda \omega \,.\, \lambda \omega' \,.\, \exists x [m\, \omega\, \omega']$ $\text{someone}_n : T \rightarrow T$
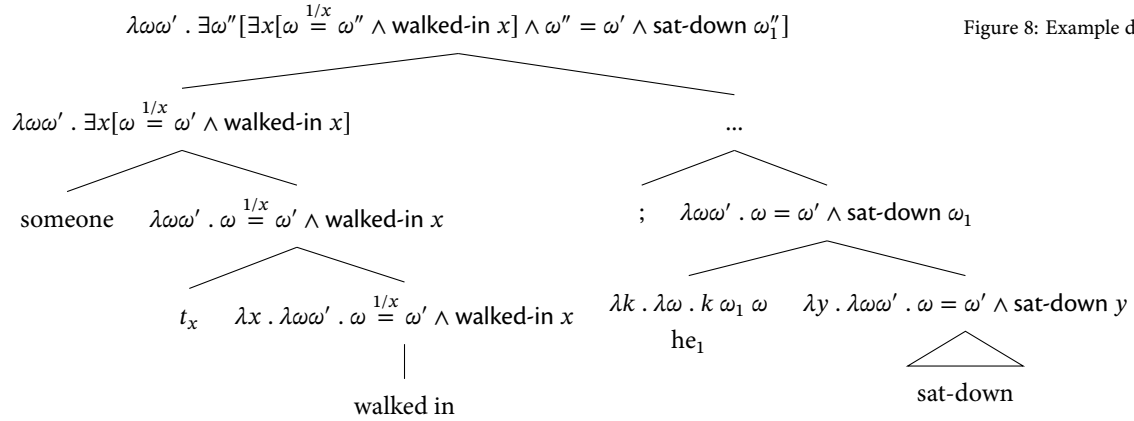
$$\lambda\omega\omega' \, . \, \exists\omega''[\exists x[\omega \overset{1/x}{=} \omega'' \wedge \text{walked-in } x] \wedge \omega'' = \omega' \wedge \text{sat-down } \omega_1'']$$

Figure 8: Example derivation

$$\lambda\omega\omega' \, . \, \exists x[\omega \overset{1/x}{=} \omega' \wedge \text{walked-in } x]$$

...

someone $\quad \lambda\omega\omega' \, . \, \omega \overset{1/x}{=} \omega' \wedge \text{walked-in } x$

; $\quad \lambda\omega\omega' \, . \, \omega = \omega' \wedge \text{sat-down } \omega_1$

$t_x \quad \lambda x \, . \, \lambda\omega\omega' \, . \, \omega \overset{1/x}{=} \omega' \wedge \text{walked-in } x$

$\lambda k \, . \, \lambda\omega \, . \, k\,\omega_1\,\omega \quad \lambda y \, . \, \lambda\omega\omega' \, . \, \omega = \omega' \wedge \text{sat-down } y$

he$_1$

walked in

sat-down

2.3 Accessibility

2.4 From dynamic semantics to event semantics

Traditions in event semantics:

Neo-Davidsonian (Castañeda 1967, Parsons 1990):

(29) $[\![\text{love}]\!] \coloneqq \lambda e \, . \, \text{love } e$ $\qquad\qquad\qquad\qquad$ v → t

Thematic role functions (see also Elliott 2017):

(30) THEME $\coloneqq \lambda f \, . \, \lambda x \, . \, \lambda e \, . \, \text{theme } e = x \wedge f\,e$ $\qquad$ (v → t) → e → v → 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.[15] 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.

[15] 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 seman-
tics. We'll adopt his system here.

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

(31) $D\ a := g \to \{(a, g)\}$

(32)   Unit (def.)
$a^{\eta} := \lambda g \,.\, \{(a, g)\}$

> Redo definition of bind

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

(34) $\text{pro}_n := \lambda g \,.\, \{(g_n, g)\}$ $D\ e$

(35) $\text{some boy}_n := \lambda g \,.\, \{(x, g) \mid \text{boy}\ x\}$ $D\ e$

(36) $m^{\Delta_n} := \lambda g \,.\, \bigcup_{(x,h) \in m\ g} \{(x, h^{[n \to x]})\}$ $D\ e \to D\ e$

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

References

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

Barker, Chris & Chung-chieh Shan. 2014. *Continuations and natural language*
(Oxford studies in theoretical linguistics 53). Oxford University Press.
228 pp.

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

Castañeda, Hector-Neri. 1967. Comments. In Nicholas Resher (ed.), *The logic of decision and action*, 104–112. Pittsburgh: University of Pittsburgh Press.

Charlow, Simon. 2014. *On the semantics of exceptional scope*. Dissertation.

Charlow, Simon. 2019. Static and dynamic exceptional scope. lingbuzz/004650. accepted at *Journal of Semantics*.

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

Chierchia, Gennaro. 2020. Origins of weak crossover: When dynamic semantics meets event semantics. *Natural Language Semantics* (28).

Dekker, Paul. 1994. Predicate logic with anaphora. *Semantics and Linguistic Theory* 4(0). 79–95.

Elliott, Patrick D. 2017. *Elements of clausal embedding*. University College London dissertation.

Elliott, Patrick D. 2019. Two souls of disjunction. unpublished manuscript.

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

Heim, Irene. 1982. *The semantics of definite and indefinite noun phrases*. 2011 edition - typesetting by Anders J. Schoubye and Ephraim Glick. University of Massachusetts - Amherst dissertation.

Heim, Irene. 1983. On the projection problem for presuppositions. In *Proceedings of WCCFL 2*, 114–125. Stanford University.

Parsons, Terence. 1990. *Events in the semantics of English: a study in subatomic semantics*. The MIT Press.

Rothschild, Daniel & Matthew Mandelkern. 2017. Dynamic semantics and pragmatic alternatives. Lecture notes from a course taught at ESSLLI 2017.

Shan, Chung-Chieh & Chris Barker. 2006. Explaining Crossover and Superiority as Left-to-right Evaluation. *Linguistics & Philosophy* 29(1). 91–134.