The Center of Research in Syntax, Semantics and Phonology
Wednesday 14 October through Friday 16 October, 2015
CRISSP/KU Leuven Brussels Campus

Continuations, Scope, and Natural Language

Chris Barker
New York University
Department of Linguistics

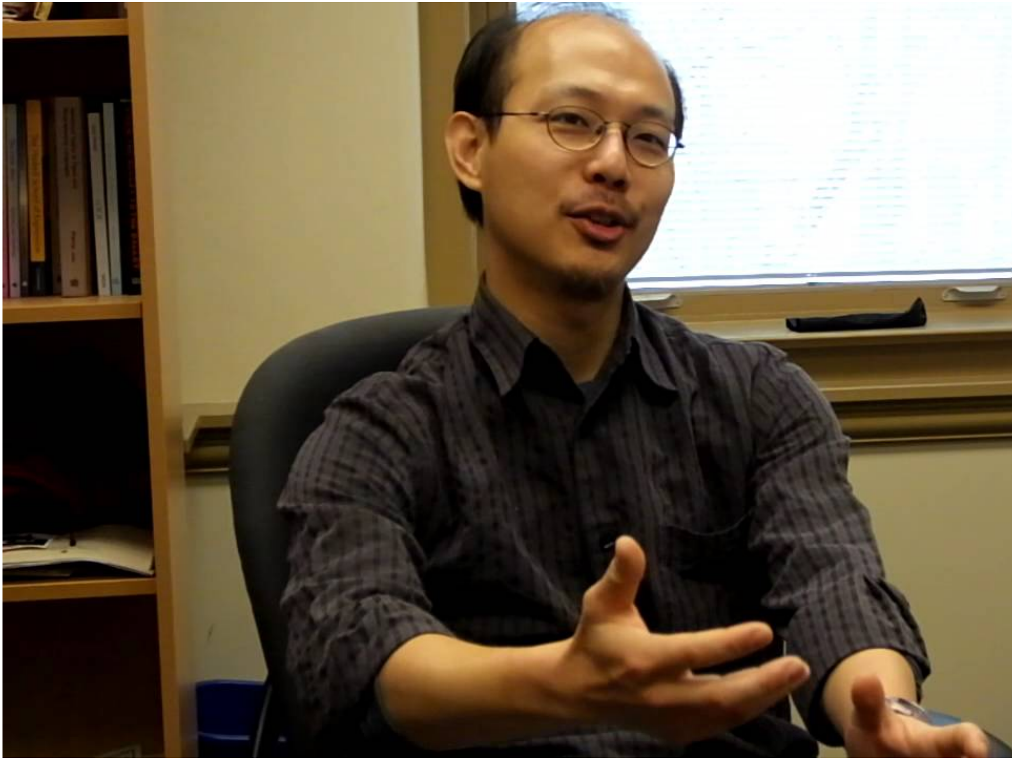
Abstract Scope-taking is a hallmark of natural language: not only is it widespread in the world's languages, it is pervasive within individual languages. It is so familiar to us linguists that it is sometimes hard to appreciate just how astonishing it is for an expression to take material that surrounds it as its semantic argument. For instance, in *Ann gave everyone cookies*, the semantic argument of the quantificational DP *everyone* is the property constructed by abstracting over the direct object position, i.e., $\lambda x.\textbf{gave}(x)(\textbf{cookies})(\textbf{Ann})$. Clearly, a deep and complete understanding of scope-taking is of foundational importance. Building on joint work with Chung-chieh Shan, I will bring to bear insights and techniques from the theory of programming languages, in particular, the concept of a CONTINUATION. One potential advantage of continuations over other approaches is that continuations allow fine-grained control over the order of evaluation. This allows a new account of sensitivity to linear order in weak crossover, reconstruction, negative polarity licensing, and dynamic anaphora. I will go on to explain how continuations allow understanding the traditional method of Quantifier Raising not as an ad-hoc heuristic for constructing so-called logical forms, but as a bone fide logical inference rule in the context of a substructural logic. This will lead to an account of parasitic scope and recursive scope, as in adjectives such as *same* and *different*, as well as of sluicing as a kind of anaphora, including accounts of sprouting examples (*Ann left, but I dont know when*) and Andrews Amalgams (*Ann ate I dont know what yesterday*).

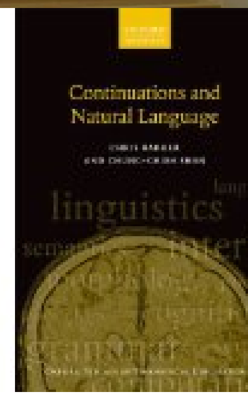
Plan

- Lecture 1
  - Scope
    - Scope basics
    - Quantificational binding and c-command
    - Theories of scope
    - Kinds of scope
      - Parasitic scope
      - Recursive scope
  - Continuations and order
    - Continuation basics: COMBINE, LIFT, and LOWER
    - Weak crossover
    - Order asymmetries in discourse anaphora
    - Linear order sensitivity in negative polarity
- Lecture 2
  - WH-movement
    - In-situ WH
    - Fronted WH

    * Pied Piping
  - Recnstruction
    * Inverse scope
    * Delayed evaluation
    * Reconstructed crossover
- Lecture 3
  - The logic of QR
    * What is the logical content of QR?
    * Lambek + QR
    * Parasitic scope
    * Same
  - Scope and Sluicing
    * Theories of sluicing: LF copying, PF deletion, anaphor
    * Anaphora to a continuation
    * Recursive scope: Andrews Amalgams

Some results joint work with Chung-chieh (Ken) Shan



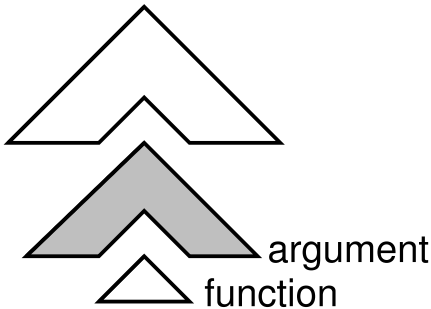


Chris Barker and Chung-chieh Shan. 2014.
Continuations in Natural Langauge. OUP.

Scope

- Scope-taking is one of the most fundamental, one of the most characteristic, and one of the most dramatic features of the syntax and semantics of natural languages.
- A phrase **takes scope** over a larger expression that contains it when the larger expression serves as the smaller phrase's semantic argument.

(1) John said [**Mary called** [everyone] **yesterday**] with relief.



Barker. 2015. Scope. Lappin & Fox, *Handbook of Sem. Theory*.

Scope versus quantification

Quantificational expressions that arguably require (non-trivial) scop

- quantificational DPs (e.g., *everyone*)
- quantificational determiners (*every*)
- quantificational adverbs (*mostly*)
- adjectives (*occasionally*, *same* and *different*)
- comparatives and superlatives (*–er*, *–est*).

Quantificational expression that occur in predicate position, and so do not need to take scope: tense, modal auxiliaries, dynamic negation, etc.

Expressions that arguably take displaced scope, but which are not necessarily quantificational: question particles, wh-words, disjunction, some analyses of proforms (both overt and silent), expressives such as *damn*, etc.

Displaced scope gives rise to ambiguity

(2) a. Ann intends to marry each man she meets.
b. *Each* takes wide scope over *intend*:
For each man x, Ann intends to marry x.
c. *Intend* takes wide scope over *each*:
Ann intends for her marriage partners to exhaust the set of men that she meets.

Relative scope ambiguity

(3) a. A man ate every cookie.
b. **Linear scope**: *a* outscopes *every*:
There is a man who ate every cookie.
c. **Inverse scope**: *every* outscopes *a*:
For every cookie x, there is some potentially different man who ate x.

(4) Every woman saw every man. [Still ambiguous!]

- The more prominent reading is the linear one.
- The preference for linear scope is robust across construction types and across languages.
- If any scoping is available, at least the linear scoping will certainly be available.

Inverse scope versus inverse linking

(5) a. [Some person from [every city]] loves it.
b. There is a person who is from every city and who loves some salient thing.
c. For every city x, there is some person y who is from x, and y loves x.

Scope islands

(6) a. Someone thought [everyone left].
b. There is a person who thought that everyone left.
c. For each person x, there is some person y such that y thought x left.

Relative clauses are particularly strong scope islands:

(7) a. A woman from every borough spoke.
b. A woman [who is from every borough] spoke.

- Scope islands are sensitive to the identity of the scope-taking element in question. In particular, indefinites are able to escape from any scope island

Scope ambiguity and ellipsis

(8) a. A woman watched every movie, and a man did too.
b. A woman watched every movie, and Mary did too.

- linear scope for both conjuncts ok
- inverse scope for both conjuncts ok
- mismatched scope relations across the conjuncts not ok
- **Derivational economy**? Quantifiers take inverse scope only if doing so has a detectable effect on truth conditions

(9) A woman watched every movie, but I don't know who.

Sluicing example also unambiguous, but for a different reason...

C-command not required for quantificational binding

Heim and Kratzer 1998:261:

A DP A semantically binds a non-null DP B iff

- A and B are co-indexed
- A c-commands B
- A is in an argument position
- Minimality holds (there is no C that semantically bind B and is closer to B) 2

(10) a. [Everyone$_i$'s mother] thinks he$_i$'s a genius.
b. [Someone from every$_i$ city] hates it$_i$.
c. John gave [to each$_i$ participant] a framed picture of her$_i$ mother.
d. We [will sell no$_i$ wine] before it$_i$s time.
e. [After unthreading each$_i$ screw], but before removing it$_i$...
f. The grade [that each$_i$ student receives] is recorded in his$_i$ file.

Theories of scope

- Quantifying In (Montague)
- Quantifier Raising (May)
- Cooper Storage
- Flexible Montague Grammar (Hendriks)
- Scope as surface constituency (Steedman)
- Type-logical grammar (Lambek)
  - Lambek-Grishin calculus (Moortgat & Bernardi)
  - Discontinuous Lambek Grammar (Morrill & Valentín)
- Continuation-based systems (Barker and Shan, de Groote)

Quantifying In (Montague)

- Verbs and other predicates denote relations over generalized quantifiers
- No type clash
- In addition, Quantifying In:

$\mathrm{QI}_{\mathrm{SYN}}$(everyone, [John [called he]]) = [John [called everyone]].
$\mathrm{QI}_{\mathrm{SEM}}$(**everyone**, **called** x **john**) = **everyone**$(\lambda x.($**called** x **john**$)$

Quantifier Raising (May)

- Dominant in linguistics and philosophy of language
- Easy to teach and easy to understand
- Canonical presentation: Heim and Kratzer 1998
- Covert movement (pace Kayne)

$$[\text{John}\,[\text{called everyone}]] \overset{\text{QR}}{\Rightarrow} [\text{everyone}(\lambda x[\text{John}\,[\text{called}\,x]])]$$

QR easily accounts for inverse scope by allowing QR to target quantifiers in any order.

$$\text{Linear scoping}: \quad [\text{someone}\,[\text{called everyone}]]$$

$$\overset{\mathsf{QR}}{\Rightarrow} [\text{everyone}(\lambda x[\text{someone}\,[\text{called}\,x]])]$$

$$\overset{\mathsf{QR}}{\Rightarrow} [\text{someone}(\lambda y[\text{everyone}(\lambda x[y\,[\text{called}\,x]])])]$$

$$\text{Inverse scoping}: \quad [\text{someone}\,[\text{called everyone}]]$$

$$\overset{\mathsf{QR}}{\Rightarrow} [\text{someone}(\lambda y[y\,[\text{called}\,\text{everyone}]])]$$

$$\overset{\mathsf{QR}}{\Rightarrow} [\text{everyone}(\lambda x[\text{someone}(\lambda y[y\,[\text{called}\,x]])])]$$

Inverse Linking in QR

Inverse linking: $[[\mathrm{some}\,[\mathrm{friend}\,[\mathrm{of}\,\mathrm{everyone}]]]\,[\mathrm{called}]]$

$$\overset{\mathsf{QR}}{\Rightarrow} [[\mathrm{some}\,[\mathrm{friend}\,[\mathrm{of}\,\mathrm{everyone}]]]\,(\lambda x[x\,\mathrm{called}]\,)]$$

$$\overset{\mathsf{QR}}{\Rightarrow} [\mathrm{everyone}(\lambda y\,[[\mathrm{some}\,[\mathrm{friend}\,[\mathrm{of}\,y]]]\,(\lambda x[x\,\mathrm{called}]\,)]\,)]$$

Unbound trace: $[[\mathrm{some}\,[\mathrm{friend}\,[\mathrm{of}\,\mathrm{everyone}]]]\,[\mathrm{called}]]$

$$\overset{\mathsf{QR}}{\Rightarrow} [\mathrm{everyone}(\lambda y\,[[\mathrm{some}\,[\mathrm{friend}\,[\mathrm{of}\,y]]]\,[\mathrm{called}]]\,)]$$

$$\overset{\mathsf{QR}}{\Rightarrow} [[\mathrm{some}\,[\mathrm{friend}\,[\mathrm{of}\,y]]]\,(\lambda x[\mathrm{everyone}(\lambda y.x)]\,[\mathrm{called}]\,)]$$

Cooper Storage

- Syntactic parsing and semantic composition proceed bottom up
- Two structures build in parallel
  - A tree structure with a partial semantic interpretation
  - A multiset (unordered list) of quantifiers
- At a clause node, take quantifiers off the store
- A derivation is complete only when the store is empty

	SYNTAX	SEMANTICS	STORE
1.	called everyone	**call** x	$[\langle$**e'one**$, x\rangle]$
2.	someone [called everyone]	**call** $x\,y$	$[\langle$**e'one**$, x\rangle, \langle$**s'on**
3.	someone [called everyone]	**s'one**$(\lambda y.$**call** $x\,y)$	$[\langle$**e'one**$, x\rangle]\rangle$
4.	someone [called everyone]	**e'one**$(\lambda x.$**s'one**$(\lambda y.$**call** $x\,y))$	[]

Flexible Montague Grammar (Hendriks)

Argument Raising (AR): if an expression ϕ has a denotation

$$\lambda x_1 \lambda x_2 \ldots \lambda x_i \ldots \lambda x_n [f(x_1, x_2, \ldots, x_i, \ldots, x_n)]$$

with type

$$a_1 \to a_2 \to \ldots \to a_i \to \ldots \to a_n \to r,$$

then ϕ also has the denotation

$$\lambda x_1 \lambda x_2 \ldots \lambda x_i \ldots \lambda x_n [x_i(\lambda x. f(x_1, x_2, \ldots, x, \ldots, x_n))]$$

with type

$$a_1 \to a_2 \to \ldots \to ((a_i \to r) \to r) \to \ldots \to a_n \to r.$$

$$\begin{array}{ccccc} \mathtt{e} \to \mathtt{e} \to \mathtt{t} & \text{AR} & \mathtt{G} \to \mathtt{e} \to \mathtt{t} & \text{AR} & \mathtt{G} \to \mathtt{G} \to \mathtt{t} \\ \text{saw} & \Rightarrow & \text{saw} & \Rightarrow & \text{saw} \\ \lambda x y.\textbf{saw}\, x\, y & & \lambda \mathcal{X} y.\mathcal{X}(\lambda x.\textbf{saw}\, x\, y) & & \lambda \mathcal{X}\mathcal{Y}.\mathcal{Y}(\lambda y.\mathcal{X}(\lambda x.\textbf{saw}\, x\, y)) \end{array}$$

Flexible Montague Grammar (Hendriks)

Value Raising (VR): if an expression ϕ has a denotation

$$\lambda x_1 ... \lambda x_n [f(x_1, ..., x_n)] \text{ with type } a_1 \to ... \to a_n \to r,$$

then for all types r', ϕ also has the denotation

$$\lambda x_1 ... \lambda x_n \lambda \kappa [\kappa (f(x_1, ..., x_n))] \text{ with type } a_1 \to ... \to a_n \to (r \to r') \to r'.$$

$$\begin{array}{ccccc} \mathtt{e} \to \mathtt{e} & \text{VR} & \mathtt{e} \to \mathtt{G} & \text{AR} & \mathtt{G} \to \mathtt{G} \\ \text{mother} & \Rightarrow & \text{mother} & \Rightarrow & \text{mother} \\ \lambda x.\textbf{mom}\, x & & \lambda x \kappa . \kappa(\textbf{mom}\, x) & & \lambda \mathcal{P} \kappa . \mathcal{P}(\lambda x . \kappa(\textbf{mom}\, x)) \end{array}$$

$$\begin{aligned} [\![\textit{left}]\!]([\![\textit{mother}]\!][\![\textit{everyone}]\!]) &= (\lambda \mathcal{P}.\mathcal{P}\textbf{left})((\lambda \mathcal{P}\kappa.\mathcal{P}(\lambda x.\kappa(\textbf{mom}\, x)))\textbf{e} \\ &= \textbf{everyone}(\lambda x.\textbf{left}(\textbf{mom}\, x)) \end{aligned}$$

- Continuation-based system (see Barker and Shan, ch. 7)

Function composition: scope as surface constituency

NB, Lambek-style slashes:

(10) a.	everyone$_a$	$S/(DP\backslash S)$	$\lambda\kappa\forall x.\kappa x$
b.	everyone$_b$	$((DP\backslash S)/DP)\backslash(DP\backslash S)$	$\lambda\kappa y\forall x.\kappa x y$
c.	no one$_c$	$(S/DP)\backslash S$	$\lambda\kappa\neg\exists x.\kappa x$
d.	no one$_d$	$((DP\backslash S)/DP)\backslash(DP\backslash S)$	$\lambda\kappa y\neg\exists x.\kappa x y$

Linear scope:

$$\dfrac{\text{everyone}_a{:}S/(DP\backslash S) \qquad \dfrac{\text{loves}{:}(DP\backslash S)/DP \quad \text{no one}_d{:}((DP\backslash S)/DP)\backslash(DI}{\text{loves no one}_d{:}DP\backslash S}}{\text{everyone}_a\ (\text{loves no one}_d){:}S}>$$

Inverse scope:

$$\dfrac{\dfrac{\text{everyone}_a{:}S/(DP\backslash S) \qquad \text{loves}{:}(DP\backslash S)/DP}{\text{everyone}_a\ \text{loves}{:}S/DP}>\mathbf{B} \qquad \text{no one}_c{:}(S/DI}{\text{everyone}_a\ \text{loves no one}_c{:}S}$$

Does medial scope-taking really exist (yes)?

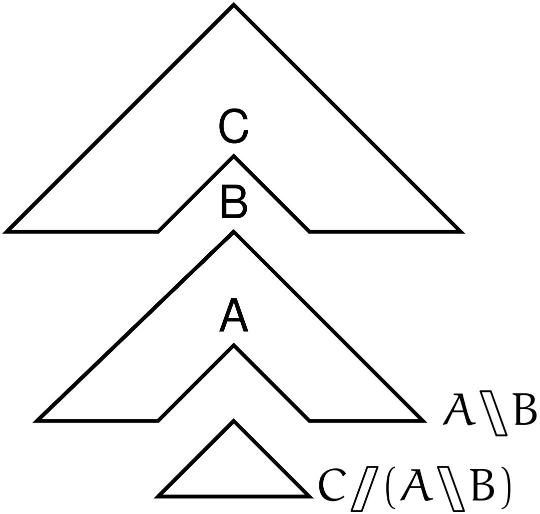
(11) [[The man who builds] each clock] also repairs it.

(12) a. [Some student from each department who had failed] complained.

b. [The man who puts each clock into its velvet case] also repairs it.

c. See if the nursing home is willing to give you the names of [some of each doctor’s other patients in the facility]

Continuations: reasoning about scope-taking



Barker and Shan 2015

(12)

$$\left(\begin{array}{cc} \dfrac{\mathrm{S} \,|\, \mathrm{S}}{\mathrm{DP}} & \dfrac{\mathrm{S} \,|\, \mathrm{S}}{\mathrm{DP}\backslash\mathrm{S}} \\ \textit{everyone} & \textit{left} \\ \dfrac{\forall y.[\;]}{y} & \dfrac{[\;]}{\textbf{left}} \end{array} \right) = \begin{array}{c} \dfrac{\mathrm{S} \,|\, \mathrm{S}}{\mathrm{S}} \\ \textit{everyone left} \\ \dfrac{\forall y.[\;]}{\textbf{left}(y)} \end{array}$$

Crossover

(22)

$$\left(\begin{array}{cc} \dfrac{\mathrm{DP} \rhd \mathrm{S} \;\big|\; \mathrm{S}}{\mathrm{DP}} & \dfrac{\mathrm{S} \;\big|\; \mathrm{S}}{\mathrm{DP}\backslash\mathrm{DP}} \\ \text{his} & \text{mother} \end{array}\right) \left(\begin{array}{cc} \dfrac{\mathrm{S} \;\big|\; \mathrm{S}}{(\mathrm{DP}\backslash\mathrm{S})/\mathrm{DP}} & \dfrac{\mathrm{S} \;\big|\; \mathrm{DP} \rhd \mathrm{S}}{\mathrm{DP}} \\ \text{loves} & \text{everyone} \end{array}\right) = \begin{array}{c} \dfrac{\mathrm{DP} \rhd \mathrm{S} \;\big|\; \mathrm{DP} \rhd \mathrm{S}}{\mathrm{S}} \\ \text{his mother loves every} \end{array}$$

(23) a. Which of his$_i$ relatives does everyone$_i$ love the most?

b. the relative of his$_i$ that everyone$_i$ loves the most

Kinds of scope-taking

- Lowering
- Spit scope
- Parasitic scope
- Recursive scope

Lowering (‘total reconstruction’)

(24) a. Some politician$_i$ is likely [t_i to address John’s constituency

b. There is a politician x such that x is likely to address John’

c. The following is likely: that there is a politician who will address John’s constituency.

Split scope

- Ger. *kein* = negation + indefinite

(25) a. How many people should I talk to?
b. What number n is such that there are n-many people I sho
c. What number n is such that I should talk to n-many people

(26) a. This paper is 10 pages long. It is required to be exactly 5 p
b. required $> (d = 15) >$ a d-long paper: it is necessary for th exactly 15 pages long.
c. $(d = 15) >$ required $>$ a d-long paper: the maximum lengt the paper is required to be at least that long is 15 pages.

The ambiguity is analyzed by assuming that the comparative operator *–er* takes split scope. The reading in (26b) arises when *required* takes scope over both parts contributed by *–er*, and the reading in (26c) arises when the top part of the split scope of *–er* takes wider scope over *required*.

Normal scope:

$$\frac{E \mid F}{A}$$

Split scope:

$$\frac{E \mid \quad F}{\left(\dfrac{C \mid D}{B}\right)}$$

Existential versus distributive quantification

(27) a. If three relatives of mine die, I'll inherit a house.
b. If there exists any set of three relatives who die, I'll inherit
c. There exists a set of three relatives each with the followin
if that person dies, I'll inherit a house.
d. There exists a set of three relatives such that if each mem
I'll inherit a house.

(28) Every child tasted every apple.

$$\frac{\exists X.[\,]}{\dfrac{\forall x \in X.[\,]}{x}} : \frac{\mathsf{S}\,|\,\mathsf{S}}{\dfrac{\mathsf{S}\,|\,\mathsf{S}}{\mathsf{DP}}}$$

Parasitic scope

1. everyone[read[the[same book]]]
2. everyone$(\lambda x.$[x[read[the[same book]]]]$)$
3. everyone(same$(\lambda f \lambda x.$[x[read[the[f(book)]]]]$))$

$$\frac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\middle|\; \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}}{\mathrm{ADJ}}$$

Recursive scope

$$\frac{\left(\dfrac{D \;\big|\; E}{C}\right) \;\Bigg|\; B}{A}$$

(29) Ann and Bill know [some of the same people].

$$\frac{\left(\dfrac{DP\backslash\!\!\backslash S \;\big|\; DP\backslash\!\!\backslash S}{DP}\right) \;\Bigg|\; DP}{A}$$

.

(13) Sally ate [I don't know what __] today

Indefinites

[Way too complicated to get into today. Choice functions, List monads, funcational readings, pseudoscope, sigh.]

(31) a. Each student read every paper that discussed some problem.
b. Every student is such that there is some problem such that the student read every paper that discussed the problem.

Branching quantifiers

[Way too complicated to get into today. Skolemization, partially ordered quantifiers, functional readings, sigh.]

(32) Some relative of each villager and some relative of each townsman hate each other.

$$\begin{pmatrix} \forall x & \exists x' \\ \forall y & \exists y' \end{pmatrix} .(\textbf{villager}\, x \wedge \textbf{townsman}\, y) \to (\textbf{rel}\, x\, x' \wedge \textbf{rel}\, y\, y' \wedge \textbf{hate}\, x' y')$$

$$\exists f \exists g \forall x \forall y.(\textbf{villager}\, x \wedge \textbf{townsman}\, y) \to (\textbf{rel}\, x\, (f x) \wedge \textbf{rel}\, y\, (g y) \wedge \textbf{hate}\, (f x)(g y))$$

Cumulative readings

(38) a. Two boys read three books.
b. two $>$ three: Two boys are such that each of them read thr
c. three $>$ two: Three books are such that each of them was
d. cumulative: a group of two boys were involved in reading a

De dicto/de re

(39) a. Lars wants to marry a Norwegian.
b. $\textbf{wants}(\exists x.\textbf{norwegian}\,x \wedge \textbf{marry}\,x\,\textbf{lars})\,\textbf{lars}$
c. $\exists x.\textbf{norwegian}\,x \wedge \textbf{wants}(\textbf{marry}\,x\,\textbf{lars})\,\textbf{lars}$

(40) Mary wants to buy an inexpensive coat.

Continuations and order

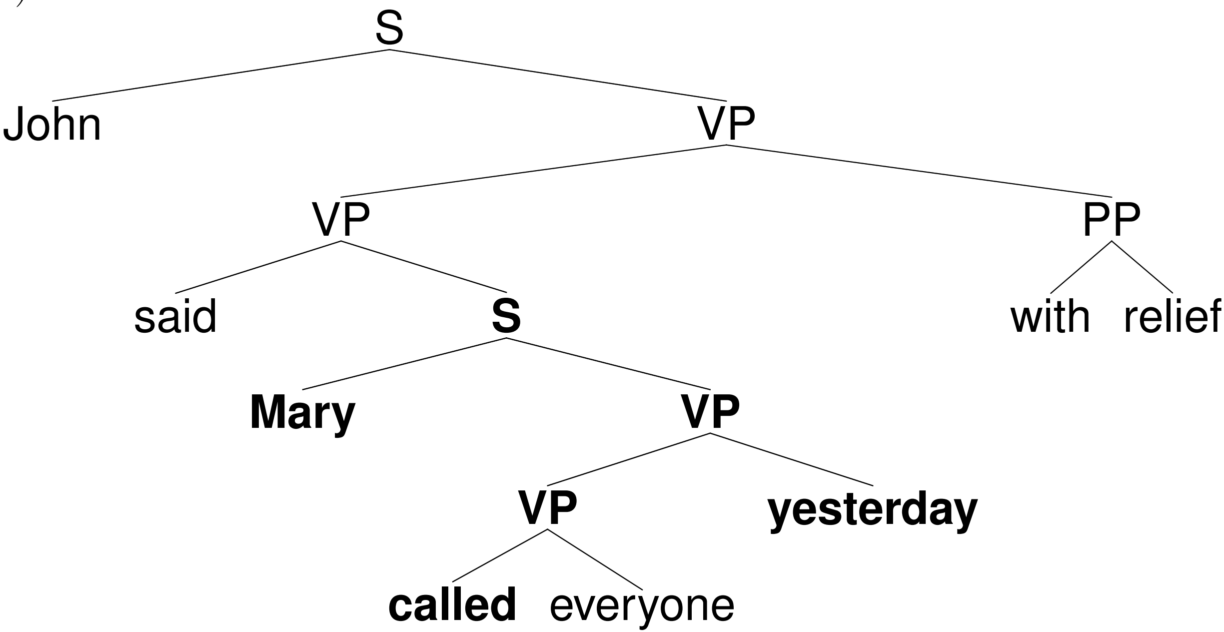
(14) **The continuation hypothesis**: some natural language expressions denote functions on their continuations, i.e., functions that take their own semantic context as an argument.

*

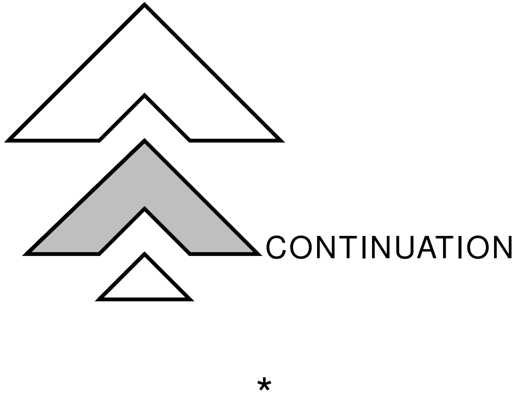
What's a continuation?
A CONTINUATION is a portion of the context surrounding an expression.

(15) John said [**Mary called** everyone **yesterday**] with relief.

(16)


S
John
VP
VP
PP
said
S
with
relief
Mary
VP
VP
yesterday
called
everyone

(17)



What makes continuations essential?

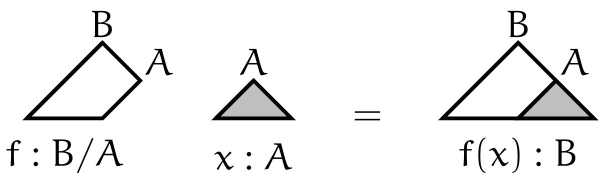
(18) a. Everyone$_i$ loves his$_i$ mother.
b. *His$_i$ mother loves everyone$_i$.

(19) a. Which of his$_i$ relatives does every man$_i$ love the most?
b. The relative of his$_i$ that every man$_i$ loves most is his mother.

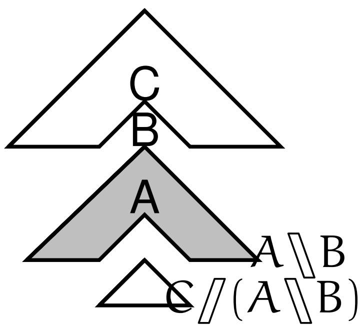
Syntactic categories: adjacency vs. containment

(20)
$$\left(\begin{array}{cc} \mathsf{DP} & \mathsf{DP}\backslash\mathsf{S} \\ \textit{John} & \textit{left} \\ \mathbf{j} & \mathbf{left} \end{array}\right) = \begin{array}{c} \mathsf{S} \\ \textit{John left} \\ \mathbf{left}(\mathbf{j}) \end{array}$$

(21)



(22)



$$\left(\begin{array}{cc} \dfrac{\mathsf{S} \mid \mathsf{S}}{\mathsf{DP}} & \dfrac{\mathsf{S} \mid \mathsf{S}}{\mathsf{DP}\backslash\mathsf{S}} \\ \textit{everyone} & \textit{left} \\ \dfrac{\forall y.[\,]}{y} & \dfrac{[\,]}{\mathbf{left}} \end{array}\right) = \begin{array}{c} \dfrac{\mathsf{S} \mid \mathsf{S}}{\mathsf{S}} \\ \textit{everyone left} \\ \dfrac{\forall y.[\,]}{\mathbf{left}\,y} \end{array} \tag{23}$$

First, purely as a matter of notation, syntactic categories of the form $C/\!\!/(A\backslash\!\!\backslash B)$ can optionally be written as $\dfrac{C \mid B}{A}$. This is what we call the 'tower' convention.

$$\begin{array}{c} \mathsf{S}/\!\!/(\mathsf{DP}\backslash\!\!\backslash\mathsf{S}) \\ \textit{everyone} \\ \lambda\kappa\forall y.\kappa y \end{array} \equiv \begin{array}{c} \dfrac{\mathsf{S} \mid \mathsf{S}}{\mathsf{DP}} \\ \textit{everyone} \\ \dfrac{\forall y.[\,]}{y} \end{array} \tag{24}$$

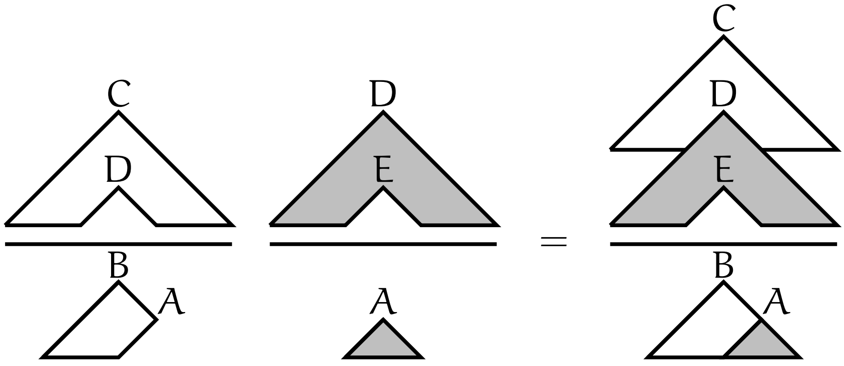
In general, a function of the form $\lambda\kappa.g[\kappa f]$ can optionally be written as $\dfrac{g[\,]}{f}$.

THE COMBINATION SCHEMA

(25) **The combination schema** ('/' variant):

$$\left(\begin{array}{cc} \dfrac{C \mid D}{B/A} & \dfrac{D \mid E}{A} \\ \text{left.exp} & \text{right.exp} \\ \dfrac{g[\,]}{f} & \dfrac{h[\,]}{x} \end{array}\right) = \begin{array}{c} \dfrac{C \mid E}{B} \\ \text{left.exp right.exp} \\ \dfrac{g[h[\,]]}{f(x)} \end{array}$$

(26)

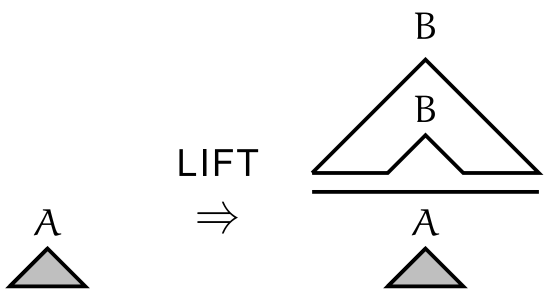


The LIFT type-shifter

(27)

$$\boxed{\begin{array}{c} A \\ \textit{phrase} \\ x \end{array} \overset{\text{LIFT}}{\Rightarrow} \begin{array}{c} \dfrac{B \mid B}{A} \\ \textit{phrase} \\ \dfrac{[\;]}{x} \end{array}}$$

(28)



(29)

$$\text{(a)}\ \begin{array}{c}\mathsf{DP}\\ \textit{John}\\ \mathbf{j}\end{array} \overset{\mathsf{LIFT}}{\Rightarrow} \begin{array}{c}\dfrac{\mathsf{S}\mid\mathsf{S}}{\mathsf{DP}}\\ \textit{John}\\ \dfrac{[\;]}{\mathbf{j}}\end{array}$$

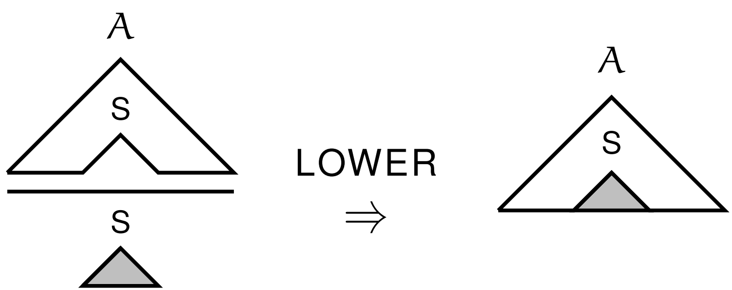
$$\text{(b)}\ \begin{array}{c}\mathsf{DP}\backslash\mathsf{S}\\ \textit{left}\\ \mathbf{left}\end{array} \overset{\mathsf{LIFT}}{\Rightarrow} \begin{array}{c}\dfrac{\mathsf{S}\mid\mathsf{S}}{\mathsf{DP}\backslash\mathsf{S}}\\ \textit{left}\\ \dfrac{[\;]}{\mathbf{left}}\end{array}$$

The LOWER type-shifter

(30)

$$\begin{array}{ccc} \dfrac{A \;\big|\; \mathrm{S}}{\mathrm{S}} & \text{LOWER} & A \\ \textit{phrase} & \Rightarrow & \textit{phrase} \\ \dfrac{\mathrm{f}[\;]}{x} & & \mathrm{f}[x] \end{array}$$

(31)



(32)

$$\begin{array}{c}\dfrac{\mathrm{S}\mid\mathrm{S}}{\mathrm{S}}\\ \textit{everyone left}\\ \dfrac{\forall y.[\;]}{\textbf{left}\,y}\end{array} \quad \overset{\mathrm{LOWER}}{\Rightarrow} \quad \begin{array}{c}\mathrm{S}\\ \textit{everyone left}\\ \forall y.\,\textbf{left}\,y\end{array}$$

A linear scope bias

$$(33)\quad \begin{array}{c}\dfrac{\mathsf{S}\mid\mathsf{S}}{\mathsf{DP}}\\ \textit{someone}\\ \dfrac{\exists x.[\,]}{x}\end{array} \left(\begin{array}{c}\dfrac{\mathsf{S}\mid\mathsf{S}}{(\mathsf{DP}\backslash\mathsf{S})/\mathsf{DP}}\\ \textit{loves}\\ \dfrac{[\,]}{\mathbf{loves}}\end{array}\quad \begin{array}{c}\dfrac{\mathsf{S}\mid\mathsf{S}}{\mathsf{DP}}\\ \textit{everyone}\\ \dfrac{\forall y.[\,]}{y}\end{array}\right)$$

$$= \begin{array}{c}\dfrac{\mathsf{S}\mid\mathsf{S}}{\mathsf{S}}\\ \textit{someone loves everyone}\\ \dfrac{\exists x.\forall y.[\,]}{\mathbf{loves}\,y\,x}\end{array} \overset{\mathsf{LOWER}}{\Rightarrow} \begin{array}{c}\mathsf{S}\\ \textit{someone loves everyone}\\ \exists x.\forall y.\mathbf{loves}\,y\,x\end{array}$$

A scope ambiguity due to LOWER

(34) Mary wants everyone to leave.

$$(35)\quad \begin{array}{c} \dfrac{\mathrm{S} \mid \mathrm{S}}{\mathrm{DP}} \\ \textit{Mary} \\ \dfrac{[\,]}{\mathbf{m}} \end{array} \left(\begin{array}{c} \dfrac{\mathrm{S} \mid \mathrm{S}}{(\mathrm{DP}\backslash \mathrm{S})/\mathrm{S}} \\ \textit{wants} \\ \dfrac{[\,]}{\mathbf{wants}} \end{array} \left(\begin{array}{c} \dfrac{\mathrm{S} \mid \mathrm{S}}{\mathrm{DP}} \\ \textit{everyone} \\ \dfrac{\forall x.[\,]}{x} \end{array} \begin{array}{c} \dfrac{\mathrm{S} \mid \mathrm{S}}{\mathrm{DP}\backslash \mathrm{S}} \\ \textit{to leave} \\ \dfrac{[\,]}{\mathbf{leave}} \end{array} \right) \right)$$

$$= \begin{array}{c} \dfrac{\mathrm{S} \mid \mathrm{S}}{\mathrm{S}} \\ \textit{M.w.e.t.l} \\ \dfrac{\forall x.[\,]}{\mathbf{wants}(\mathbf{leave}\,x)\,\mathbf{m}} \end{array} \quad \overset{\text{LOWER}}{\Rightarrow} \quad \begin{array}{c} \mathrm{S} \\ \textit{Mary wants everyone to leave} \\ \forall x.\mathbf{wants}(\mathbf{leave}\,x)\,\mathbf{m} \end{array}$$

Binding and crossover

(36) a. Everyone$_i$ loves his$_i$ mother.
b. *His$_i$ mother loves everyone$_i$.

$$\left(\frac{\mathrm{DP} \rhd \mathrm{S} \mid \mathrm{S}}{\mathrm{DP}} \quad \frac{\mathrm{S} \mid \mathrm{S}}{\mathrm{DP}\backslash\mathrm{S}} \right) \qquad \frac{\mathrm{DP} \rhd \mathrm{S} \mid \mathrm{S}}{\mathrm{S}} \quad \text{LOWER} \quad \mathrm{DP} \rhd \mathrm{S} \tag{37}$$

$$\left(\begin{matrix} \textit{he} \\ \dfrac{\lambda y.[\,]}{y} \end{matrix} \quad \begin{matrix} \textit{left} \\ \dfrac{[\,]}{\mathbf{left}} \end{matrix} \right) = \begin{matrix} \textit{he left} \\ \dfrac{\lambda y.[\,]}{\mathbf{left}\, y} \end{matrix} \Rightarrow \begin{matrix} \textit{he left} \\ \lambda y.\, \mathbf{left}\, y \end{matrix}$$

(38)

$$\boxed{\begin{array}{c} \begin{array}{c|c} A & B \\ \hline \end{array} \\ \text{DP} \\ \textit{phrase} \\ \dfrac{f[\ ]}{x} \end{array} \quad \overset{\text{BIND}}{\Rightarrow} \quad \begin{array}{c} \begin{array}{c|c} A & \text{DP} \rhd B \\ \hline \end{array} \\ \text{DP} \\ \textit{phrase} \\ \dfrac{f[[\ ]x]}{x} \end{array}}$$

(39)

$$\begin{array}{c} \begin{array}{c|c} \text{S} & \text{S} \\ \hline \end{array} \\ \text{DP} \\ \textit{everyone} \\ \dfrac{\forall x.[\ ]}{x} \end{array} \quad \overset{\text{BIND}}{\Rightarrow} \quad \begin{array}{c} \begin{array}{c|c} \text{S} & \text{DP} \rhd \text{S} \\ \hline \end{array} \\ \text{DP} \\ \textit{everyone} \\ \dfrac{\forall x.[\ ]x}{x} \end{array}$$

Binding and the irrelevance of c-command

$$(40)\quad \begin{array}{c} \dfrac{\mathsf{S} \mid \mathsf{DP} \triangleright \mathsf{S}}{\mathsf{DP}} \\ \textit{everyone} \\ \dfrac{\forall x.[\,]x}{x} \end{array} \left(\begin{array}{c} \dfrac{\mathsf{DP} \triangleright \mathsf{S} \mid \mathsf{DP} \triangleright \mathsf{S}}{(\mathsf{DP}\backslash \mathsf{S})/\mathsf{DP}} \\ \textit{loves} \\ \dfrac{[\,]}{\textbf{loves}} \end{array} \left(\begin{array}{c} \dfrac{\mathsf{DP} \triangleright \mathsf{S} \mid \mathsf{S}}{\mathsf{DP}} \\ \textit{his} \\ \dfrac{\lambda y.[\,]}{y} \end{array} \begin{array}{c} \dfrac{\mathsf{S} \mid \mathsf{S}}{\mathsf{DP}\backslash \mathsf{DP}} \\ \textit{mother} \\ \dfrac{[\,]}{\textbf{mom}} \end{array} \right)\right)$$

$$= \begin{array}{c} \dfrac{\mathsf{S} \mid \mathsf{S}}{\mathsf{S}} \\ \textit{Everyone loves his mother} \\ \dfrac{\forall x.(\lambda y.[\,])x}{\textbf{loves}\,(\textbf{mom}\,y)\,x} \end{array} \quad \overset{\mathsf{LOWER}}{\Rightarrow} \quad \begin{array}{c} \mathsf{S} \\ \textit{Everyone loves his mother} \\ \forall x.(\lambda y.\textbf{loves}\,(\textbf{mom}\,y)\,x)x \end{array}$$

$$(41)\quad \left(\begin{array}{cc} S \mid DP \rhd S & DP \rhd S \mid DP \rhd S \\ \hline DP & DP\backslash DP \\ \text{everyone's} & \text{mother} \\ \dfrac{\forall x.[\,]x}{x} & \dfrac{[\,]}{\textbf{mother}} \end{array}\right) \left(\begin{array}{cc} DP \rhd S \mid DP \rhd S & DP \rhd S \mid S \\ \hline (DP\backslash S)/DP & DP \\ \text{loves} & \text{him} \\ \dfrac{[\,]}{\textbf{loves}} & \dfrac{\lambda y.[\,]}{y} \end{array}\right)$$

A FIRST CROSSOVER EXAMPLE

$$(42)\quad \left(\begin{array}{cc} DP \rhd S \mid S & S \mid S \\ \hline DP & DP\backslash DP \\ \text{his} & \text{mother} \end{array}\right) \left(\begin{array}{cc} S \mid S & S \mid DP \rhd S \\ \hline (DP\backslash S)/DP & DP \\ \text{loves} & \text{everyone} \end{array}\right)$$

$$= \begin{array}{c} DP \rhd S \mid DP \rhd S \\ \hline S \\ \text{his mother loves everyone} \end{array}$$

(43) a.*He$_i$ loves everyone$_i$.
b.?His$_i$ mother loves everyone$_i$.

Reversing the order of evaluation

$$\left(\begin{array}{cc} D \mid E & C \mid D \\ \hline A/B & B \\ \textit{left} & \textit{right} \\ \dfrac{g[\,]}{f} & \dfrac{h[\,]}{x} \end{array}\right) = \begin{array}{c} C \mid E \\ \hline A \\ \textit{left right} \\ \dfrac{h[g[\,]]}{f(x)} \end{array} \tag{44}$$

$$
(45)\quad
\begin{array}{c}
\dfrac{\mathsf{S}\,|\,\mathsf{S}}{\mathsf{DP}} \\
\textit{someone} \\
\dfrac{\exists x.[\,]}{x}
\end{array}
\left(
\begin{array}{c}
\dfrac{\mathsf{S}\,|\quad\mathsf{S}}{(\mathsf{DP}\backslash\mathsf{S})/\mathsf{DP}} \\
\textit{loves} \\
\dfrac{[\,]}{\mathbf{loves}}
\end{array}
\quad
\begin{array}{c}
\dfrac{\mathsf{S}\,|\,\mathsf{S}}{\mathsf{DP}} \\
\textit{everyone} \\
\dfrac{\forall y.[\,]}{y}
\end{array}
\right)
$$

$$
= \begin{array}{c}
\dfrac{\mathsf{S}\,|\,\mathsf{S}}{\mathsf{S}} \\
\textit{Someone loves everyone} \\
\dfrac{\forall y\,\exists x.[\,]}{\mathbf{loves}\,y\,x}
\end{array}
\quad \overset{\mathsf{LOWER}}{\Rightarrow} \quad
\begin{array}{c}
\mathsf{S} \\
\textit{Someone loves everyone} \\
\forall y.\exists x.\mathbf{loves}\,y\,x
\end{array}
$$

$$
(46)\quad
\begin{array}{c}
\dfrac{\mathsf{DP} \rhd \mathsf{S} \mid \mathsf{S}}{\mathsf{DP}} \\
\textit{he} \\
\dfrac{\lambda x.[\;]}{x}
\end{array}
\left(
\begin{array}{cc}
\dfrac{\mathsf{DP} \rhd \mathsf{S} \mid \mathsf{DP} \rhd \mathsf{S}}{(\mathsf{DP}\backslash\mathsf{S})/\mathsf{DP}} & \dfrac{\mathsf{S} \mid \mathsf{DP} \rhd \mathsf{S}}{\mathsf{DP}} \\
\textit{loves} & \textit{everyone} \\
\dfrac{[\;]}{\mathbf{loves}} & \dfrac{\forall y.([\;]y)}{y}
\end{array}
\right)
$$

$$
= \begin{array}{c}
\dfrac{\mathsf{S} \mid \mathsf{S}}{\mathsf{S}} \\
\textit{He loves everyone} \\
\dfrac{\forall y\,(\lambda x.([\;]y))}{\mathbf{loves}\,y\,x}
\end{array}
\;\overset{\text{LOWER}}{\Rightarrow}\;
\begin{array}{c}
\mathsf{S} \\
\textit{He loves everyone} \\
\forall y.(\lambda x.\mathbf{loves}\,y\,x)\,y
\end{array}
$$

DEFAULT EVALUATION ORDER IS LEFT-TO-RIGHT

(47) By default, natural language expressions are processed from left to right.

Order asymmetries in discourse anaphora

$$(48)\quad \left(\begin{array}{cc} \dfrac{\mathsf{S} \mid \mathsf{DP} \rhd \mathsf{S}}{\mathsf{DP}} & \dfrac{\mathsf{DP} \rhd \mathsf{S} \mid \mathsf{DP} \rhd \mathsf{S}}{\mathsf{DP}\backslash\mathsf{S}} \\ \textit{someone} & \textit{entered} \\ \dfrac{\exists y.\,([\,]\,y)}{y} & \dfrac{[\,]}{\textbf{entered}} \end{array} \right) \left(\begin{array}{c} \dfrac{\mathsf{DP} \rhd \mathsf{S} \mid \mathsf{DP} \rhd \mathsf{S}}{(\mathsf{S}\backslash\mathsf{S})/\mathsf{S}} \\ \textit{[period]} \\ \dfrac{[\,]}{\textbf{\&}} \end{array} \left(\begin{array}{cc} \dfrac{\mathsf{DP} \rhd \mathsf{S} \mid \mathsf{S}}{\mathsf{DP}} & \dfrac{\mathsf{S} \mid \mathsf{S}}{\mathsf{DP}\backslash\mathsf{S}} \\ \textit{he} & \textit{left} \\ \dfrac{\lambda x.[\,]}{x} & \dfrac{[\,]}{\textbf{left}} \end{array} \right) \right)$$

$$\begin{array}{c} \dfrac{\mathsf{S} \mid \mathsf{S}}{\mathsf{S}} \\ = \textit{Someone entered. He left} \\ \dfrac{\exists y.\lambda x.[\,]\,y}{\textbf{\&}(\textbf{entered}\,y)(\textbf{left}\,x)} \end{array} \quad \overset{\textsc{lower}\text{, beta}}{\Rightarrow} \quad \begin{array}{c} \mathsf{S} \\ \textit{Someone entered. He left} \\ \exists y.\textbf{\&}(\textbf{entered}\,y)(\textbf{left}\,y) \end{array}$$

Order effects in negative polarity licensing

(49) a. No one saw anyone.
b. *Anyone saw no one.

(50) a. I gave nothing to anybody.
b. *I gave anything to nobody.
c. I gave nobody anything.
d. *I gave anybody nothing.

The view from Ladusaw 1979

Ladusaw (1979) notes this mystery in his Inherent Scope Condition: "If the NPI is clausemate with the trigger, the trigger must precede" (section 4.4). He goes on (section 9.2) to speculate that this left-right requirement is related to quantifier scope and sentence processing, just as we are claiming:

> I do not at this point see how to make this part of the Inherent Scope Condition follow from any other semantic principle. This may be because the left-right restriction, like the left-right rule for unmarked scope relations, should be made to follow from the syntactic and semantic processing of sentences . . . .

Negative polarity, order, and scope

(51) $$\forall s_1 \forall s_2. \big(\forall x.\, s_2(x) \to s_1(x)\big) \to q(s_1) \to q(s_2).$$

(52) a. No one saw anyone.
b. *Everyone saw anyone.
c. *Alice saw anyone.

(53) *No one thought everyone saw anyone.

(54) a. No one gave anyone everything.
b. $\neg\exists z \exists y \forall x.$**gave** $x\, y\, z$
c. *$\neg\exists z \forall x \exists y.$**gave** $x\, y\, z$

(55) a. No one$_i$ called his$_i$ mother.
b. No one called anyone's mother.

(56) a. [No one$_i$'s mother] called him$_i$.
b. [No one's mother] called anyone.

(57) a. *His$_i$ mother called no one$_i$.
b. *Anyone's mother called no one.

(58) a. John sent no one$_i$ his$_i$ grade.
b. John sent no one$_i$ anyone's grade.

(59) a. John sent no one$_i$ to his$_i$ home town.
b. John sent no one$_i$ to anyone's home town.

(60) John gave [the phone number of no one's mother] to anyone.

(61) a.*John sent his$_i$ mother no one$_i$.
b.*John sent anyone's mother no one$_i$.

(62) a.?John sent his$_i$ grade to no one$_i$'s mother.
b.*John sent anyone's grade to no one's mother.

An evaluation-order account

(63) $$\text{everyone: } \dfrac{\mathrm{S} \mid \mathrm{S}}{\mathrm{DP}}, \quad \text{no one: } \dfrac{\mathrm{S} \mid \mathrm{S}^-}{\mathrm{DP}}, \quad \text{anyone: } \dfrac{\mathrm{S}^- \mid \mathrm{S}^-}{\mathrm{DP}}.$$

(64) $$\left(\begin{array}{c} \dfrac{\mathrm{S} \mid \mathrm{S}^-}{\mathrm{DP}} \\ \text{no one's} \\ \dfrac{\neg\exists x.[\,]}{x} \end{array} \begin{array}{c} \dfrac{\mathrm{S}^- \mid \mathrm{S}^-}{\mathrm{DP}\backslash\mathrm{DP}} \\ \text{mother} \\ \dfrac{[\,]}{\textbf{mother}} \end{array} \right) \left(\begin{array}{c} \dfrac{\mathrm{S}^- \mid \mathrm{S}^-}{(\mathrm{DP}\backslash\mathrm{S})/\mathrm{DP}} \\ \text{loves} \\ \dfrac{[\,]}{\textbf{loves}} \end{array} \begin{array}{c} \dfrac{\mathrm{S}^- \mid \mathrm{S}}{\mathrm{DP}} \\ \text{anyone} \\ \dfrac{\exists y.[\,]}{y} \end{array} \right)$$

(65) $$\begin{array}{c} \dfrac{\mathrm{S} \mid \mathrm{S}^-}{\mathrm{DP}} \\ \text{no one} \\ \dfrac{\neg\exists x.[\,]}{x} \end{array} \left(\left(\begin{array}{c} \dfrac{\mathrm{S}^- \mid \mathrm{S}^-}{((\mathrm{DP}\backslash\mathrm{S})/\mathrm{DP})/\mathrm{DP}} \\ \text{gave} \\ \dfrac{[\,]}{\textbf{gave}} \end{array} \begin{array}{c} \dfrac{\mathrm{S}^- \mid \mathrm{S}}{\mathrm{DP}} \\ \text{anyone} \\ \dfrac{\exists y.[\,]}{y} \end{array} \right) \begin{array}{c} \dfrac{\mathrm{S} \mid \mathrm{S}}{\mathrm{DP}} \\ \text{everything} \\ \dfrac{\forall z.[\,]}{z} \end{array} \right)$$

$$
(66)\qquad
\begin{array}{c}
\begin{array}{c|c} \mathsf{S} & \mathsf{S}^- \\ \hline \mathsf{S}^- & \mathsf{S}^- \end{array} \\ \hline
\mathsf{DP} \\
\text{no one} \\
\forall x.[\,]x \\ \hline
[\,] \\ \hline
x
\end{array}
\left(
\left(
\begin{array}{c}
\begin{array}{c|c} \mathsf{S}^- & \mathsf{S}^- \\ \hline \mathsf{S}^- & \mathsf{S}^- \end{array} \\ \hline
((\mathsf{DP}\backslash \mathsf{S})/\mathsf{DP})/\mathsf{DP} \\
\text{gave} \\
[\,] \\ \hline
[\,] \\ \hline
\textbf{gave}
\end{array}
\;
\begin{array}{c}
\begin{array}{c|c} \mathsf{S}^- & \mathsf{S}^- \\ \hline \mathsf{S}^- & \mathsf{S} \end{array} \\ \hline
\mathsf{DP} \\
\text{anyone} \\
[\,] \\ \hline
\exists y.[\,] \\ \hline
y
\end{array}
\right)
\;
\begin{array}{c}
\begin{array}{c|c} \mathsf{S}^- & \mathsf{S}^- \\ \hline \mathsf{S} & \mathsf{S} \end{array} \\ \hline
\mathsf{DP} \\
\text{everything} \\
\forall z.[\,] \\ \hline
[\,] \\ \hline
z
\end{array}
\right)
$$

Other theories of order in NPI licensing

(67) a. Examples with any relevance didn't come up in the discussion.
b. Examples with no relevance did come up in the discussion.

(68) a. No man loves any woman.
b. *Any man loves no woman.

(69) a. John gave [the address of no one's mother] to anyone.
b. *John gave [the address of anyone's mother] to no one.