Long-distance dependencies in continuation grammar

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Introduction

Barker & Shan (B&S) develop a Combinatory Categorial Grammar which uses the notion of *continuations* for semantic scope-taking. One hallmark of B&S is their explanatory account of crossover effects (Shan and Barker 2006).

Today: We critically evaluate the B&S framework, based on the behavior of *long-distance dependencies*.

- Data from quantifier scope-taking and long-distance dependencies motivate some refinements to the B&S theory...
- ...but these necessary refinements then result in undoing their positive predictions for crossover effects.

- Quantifiers, pronouns, and gaps all "take scope" in the same way for B&S, but their scope-taking behavior is empirically different. We show that the B&S framework has fundamental difficulties modeling such behavior.

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§2 Background: Barker & Shan's continuation-based grammar

B&S: CCG with continuations

Barker and Shan (Barker 2002; Shan 2004, 2007; Shan and Barker 2006; Barker and Shan 2006, 2008, 2014) develop a CCG using *continuations*. We refer to these works collectively as *B&S*.

DP	(DP \ S) / DP	DP		S	← syntactic type
Mary	likes	John	=	John likes Mary	← surface form
m	**likes**	**j**		**likes j m**	← denotation

B&S: CCG with continuations

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$$\begin{array}{ccccccl} \text{DP} & (\text{DP}\backslash\text{S})/\text{DP} & \text{DP} & & \text{S} & & \leftarrow \text{syntactic type} \\ \text{Mary} & \text{likes} & \text{John} & = & \text{John likes Mary} & & \leftarrow \text{surface form} \\ \mathbf{m} & \mathbf{likes} & \mathbf{j} & & \mathbf{likes}\,\mathbf{j}\,\mathbf{m} & & \leftarrow \text{denotation} \end{array}$$

Continuations

Continuations refer to the "computational future of an expression" (Shan and Barker 2006: 95), i.e. the procedures that will later apply to the expression. B&S use continuation-passing to implement semantic scope.

In addition to common $\backslash$ and $/$ type constructors for left and right composition, B&S introduce $\backslash\!\!\backslash$ and $/\!\!/$ for continuation-passing.

Informally, following B&S (2014: 6):

- $A \backslash\!\!\backslash B$ would be a B if we could add an A inside it;
- $C /\!\!/ D$ would be a C if we could add a surrounding D.

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Multi-level towers

B&S introduce *multi-level towers* with the interpretation in (**??**), where higher levels of the towers represent continuation-passing.

(1)
$$\dfrac{C \mid B}{A} \qquad\qquad C \sslash (A \bbslash B)$$
$$\text{expression} \quad := \quad \text{expression}$$
$$\dfrac{f[\,]}{a} \qquad\qquad \lambda\kappa \,.\, f(\kappa\,(a))$$

Composition of towers

Composing two expressions:

(2)
$$\frac{C \mid D}{A} \quad \frac{D \mid E}{A \backslash B} \qquad \frac{C \mid E}{B}$$
$$\text{left-exp} \quad \text{right-exp} \quad = \quad \text{left-exp right-exp}$$
$$\frac{g[\,]}{x} \quad \frac{h[\,]}{f} \qquad \frac{g(h[\,])}{f(x)}$$

Notice that adjacent types on the higher levels have to match.

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$$\frac{g[\ ]}{x} \quad \frac{h[\ ]}{f} \qquad \frac{g(h[\ ])}{f(x)}$$

Notice that adjacent types on the higher levels have to match.

Scope-taking and type-shifters

Scope-taking expressions like quantifiers have two-level denotations.

$$\frac{S \mid S}{DP} \quad (DP \backslash S) / DP \quad \frac{S \mid S}{DP}$$

someone	likes	everyone
$\dfrac{\exists x \,.\, [\,]}{x}$	**likes**	$\dfrac{\forall y \,.\, [\,]}{y}$

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$$\frac{S \mid S}{DP} \qquad \frac{S \mid S}{(DP \backslash S) / DP} \qquad \frac{S \mid S}{DP}$$

$$\text{someone} \qquad \text{likes} \qquad \text{everyone}$$

$$\frac{\exists x \,.\, [\,]}{x} \qquad \frac{[\,]}{\textbf{likes}} \qquad \frac{\forall y \,.\, [\,]}{y}$$

We use LIFT (**??**) to match non-scope-taking expressions for composition.

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$$\text{someone} \quad \text{likes} \quad \text{everyone} \quad = \quad \text{someone likes everyone}$$

$$\dfrac{\exists x \,.\, [\,]}{x} \quad \dfrac{[\,]}{\textbf{likes}} \quad \dfrac{\forall y \,.\, [\,]}{y} \qquad \dfrac{\exists x \,.\, \forall y \,.\, [\,]}{\textbf{likes}\; y\, x}$$

Scope-taking and type-shifters

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$$\frac{S \mid S}{DP}\ \text{someone}\ \frac{\exists x\,.\,[\,]}{x} \quad \frac{S \mid S}{(DP\backslash S)/DP}\ \text{likes}\ \frac{[\,]}{\textbf{likes}} \quad \frac{S \mid S}{DP}\ \text{everyone}\ \frac{\forall y\,.\,[\,]}{y} \;=\; \frac{S \mid S}{S}\ \text{someone likes everyone}\ \frac{\exists x\,.\,\forall y\,.\,[\,]}{\textbf{likes}\ y\,x}$$

$$\overset{\downarrow}{\Rightarrow}\quad S\ \ \text{someone likes everyone}\ \ \exists x\,.\,\forall y\,.\,\textbf{likes}\ y\,x$$

We then LOWER (**??**) the expression at the end.

Scope-taking and type-shifters

We can also derive inverse scope using multi-level towers.

S | S	S | S	S | S
S | S	S | S	S | S
DP	(DP \ S) / DP	DP
someone	likes	everyone
$[\,]$	$[\,]$	$\forall y\,.\,[\,]$
$\exists x\,.\,[\,]$	$[\,]$	$[\,]$
x	**likes**	y

We use "internal LIFT" to raise ∀ to a higher level.

Scope-taking and type-shifters

We can also derive inverse scope using multi-level towers.

$$\frac{\mathrm{S} \mid \mathrm{S}}{\frac{\mathrm{S} \mid \mathrm{S}}{\mathrm{DP}}} \quad \frac{\mathrm{S} \mid \mathrm{S}}{\frac{\mathrm{S} \mid \mathrm{S}}{(\mathrm{DP} \backslash \mathrm{S}) \,/\, \mathrm{DP}}} \quad \frac{\mathrm{S} \mid \mathrm{S}}{\frac{\mathrm{S} \mid \mathrm{S}}{\mathrm{DP}}} \qquad \frac{\mathrm{S} \mid \mathrm{S}}{\frac{\mathrm{S} \mid \mathrm{S}}{\mathrm{S}}}$$

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$$\frac{[\,]}{\frac{\exists x \,.\, [\,]}{x}} \quad \frac{[\,]}{\frac{[\,]}{\textbf{likes}}} \quad \frac{\forall y \,.\, [\,]}{\frac{[\,]}{y}} \qquad \frac{\forall y \,.\, [\,]}{\frac{\exists x \,.\, [\,]}{\textbf{likes}\; y\; x}}$$

Scope-taking and type-shifters

We can also derive inverse scope using multi-level towers.

$$
\begin{array}{c}
\dfrac{S \mid S}{S \mid S} \\ \hline DP \\ \text{someone} \\ \dfrac{[\,]}{\exists x\,.\,[\,]} \\ \hline x
\end{array}
\quad
\begin{array}{c}
\dfrac{S \mid S}{S \mid S} \\ \hline (DP\backslash S)/DP \\ \text{likes} \\ \dfrac{[\,]}{[\,]} \\ \hline \textbf{likes}
\end{array}
\quad
\begin{array}{c}
\dfrac{S \mid S}{S \mid S} \\ \hline DP \\ \text{everyone} \\ \dfrac{\forall y\,.\,[\,]}{[\,]} \\ \hline y
\end{array}
\quad = \quad
\begin{array}{c}
\dfrac{S \mid S}{S \mid S} \\ \hline S \\ \text{someone likes everyone} \\ \dfrac{\forall y\,.\,[\,]}{\exists x\,.\,[\,]} \\ \hline \textbf{likes}\ y\ x
\end{array}
$$

$$
\overset{\downarrow\downarrow}{\Longrightarrow}\quad
\begin{array}{c}
S \\ \text{someone likes everyone} \\ \forall y\,.\,\exists x\,.\,\textbf{likes}\ y\ x
\end{array}
$$

Pronouns

The syntactic category $A \triangleright B$ represents a B that contains an unbound pronoun of category A, for example:

$$\frac{\text{DP} \triangleright \text{S} \;\big|\; \text{S}}{\text{DP}}$$

$$\text{he}$$

$$\frac{\lambda x \,.\, [\,]}{x}$$

Pronouns are represented as inherently multi-level towers, meaning that they are also scope-taking expressions.

Pronouns

The DP $\triangleright$ S type propagates to the left, denoting an open pronoun exists in the expression until it is bound (hypothetically).

$$
\begin{array}{cccc}
\dfrac{\mathrm{DP} \triangleright \mathrm{S} \;\big|\; \mathrm{DP} \triangleright \mathrm{S}}{\mathrm{DP}} &
\dfrac{\mathrm{DP} \triangleright \mathrm{S} \;\big|\; \mathrm{DP} \triangleright \mathrm{S}}{(\mathrm{DP} \backslash \mathrm{S}) \,/\, \mathrm{S}} &
\dfrac{\mathrm{DP} \triangleright \mathrm{S} \;\big|\; \mathrm{S}}{\mathrm{DP}} &
\dfrac{\mathrm{S} \;\big|\; \mathrm{S}}{\mathrm{DP} \,/\, \mathrm{S}} \\
\text{John} & \text{said} & \text{he} & \text{cried} \\
\dfrac{[\,]}{\mathbf{j}} & \dfrac{[\,]}{\mathbf{said}} & \dfrac{\lambda x\,.\,[\,]}{x} & \dfrac{[\,]}{\mathbf{cried}}
\end{array}
$$

We apply BIND (**??**) to *John* for it to bind the pronoun to its right.

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Movement

Continuation-passing provides an in-situ account of movement dependencies using gaps.

Gaps introduce a variable and λ binder like pronouns:

$$\frac{\mathsf{DP} \mathbin{\backslash\!\!\backslash} \mathsf{S} \;\big|\; \mathsf{S}}{\mathsf{DP}}$$

$$\overline{}$$

$$\frac{\lambda x\,.\,[\,]}{x}$$

Similarly, DP $\backslash\!\!\backslash$ S propagates to the left to get bound.

Crossover

One advertised feature of B&S's proposal is its explanation for *crossover effects* (Postal 1971) using linear evaluation.

(**??**) a. Which girl$_i$ did John introduce ___ to her$_i$ second cousin?

b. ??Which girl$_i$ did John introduce her$_i$ second cousin to ___?

(**??**) a. ✓ *wh*$_i$ ... ___$_i$ ... *pro*$_i$

b. * *wh*$_i$ ... *pro*$_i$ ... ___$_i$

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Explaining crossover effects

For B&S, in grammatical *wh-pro*-binding configurations (**??**/**??**a), *the gap binds the pronoun to its right*.

$$\begin{array}{ccccc} & & \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\big|\; \mathrm{S}}{\mathrm{DP}} & & \dfrac{\mathrm{DP} \triangleright \mathrm{S} \;\big|\; \mathrm{S}}{\mathrm{PP}} \\ \mathrm{S}/(\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}) & & & & \\ \text{which girl} & \ldots & \_\_\_ & \ldots & \text{to her second cousin} \\ \lambda\kappa\,.\,\mathbf{wh}(\mathbf{girl}\ y \wedge \kappa(y)) & & \dfrac{\lambda x\,.\,[\,]}{x} & & \dfrac{\lambda c\,.\,[\,]}{\mathbf{second\ cousin}\ c} \end{array}$$

BIND (**??**) cannot apply to the fronted *wh*-phrase itself.

Therefore, the binding is grammatical in (**??**a), but in (**??**b) there is no preceding gap that can bind the pronoun, leading to ungrammaticality. This explains the crossover asymmetry.

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$\mathrm{S}/(\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S})$				
which girl	...	___	...	to her second cousin
$\lambda\kappa\,.\,\mathbf{wh}(\mathbf{girl}\ y \wedge \kappa(y))$		$\dfrac{\lambda x\,.\,[\,]\ x}{x}$		$\dfrac{\lambda c\,.\,[\,]}{\mathbf{second\ cousin}\ c}$

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\mathrm{S}/(\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}) & & & & \\
\text{which girl} & \ldots & \underline{\quad\quad} & \ldots & \text{to her second cousin} \\
\lambda\kappa\,.\,\mathbf{wh}(\mathbf{girl}\; y \wedge \kappa(y)) & & \dfrac{\lambda x\,.\,[\;]\; x}{x} & & \dfrac{\lambda c\,.\,[\;]}{\mathbf{second\ cousin}\; c}
\end{array}
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Preview

§3 B&S does not restrict quantifier scope-taking...

- We formalize a suggested fix (A).

(A) complicates the binding of embedded gaps and pronouns...

- We propose minimal modifications (B) so that we can model such examples together with (A).

§4 (A) and (B) together lead to incorrect predictions for crossover, undoing a key advantage of the B&S framework.

§5 Discussion

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- We formalize a suggested fix Ⓐ.

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§5 Discussion

§3 Scope-taking across clause boundaries

Scope

(??) # Someone said [everyone is married to Sue]. $^{\checkmark}\exists > \forall$, *$\forall > \exists$

B&S overgenerates

B&S overgenerates the unattested inverse-scope reading of *Someone said everyone is married to Sue* (**??**):

$$
\begin{array}{cccc}
\begin{array}{c}\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \end{array} \\ \mathrm{DP} \\ \text{someone} \\ [\,] \\ \hline \exists x\,.\,[\,] \\ \hline x \end{array}
&
\begin{array}{c}\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \end{array} \\ (\mathrm{DP}\backslash \mathrm{S})\,/\,\mathrm{S} \\ \text{said} \\ [\,] \\ \hline [\,] \\ \hline \textbf{said} \end{array}
&
\begin{array}{c}\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \end{array} \\ \mathrm{DP} \\ \text{everyone} \\ \forall y\,.\,[\,] \\ \hline [\,] \\ \hline y \end{array}
&
\begin{array}{c}\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \end{array} \\ \mathrm{DP}\backslash \mathrm{S} \\ \text{is married to Sue} \\ [\,] \\ \hline [\,] \\ \hline \textbf{married to s} \end{array}
\end{array}
$$

$$
= \begin{array}{c}\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \end{array} \\ \mathrm{S} \\ \text{sm. said ev. is married to Sue} \\ \forall y\,.\,[\,] \\ \hline \exists x\,.\,[\,] \\ \hline \textbf{said}\,(\textbf{married to s}\ y)\ x \end{array}
\overset{\downarrow\downarrow}{\Longrightarrow}
\begin{array}{c} \mathrm{S} \\ \text{sm. said ev. is married to Sue} \\ \forall y\,.\,\exists x\,.\,\textbf{said}\,(\textbf{married to s}\ y)\ x \end{array}
$$

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\end{array}
\qquad
\begin{array}{c}
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\end{array}
\qquad
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\end{array}
\qquad
\begin{array}{c}
\begin{array}{c|c} S & S \\ \hline S & S \end{array} \\ \hline \text{DP}\backslash \text{S} \\ \text{is married to Sue} \\ [\,] \\ \hline [\,] \\ \hline \textbf{married to s}
\end{array}
$$

$$
=\;
\begin{array}{c}
\begin{array}{c|c} S & S \\ \hline S & S \end{array} \\ \hline \text{S} \\ \text{sm. said ev. is married to Sue} \\ \forall y\,.\,[\,] \\ \hline \exists x\,.\,[\,] \\ \hline \textbf{said}\,(\textbf{married to s}\; y)\; x
\end{array}
\;\overset{\downarrow\downarrow}{\Rightarrow}\;
\begin{array}{c}
\text{S} \\ \text{sm. said ev. is married to Sue} \\ \forall y\,.\,\exists x\,.\,\textbf{said}\,(\textbf{married to s}\; y)\; x
\end{array}
$$

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$$
\begin{array}{cccc}
\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \multicolumn{2}{c}{DP} \end{array}
&
\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \multicolumn{2}{c}{(DP\backslash S)/S} \end{array}
&
\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \multicolumn{2}{c}{DP} \end{array}
&
\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \multicolumn{2}{c}{DP\backslash S} \end{array}
\\
\text{someone} & \text{said} & \text{everyone} & \text{is married to Sue}
\\
\begin{array}{c} [\,] \\ \hline \exists x\,.\,[\,] \\ \hline x \end{array}
&
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&
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\end{array}
$$

$$
\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \multicolumn{2}{c}{S} \end{array}
\qquad\qquad\qquad
S
$$

$$
= \quad \begin{array}{c} \text{sm. said ev. is married to Sue} \\ \forall y\,.\,[\,] \\ \hline \exists x\,.\,[\,] \\ \hline \textbf{said}\,(\textbf{married to s}\,y)\,x \end{array}
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$$

Scope Island Evaluation

B&S note this problem. Charlow (2014: 65) suggests that scope islands must be evaluated by "collapsing it into a single level."

We codify this requirement as follows:

(??) **Scope Island Evaluation**
If the expression is a scope island, apply LOWER as many times as possible ($\downarrow^*$).

Embedded tensed clauses are scope islands.

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Scope Island Evaluation

$\frac{S \mid S}{S \mid S}$	$\frac{S \mid S}{S \mid S}$	$\frac{S \mid S}{S \mid S}$	$\frac{S \mid S}{S \mid S}$
DP	(DP \ S) / S	DP	DP \ S
someone	said	everyone	is married to Sue
$[\,]$	$[\,]$	$\forall y \,.\, [\,]$	$[\,]$
$\exists x \,.\, [\,]$	$[\,]$	$[\,]$	$[\,]$
x	**said**	y	**married to s**

Scope Island Evaluation

$S \mid S$	$S \mid S$	$S \mid S$
$S \mid S$	$S \mid S$	$S \mid S$
DP	(DP \ S) / S	S
someone	said	everyone is married to Sue
$[\,]$	$[\,]$	$\forall y\,.\,[\,]$
$\exists x\,.\,[\,]$	$[\,]$	$[\,]$
x	**said**	**married to s** y

Scope Island Evaluation

$$
\begin{array}{ccc}
\dfrac{\dfrac{S \mid S}{S \mid S}}{DP} & \dfrac{\dfrac{S \mid S}{S \mid S}}{(DP \backslash S) / S} & S \\
\text{someone} & \text{said} & \text{everyone is married to Sue} \\
\dfrac{\dfrac{[\,]}{\exists x\,.\,[\,]}}{x} & \dfrac{\dfrac{[\,]}{[\,]}}{\textbf{said}} & \forall y\,.\,\textbf{married to s}\;y
\end{array}
$$

Scope Island Evaluation

$S \mid S$	$S \mid S$	$S \mid S$
$S \mid S$	$S \mid S$	$S \mid S$
DP	$(DP \backslash S) / S$	S
someone	said	everyone is married to Sue
$[\,]$	$[\,]$	$[\,]$
$\exists x \,.\, [\,]$	$[\,]$	$[\,]$
x	$\textbf{said}$	$\forall y \,.\, \textbf{married to s}\, y$

Scope Island Evaluation

$$
\begin{array}{c}
\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \end{array} \\
DP \\
\text{someone} \\
\dfrac{[\,]}{\dfrac{\exists x \,.\, [\,]}{x}}
\end{array}
\qquad
\begin{array}{c}
\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \end{array} \\
(DP \backslash S) / S \\
\text{said} \\
\dfrac{[\,]}{\dfrac{[\,]}{\textbf{said}}}
\end{array}
\qquad
\begin{array}{c}
\begin{array}{c|c} S & S \\ \hline S & S \\ \hline \end{array} \\
S \\
\text{everyone is married to Sue} \\
\dfrac{[\,]}{\dfrac{[\,]}{\forall y \,.\, \textbf{married to s}\; y}}
\end{array}
$$

$$
\overset{\downarrow\downarrow}{\Longrightarrow} \quad
\begin{array}{c}
S \\
\text{sm. said ev. is married to Sue} \\
\exists x \,.\, \forall y \,.\, \textbf{said}\,(\textbf{married to s}\; y)\; x
\end{array}
$$

Problems with embedded gaps and pronouns

Recall that pronouns and gaps are "scope-taking" in B&S: they posit a λ binder on a higher level, to be bound from the left.

(??) a. ✓ Which girl$_i$ did you say [Mary saw ___$_i$]?

b. ✓ Every girl$_i$ said [Mary saw her$_i$].

- Scope Island Evaluation blocks the binding of gaps (10a) and pronouns (10b) in embedded tensed clauses, contrary to fact.

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(**??**) a. $^{\checkmark}$ Which girl$_i$ did you say [Mary saw ___$_i$]?

b. $^{\checkmark}$ Every girl$_i$ said [Mary saw her$_i$].

- Scope Island Evaluation blocks the binding of gaps (10a) and pronouns (10b) in embedded tensed clauses, contrary to fact.

Embedded gaps

Clauses with DP gaps that undergo Scope Island Evaluation will be of category DP\ S, the category of a clause missing a DP to its left.

$$
\begin{array}{c}
\dfrac{\mathrm{DP} \mathbin{\backslash\!\backslash} \mathrm{S} \;\big|\; \mathrm{DP} \mathbin{\backslash\!\backslash} \mathrm{S}}{\mathrm{DP}} \\
\text{Mary} \\
\dfrac{[\,]}{\mathbf{m}}
\end{array}
\quad
\begin{array}{c}
\dfrac{\mathrm{DP} \mathbin{\backslash\!\backslash} \mathrm{S} \;\big|\; \mathrm{DP} \mathbin{\backslash\!\backslash} \mathrm{S}}{(\mathrm{DP} \backslash \mathrm{S}) \,/\, \mathrm{DP}} \\
\text{saw} \\
\dfrac{[\,]}{\mathbf{saw}}
\end{array}
\quad
\begin{array}{c}
\dfrac{\mathrm{DP} \mathbin{\backslash\!\backslash} \mathrm{S} \;\big|\; \mathrm{S}}{\mathrm{DP}} \\
\underline{\quad} \\
\dfrac{\lambda x \,.\, [\,]}{x}
\end{array}
\quad = \quad
\begin{array}{c}
\dfrac{\mathrm{DP} \mathbin{\backslash\!\backslash} \mathrm{S} \;\big|\; \mathrm{S}}{\mathrm{S}} \\
\text{Mary saw } \underline{\quad} \\
\dfrac{\lambda x \,.\, [\,]}{\mathbf{saw}\, x\, \mathbf{m}}
\end{array}
$$

- The syntactic category of the expression cannot compose as a S.
- The λ binder for the gap is on the lowest level and ceases to propagate as a scope-taking expression.

Embedded gaps

Clauses with DP gaps that undergo Scope Island Evaluation will be of category $\mathrm{DP}\backslash\mathrm{S}$, the category of a clause missing a DP to its left.

$$\begin{array}{c} \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\big|\; \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \\ \hline \mathrm{DP} \\ \text{Mary} \\ \frac{[\,]}{\mathbf{m}} \end{array} \quad \begin{array}{c} \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\big|\; \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \\ \hline (\mathrm{DP}\backslash\mathrm{S}) \,/\, \mathrm{DP} \\ \text{saw} \\ \frac{[\,]}{\mathbf{saw}} \end{array} \quad \begin{array}{c} \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\big|\; \mathrm{S} \\ \hline \mathrm{DP} \\ \_\_\_ \\ \frac{\lambda x \,.\, [\,]}{x} \end{array} \quad = \quad \begin{array}{c} \mathrm{DP}\backslash\mathrm{S} \\ \text{Mary saw \_\_\_} \\ \lambda x \,.\, \mathbf{saw}\, x\, \mathbf{m} \end{array}$$

- The syntactic category of the expression cannot compose as a S.
- The λ binder for the gap is on the lowest level and ceases to propagate as a scope-taking expression.

Embedded gaps: Intermediate gaps

We resolve this problem by positing *intermediate gaps* at the left edge of gapped clauses after they undergo Scope Island Evaluation.

(??)

$$\frac{\dfrac{\mathsf{DP}\,\backslash\!\!\backslash\,\mathsf{S} \,\big|\, \mathsf{S}}{\mathsf{DP}}}{\dfrac{\lambda y\,.\,[\,]}{y}}\;\_\_\_ \qquad \frac{\mathsf{DP}\,\backslash\,\mathsf{S}}{\lambda x\,.\,\mathbf{saw}\,x\,\mathbf{m}}\;\text{Mary saw \_\_\_} \quad = \quad \frac{\dfrac{\mathsf{DP}\,\backslash\!\!\backslash\,\mathsf{S} \,\big|\, \mathsf{S}}{\mathsf{S}}}{\dfrac{\lambda y\,.\,[\,]}{\mathbf{saw}\,y\,\mathbf{m}}}\;\text{\_\_\_ Mary saw \_\_\_}$$

Adding the intermediate gap results in the same meaning as the embedded clause prior to Scope Island Evaluation.

Embedded gaps: Intermediate gaps

We resolve this problem by positing *intermediate gaps* at the left edge of gapped clauses after they undergo Scope Island Evaluation.

(**??**)

$$\begin{array}{cccc} \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \mid \mathrm{S}}{\mathrm{DP}} & \mathrm{DP}\backslash\mathrm{S} & & \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \mid \mathrm{S}}{\mathrm{S}} \\ \_\_\_ & \text{Mary saw \_\_\_} & = & \text{\_\_\_ Mary saw \_\_\_} \\ \dfrac{\lambda y \,.\, [\,]}{y} & \lambda x \,.\, \mathbf{saw}\, x\, \mathbf{m} & & \dfrac{\lambda y \,.\, [\,]}{\mathbf{saw}\, y\, \mathbf{m}} \end{array}$$

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Embedded gaps: Intermediate gaps

We resolve this problem by positing *intermediate gaps* at the left edge of gapped clauses after they undergo Scope Island Evaluation.

(**??**)

$$\begin{array}{c} \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \mid \mathrm{S}}{\mathrm{DP}} \\ \_\_\_ \\ \dfrac{\lambda y\,.\,[\;]}{y} \end{array} \quad \begin{array}{c} \dfrac{\mathrm{S} \mid \mathrm{S}}{\mathrm{DP} \backslash \mathrm{S}} \\ \text{Mary saw } \_\_\_ \\ \dfrac{[\;]}{\lambda x\,.\,\textbf{saw}\, x\, \textbf{m}} \end{array} \quad = \quad \begin{array}{c} \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \mid \mathrm{S}}{\mathrm{S}} \\ \_\_\_ \text{ Mary saw } \_\_\_ \\ \dfrac{\lambda y\,.\,[\;]}{\textbf{saw}\, y\, \textbf{m}} \end{array}$$

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We resolve this problem by positing *intermediate gaps* at the left edge of gapped clauses after they undergo Scope Island Evaluation.

(**??**)

$$\dfrac{\mathrm{DP} \mathbin{\backslash\!\backslash} \mathrm{S} \;\middle|\; \mathrm{S}}{\mathrm{DP}} \qquad \dfrac{\mathrm{S} \;\middle|\; \mathrm{S}}{\mathrm{DP} \backslash \mathrm{S}} \qquad \qquad \dfrac{\mathrm{DP} \mathbin{\backslash\!\backslash} \mathrm{S} \;\middle|\; \mathrm{S}}{\mathrm{S}}$$

$$\text{\_\_\_} \qquad \text{Mary saw \_\_\_} \quad = \quad \text{\_\_\_ Mary saw \_\_\_}$$

$$\dfrac{\lambda y\,.\,[\,]}{y} \qquad \dfrac{[\,]}{\lambda x\,.\,\mathbf{saw}\,x\,\mathbf{m}} \qquad \qquad \dfrac{\lambda y\,.\,[\,]}{\mathbf{saw}\,y\,\mathbf{m}}$$

Adding the intermediate gap results in the same meaning as the embedded clause prior to Scope Island Evaluation.

Embedded gaps: Intermediate gaps

We resolve this problem by positing *intermediate gaps* at the left edge of gapped clauses after they undergo Scope Island Evaluation.

(**??**)

$$\frac{\mathsf{DP} \mathbin{\backslash\!\!\backslash} \mathsf{S} \,\big|\, \mathsf{S}}{\mathsf{DP}} \quad \frac{\mathsf{S} \,\big|\, \mathsf{S}}{\mathsf{DP} \backslash \mathsf{S}} \qquad \frac{\mathsf{DP} \mathbin{\backslash\!\!\backslash} \mathsf{S} \,\big|\, \mathsf{S}}{\mathsf{S}}$$

$$\underline{\quad} \qquad \text{Mary saw } \underline{\quad} \quad = \quad \underline{\quad} \text{ Mary saw } \underline{\quad}$$

$$\frac{\lambda y\,.\,[\,]}{y} \qquad \frac{[\,]}{\lambda x\,.\,\mathbf{saw}\,x\,\mathbf{m}} \qquad \frac{\lambda y\,.\,[\,]}{\mathbf{saw}\,y\,\mathbf{m}}$$

Adding the intermediate gap results in the same meaning as the embedded clause prior to Scope Island Evaluation.

Embedded pronouns

We encounter a similar problem with embedded bound pronouns:

$$\dfrac{\mathsf{DP} \rhd \mathsf{S} \;\big|\; \mathsf{DP} \rhd \mathsf{S}}{\mathsf{DP}} \quad \dfrac{\mathsf{DP} \rhd \mathsf{S} \;\big|\; \mathsf{DP} \rhd \mathsf{S}}{(\mathsf{DP} \backslash \mathsf{S}) / \mathsf{DP}} \quad \dfrac{\mathsf{DP} \rhd \mathsf{S} \;\big|\; \mathsf{S}}{\mathsf{DP}} \qquad \dfrac{\mathsf{DP} \rhd \mathsf{S} \;\big|\; \mathsf{S}}{\mathsf{S}}$$

$$\text{Mary} \quad \text{saw} \quad \text{her} \quad = \quad \text{Mary saw her}$$

$$\dfrac{[\,]}{\mathbf{m}} \quad \dfrac{[\,]}{\mathbf{saw}} \quad \dfrac{\lambda x\,.\,[\,]}{x} \qquad \dfrac{\lambda x\,.\,[\,]}{\mathbf{saw}\,x\,\mathbf{m}}$$

- The resulting expression after Scope Island Evaluation is of category $\mathsf{DP} \rhd \mathsf{S}$ and cannot combine with an S-selecting verb.
- An additional problem: no existing expressions combine with expressions of category $\mathsf{DP} \rhd \mathsf{S}$ on the lowest level.

Embedded pronouns

We encounter a similar problem with embedded bound pronouns:

$$\begin{array}{c}\text{DP} \triangleright \text{S} \mid \text{DP} \triangleright \text{S} \\ \hline \text{DP} \\ \text{Mary} \\ \dfrac{[\,]}{\textbf{m}}\end{array} \quad \begin{array}{c}\text{DP} \triangleright \text{S} \mid \text{DP} \triangleright \text{S} \\ \hline (\text{DP} \backslash \text{S}) / \text{DP} \\ \text{saw} \\ \dfrac{[\,]}{\textbf{saw}}\end{array} \quad \begin{array}{c}\text{DP} \triangleright \text{S} \mid \text{S} \\ \hline \text{DP} \\ \text{her} \\ \dfrac{\lambda x . [\,]}{x}\end{array} \quad = \quad \begin{array}{c}\text{DP} \triangleright \text{S} \\ \text{Mary saw her} \\ \lambda x . \textbf{saw}\, x\, \textbf{m}\end{array}$$

- The resulting expression after Scope Island Evaluation is of category DP $\triangleright$ S and cannot combine with an S-selecting verb.
- An additional problem: no existing expressions combine with expressions of category DP $\triangleright$ S on the lowest level.

Embedded pronouns: prolift

We propose a new type-shifter:

(**??**)

$$\frac{B \mid C}{\mathrm{DP} \triangleright A} \quad \text{expression} \quad \frac{f[\,]}{\lambda x\,.\,g(x)} \quad \overset{\textsc{prolift}}{\Longrightarrow} \quad \frac{\mathrm{DP} \triangleright B \mid C}{A} \quad \text{expression} \quad \frac{\lambda x\,.\,f[\,]}{g(x)}$$

PROLIFT returns the pronoun's λ binder and corresponding DP$\triangleright$-category to a *higher level* from which it can propagate leftward.

Embedded pronouns: prolift

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PROLIFT returns the pronoun's λ binder and corresponding DP$\rhd$-category to a *higher level* from which it can propagate leftward.

$\mathrm{DP} \rhd \mathrm{S}$
Mary saw her
$\lambda x\,.\,\mathbf{saw}\,x\,\mathbf{m}$

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PROLIFT returns the pronoun's λ binder and corresponding DP$\triangleright$-category to a *higher level* from which it can propagate leftward.

$$\frac{\text{S} \mid \text{S}}{\text{DP} \triangleright \text{S}} \quad \text{Mary saw her} \quad \frac{[\,]}{\lambda x \,.\, \textbf{saw}\, x\, \textbf{m}}$$

Embedded pronouns: prolift

We propose a new type-shifter:

(**??**)

$$\frac{B \mid C}{\text{DP} \triangleright A} \quad \frac{\text{DP} \triangleright B \mid C}{A}$$

$$\begin{array}{c} \dfrac{B \mid C}{\text{DP} \triangleright A} \\ \text{expression} \\ \dfrac{f[\,]}{\lambda x\,.\,g(x)} \end{array} \overset{\text{PROLIFT}}{\Longrightarrow} \begin{array}{c} \dfrac{\text{DP} \triangleright B \mid C}{A} \\ \text{expression} \\ \dfrac{\lambda x\,.\,f[\,]}{g(x)} \end{array}$$

PROLIFT returns the pronoun's λ binder and corresponding DP$\triangleright$-category to a *higher level* from which it can propagate leftward.

$$\begin{array}{c} \dfrac{\text{DP} \triangleright \text{S} \mid \text{S}}{\text{S}} \\ \text{Mary saw her} \\ \dfrac{\lambda x\,.\,[\,]}{\textbf{saw}\,x\,\textbf{m}} \end{array}$$

Summary

- To accurately model restrictions on quantifier scope-taking, we codified a suggestion by Charlow (2014) as *Scope Island Evaluation*.
- To model the grammatical binding of embedded gaps and pronouns and maintain Scope Island Evaluation, we proposed intermediate gaps and PROLIFT.

Summary

- To accurately model restrictions on quantifier scope-taking, we codified a suggestion by Charlow (2014) as *Scope Island Evaluation*.
- To model the grammatical binding of embedded gaps and pronouns and maintain Scope Island Evaluation, we proposed intermediate gaps and PROLIFT.

§4 Crossover in long-distance configurations

Consequences for crossover

These three amendments to the theory — Scope Island Evaluation, intermediate gaps, and PROLIFT, all necessary to account for the behavior of quantifier scope-taking as well as long-distance dependencies — together lead to *incorrect predictions for crossover effects*.

Crossover with embedded clauses

Recall that the derivation and explanation of *crossover* asymmetries (**??**) were claimed to be an advantage of the B&S framework.

(**??**) a. ✓*wh*$_i$ ... ___$_i$ ... *pro*$_i$

b. **wh*$_i$ ... *pro*$_i$ ... ___$_i$

- The revised B&S framework predicts the crossover violation in (**??**b) to be grammatical, contrary to fact.

(**??**) a. Which girl$_i$ do you think [___ loves her$_i$ mother]?

b. ?? Which girl$_i$ do you think [her$_i$ mother loves ___]?

For grammatical embedded gap binding, we hypothesize an intermediate gap. This gap precedes the pronoun and can bind it!

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b. ?? Which girl$_i$ do you think ___$_i$ [her$_i$ mother loves ___]?

For grammatical embedded gap binding, we hypothesize an intermediate gap. This gap precedes the pronoun and can bind it!

??Which girl$_i$ do you think [her$_i$ mother loves __]?

$$\dfrac{\mathrm{DP} \rhd (\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}) \;\Big|\; \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}}{\mathrm{DP}} \qquad \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}}{(\mathrm{DP} \backslash \mathrm{S}) \,/\, \mathrm{DP}} \qquad \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{S}}{\mathrm{DP}}$$

$$\text{her mother} \qquad \text{loves} \qquad \_\_\_$$

$$\dfrac{\lambda d \,.\, [\,]}{\textbf{mother}\; d} \qquad \dfrac{[\,]}{\textbf{loves}} \qquad \dfrac{\lambda x \,.\, [\,]}{x}$$

$$= \quad \dfrac{\mathrm{DP} \rhd (\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}) \;\Big|\; \mathrm{S}}{\mathrm{S}} \atop {\text{her mother loves \_\_\_} \atop \dfrac{\lambda d \,.\, \lambda x \,.\, [\,]}{\textbf{loves}\; x\, (\textbf{mother}\; d)}} \quad \overset{\downarrow *}{\Longrightarrow} \quad {\mathrm{DP} \rhd (\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}) \atop {\text{her mother loves \_\_\_} \atop \lambda d \,.\, \lambda x \,.\, \textbf{loves}\; x\, (\textbf{mother}\; d)}} \quad \xrightarrow{\text{LIFT, PROLIFT}}$$

??Which girl$_i$ do you think [her$_i$ mother loves __]?

$$\dfrac{\mathrm{DP} \triangleright (\mathrm{DP} \,\backslash\!\backslash\, \mathrm{S}) \;\big|\; \mathrm{DP} \,\backslash\!\backslash\, \mathrm{S}}{\mathrm{DP}} \qquad \dfrac{\mathrm{DP} \,\backslash\!\backslash\, \mathrm{S} \;\big|\; \mathrm{DP} \,\backslash\!\backslash\, \mathrm{S}}{(\mathrm{DP} \backslash \mathrm{S}) \,/\, \mathrm{DP}} \qquad \dfrac{\mathrm{DP} \,\backslash\!\backslash\, \mathrm{S} \;\big|\; \mathrm{S}}{\mathrm{DP}}$$

$$\text{her mother} \qquad \text{loves} \qquad \underline{\quad}$$

$$\dfrac{\lambda d \,.\, [\;]}{\mathbf{mother}\; d} \qquad \dfrac{[\;]}{\mathbf{loves}} \qquad \dfrac{\lambda x \,.\, [\;]}{x}$$

$$= \quad \begin{array}{c} \dfrac{\mathrm{DP} \triangleright (\mathrm{DP} \,\backslash\!\backslash\, \mathrm{S}) \;\big|\; \mathrm{S}}{\mathrm{S}} \\ \text{her mother loves } \underline{\quad} \\ \dfrac{\lambda d \,.\, \lambda x \,.\, [\;]}{\mathbf{loves}\; x \,(\mathbf{mother}\; d)} \end{array} \quad \overset{\downarrow *}{\Longrightarrow} \quad \begin{array}{c} \mathrm{DP} \triangleright (\mathrm{DP} \,\backslash\!\backslash\, \mathrm{S}) \\ \text{her mother loves } \underline{\quad} \\ \lambda d \,.\, \lambda x \,.\, \mathbf{loves}\; x \,(\mathbf{mother}\; d) \end{array} \quad \xrightarrow{\text{LIFT, PROLIFT}}$$

??Which girl$_i$ do you think [her$_i$ mother loves __]?

$$\dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}}{\mathrm{DP}} \quad \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}}{(\mathrm{DP}\backslash \mathrm{S})\,/\,\mathrm{S}} \quad \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{DP} \triangleright \mathrm{S}}{\mathrm{DP}} \quad \dfrac{\mathrm{DP} \triangleright \mathrm{S} \;\Big|\; \mathrm{S}}{\mathrm{DP}\backslash \mathrm{S}}$$

$$\text{you} \qquad \text{think} \qquad \underline{\quad} \qquad \text{her mother loves } \underline{\quad}$$

$$\dfrac{[\,]}{\textbf{you}} \quad \dfrac{[\,]}{\textbf{think}} \quad \dfrac{\lambda y\,.\,[\,]\,y}{y} \quad \dfrac{\lambda d\,.\,[\,]}{\lambda x\,.\,\textbf{loves}\,x\,(\textbf{mother}\,d)}$$

$$= \begin{array}{c} \dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{S}}{\mathrm{S}} \\ \text{you think } \underline{\quad} \text{ her mother loves } \underline{\quad} \\ \dfrac{\lambda y\,.\,[\,]}{\textbf{loves}\,y\,(\textbf{mother}\,y)} \end{array} \overset{\downarrow *}{\Longrightarrow} \begin{array}{c} \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \\ \text{you think } \underline{\quad} \text{ her mother loves } \underline{\quad} \\ \lambda y\,.\,\textbf{loves}\,y\,(\textbf{mother}\,y) \end{array}$$

??Which girl$_i$ do you think [her$_i$ mother loves __]?

$$\begin{array}{c}\dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}}{\mathrm{DP}} \\ \text{you} \\ \dfrac{[\,]}{\textbf{you}}\end{array} \quad \begin{array}{c}\dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S}}{(\mathrm{DP} \backslash \mathrm{S}) \,/\, \mathrm{S}} \\ \text{think} \\ \dfrac{[\,]}{\textbf{think}}\end{array} \quad \begin{array}{c}\dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{DP} \triangleright \mathrm{S}}{\mathrm{DP}} \\ \text{\_\_\_} \\ \dfrac{\lambda y \,.\, [\,]\, y}{y}\end{array} \quad \begin{array}{c}\dfrac{\mathrm{DP} \triangleright \mathrm{S} \;\Big|\; \mathrm{S}}{\mathrm{DP} \backslash \mathrm{S}} \\ \text{her mother loves \_\_\_} \\ \dfrac{\lambda d \,.\, [\,]}{\lambda x \,.\, \textbf{loves}\; x\, (\textbf{mother}\; d)}\end{array}$$

$$= \begin{array}{c}\dfrac{\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \;\Big|\; \mathrm{S}}{\mathrm{S}} \\ \text{you think \_\_\_ her mother loves \_\_\_} \\ \dfrac{\lambda y \,.\, [\,]}{\textbf{loves}\; y\, (\textbf{mother}\; y)}\end{array} \overset{\downarrow *}{\Longrightarrow} \begin{array}{c}\mathrm{DP} \mathbin{\backslash\!\!\backslash} \mathrm{S} \\ \text{you think \_\_\_ her mother loves \_\_\_} \\ \lambda y \,.\, \textbf{loves}\; y\, (\textbf{mother}\; y)\end{array}$$

??Which girl$_i$ do you think [her$_i$ mother loves ___]?

which girl	you think ___ her mother loves ___
$S/(DP \mathbin{\backslash\!\!\backslash} S)$	$DP \mathbin{\backslash\!\!\backslash} S$
$\lambda\kappa\,.\,\textbf{wh}(\lambda g\,.\,\textbf{girl}\,g \wedge \kappa(g))$	$\lambda y\,.\,\textbf{loves}\,y\,(\textbf{mother}\,y)$

$$\begin{array}{c} S \\ = \text{which girl do you think \_\_\_ her mother loves \_\_\_} \\ \textbf{wh}(\lambda g\,.\,\textbf{girl}\,g \wedge \textbf{loves}\,g\,(\textbf{mother}\,g)) \end{array}$$

Summary

Scope Island Evaluation, intermediate gaps, and PROLIFT — all necessary to model both quantifier scope-taking and long-distance binding — together overgenerates long-distance crossover configurations such as (**??**b) as acceptable.

§5 Discussion

Summary

B&S develop a CCG where continuations are passed linearly to model scope-taking and binding.

A claimed advantage of this framework (Shan and Barker 2006) is its explanation for *crossover effects* (Postal 1971).

Summary

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- Limitations on quantifier scope-taking motivate *Scope Island Evaluation*, a requirement that all scope islands (including embedded tensed clauses) be fully LOWER-ed.
- The availability of long-distance movement and binding dependencies motivated further refinements to the theory.
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Choose two:

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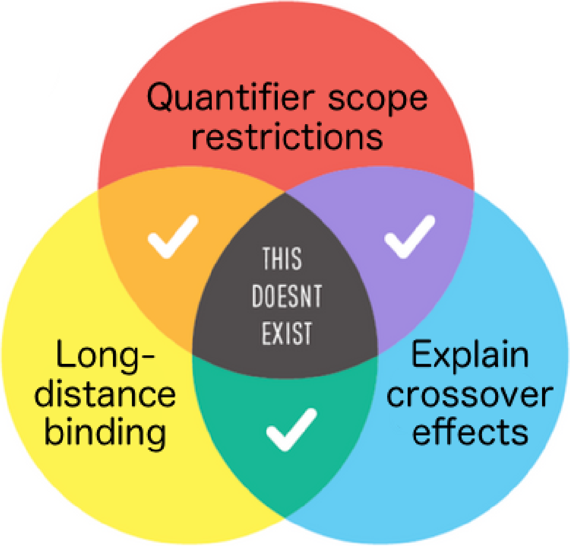
Quantifier scope restrictions
Long-distance binding
Explain crossover effects
THIS DOESNT EXIST

The problem

At issue is B&S's *uniform treatment of quantifier scope-taking, pronominal binding, and filler-gap (movement) dependencies*.

But these dependencies are sensitive to different locality restrictions:

- Quantifiers generally resist scoping out of tensed clauses, although there is some speaker variation (Wurmbrand 2018).
- Movement dependencies can cross tensed clauses, but are sensitive to *syntactic islands* (Ross 1967).
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Thank you!

We thank Chris Barker for helpful correspondence and encouraging discussion and Kenyon Branan for comments on this presentation.

Questions?

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