

Quantifier raising continued

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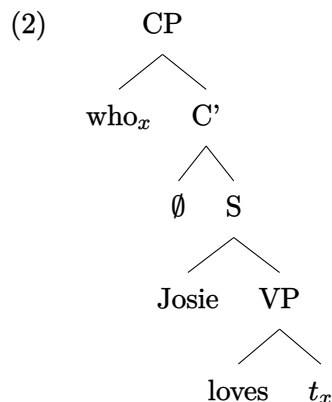
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1 Recap: movement and traces

(1) dog who_i Josie loves t_i .

The *who* of the relative clause *moves*, and leaves behind a silent pronoun (called a trace) in its “base” position.



We assume that the syntax pairs the moved expression *who* and its trace with matching variables - this will be important for the purposes of interpretation.

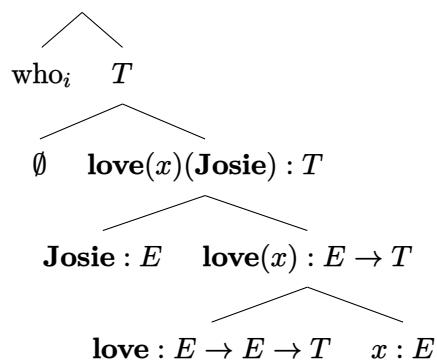
We'll assume that traces are translated directly as variables. So, for example *Josie loves t_x* is translated as:

(3) **love**(*x*)(**Josie**)

In order to ensure that the variable gets bound by a matching lambda operator we (sadly) need a special, syncategorematic rule for translating structures involving binding operators. This special translation rule is called **Predicate Abstraction**.

- γ is a syntax tree whole only two subtrees are α_x and β .
- β is translated as β' , an expression of type T
- Then translate γ as $\lambda x . \beta'$

(4) Predicate abstraction
 $\lambda x . \mathbf{love}(x)(\mathbf{Josie})$



In order to account for cases without an overt *wh*-operator, i.e., relative clauses formed with *that*, or with nothing at all such as “the dog Josie loves”, it’s common to post a silent counterpart of *who_x*: *Op_x*.

- (5) boy [*Op_x* Josie loves *t_x*]

We can account for the composition of the relative clause and noun by invoking the same conjunctive type-shifter which we used for adjectival modification.

- (6) $\wedge(\lambda x . \text{love}(x)(\mathbf{Josie}))(\mathbf{dog})$

1.1 Locality

You might be skeptical about this analysis, especially when *Op_i* is implicated, but relative clause formation shows many of the same restrictions, as e.g., question formation in English.

- (7) *The boy [*Op_x* every friend of *t_x* insulted].
(8) *Who_{*x*} did every friend of *t_x* insult?
(9) *The boy [*Op_x* Sarah insulted *t_x* and praised Josie].
(10) *Who_{*x*} did Sarah insult *t_x* and praise Josie?

These constraints on movement are known as **island constraints** (Ross 1967).

The fact that relativization and *wh*-movement are subject to the same constraints suggests that they should receive a unified analysis (Chomsky 1977).

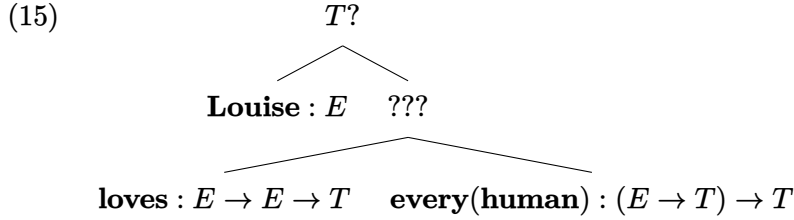
One interesting fact about this kind of movement is that it can proceed an arbitrary distance out of embedded environments.

- (11) the boy [*Op_x* Sarah believes [Josie insulted *t_x*]].
(12) Who_{*i*} does Sarah believe [Josie insulted *t_x*]?
(13) the boy [*Op_x* Sarah told me [that Sam believes [Josie insulted *t_x*]]].
(14) Who_{*x*} did Sarah told me [that Sam believes [Josie insulted *t_x*]]?
 - We don’t have a good treatment of the semantics of verbs like *believes*, but for the time being let’s assume that it’s of type $T \rightarrow E \rightarrow T$.
 - Show how composition proceeds in the first example, above.

Once we introduce *movement* in order to understand certain sentences with quantifiers, we’ll return to this concept. It will be one of our initial motivations for moving over to continuation semantics. But first...

2 Quantifiers in object position

A problem! Quantificational NPs can't compose when they're in any position other than subject position.



Remember that *every human* has the following meaning (roughly):

(16) $\lambda P . \forall x [\text{human}(x) \rightarrow P(x)]$

In this case, an appropriate value for P would be one which maps an individual to true if Louise loves them, i.e.:

(17) $\lambda x . \text{love}(x)(\text{Louise})$

We derive this component via a new syntactic transformation: *Quantifier raising*.

Recall the special translation rule **Predicate abstraction**.

- γ is a syntax tree whole only two subtrees are α_x and β .
- β is translated as β' , an expression of type T
- Then translate γ as $\lambda x . \beta'$

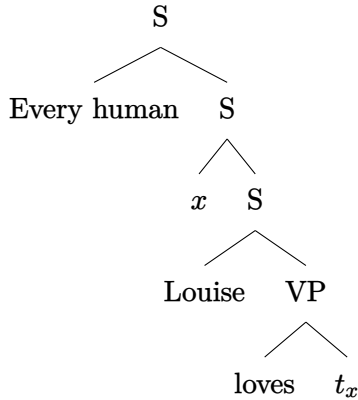
We'll assume that any NP can be supplied with a variable by the syntax, and may move.

We'll need to modify the translation rule slightly however, since NPs do more than just induce abstraction:

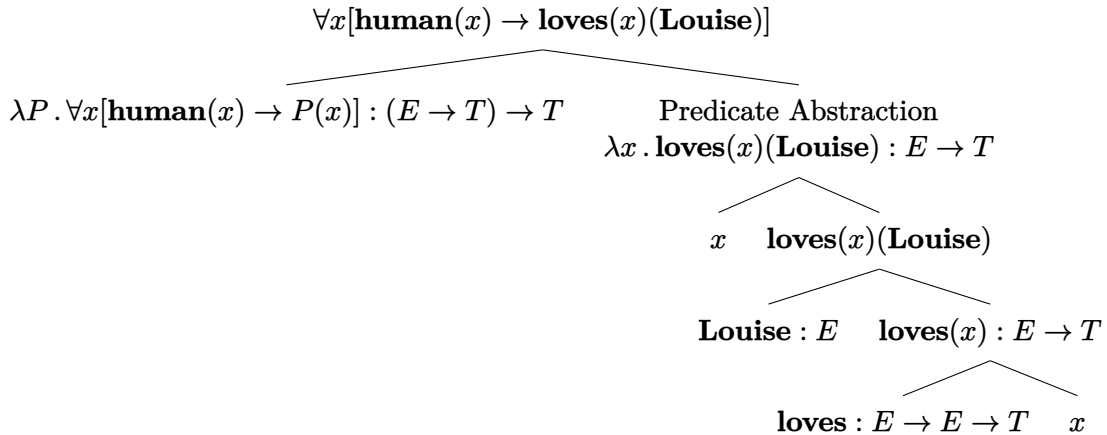
- γ is a syntax tree whole only two subtrees are x and β , where x is a variable.
- β is translated as β' , an expression of type T
- Then translate γ as $\lambda x . \beta'$

Following (Heim & Kratzer 1998), we assume that movement of an NP involves rebracketing of the associated variable with the sister of the moved NP.

(18)

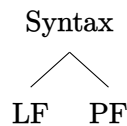


(19)



The idea of Quantifier raising was originally formulated in a syntactic theory with several levels of representation (May 1977):

- Narrow syntax (sometimes split into deep and surface structure)
- Logical Form (the input to semantic interpretation)
- Phonological Form (the input to pronunciation)



Quantifier raising is an operation that takes place on the branch from Syntax to LF, therefore it has semantic consequences but not phonological consequences.

Other operations, like *wh*-movement, and relative clause formation, take place in the syntax, and therefore have both semantic *and* phonological consequences.

2.1 Scope ambiguities with operators

(20) John hasn't read exactly three books.

1. *The cardinality of books that John hasn't read is 3.* Can be true, for example, if John has read 3 of the books, and hasn't read 3 of the books.
2. *It's not the case that the cardinality of books that John has read is 3.* Can be true, for example, if John has read 4 of the books and hasn't read 2 of them.

Note that, in scenario 1, the first reading is true, and the second is false; in scenario 2; the first reading is false, and the second reading is true, so these readings are semantically independent.

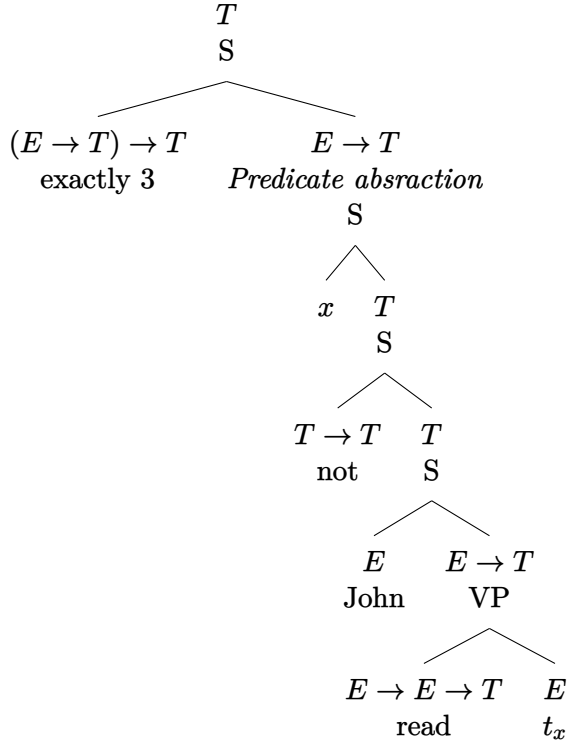
(21) $\text{Card}(\{x \mid \text{book}(x)\} \cap \{x \mid \neg \text{read}(x)(\text{John})\}) = 3$

(22) $\text{Card}(\{x \mid \text{book}(x)\} \cap \{x \mid \text{read}(x)(\text{John})\}) \neq 3$

The possibility of quantifier raising derives these two readings.

2.1.1 Wide scope reading

Let's start with the *wide scope reading of exactly 3*, which corresponds to scenario 1, and the tree below.



The complement of *not* is an open sentence containing a trace:

$$(23) \quad \mathbf{not}(\mathbf{read}(x)(j))$$

Movement of *exactly 3* creates an *abstraction variable* x , which triggers predicate abstraction.

The result is a functional expression of type $E \rightarrow T$.

name: open

$$(24) \quad \lambda x . \mathbf{not}(\mathbf{read}(x)(j))$$

What set does this characterize? The set of books that weren't read by John.

$$(25) \quad \{ x \mid \text{John didn't read } x \}$$

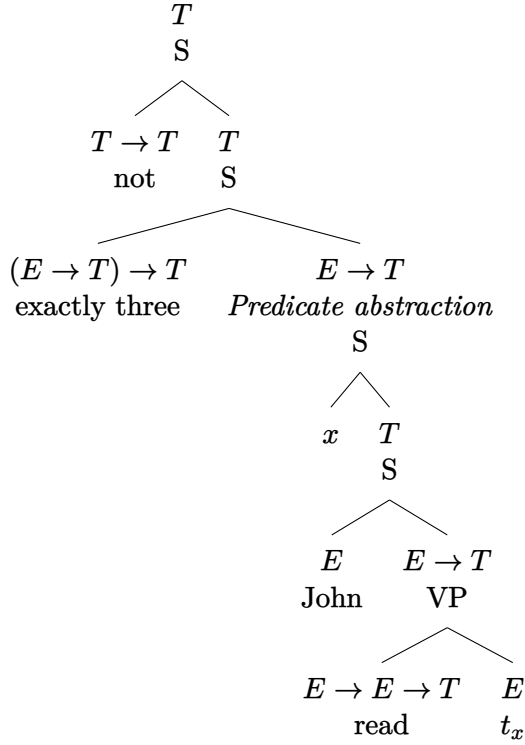
Exactly 3 books is a function from P to true, if the cardinality of the intersection of P with the set of books is 3.

$$(26) \quad \llbracket \mathbf{exactly3books}(P) \rrbracket = \text{true iff } \mathbf{card}(\{ x \mid x \text{ is a book } \} \cap P) = 3$$

We now apply the meaning of *exactly 3* to the meaning of the result of predicate abstraction:

$$\begin{aligned}
 (27) \quad &= \text{true iff } \mathbf{card}(\{x \mid x \text{ is a book}\} \cap \{x \mid \text{John didn't read } x\}) = 3 \\
 &= \text{true iff } \mathbf{card}(\{x \mid x \text{ is a book that John didn't read}\}) = 3
 \end{aligned}$$

2.1.2 Narrow scope reading



Here, *exactly 3* moves and adjoins *below* negation; the complement of *exactly 3 books* is the following open sentence:

$$(28) \quad \mathbf{read}(x)(j)$$

The abstraction variable x , created by movement of *exactly 3 books*, triggers predicate abstraction:

$$(29) \quad \lambda x . \mathbf{read}(x)(j)$$

This function characterise the following set:

$$(30) \quad \{x \mid \text{John read } x\}$$

We combine this with *exactly 3 books*, as before, and get the following truth-conditions:

$$(31) \quad \llbracket \text{exactly3books}(\lambda x . \text{read}(x)(j)) \rrbracket \\ \text{true iff } \mathbf{card}(\{x \mid x \text{ is a book that John read}\}) = 3$$

Now negation applies and flips the truth conditions:

$$(32) \quad \text{false iff } \mathbf{card}(\{x \mid x \text{ is a book that John read}\}) = 3 \\ = \text{true iff } \mathbf{card}(\{x \mid x \text{ is a book that John read}\}) \neq 3$$

We therefore derive the two readings by allowing quantifier raising to adjoin the moved quantifier to any node of type T .

2.1.3 A note on quantifiers in subject position

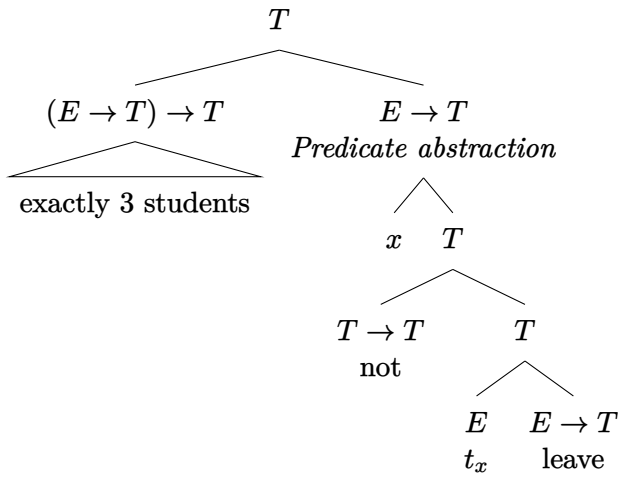
Note that there is no type reason for quantifiers in subject position to undergo quantifier raising, but doing so is harmless.

It might also be useful for examples such as the following:

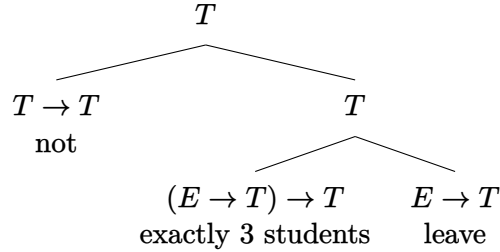
$$(33) \quad \text{Exactly 3 students didn't leave.}$$

This also seems like it has an ambiguity between a reading where *exactly 3 takes scope over negation*, and one where *exactly 3 takes scope below negation*.

We could assume the following logical form for the wide-scope reading:



The narrow-scope reading, on the other hand, may simply involve *exactly 3 students* remaining in-situ.



2.1.4 A locality problem for quantifier raising

The idea sketched here is that quantifier scope ambiguities can be derived by assuming a silent counterpart of the operation used for relativization/wh-movement (May 1977).

Although, as we saw, relativization and wh-movement are subject to strict locality conditions, both can proceed from out of an embedded clause.

- (34) the boy [Op_x Sarah believes [Josie insulted t_x]].
- (35) Who_i does Sarah believe [Josie insulted t_x]?
- (36) the boy [Op_x Sarah told me [that Sam believes [Josie insulted t_x]]].
- (37) Who_x did Sarah told me [that Sam believes [Josie insulted t_x]]?

Quantifier raising doesn't seem to parallel this behaviour. Consider the following example:

- (38) Sarah didn't tell me that Sam read exactly three books.

Imagine that Sam read four books:

- War and Peace
- Anna Karenina
- The Idiot
- The White Guard

Sarah told me that Sam read *The White Guard*, but she neglected to tell me that he read *War and Peace*, *Anna Karenina*, and *The Idiot*.

The sentence intuitively feels *false* in this scenario, but a super wide scope reading would predict it should be true:

(39) exactly three books λx [Sarah didn't tell me [that Sam read t_x]]

The only attested reading corresponds to a scenario where Sam read exactly three books, but Sarah didn't tell me that he did.

(40) Sarah didn't tell me [exactly three books λx [that Sam read t_x]]

If quantifier raising is silent counterpart of relativization and wh-movement, then this is mysterious.

We'll use this as an initial motivation to explore a different derivation for quantifiers in object position, based on *type shifting* (next week).

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