Introduction to Semantics

Lecture 5: Quantifier Scope

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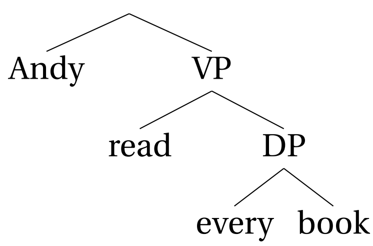
1 Quantificational DPs in object position

So far we have only discussed sentences involving quantificational DPs in subject position.

Quantificational DPs can be found in other positions as well. Among those, let us discuss quantificational DPs as direct objects of transitive verbs as in the following examples.

(1) a. Andy read every book.
    b. Becky saw no cat.
    c. Chrissy invited at least one philosopher.

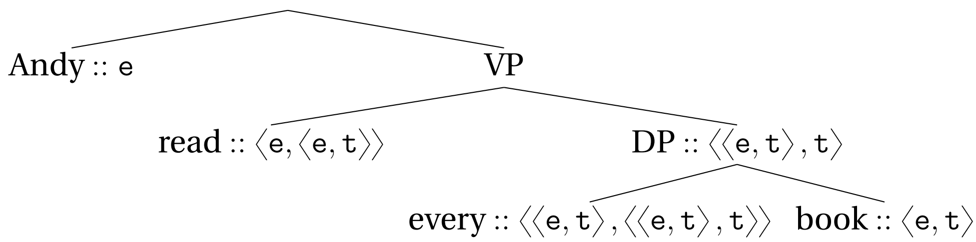
Let us focus on the first example here, which we assume has the following structure.



We have in fact worked out the denotations of all the ingredients of this sentence:

(2) For any model $\mathcal{M}$,
    a. $[\![\texttt{Andy}]\!]_{\mathcal{M}} \in D$
    b. $[\![\texttt{read}]\!]_{\mathcal{M}} = \lambda x \in D.\ \lambda y \in D.\ 1$ iff y read x in $\mathcal{M}$
    c. $[\![\texttt{every}]\!]_{\mathcal{M}} = \lambda g \in D_{\langle \texttt{e},\texttt{t}\rangle}.\lambda f \in D_{\langle \texttt{e},\texttt{t}\rangle}.\ 1$ iff $\mathsf{set}(g) \subseteq \mathsf{set}(f)$
    d. $[\![\texttt{book}]\!]_{\mathcal{M}} = \lambda x \in D.\ 1$ iff x is a book in $\mathcal{M}$

However, we cannot interpret this sentence, because the semantic types do not work out.



'Read' and 'every book' cannot combine via Functional Application!

A situation like this is called a **type mismatch**.

Clearly, $[\![\texttt{read}]\!] \notin [\![\texttt{every book}]\!]$, no matter what the model is like, because a set of ordered pairs like (2) is simply the wrong 'type' of thing to compose with a set of sets of individuals like (1). A situation like this is called a *type mismatch*.

There are three strategies we could take here.

1. Reanalyze 'read'.
2. Reanalyze 'every book'.
3. Reanalyze the structure.

We will only discuss Strategy 3 in class, but in case you are interested in the other two, I will spell out the core ideas below. I see no principled reason to reject these approaches, but ultimately, proponents of these approaches should say something about the constraints on quantifier scope that will be discussed later on this handout as well.

1.1 Reanalyzing the transitive verb

Recall that the denotations of proper names can be seen as generalized quantifiers too. Then, we can assume that 'read' actually always combines with a generalized quantifier as in (3).

(3) $$[\![\texttt{read}]\!]_{\mathcal{M}} = \lambda Q \in D_{\langle\langle \texttt{e},\texttt{t}\rangle,\texttt{t}\rangle}.\ \lambda y \in D.\ Q(\lambda x \in D.\ 1 \text{ iff } y \text{ read } x \text{ in } \mathcal{M})$$

It's maybe not so obvious how I arrived at this denotation with Q at the beginning, but one can think of this as doing Quantifier Raising in the semantics.

One could also assume that the subject is always a generalized quantifier:

(4) $$[\![\texttt{read}]\!]_{\mathcal{M}} = \lambda O \in D_{\langle\langle \texttt{e},\texttt{t}\rangle,\texttt{t}\rangle}.\ \lambda S \in D_{\langle\langle \texttt{e},\texttt{t}\rangle,\texttt{t}\rangle}.\ S(\lambda y \in D.\ O(\lambda x \in D.\ 1 \text{ iff } y \text{ read } x \text{ in } \mathcal{M}))$$

This will only account for the surface scope reading; We could also have a separate lexical entry for the inverse scope reading (see below).

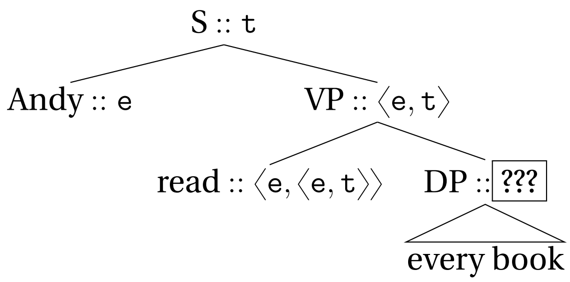
(5) $$[\![\texttt{read}_{\texttt{inv}}]\!]_{\mathcal{M}} = \lambda O \in D_{\langle\langle \texttt{e},\texttt{t}\rangle,\texttt{t}\rangle}.\ \lambda S \in D_{\langle\langle \texttt{e},\texttt{t}\rangle,\texttt{t}\rangle}.\ O(\lambda x \in D.\ S(\lambda y \in D.\ 1 \text{ iff } y \text{ read } x \text{ in } \mathcal{M}))$$

Note that we can't have the exact same object language expression mapped to two different denotations, because we assume that $[\![\cdot]\!]_{\mathcal{M}}$ is a function. So we need to indicate that the above two expressions are distinct expressions.

An analysis like this that involves a systematic change of semantics types is called **type-shifting**.

1.2 Reanalyzing the quantifier

We assigned $\langle\langle \mathtt{e},\mathtt{t}\rangle,\mathtt{t}\rangle$ to quantificational DPs, because we started with examples with quantificational DPs in subject position. Had we started with (1a), we would have arrived at a different semantic type.



Given that 'every book' cannot be of type $\mathtt{e}$ (see Lecture 3), it's got to be of type $\langle\langle \mathtt{e},\langle \mathtt{e},\mathtt{t}\rangle\rangle,\langle \mathtt{e},\mathtt{t}\rangle\rangle$. The type-$\langle\langle \mathtt{e},\langle \mathtt{e},\mathtt{t}\rangle\rangle,\langle \mathtt{e},\mathtt{t}\rangle\rangle$ version of 'every book' will look like (6).

(6) $[\![\mathtt{every\ book}]\!]_{\mathcal{M}} = \lambda R \in D_{\langle \mathtt{e},\langle \mathtt{e},\mathtt{t}\rangle\rangle}.\lambda x \in D.\ 1 \text{ iff for every book } y \text{ in } \mathcal{M},\ R(y)(x) = 1$

But evidently, this cannot be used in subject position. We could have two versions for each quantifier:

(7) a. $[\![\mathtt{every_{subj}\ book}]\!]_{\mathcal{M}} = \lambda f \in D_{\langle \mathtt{e},\mathtt{t}\rangle}.\ 1 \text{ iff for every book } x \text{ in } \mathcal{M},\ f(x) = 1$
b. $[\![\mathtt{every_{obj}\ book}]\!]_{\mathcal{M}} = \lambda R \in D_{\langle \mathtt{e},\langle \mathtt{e},\mathtt{t}\rangle\rangle}.\lambda x \in D.\ 1 \text{ iff for every book } y \text{ in } \mathcal{M},\ R(y)(x) = 1$

From these, we can deduce the denotations of the quantificational determiner.

(8) a. $[\![\mathtt{every_{subj}}]\!]_{\mathcal{M}}$
$= \lambda g \in D_{\langle \mathtt{e},\mathtt{t}\rangle}.\lambda f \in D_{\langle \mathtt{e},\mathtt{t}\rangle}.\ 1 \text{ iff for every } x \in D \text{ such that } g(x) = 1,\ f(x) = 1$
b. $[\![\mathtt{every_{obj}}]\!]_{\mathcal{M}}$
$= \lambda g \in D_{\langle \mathtt{e},\mathtt{t}\rangle}.\lambda R \in D_{\langle \mathtt{e},\langle \mathtt{e},\mathtt{t}\rangle\rangle}.\lambda x \in D.\ 1 \text{ iff for every } y \text{ such that } g(y) = 1,\ R(y)(x) = 1$

You might think that it's not ideal to postulate such a lexical ambiguity for each and every quantificational determiner. But it should be noticed that the ambiguity is systematic. In particular, one version can be defined in terms of the other.

Perhaps it's easier to see that (8b) can be rewritten in terms of (8a).

(9) $[\![\mathtt{every_{obj}}]\!]_{\mathcal{M}}$
$= \lambda g \in D_{\langle \mathtt{e},\mathtt{t}\rangle}.\lambda R \in D_{\langle \mathtt{e},\langle \mathtt{e},\mathtt{t}\rangle\rangle}.\lambda x \in D.\ 1 \text{ iff } [\![\mathtt{every_{subj}}]\!]_{\mathcal{M}}(g)(\lambda y \in D.\ R(y)(x)) = 1$

Note that this is essentially QR-ing in the semantics.

In addition, (8a) can be defined in terms of (8b).

(10) $[\![\texttt{every}_{\texttt{subj}}]\!]_{\mathcal{M}} = \lambda g \in D_{\langle \texttt{e},\texttt{t}\rangle}.\lambda f \in D_{\langle \texttt{e},\texttt{t}\rangle}.$
1 iff for some $x \in D$, $[\![\texttt{every}_{\texttt{obj}}]\!]_{\mathcal{M}}(g)(\lambda y \in D.\lambda z \in D.\ f(y))(x) = 1$

Note that λz is not binding anything. It's just there to adjust the type. Also, x is essentially vacuous. As long as the model is non-empty (and by assumption it's not), it plays no significant role.

We can define general type-shifting rules for turning type-$\langle\langle \texttt{e},\texttt{t}\rangle,\langle\langle \texttt{e},\texttt{t}\rangle,\texttt{t}\rangle\rangle$ determiners into type-$\langle\langle \texttt{e},\texttt{t}\rangle,\langle\langle \texttt{e},\langle \texttt{e},\texttt{t}\rangle\rangle,\langle \texttt{e},\texttt{t}\rangle\rangle\rangle$ determiners and vice versa.

(11) a. For any $S \in \langle\langle \texttt{e},\texttt{t}\rangle,\langle\langle \texttt{e},\texttt{t}\rangle,\texttt{t}\rangle\rangle$,
$\mathsf{obj}(S) = \lambda g \in D_{\langle \texttt{e},\texttt{t}\rangle}.\lambda R \in D_{\langle \texttt{e},\langle \texttt{e},\texttt{t}\rangle\rangle}.\lambda x \in D.\ 1$ iff $Q(g)(\lambda y \in D.\ R(y)(x)) = 1$

b. For any $O \in \langle\langle \texttt{e},\texttt{t}\rangle,\langle\langle \texttt{e},\langle \texttt{e},\texttt{t}\rangle\rangle,\langle \texttt{e},\texttt{t}\rangle\rangle\rangle$,
$\mathsf{subj}(O) = \lambda g \in D_{\langle \texttt{e},\texttt{t}\rangle}.\lambda f \in D_{\langle \texttt{e},\texttt{t}\rangle}.\ 1$ iff for some $x \in D$, $O(g)(\lambda y \in D.\lambda z \in D.\ f(y))(x) = 1$

Importantly:

(12) a. For any $S \in \langle\langle \texttt{e},\texttt{t}\rangle,\langle\langle \texttt{e},\texttt{t}\rangle,\texttt{t}\rangle\rangle$, $\mathsf{subj}(\mathsf{obj}(S)) = S$

b. For any $O \in \langle\langle \texttt{e},\texttt{t}\rangle,\langle\langle \texttt{e},\langle \texttt{e},\texttt{t}\rangle\rangle,\langle \texttt{e},\texttt{t}\rangle\rangle\rangle$, $\mathsf{obj}(\mathsf{subj}(O)) = O$

This means that there is a one-to-one correspondence between the domains of these two complex semantic types, and we can see each pair as coming from the same thing.

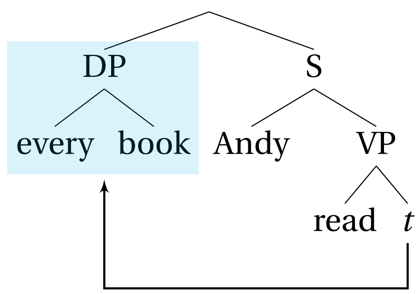
Given this one-to-one correspondence, therefore, it's not really conceptually undesirable to postulate multiple semantic types for the same quantificational determiner. In some sense, there is only one core meaning behind it, and the versions of the quantificational determiner are merely two instantiations of that.

2 Quantifier Raising

The approach to the type-mismatch problem we will consider involves a radical assumption: The structure that is interpreted is different from the structure that is pronounced.

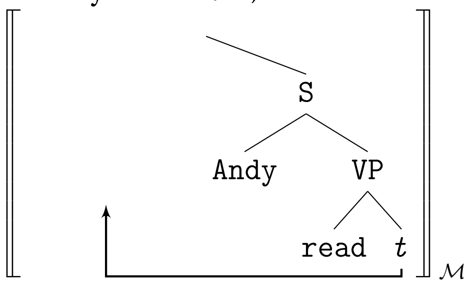
In particular, the structure that is interpreted, which is called the **Logical Form (LF)**, is the result of applying a transformation rule/covert movement called *Quantifier Raising (QR)*.

According to this idea, the LF of the sentence looks different from the pronounced structure we saw above. Specifically, it is derived from the pronounced structure by applying QR to the object quantificational DP, as depicted below.



How does this solve the type-mismatch problem? The crucial assumption is that the movement creates a type-$\langle \mathtt{e}, \mathtt{t} \rangle$ predicate. That is,

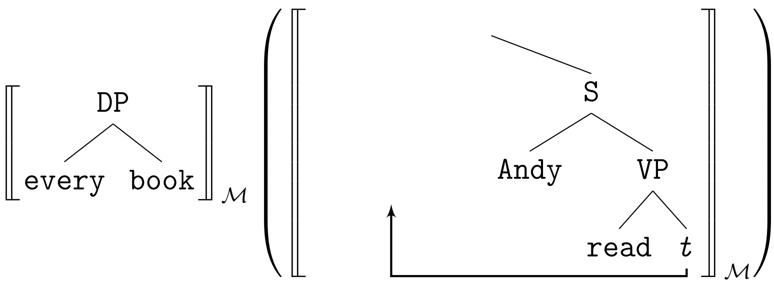
(13) For any model $\mathcal{M}$,

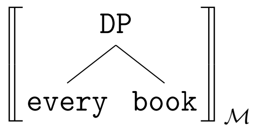


$= \lambda x \in D.\ 1$ iff Andy read x in $\mathcal{M}$

We will discuss how this is interpreted compositionally in Week 2, but for now what matters is that now the quantificational DP, which denotes a generalized quantifier of type $\langle\langle \mathtt{e}, \mathtt{t} \rangle, \mathtt{t} \rangle$ can combine with the rest of the structure.

(14) For any model $\mathcal{M}$,



$=$  $(\lambda x \in D.\ 1 \text{ iff Andy read } x \text{ in } \mathcal{M})$

$=[\lambda f \in D_{\langle \mathtt{e},\mathtt{t} \rangle}.\ 1 \text{ iff for every book } x \text{ in } \mathcal{M},\ f(x) = 1](\lambda x \in D.\ 1 \text{ iff Andy read } x \text{ in } \mathcal{M})$

$=1$ iff for every book x in $\mathcal{M}$, Andy read x in $\mathcal{M}$

3 Sentences with multiple quantifiers

We have analyzed sentences with quantificational subjects and sentences with quantificational objects. It is possible to have both a quantificational subject and a quantificational object at the same time, as in (15).

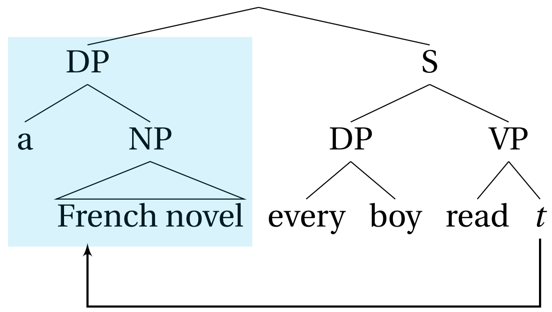
(15) Every boy read a French novel.

Suppose that there are three French novels, Novel 1, Novel 2, and Novel 3, and four boys, Andy, Bob, Chris, and Daniel. Suppose further that Andy and Bob read Novel 1, Chris read Novel 2 and Daniel read Novel 3. This situation can be represented by the following diagram where the arrows represent the 'read'-relation.

$$\begin{tikzcd}[row sep=tiny] \text{Andy} \arrow[r] & \text{FrenchNovel 1} \\ \text{Bob} \arrow[ur] & \\ \text{Chris} \arrow[r] & \text{FrenchNovel 2} \\ \text{Daniel} \arrow[r] & \text{FrenchNovel 3} \end{tikzcd}$$

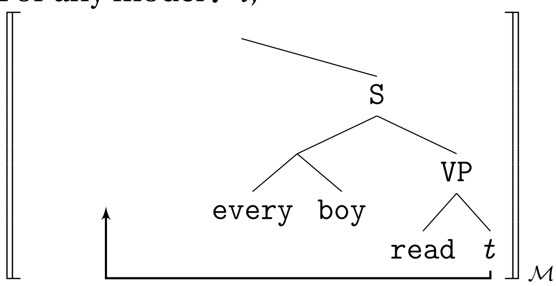
In this situation, (15) is judged to be true.

This judgment is, however, not predicted by our analysis so far. With QR of the object quantifier, the LF structure of the sentence will look like this.



Firstly, the semantic types work out: The node labeled 'S' should denote a truth-value, so it's of type t, and QR creates a type $\langle e, t\rangle$ predicate out of it. Putting aside again the details of how to interpret the movement for now, the denotation of the sister of the QR'ed object quantifier will be:

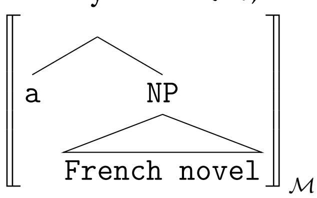
(16) For any model $\mathcal{M}$,



$= \lambda x \in D.\, 1$ iff for every boy y in $\mathcal{M}$, y read x in $\mathcal{M}$

The existential quantifier 'a French novel' denotes:

(17) For any model $\mathcal{M}$,



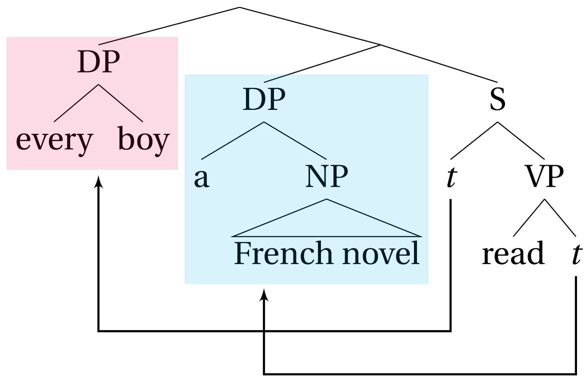
$= \lambda f \in D_{\langle e,t\rangle}.\, 1$ iff there is a French novel x in $\mathcal{M}$ such that $f(x) = 1$

Applying (17) to (16), we will get a truth-value 1 iff there is a French novel x in $\mathcal{M}$ such that $[\lambda x \in D.\ 1$ iff for every boy y in $\mathcal{M}$, y read x in $\mathcal{M}](x) = 1$, which is to say that there is a French novel in $\mathcal{M}$ that every boy read. In the above scenario we considered, none of the French novels was read by every boy, so the sentence is predicted to be false. But we judge the sentence to be true.

It is considered that the truth-conditions we derived do actually correspond to a possible reading of the sentence but this reading is not the only reading of the sentence. Thus is, the sentence is actually ambiguous and have a different reading that is true in the above scenario.

Note that this ambiguity does not come from ambiguity in the lexical meanings of the words used in the sentence. So it is not a case of lexical ambiguity. It seems that quantifiers are somehow responsible for the ambiguity, so it is called **quantifier scope ambiguity**. (The idea of 'quantifier scope' will be explained below)

According to our theory with QR, quantifier scope ambiguity is analyzed as a special case of **structural ambiguity** at LF (NB: in other theories of quantifier scope, quantifier scope ambiguity is not necessarily reduced to structural ambiguity). Specifically, the other reading is derived by applying QR to the subject quantifier, in addition to the object quantifier, so that it sits above the object quantifier. This is depicted in the following tree diagram.



Again, we will only discuss how to compositionally interpret this structure next week, but the truth-conditions we derive for this structure will be:

(18) For every boy x in $\mathcal{M}$, there is a French novel y in $\mathcal{M}$, x read y in $\mathcal{M}$

And this is true in the above example scenario.

To summarize, our example sentence is ambiguous because one and the same surface structure corresponds to two different LF representations, which differ from each other in terms of the relative positions of the quantifiers (and how many instances of QR are involved). And such an ambiguity is called a quantifier scope ambiguity.

4 Evidence for quantifier scope ambiguity

Above, I just asserted that the sentence with two quantifiers, repeated in (19), is ambiguous, but is that really true?

(19) Every boy read a French novel.

To facilitate the following discussion, let's give names to the two purported readings of the sentence. We will call the first reading we considered above the **inverse scope reading**, because the order of quantifiers in the Predicate Logic representation is the inverse of the order of appearance in the pronounced sentence, and the second reading the **surface scope reading**, as the orders match. The two readings are paraphrased in English and Predicate Logic below for the sake of clarify.

(20) *Inverse Scope Reading*
   a. There is a French novel that every boy read.

b. $\exists x((Fx \wedge Nx) \wedge \forall y(By \rightarrow Ryx))$

(21) *Surface Scope Reading*

a. For every boy there is a French novel that he read.

b. $\forall y(By \rightarrow \exists x((Fx \wedge Nx) \wedge Ryx))$

An important fact to be noticed about these readings is that the inverse scope reading entails the surface scope reading but the surface scope reading does not entail the inverse scope reading. Specifically, whenever the inverse scope reading is true, there is at least one French novel that every boy read. Then it must be the case that for every boy, there is at least one French novel he read. On the other hand, we can find a scenario where the surface scope reading is true but the inverse scope reading is not true. An example of such a scenario is the one we considered above.

This asymmetric entailment relation between the two readings confused a lot of linguists in the past, and led them to claim that one of these two readings is actually not there as a separate reading.[1] The idea is that one of the readings subsumes the other reading, so there is no real empirical evidence for the subsumed reading and hence it is theoretically dispensable. Interestingly, some claimed that only the inverse scope reading was necessary, while others claimed that only the surface scope reading was necessary. Clearly, at least one of these claims must be wrong. In fact it is now considered that both of them are wrong and the sentence has both readings. In what follows, we will quickly go over reasoning behind the two claims that say that there is no ambiguity, and after that, review some empirical reasons to think that both of them are in fact wrong.

Firstly, those who thought that only the inverse scope reading was necessary and the surface scope reading could be dispensed with are simply wrong. Their reasoning seems to go as follows. The inverse scope reading entails the surface scope reading, which means that whenever the inverse scope is true, the surface scope reading is also true, so the surface scope reading is superfluous. This is simply fallacious. It is indeed true that whenever the inverse scope reading is true, the surface reading is also true, but because the entailment here is only one-way, there are situations where the surface scope reading is true but the inverse scope reading is false, and we saw one such example scenario. Since the sentence is judged as true in this scenario, we are forced to say that the sentence has at least the surface scope reading.

Secondly, the other view that the sentence only has the surface scope reading is a bit more sensible. The idea is as follows. Since the inverse scope reading entails the surface scope reading, it is impossible to find a situation where only the inverse scope reading is true. In other words, the surface scope reading is true in a superset of situations where the inverse scope reading is true, so whether or not the inverse scope reading exists, the set of situations where the sentence is true will be the same. So we can account for our truth-conditional intuitions about the sentence without recourse to the inverse scope reading.

But there are still reasons to think that both readings exist, not just the surface scope reading. We will discuss four such reasons.

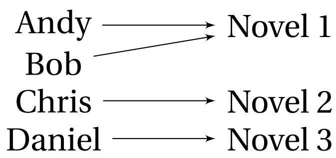
[1] If you are interested, read Eddy Ruys (2001) Wide scope indefinites: the genealogy of a mutant meme, unpublished manuscript, Universiteit Utrecht.

4.1 Double judgments

Consider the sentence with two quantifiers again.

(22) Every boy read a French novel.

In the situation we considered above, repeated below, the surface scope reading is true, while the inverse scope reading is false.



As we remarked above, because the sentence is judged as true with respect to this scenario, we are confident that the surface scope reading exists. But if the sentence can also be judged as false with respect to this scenario, that can be taken as evidence for the availability of the inverse scope reading. So, if you (and/or your native speaker informants) think that the sentence is both true and false at the same time, this is good evidence that both readings exist.

Notice that similar double judgments arise with other types of ambiguity, although in these examples, the two readings do not stand in an entailment relation, so might be easier to distinguish.

(23) a. I went to the bank on Wednesday. (lexical ambiguity)
b. John saw the man with binoculars. (structural ambiguity)

4.2 Embedding

When the sentence is embedded under certain linguistic contexts (more precisely, non-upward monotonic contexts), the entailment relation changes. To see this, consider the following sentence, which is the negation of the original sentence.

(24) It's false that every boy read a French novel.

The two readings of this sentence are:

(25) *Inverse Scope Reading*
a. There is no French novel that every boy read.
b. $\neg\exists \mathtt{x}((\mathtt{Fx} \wedge \mathtt{Nx}) \wedge \forall \mathtt{y}(\mathtt{By} \rightarrow \mathtt{Ryx}))$

(26) *Surface Scope Reading*
a. For not every boy there is a French novel that he read.
b. $\neg\forall \mathtt{y}(\mathtt{By} \rightarrow \exists \mathtt{x}((\mathtt{Fx} \wedge \mathtt{Nx}) \wedge \mathtt{Ryx}))$

In this case the surface scope reading entails the inverse scope reading, rather than the other way around. When the surface scope reading is true, there must be at least one boy who didn't read any French novel. Then, it must be the case that no French novel was read by every boy, so the inverse scope reading must be true. The entailment does not go through in the other direction, meaning we can find a scenario where the inverse scope reading is true but the surface scope reading is false. One such context is actually the one we already saw above. If the sentence is judged to be true in this scenario, that will be taken as evidence that the inverse scope of this sentence exists.

4.3 Switching the quantifiers

Another way to alter the entailment pattern is by switching the quantifiers, as in the following example.

(27) A boy read every French novel.

The two readings of the sentence are:

(28) *Inverse Scope Reading*

a. For every French novel, there is a boy that read it.

b. $\forall x((Fx \wedge Nx) \rightarrow \exists y(By \wedge Ryx))$

(29) *Surface Scope Reading*

a. There is a boy that read every French novel.

b. $\exists y(By \wedge \forall x((Fx \wedge Nx) \rightarrow Ryx))$

In this case, the surface scope reading entails the inverse scope reading, but not vice versa. This means that we can find a scenario where only the inverse scope reading is true. Again, the same scenario as before is one such case. The sentence can be judged as true in this scenario, so that evidences that the inverse scope reading exists.

4.4 Other quantifiers

There are combinations of quantifiers that don't give rise to asymmetric entailment patterns. Consider, for example, (30).

(30) A boy read exactly two French novels.

The two readings of (30) are the following. The Predicate Logic representations might not be very helpful but I'll keep them for the sake of consistency.

(31) *Inverse Scope Reading*

a. There are exactly two French novels that were read by a boy.

b. $$\exists x_1 \left(\begin{array}{l} ((Fx_1 \wedge Nx_1) \wedge \exists y_1(By_1 \wedge Ry_1x_1)) \wedge \\ \exists x_2 \left(\begin{array}{l} (\neg x_1 = x_2 \wedge ((Fx_2 \wedge Nx_2) \wedge \exists y_2(By_2 \wedge Ry_2x_2))) \wedge \\ \neg \exists x_3 \left(\begin{array}{l} (\neg x_1 = x_3 \wedge \neg x_2 = x_3) \wedge \\ ((Fx_3 \wedge Nx_3) \wedge \exists y_3(By_3 \wedge Ry_3x_3)) \end{array} \right) \end{array} \right) \end{array} \right)$$

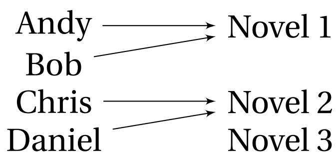
(32) *Surface Scope Reading*

a. There is a boy that read exactly two French novels.

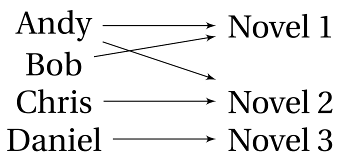
b. $$\exists y \exists x_1 \left(\begin{array}{l} ((Fx_1 \wedge Nx_1) \wedge (By \wedge Ry)) \wedge \\ \exists x_2 \left(\begin{array}{l} (\neg x_1 = x_2 \wedge ((Fx_2 \wedge Nx_2) \wedge Ryx_2)) \wedge \\ \neg \exists x_3 \left(\begin{array}{l} (\neg x_1 = x_3 \wedge \neg x_2 = x_3) \wedge \\ ((Fx_3 \wedge Nx_3) \wedge Ryx_3) \end{array} \right) \end{array} \right) \end{array} \right)$$

There is no entailment in either direction between these two sentences. To see this in concrete terms, consider the following two situations.

(33)



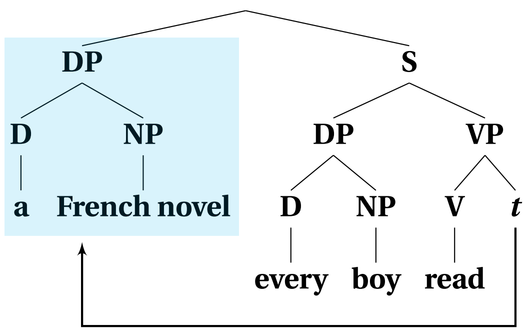
(34)

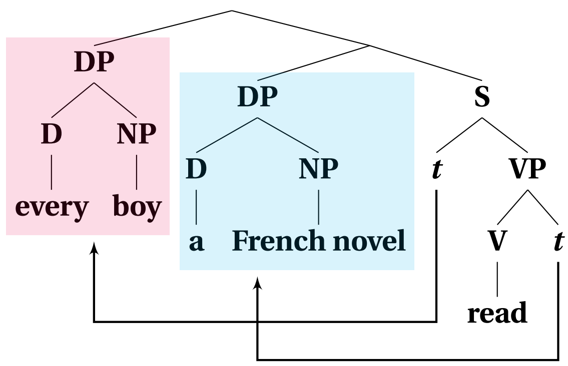


In (33), only the inverse scope reading is true, while in (34), only the surface scope reading is true. If the sentence is judged as true, both readings must exist.

5 Quantifier scope

As we just saw, sentences with multiple quantifiers (sometimes) give rise to quantifier scope ambiguity. We account for this ambiguity in terms of structural ambiguity by postulating two LF representations. For our example, 'Every boy read a French novel', for instance, the two LFs look like:

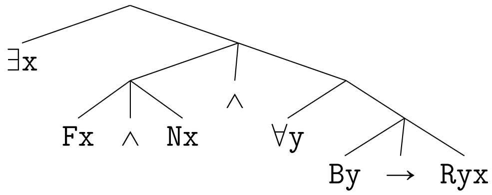




Unlike natural language, Predicate Logic is designed to not give rise to quantifier scope ambiguity. Therefore, for each formula of Predicate Logic, there is only one interpretation, no matter how many quantifiers occur in it. For instance, consider the formula:

(35) $\exists x((Fx \wedge Nx) \wedge \forall y(By \rightarrow Ryx))$

It might be useful to represent the structure of this formula in a tree diagram as follows (omitting parentheses, as they are superfluous in a tree representation).



For this formula, we say that the *scope* of the quantifier $\exists\mathtt{x}$ is the rest of the sentence, namely, $((\mathtt{Fx} \wedge \mathtt{Nx}) \wedge \forall\mathtt{y}(\mathtt{By} \rightarrow \mathtt{Ryx}))$, while the scope of the quantifier $\forall\mathtt{y}$ is $(\mathtt{By} \rightarrow \mathtt{Ryx})$.

In Predicate Logic, a quantifier is always prefixed to some formula ϕ, as in $\exists\mathtt{x}\phi$ and $\forall\mathtt{x}\phi$, and this formula ϕ is the scope of the quantifier. So we can define the idea of quantifier scope in a syntactic way.

At the same time, quantifier scope is a semantic concept as well. Roughly, it is the part of the formula for which the meaning of the quantifier matters. In particular, it matters when the scope of one quantifier contains another quantifier. In the above example formula, the scope of the quantifier $\exists\mathtt{x}$ includes the other quantifier $\forall\mathtt{y}$, i.e., the latter occurs in the scope of the former, but not vice versa. There are several conventional ways of describing this state of affairs that are used often in linguistics. You might encounter them, so I'll list representative ones below. They all mean the same thing.

- $\exists\mathtt{x}$ takes scope over $\forall\mathtt{y}$.
- $\forall\mathtt{y}$ takes scope under $\exists\mathtt{x}$.
- $\forall\mathtt{y}$ is in the scope of $\exists\mathtt{x}$.
- $\exists\mathtt{x}$ takes wide scope with respect to $\forall\mathtt{y}$.
- $\forall\mathtt{y}$ takes narrow scope with respect to $\exists\mathtt{x}$.
- The scope of $\exists\mathtt{x}$ is wider than the scope of $\forall\mathtt{y}$.
- The scope of $\forall\mathtt{y}$ is narrow than the scope of $\exists\mathtt{x}$.

In the case of natural language, the scope of a quantifier cannot always be determined from the surface form. We saw some examples that exhibit quantifier scope ambiguity, and they demonstrate that the relative scopal relation between quantifiers is not uniquely determined by the pronounced form of the sentence, unlike in Predicate Logic.

Notice the similarity between LF representations and Predicate Logic formulas. In an LF representation, the quantificational DPs are prefixed to sentences due to QR, just like quantifiers in Predicate Logic formulas, and in their original places where the quantifiers are pronounced, you see traces, which are like variables in Predicate Logic. These variables determines which argument positions of which predicates the quantifier operates on. In natural language, quantificational DPs are pronounced in places where variables would appear in Predicate Logic, but as a consequence, their scope is not overtly indicated in the pronounced structure, and it is only determined via a covert syntactic operation of QR.

6 Constraints on quantifier scope

In what follows we will see some data illustrating the fact that quantifier scope in natural language is somehow systematically constrained. However, I have to say that we do not have a very good theory of these constraints on quantifier scope.

If we assume that **Quantifier Raising (QR)** determines quantifier scope, we can understand some of the constraints as syntactic constraints on QR, but it is unclear if this idea is on the right track.

6.1 Some locality constraints on overt *wh*-movement

(36) *Complex NP Island*

*Which novel did somebody meet a man [that has read *t*]?

(37) *Coordinate Structure Island*

*Which novel did somebody [read *t* and watched TV] before going to bed?

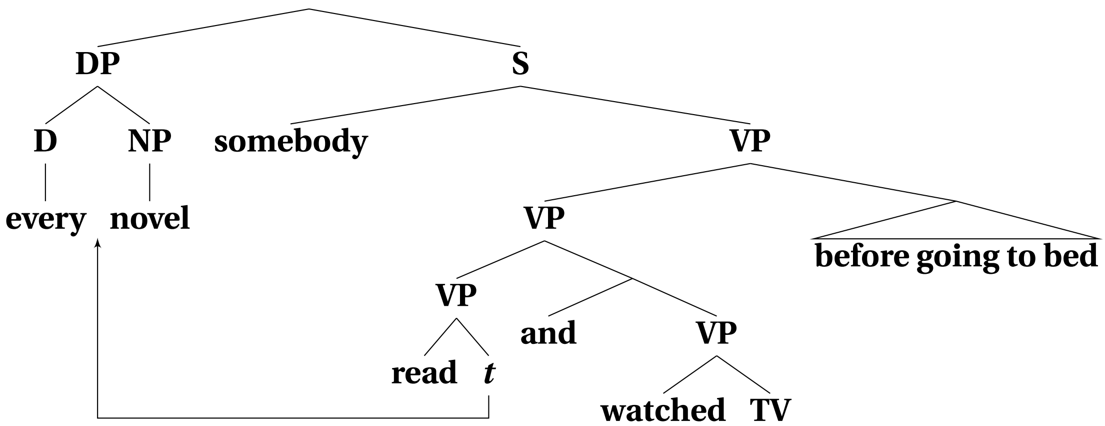
6.2 Parallel constraints on QR

(38) *Complex NP Island*

Somebody met a man that has read every novel.

(39) *Coordinate Structure Island*

Somebody [read every novel and watched TV] before going to bed.



But constraints on quantifier scope cannot be reduced to general constraints on all movements.

6.3 Clause boundedness

Finite-clauses are not islands for *wh*-movement.

(40) a. Which novel did somebody say that John wrote *t*?
b. Which novel did you think that somebody said that John wrote *t*?
c. Which novel did Bill claim that you thought that somebody said that John wrote *t*?

Unlike *wh*-movement, quantifier scope is generally bounded by finite clauses.

(41) Somebody said that John wrote every novel.

Some exceptions:

(42) a. I demanded that you read not a single book. (Fox 2003: p. 85)
b. Determine whether each number in the list is even or odd. (Szabolcsi 2010: p. 107)
c. Someone is always willing to believe that every politician is corrupt. (Reinhart 1997: p. 349)
d. Every child who was born to every famous woman became famous too. (Winter 1997: p. 417)
e. A delegate who was elected from each district was disqualified. (Winter 1997: p. 417)
f. Somebody said that he could jump over every frog that Jessie did. (Syrett 2015: p. 585)

6.4 Scope freezing

Tthe direct object in a double object construction can *wh*-move, but the corresponding quantification sentence lacks an inverse scope reading (R. K. Larson 1988, R. Larson 1990, Bruening 2001).

(43) a. Which doll did you give a child t?
b. You gave a child each doll.

Compare:

(44) a. You gave each doll to a child.
b. You gave a doll to each child.

Inverse scope with respect to the subject is possible.

(45) A teacher gave me every book.

6.5 Nested DPs

(46) *Subject Island Constraint*
*Which city does somebody from t despise London?

The inverse scope reading is possible in this configuration.

(47) Someone from every city despises London.

6.6 Semantic restrictions on quantifier scope

Generally, negative quantifiers like ‘no NP’ and ‘few NP’ do not show scope ambiguity.

(48) a. A boy climbed every tree.
 b. A boy climbed many trees.

(49) a. A boy climbed no tree.
 b. A boy climbed few trees.

The inverse scope readings of (49) would be the following:

(50) a. For no tree, is there a boy who climbed it. (or in other words, no boys climbed any tree)
 b. For few trees, is there a boy who climbed it.

Similarly, compare:

(51) a. One boy watched every French movie.
 b. Most of the boys watched every French movie.

(52) a. No boy watched every French movie.
 b. Few of the boys watched every French movie.

7 Indefinites and exceptional wide scope

Indefinites are quantificational DPs like ‘a NP’, ‘some NP’, ‘two NP’, etc. The above constraints don’t apply to indefinites.

7.1 Finite clauses

(53) a. Every student had to buy a book that a linguist at Harvard wrote.
 b. If some relative of John’s dies, he’ll inherit a fortune.

These sentences have the following inverse scope readings:

(54) a. There is a linguist at Harvard such that every student had to buy a book he she wrote.
 b. There is some relative of John’s such that if he or she dies, he’ll inherit a fortune.

Such interpretations are not possible with other types of quantificational DPs:

(55) a. Every student had to buy a book that every professor at UCL wrote.
 b. If every relative of John’s dies, he’ll inherit a fortune.

These cannot mean:

(56) a. Every professor at UCL is such that every student had to buy a book he/she wrote.
b. Every relative of John's is such that if he or she dies, he'll inherit a fortune.

Wh-movement is impossible from these positions:

(57) a. *Which professor at UCL did every student have to buy a book that t wrote?
b. *Which relative of John's will he inherit a fortune, if t dies?

7.2 Scope freezing

Similarly, indefinites are exempt from the scope freezing effects of the double object construction.

(58) I decided to assign every student a book about λ-calculus.

7.3 Semantic constraints

Finally, indefinites can take scope over negative quantifiers.

(59) a. No boy climbed a tall tree.
b. Few boys watched a French movie.

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