Determiners and Quantifiers
Type Shifting and Flexible Types
QDPs in Object Position
Quantier Raising
On Variables

ESSLLI Summerschool 2014: Intro to Compositional Semantics

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Fourth Lecture: Determiners and Quantifiers

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(1) a. Every student snored
    b. A woman snored
    c. No fly snored

every, a, no (and sometimes also *the*) are called quantifying determiners. The subject phrases are QDPs (quantifying determiner phrases).

(2) What are the truth conditions for (1)?

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(2) What are the truth conditions for (1)?
a. $[\![\text{every} + \text{NP} + \text{Predicate}]\!]_s = 1$ iff $[\![\text{NP}]\!]_s \subseteq [\![\text{Predicate}]\!]_s$
b. $[\![\text{a} + \text{NP} + \text{Predicate}]\!]_s = 1$ iff $[\![\text{NP}]\!]_s \cap [\![\text{Predicate}]\!]_s \neq \emptyset$
c. $[\![\text{no} + \text{NP} + \text{Predicate}]\!]_s = 1$ iff $[\![\text{NP}]\!]_s \cap [\![\text{Predicate}]\!]_s = \emptyset$

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(3) From (2) we may construe quantifiers as 2-place relations:
a. $[\![\text{every}]\!]_s := \{ \langle X, Y \rangle : X \subseteq Y \}$
b. $[\![\text{a}]\!]_s := \{ \langle X, Y \rangle : X \cap Y \neq \emptyset \}$
c. $[\![\text{no}]\!]_s := \{ \langle X, Y \rangle : X \cap Y = \emptyset \}$

X and Y stand for sets of individuals. X is called the restriction of the quantifier, Y is called its scope. By convention, the restriction in (3) precedes the scope!

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(4) a. $\langle [\![\text{student}]\!]_S, [\![\text{snore}]\!]_S \rangle \in [\![\text{every}]\!]_S$

b. $\langle [\![\text{woman}]\!]_S, [\![\text{snore}]\!]_S \rangle \in [\![\text{a}]\!]_S$

c. $\langle [\![\text{fly}]\!]_S, [\![\text{snore}]\!]_S \rangle \in [\![\text{no}]\!]_S$

The problem of compositionality:

(5) [[every student] snores]

(6) a. $[\![\text{every} + \text{NP}]\!]_S = \{ X : \langle [\![\text{NP}]\!]_S, X \rangle \in [\![\text{every}]\!]_S \}$

b. $[\![\text{a} + \text{NP}]\!]_S = \{ X : \langle [\![\text{NP}]\!]_S, X \rangle \in [\![a]\!]_S \}$

c. $[\![\text{no} + \text{NP}]\!]_S = \{ X : \langle [\![\text{NP}]\!]_S, X \rangle \in [\![\text{no}]\!]_S \}$

We thus have to plug in the NP at the first position of the quantifier.

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(7) General scheme:

$$[\![\text{QDet} + \text{NP}]\!]_s = [\![\text{QDet}]\!] \overleftarrow{*} [\![\text{NP}]\!]_s = \{ X : \langle [\![\text{NP}]\!]_s, X \rangle \in [\![\text{QDet}]\!] \}$$

(8) a. $[\![\text{every} + \text{NP}]\!]_s = \{ X : [\![\text{NP}]\!]_s \subseteq X \}$

b. $[\![\text{a} + \text{NP}]\!]_s = \{ X : [\![\text{NP}]\!]_s \cap X \neq \emptyset \}$

c. $[\![\text{no} + \text{NP}]\!]_s = \{ X : [\![\text{NP}]\!]_s \cap X = \emptyset \}$

(9) $[\![\text{QDP} + \text{Predicate}]\!]_s = 1$ iff
$[\![\text{Predicate}]\!]_s \in [\![\text{QDP}]\!]_s$ iff
$[\![QDP]\!]_s * [\![\text{Predicate}]\!]_s = 1$

(10) $[\![\text{no fly snored}]\!]_s = 1$ iff
$[\![\text{snored}]\!]_s \in [\![\text{no fly}]\!]_s$ iff
$[\![\text{snored}]\!]_s \in ([\![\text{no}]\!]_s \overleftarrow{*} [\![\text{fly}]\!])$ iff
$\{ x : x \text{ snored in } s \} \in (\{ x : x \text{ is a fly in } s \} \overleftarrow{*} \{ \langle X, Y \rangle : X \cap Y = \emptyset \})$ iff
$\{ x : x \text{ snored in } s \} \in \{ Y : \{ x : x \text{ is a fly in } s \} \cap Y = \emptyset \}$ iff
$\{ x : x \text{ is a fly in } s \} \cap \{ x : x \text{ snored in } s \} = \emptyset$

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Note that for subject + predicate we actually have two cases:

(11) a. $[\![$referential argument expression + predicate$]\!]_s = 1$ iff
$[\![$referential argument$]\!]_s * [\![$predicate$]\!]_s = 1$ iff
$[\![$referential argument$]\!]_s \in [\![$predicate$]\!]_s$

b. $[\![$QDP + predicate$]\!]_s = 1$ iff
$[\![$QDP$]\!]_s * [\![$predicate$]\!]_s = 1$ iff
$[\![$QDP$]\!]_s \ni [\![$predicate$]\!]_s$

This is because our notation $\alpha * \beta$ actually allows for two interpretations:

a. $\alpha = y$ (a refential expression), $\beta = R$ (a predicate), so that
$\alpha * \beta = y * R = 1$ iff $\alpha \in \beta$ (cf. (11-a)), or

b. $\alpha = R$ (a quantifying expression) and $\beta = y$ a predicate, so that
$\alpha * \beta = R * y = 1$ iff $\beta \in \alpha$ (cf. (11-b)).

The correct interpretation depends on the “logical types” of α and β. This kind of semantics is also called type driven interpretation.

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In more classical approaches, however, this flexibility is not allowed. In particular, the logical types of the corresponding components of semantic rules are fixed. In particular, there is no such convention that $R * y = y * R$. We would therefore need two rules:

(12) a. $[\![\text{term + predicate}]\!]_s = 1$ iff $[\![\text{term}]\!]_s \in [\![\text{predicate}]\!]_s$
b. $[\![\text{QDP + predicate}]\!]_s = 1$ iff $[\![\text{predicate}]\!]_s \in [\![\text{QDP}]\!]_s$

However, some more restrictive theories require a one-to-one-correspondance between syntactic and semantic rules, and moreover one between syntactic categories and semantic types. In such a theory, the semantic difference between term and QDP in (12) must be ignorable.

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In these approaches, it is assumed that all subjects, even terms, are sets of sets (have the logical type of quantifying DPs):

(13) $[\![\text{subject + predicate}]\!]_s = 1 \text{ iff } [\![\text{predicate}]\!]_s \in [\![\text{subject}]\!]_s$

For referential expressions, a rule called type shifiting or Montague Lifting converts a referential expression into a set of sets:

(14) $\text{LIFT(a)} = \{X : \text{a} \in X\}$

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Accordingly,

(15) $[\![\text{John snores}]\!]_s = 1$ iff
$[\![\text{snores}]\!]_s \in [\![\text{John}]\!]_s$ iff
$[\![\text{snores}]\!]_s \in \text{LIFT}(\text{John})$ iff
$[\![\text{snores}]\!]_s \in \{X : \text{John} \in X\}$ iff
$\text{John} \in [\![\text{snores}]\!]_s$

Or alternatively,

(16) $[\![\text{John snores}]\!]_s = 1$ iff
$[\![\text{snores}]\!]_s \in \left[\!\!\left[\text{John}^{DP}\right]\!\!\right]_s$ iff
$[\![\text{snores}]\!]_s \in \text{LIFT}([\![\text{John}]\!]_s)$ iff
$[\![\text{snores}]\!]_s \in \{X : [\![\text{John}]\!]_s \in X\}$ iff
$[\![\text{John}]\!]_s \in [\![\text{snores}]\!]_s$

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(17) Paul loves every girl

The problem: a simple rule like argument reduction is not applicable!

First solution: *In situ* interpretation

(18) Let R be an n-place relation and $\mathcal{Q}$ a set of sets.
$R \overrightarrow{*_Q} \mathcal{Q} = \mathcal{Q} \overrightarrow{*_Q} R = \{ \langle x_1, \ldots x_{n-1} \rangle : \{ y : \langle x_1, \ldots\ x_{n-1}, y \rangle \in R \} \in \mathcal{Q} \}$

(19) $\left[\!\left[\text{loves } \boxed{\text{every girl}} \right]\!\right]_S = [\![\text{loves}]\!]_S \overrightarrow{*_Q} [\![\text{every girl}]\!]_S =$
$[\![\text{loves}]\!]_S \overrightarrow{*_Q} \{ X : [\![\text{girl}]\!]_S \subseteq X \} = 1$ iff
$\{ x_1 : \{ y : \langle x_1, y \rangle \in [\![\text{loves}]\!]_S \} \in \{ X : [\![\text{girl}]\!]_S \subseteq X \} \}$ iff
$\{ x_1 : [\![girl]\!]_S \subseteq \{ y : \langle x_1, y \rangle \in [\![\text{loves}]\!]_S \} \}$

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(20) $\left[\!\left[\boxed{\text{John} \boxed{\text{loves} \boxed{\text{every girl}}}} \right]\!\right]_s$ = 1 iff

$j \in \{ x_1 : [\![\text{girl}]\!]_s \subseteq \{ y : \langle x_1, y \rangle \in [\![\text{loves}]\!]_s \} \}$ iff

$[\![girl]\!]_s \subseteq \{ y : \langle j, y \rangle \in [\![\text{loves}]\!]_s \}$

Note: The rule that applies $\overrightarrow{*_Q}$ also covers the case of quantified subjects.

More generally, we can dispense with the simple rule for terms in favor or the more complicated one for QDPs.

Quantifier Raising

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(21) $\left[\!\!\left[\text{A carpet } \boxed{\text{touches } \boxed{\text{every wall}}}\right]\!\!\right]_s = 1$ iff

$[\![\text{a carpet}]\!]_s *_Q [[\![\text{touches}]\!]_s \overrightarrow{*_Q} [\![\text{every wall}]\!]_s] = 1$ iff

$[\![\text{a carpet}]\!]_s \ni [[\![\text{touches}]\!]_s \overrightarrow{*_Q} [\![\text{every wall}]\!]_s]$

This derives the reading with *every wall* in the scope of *a carpet*. To get the reverse reading, we apply QR:

(22) $\boxed{\text{every wall}}_x \ \boxed{\text{a carpet touches } \mathrm{t}_x}$

Now we have to interpret (22) as "the set of walls is a subset of the set of x being touched by a carpet." More generally:

(23) $\mathcal{Q} \ni \{\, x : x \text{ is touched by a carpet} \,\}$ iff

$\mathcal{Q} * \{\, x : x \text{ is touched by a carpet} \,\} = 1$ iff

$\mathcal{Q} * \{\, x : \text{a carpet touches } x \,\} = 1$ iff

$\mathcal{Q} * \{\, x : [\![\text{a carpet touches } x]\!]_s = 1 \,\} = 1$

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General rule:

(24) $$[\![\, \boxed{\boxed{\text{DP}}_x \boxed{\ldots \text{t}_x \ldots}} \,]\!]_s = [\![\text{DP}]\!]_s * \{\, x : [\![\ldots t_x \ldots]\!]_s = 1 \,\}$$

Assumptions:

- $[\![t_x]\!]_s = x$;
- t_x is a referential expression, x is a term.
- the second box is a clause (a sentence, a CP, anything the extension of which is a truth value)

Note: if we want to generalize to QDPs, $[\![t_x]\!]_s = \{\, Y : x \in Y \,\}$

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Recall that QDPs in object position cannot be interpreted by $\vec{*}$. A second way to resolve the problem is the application of QR:

(25) $[\text{John}\ [\text{loves}\ [\text{every girl}]]] \rightsquigarrow$

$[[\text{every girl}]_x\ [\text{John}\ [\text{loves t}_x]]]$

(26) $\left[\!\left[[[\text{every girl}]_x\ [\text{John}\ [\text{loves t}_x]]] \right]\!\right]_s =$

$[\![\text{every girl}]\!]_s * \{\, x : [\![\text{John}]\!]_s * [[\![\text{loves}]\!]_s \,\vec{*}\, [\![t_x]\!]_s]$

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Notes on the use of variables:

Variables are essential for multiple applications of QR. They relate the QDP to the argumentent position of the verb.

(27) A man bought a present for every child

Assume we want a reading with *every child* having wide scope with respect to a present, and *a man* having wide scope with respect to *every child*.

(28) [[a man]$_x$ [[every child]$_y$ [[a present]$_z$ [x bought z for y]]]]

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A note on so-called bound variable pronouns (BVPs):

(29) every man loves his mother
(≠ every man loves every man's mother

(30) LF: [[every man]$_x$ [t$_x$ loves [his$_x$ mother]]]

Assume his$_x$ = he$_x$'s and $[\![\text{he}_x]\!]_s = x$

(31)
$$[\![\text{every man}]\!]_s * \{\, x : [\![x \text{ loves he}_x\text{'s mother}]\!]_s = 1 \,\} =$$
$$[\![\text{every man}]\!]_s * \{\, x : x \in [\![\text{loves}]\!]_s \overrightarrow{*} [\![\text{he}_x\text{'s mother}]\!]_s \,\} =$$
$$[\![\text{every man}]\!]_s * \{\, x : x \in [\![\text{loves}]\!]_s \overrightarrow{*} [\![\text{mother}]\!]_s([\![he_x]\!]_s) \,\} =$$
$$[\![\text{every man}]\!]_s * \{\, x : x \in [\![\text{loves}]\!]_s \overrightarrow{*} [\![\text{mother}]\!]_s(x) \,\}$$

In this framework, BVPs can be interpreted as bound by a QDP only if the QDP is QRed. The reason is that only after quantifier raising, the quantifying expression gets attached a variable, parallel to expressions like $(\forall x)$ or $(\exists x)$ in Predicate Logic.

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Another cautionary note:

The interpretation of QR uses the operation of set building or comprehension by forming the set $\{ x : [\![\dots t_x \dots]\!]_s = 1 \}$. We also assumed that $[\![t_x]\!]_s = x$. But x is strictly speaking not a denotation or reference, but an element of the language we use to describe denotations. This is a serious flaw which can be overcome by using various method, the most popular being the use of assignment functions for variables, ie. functions that assign values to x.

It would then follow, that $[\![t_x]\!]_s = g(x)$, where g is such a function. But then all interpretations must depend not only on s, but on g. Unfortunately, there is still a problem for compositionality. The reason is that set formation cannot depend on a variable assignment $g(x)$ that determines a denotation but must consider all such functions h with potentially different values than g. This is again a problem because then the semantics cannot depent on things, sitations and truth values alone, but also on such functions (ie. such functions are part of the ontology).

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This problem is addressed but not completely solved in Chapter 10 of our book.

In fact, there is no straightforward and fully satisfying solution to the problem of compositionality. . .