3.5 Generalized Quantifiers in DRT

3.5.1 A Simple Extension to Non-Universal Quantifiers

The rules for DRS construction and interpretation we have considered so far just cover one logical type of quantifier, namely the universal quantifier. But we also want to be able to treat sentences with other quantifiers, like the following ones:

(23) a. Most farmers who own a donkey like it.

b. Many farmers who own a donkey like it.

c. Few farmers who own a donkey like it.

d. No farmer who owns a donkey likes it.

(24) a. Most of the time, if a farmer owns a donkey, he likes it.

a'. If a farmer owns a donkey, he usually likes it.

b. If a farmer owns a donkey, he often likes it.

c. If a farmer owns a donkey, he rarely likes it.

d. If a farmer owns a donkey, he never likes it.

Obviously we cannot represent these quantifiers with just one symbol “ ”. So let us represent them in the following format, illustrated for (a) (Kamp & Reyle have the symbol MOST in a diamond):

(25)

[u v farmer(u) donkey(v) [u owns v]]	MOST	[[u likes v]]

In general, we will represent quantified sentences by a symbol Q that stands for a particular quantificational force. For example, *most* and *usually* will be represented by MOST, *many* and *often* by MANY, *few* and *rarely* by FEW, and *no* and *never* by NO.

With a complex condition K Q K′, we have that K′ is subordinate to K, and that K and K′ are subordinate to the DRS in which they are contained.

How should we interpret DRSs with a quantifier symbol Q? We can make use of the central insight of Generalized Quantifier theory, according to which a quantifier is a relation between two sets. For example:

(26) *Every boy slept*: EVERY(⟦boy⟧)(⟦slept⟧) where EVERY(X)(Y) iff X Y.

(27) *Most boys slept*: MOST(⟦boy⟧)(⟦slept⟧), where MOST(X)(Y) iff [#(X ∩ Y) > #(X — Y)],

In DRT, quantifiers should express relations between sets of embeddings. The interpretation rule refers to the quantifier Q, stated informally, is as follows:

(28) Def: A function g verifies a condition K Q K′ in M iff
Q extensions g′ of g, where Dom(g) = Dom(g) U(K), that verify K in M
can be extended to g″, where Dom(g′) = Dom(g′) U(K′), that verify K′ in M.

For example, g verifies the condition (25) iff

- MOST extensions g′ of g, where Dom(g) = Dom(g)   {u, v}, that verify “farmer(u)”, “donkey(v)”, “[u has v]”
  can be extended to g″ (where in this case g″ = g′) such that g″ verifies “[u likes v]”

More formally, taking Q to be a generalized quantifier (a relation between two sets):

(29) Def: A function g verifies a condition K Q K′ iff
Q({g′ | g   g′ and Dom(g′) = Dom(g)   U(K) and g′ verifies K in M})
({g| h[g   h and Dom(h) = Dom(g)   U(K)   U(K′) and h verifies K′ in M})

3.5.2 Asymmetric Quantification

The interpretation rule (29) seems to be a straightforward extension of the rule for universal quantifiers. However,there is a problem with cases like the following one:

Assume a model M with 10 farmers (f1...f10) that own donkeys. One of them owns 100 donkeys (d1..d100) and likes all of them. The other farmers own one donkey each (d101...d109) and don’t like them. Are the following sentences true?

(30) a. Most farmers that own a donkey like it.

b. If a farmer owns a donkey, he usually likes it.

Clearly, (a) is false in such a situation. Things are perhaps less obvious with (b), but you probably would consider it as false, too.

However,the DRS interpretation rule says that they are true:

Assume that (25) is the only condition of a DRS. According to our definition, it is true in M iff there is a function (here, the empty function) g that verifies (25). In turn, the empty function g verifies (25) in M iff most g with Dom(g) = {u, v} that verify the antecedent DRS verify the consequent DRS.

We have the following situation:

Functions verifying antecedent DRS:	Verifies the consequent DRS?	
{ u, f1 , v, d1 }	yes	
{ u, f1 , v, d2 }	yes	
{ u, f1 , v, d3 }	yes	100 cases
…..	…	
{ u, f1 , v, d100 }	yes	
{ u, f2 , v, d101 }	no	
{ u, f3 , v, d102 }	no	9 cases
…	…	
{ u, f10 , v, d109 }	no	

There are 109 distinct functions g that verify the antecedent DRS, of which the vast majority, 100, also verify the consequent DRS. Hence the condition is verified in M, contrary to our intuition.

This problem, which was pointed out by Kadmon (1987), is known as the **proportion problem**. The heart of the problem is that we treated the discourse referent for the farmer and the one for the donkey on the same level (we effectively quantified over farmer/donkey pairs). That is, we treated this example as a case of **symmetric quantification**. However,there is a clear asymmetry in the roles of the two discourse referents: What counts for quantification (at least in a case like 32.a) is the farmer discourse referent, not the donkey discourse referent. This shows that in those cases we don’t have truly “unselective quantifiers”, as claimed by Lewis (1975).

Let us therefore introduce a notation that highlights one variable, e.g. " MOST(u)", as the one relevant for counting cases. The DRS construction rule for nominal quantifiers must identify the discourse referent of its head noun and create conditions like the following one:

(31)

u v farmer(u) donkey(v) [u owns v]	MOST(u)	[u likes v]

Such conditions are called **duplexconditions**

The truth conditions must respect this choice of a special discourse referent. One proposal (cf. Kamp & Reyle p. 317:)

(32) Def: A function g verifies a condition "K_1 Q(d) K_2" in M iff
Q({a | g′[g g′ & Dom(g′) = Dom(g) U(K_1) & g′(d) = a & g′ verifies K_1 in M]})
({a| g′[g g′ & Dom(g′) = Dom(g) U(K_1) & g′(d) = a & g′ verifies K_1 in M &
g″[g′ g″ & Dom(g″) = Dom(g′) U(K_2) & g″ verifies K_2 in M]]})

This definition gives us what we want:

a) We still quantify over all the discourse referents in the antecedent box. In particular, indefinites within the antecedent will get quantified over.

b) But what counts when it comes to determining whether a particular quantificational relation obtains is the number of objects (a) the designated discourse referent (d) refers to.

We may allow quantification over more than one discourse referent by allowing duplex conditions like K_1 Q(d_1, ...d_n) K_2 and the following interpretation:

(33) Def: A function g verifies a condition "K_1 Q(d_1,…d_n) K_2" in M iff
Q({ a_1,…a_n | g′[g g′ & Dom(g′) = Dom(g) U(K_1)
& g′(d_1) = a_1 & … g′(d_n) = a_n & g′ verifies K_1 in M]})
({ a_1,…a_n | g′[g g′ & Dom(g′) = Dom(g) U(K_1) &
& g′(d_1) = a_1 & … g′(d_n) = a_n & g′ verifies K_1 in M &
g″[g′ g″ & Dom(g″) = Dom(g′) U(K_2) & g″ verifies K_2 in M]]})

The example introduced above is treated as follows. Clearly, the sentence will come out as false.

Individuals in restrictor set:	Also in matrix set?	
f1 (because of d1 or d2 or ... d100)	yes	1 case
f2 (because of d101)	no	9 cases
f3 (because of d102)	no	
…	…	
f10 (because of d109)	no	

It seems clear that we have asymmetric quantification in cases of nominal quantifiers (the discourse referent associated with the head noun is "the boss", in Kadmon's terms). But what about conditional sentences? The phenomena we have to deal with are much more complex:

For example, sentence accent seems to play a role:

(34) a. If a painter lives in a VILLAGE, it is usually nice.
(= most painters that live in a village live in a nice one)

b. If a PAINTER lives in a village, it is usually nice.
(= most villages in which there lives a painter are nice)

In (34.a) we get the so-called **subject-asymmetric reading**, and in (b) the **object-asymmetric reading**.

It seems that there are true **symmetric** readings:

(35) If a woman has a child with a man, she usually keeps in touch with him.

It seems that for a sentence like (35) each woman-man pair such that the woman has a child with the man has to be counted separately.

1. Weak and Strong Interpretations

Another problem that appears with the usual modeling of quantification in DRT can be illustrated with the following examples:

(36) a. Every farmer who owns a donkey beats it.

b. If a farmer owns a donkey, he beats it.

Assume a model M with five farmers that own donkeys:

f1 owns d1a, d1b, beats d1a, d1b,
f2 owns d2a, d2b, beats d2a, d2b,
f3 owns d3, beats d3,
f4 owns d4a, d4b, d4c, d4d, beats d4a,
f5 owns d5a, d5b, beats d5b.

That is, every farmer that owns donkeys beats at least some but perhaps not all of the donkeys that he owns. Are sentences (36.a,b) intuitively true? Most people say no. Which prediction does DRT make? Let’s check. The example will yield one of the following DRS conditions:

(37) Classical DRT: DRT with generalized quantifiers:

u v farmer(u) donkey(v) [u owns v]	[u likes v]	u v farmer(u) donkey(v) [u owns v]	EVERY(u)	[u likes v]

Assume for simplicity that there is no previous discourse, that is, the DRSs given above are the only conditions. Then we have:

- Classical DRT: The DRS is verified by the empty function in M iff
  every function g: {u, v}→ A such that g(u) is a farmer, g(v) is a donkey, and g(u) owns g(v) is such that it also holds that g(u) beats g(v).

Clearly, this is false in M. Take e.g. g(u) = f2 and g(v) = d2c; it holds that g(u) owns g(v), but it is not the case that g(u) beats g(v).

- DRT with Generalized Quantifiers: The DRS is verified iff the following holds:

  EVERY({a| g[g:{u, v}→ A g(u) = a & g(u) F(farmer) & g(v) F(donkey)
  & g(u), g(v) F(own)]},
  {a| h[h: {u, v}→ A, where h(u) = a & h(u) F(farmer) & h(v) F(donkey)
  & g(u), g(v) F(own) & g(u), g(v) F(beat)]})

  where EVERY(A)(B) iff A B.

Now, this turns out to be true in M! Reason:

For a = f1, we have e.g. g(u) = f1, g(v) = d1a, and g = h,
for a = f2, we have e.g. g(u) = f2, g(v) = d2a, and g = h,
for a = f3, we have e.g. g(u) = f3, g(v) = d3, and g = h,
for a = f4, we have e.g. g(u) = f4, g(v) = d4a, and g = h,
for a = f5, we have e.g. g(u) = f5, g(v) = d5a, and g = h.

- That is, for every farmer that has a donkey there is some donkey or other that he beats.
- In order to get the same interpretation as in classical DRT we have to modify the interpretation rule for duplex conditions in the following way. We call this the **strong** interpretation and contrast it with the weak interpretation given in (32).

(38) Def: Strong interpretation of duplex condition.

A function g strongly verifies a condition "K_1 Q(d) K_2" in M iff
Q({a | g′[g g′ & Dom(g′) = Dom(g) U(K_1) & g′(d) = a & g′ verifies K_1 in M]})
({a| g′[g g′ & Dom(g′) = Dom(g) U(K_1) & g′(d) = a & g′ verifies K_1 in M ⇒
g″[g′ g″ & Dom(g″) = Dom(g′) U(K_2) & g″ verifies K_2 in M]]})

Note that the definition contains in the second argument of Q a universal quantifier. For our example this means that every farmer a that owns a donkey must be such that a beats every donkey that he owns. But this is not the case in our model; the farmers f2, f4, f5 are counterexamples.

We have seen that we can change the "weak" interpretation of duplex conditions (32) to the "strong" interpretation (38). A different (and much more difficult) question is which interpretation we actually find in natural language. Examples like (36) seem to favor the strong interpretation. But other examples clearly favor the weak interpretation:

(39) a. Every person who had a dime put it into the parking meter. (Schubert & Pelletier 1988)

b. Every customer who had a credit card paid with it. (Heim)

c. No farmer who had a donkey beat it.

Examples (a, b) show that the meaning of the VP may matter. For example, (a) can be true even though the persons did not put all the dimes they possessed into the parking meter. Example © shows that the quantifier itself has some influence. In the strong interpretation, the DRS of © would be true if no farmer beats all of his donkeys. But © is true iff no farmer beats any of his donkeys.

Further reading:

Youngeun Yoon, "Total and partial predicates and the weak and strong interpretation", *Natural Language Semantics* 4 (1996), based on a UT dissertation.

Chris Barker, "Presuppositions for proportional quantifiers", *Natural Language Semantics* 4 (1996)

Bart Geurts, "Donkey business", to appear in *Linguistics and Philosophy*.

Manfred Krifka, "Pragmatic Strengthening in Plural Predications and Donkey Sentences". *Semantics and Linguistic Theory* VI, 1996.

Exercises:

1. Specify a DRS construction rule for reflexive pronouns, in the format we have used so far, and show how it works with the example *Pedro shaves himself* (that is, show how it leads to a proper DRS, together with other rules that we have established already).

2. The rule CR.ID for indefinite NPs was stated in a way that caused the introduction of a discourse referent in the local DRS in which the indefinite NP occurred. Consider the following sentences with indefinite NPs marked by the determiner *a certain*:

   a. *Every student to whom every professor recommends a certain book that is currently on the top of the New York Times bestseller list is lucky.*

   b. *Every student to whom every professor recommends a certain book which the student has already read is lucky.*

   c. *Every student to whom every professor recommends a certain book that the professor likes is lucky.*

   Tasks:
   (i) Give the most plausible DRS for each of the sentences (a), (b) and (c).
   (ii) Which readings are not compatible with our current analysis of indefinite NPs like *a (certain) book*, and why?
   (iii) Can you give a modified rule CR.ID' that does account for the possibilities we find in sentences (a) - (c)?

3. Take the DRS that we constructed for the sentence

   Most of the time, if a farmer owns a donkey, he likes it.

   in section (3.5.1) and evaluate it with respect to the following model:
   M= A, F, with A = {p, j, m, c, a, d1, d2, d3, d4, d5, d6, d7, d8, d9},
   F(*farmer*) = {p, j, m, c, a}, F(*donkey*) = {d1, d2, d3, d4, d5, d6, d7, d8, d9},
   F(*own*) = { p, d1 , p, d2 , p, d3 , p, d4 , j, d5 , j, d6 , m, d7 , c, d8 , a, d9 }
   F(*like*) = { p, d1 , p, d2 , p, d3 , p, d4 , j, d5 }

4. Construct a DRS for the above sentence in its subject-asymmetric reading and evaluate it with respect to the model above, using rule(32).

5. Assume the following model M = U, F ,
   with U = {f1, f2, f3, f4, d1, d2, d3, d4, d5, d6},
   F(*farmer*) = {f1, f2, f3, f4}, F(*donkey*) = {d1, d2, d3, d4, d5, d6},
   F(*own*) = { f1, d1 , f2, d2 , f3, d3 , f4, d4 , f4, d5 , f4, d6 }
   F(*beat*) = { f2, d2 , f3, d3 , f4, d4 }.
   a) Construct a DRS for the sentence *Most farmers that own a donkey beat it.*
   (Of course you will have to construct a subject-asymmetric reading.)
   b) Derive its interpretation under the "weak" reading.
   b) Derive its interpretation under the "strong" reading (cf. (38)).