

APPENDIX to Lecture 7. Kamp-Heim II.

3. Kamp's Discourse Representation Theory

Here is an excerpt from (Partee 1984), “Nominal and temporal anaphora”: Section II, pp. 247-252. We will return to this article later; now I just want to use the part that gives an introduction to Kamp’s Discourse Representation Theory as it is described in (Kamp 1981), which is identical to (Kamp 1984), and I’m copying the pdf pages so that I don’t have to try to redraw the diagrams by hand.

III. DISCOURSE REPRESENTATIONS

In this section we sketch the key features of Kamp’s theory of discourse representations (Kamp, 1981a) as it applies to nominal anaphora. (A theory of anaphora which shares many properties with Kamp’s approach is developed in Heim (1982 and 1983); we are presenting Kamp’s version in part because it is more widely accessible and in part because Kamp and Hinrichs have made substantial progress in extending that framework to deal with temporal anaphora, but we believe that the same kind of account is in principle equally compatible with Heim’s framework.) The reader familiar with Kamp (1981a) can skip this section.

Kamp’s approach makes crucial use of an intermediate level of representation, ‘discourse representation structures’, mediating between syntax and model-theoretic interpretation. In rough terms, a discourse representation can be thought of in the simplest cases as a description of a partial model. A simple discourse representation counts as true with respect to a complete model if it is *embeddable* into the model; embeddability is a technical notion in Kamp’s system which plays a role somewhat analogous to satisfaction conditions in standard semantics for predicate logic. (I will not give the definition – see Kamp (1981a) – but I will illustrate it with examples shortly.) In more complex cases, the discourse representation structure consists of a structured set of discourse representations, and the embeddability conditions for the entire structure are recursively defined in terms of the embeddability of the substructures.

The fragment of English treated in Kamp (1981a), which is sufficient for our purposes in this section, includes simple sentences with transitive and intransitive verbs, proper nouns, third-person singular pronouns, and noun

phrases introduced by *a* and *every*, with and without relative clauses; it also includes *if*-*then* sentences.⁴ A discourse is simply a finite sequence of sentences. The simplest cases are those discourses in which none of the sentences contains an *if*-*then* or an *every*; as an example we give the discourse representation (DR) of the two-sentence discourse (3a), repeated here as (8):

(8) Pedro owns a donkey. He beats it.

The first sentence of (8) induces the following DR (Kamp, 1981a, p. 287):

DR(8)	u	v
	Pedro owns a donkey	
	$u = \text{Pedro}$	
	u owns a donkey	
	donkey (v)	
	u owns v	

The representation is constructed by processing the first sentence top-down in accordance with the syntax-driven construction rules. When the noun phrase 'Pedro' is processed, three things happen: the 'discourse entity' u is added to the DR, and the conditions $u = \text{Pedro}$ and u owns a donkey are introduced.⁵ The latter is further processable: the discourse entity v is introduced, and the conditions $\text{donkey} (v)$ and u owns v are added to the DR. In general, each occurrence of a proper name or an indefinite noun phrase will lead to the introduction of a new discourse entity in the DR; by contrast, pronouns must be interpreted as referring to discourse entities already contained in a DR. (The assimilation of deictic uses of pronouns to this treatment will be discussed at the end of this section.) The complete DR for (8) is then the following (Kamp, p. 287):

DR(8)	u	v
	Pedro owns a donkey	
	$u = \text{Pedro}$	
	u owns a donkey	
	donkey (v)	
	u owns v	
	He beats it	
	u beats it	
	u beats v	

(In fact, we could just as well omit from the final DR all those intermediate steps which are further processed within the same DR, but we will retain them to show the order of steps of DR-construction.)

The discourse (8) will be true in a model M with respect to DR(8) just in case there is a way of embedding DR(8) into M , i.e. a mapping of u and v onto individuals in M such that all of the conditions in DR(8) are satisfied. (This assumes that we already have a mapping of the proper names, common nouns, etc. into corresponding individuals, sets (or perhaps properties) and relations in M .)

Note that the existential quantifier in the embeddability condition ('there is a way of embedding ...') has the effect of giving the discourse entity v corresponding to a donkey an existentially quantified interpretation, but with scope extending over the whole discourse. Thus the truth conditions assigned to (8) in Kamp's system are the same as those for the first-order sentence (8'), or equivalently (8'').

$$(8) \quad (\exists u)(\exists v)(u = p \ \& \ \text{donkey}(v) \ \& \ \text{own}(p, v) \ \& \ \text{beat}(u, v)).$$

$$(8'') \quad (\exists v)(\text{donkey}(v) \ \& \ \text{own}(p, v) \ \& \ \text{beat}(p, v)).$$

The idea that indefinite noun phrases introduce what amount to free variables, which only get 'bound' in the passage from discourse representation structure to truth-conditions via embeddability, is part of what allows Kamp (and likewise Heim) to provide a unified treatment of pronouns with definite and indefinite antecedents. All pronouns are treated identically at the discourse representation level: any pronoun may be replaced at the appropriate construction step by any discourse entity accessible to it in the discourse representation.⁶ The relation of the 'discourse entities', such as u and v in DR(8), to actual entities in the model is not in general a simple correspondence, because of the implicit existential quantifier in the embeddability condition.⁷

Any discourse which consists of just such simple sentences, without conditional sentences or universal quantifiers, gives rise to a single discourse representation like that for (8), with each subsequent sentence leading to expansion of the information in the representation; new discourse entities are added with each new proper name or indefinite noun phrase, and a pronoun can be assigned to any suitable entity that has been introduced into the representation by the time that pronoun is processed.⁸ Universal quantifiers and conditional sentences give rise to more complex discourse representation structures with special embedding conditions which are relevant to (so-called) bound variable anaphora⁹ and the treatment of donkey-sentences. We illustrate this first with the conditional sentence (6a), repeated here as (9).

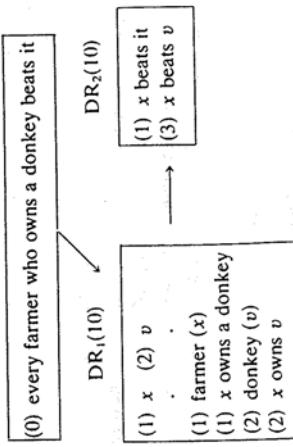
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In steps (4) and (5) we are able to assign the entities u and v to the pronouns because DR_2 is subordinate to both DR_1 and DR_0 . The embeddability condition for DRS's resulting from the *if-then* construction rule is roughly as follows (see Kamp (1981a) for full details of this and other rules): $DRS(9)$ is embeddable in M if there is a mapping which satisfies the atomic conditions in DR_0 (i.e. which assigns u to Pedro) such that every extension of it which satisfies DR_1 also satisfies (or can be extended to satisfy) DR_2 .

Before discussing the example further, let us introduce the final new rule of discourse representation construction, the rule for noun phrases introduced by *every*. When such a noun phrase is processed, two new DR's are introduced, with subordination structure exactly like that of conditional structures.¹¹ To the 'antecedent' are added a new discourse entity and conditions on it corresponding to the content of the common noun (and relative clause, if any). To the 'consequent' part is added a condition corresponding to the remainder of the sentence, with the new discourse entity in place of the original noun phrase. This is illustrated in the DRS for (6b), repeated here as (10), with parenthesized numbers again showing the order of construction.

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

$DRS(10)$:



The embeddability condition for *every*-constructions is the same as that for *if-then* sentences: every embedding that satisfies DR_1 must be extendable to an embedding that satisfies DR_2 . I will refer to such DRS configurations henceforth as universal/conditional structures.
Note that while the construction of DRS's is determined (up to the

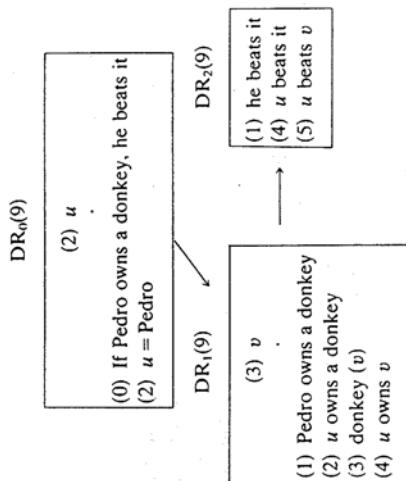
(9) If Pedro owns a donkey, he beats it.

The first step in constructing a discourse representation structure (DRS) for (9) is, as usual, to build a DR containing just the whole sentence:

$DR_0(9)$ If Pedro owns a donkey, he beats it

Since the *if-then* rule was the last rule applied in the construction of the sentence, the corresponding DRS construction rule is the first to be applied. That rule creates two additional DR's, $DR_1(9)$ and $DR_2(9)$, with $DR_1(9)$ containing the antecedent clause and $DR_2(9)$ the consequent, and with the stipulation¹⁰ that DR_1 is subordinate to DR_0 and DR_2 is subordinate to DR_1 . (The subordination relation that holds among DR's does not correspond directly to the syntactic notion of subordination; it does play a crucial role in determining the accessibility of discourse entities for pronoun assignment.) Each of the two DR's is then processed in the usual way, antecedent first, with the following proviso: when a discourse entity is introduced for a proper noun, it and its identity condition are placed in the top DR of the whole current DRS (making it available for assignment to any subsequently processed pronoun), but when an indefinite noun phrase is processed, the newly introduced entity is placed in the DR being processed (and therefore accessible to pronouns only in the same or subordinate DR's). The complete DRS for (9) is then as follows (from Kamp (1981a, p. 315); I have added arrows marking the subordination relation); numbers in parentheses indicate steps in the processing sequence.

$DRS(9)$:



choice of antecedents for pronouns) by the syntactic rules, syntactically similar sentences or discourses may receive quite different DRS's, particularly because of the difference between the rule for *every* and the rule for *a*. (Sentence conjunction with *and* could be treated much like concatenation of sentences, while *or* should probably lead to the introduction of multiple DR's.) Thus while donkey-sentences like (9) and (10) receive a natural interpretation in this system,¹² syntactically similar sentences with *every* in place of *a* fail, correctly, to get a reading in which the pronoun is linked to the *every*-phrase.

- (11) If Pedro owns every donkey, he beats it.
(12) A farmer who owns every donkey beats it.

In both (11) and (12), the pronoun *it* is in a DR which is not subordinate to the DR which contains the discourse entity introduced by the *every*-rule, and thus that entity is not available for assignment to the pronoun.

An instance of what has usually been viewed as an ordinary bound variable pronoun is that in (13), which is also handled naturally in Kamp's system (see Kamp (1981a), p. 299).

- (13) Every farmer courts a widow who admires him.

Thus we see that all of the types of uses of pronouns mentioned at the outset except the deictic use are treated uniformly in this system; deictic uses can be treated by the same pronoun rule as well if we add the hypothesis that the mechanisms that make entities in the non-linguistic context available for pronominal reference have the effect of adding corresponding discourse entities to DR's. We will assume there is such a mechanism.¹³

This unification of what otherwise appear to be very different pronoun uses is an important achievement in its own right. In the next sections we show that the system has the added advantage of being directly applicable to the treatment of tenses and adverbs in such a way that the parallels observed in the previous section fall out as direct consequences.

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