CONDITIONALS IN DR THEORY

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SECTION 1

1.

The beginning student of formal logic is taught to symbolize **if**, and various cognate expressions, by means of the material conditional of the classical propositional calculus. This practice has persisted in spite of a common awareness that it isn't right in general: English **if** has properties to which the material conditional cannot do justice.

The inadequacy of material implication becomes especially transparent in contexts where the English conditional occurs inside the scope of some other operator. A familiar example is that of the engine which will run if both the main switch and the auxiliary switch are on. Intuitively it seems quite plain that we cannot infer from this that either the engine will run if the main switch is on or the engine will run if the auxiliary switch is on. But if we symbolize the first statement as $(p \,\&\, q) \rightarrow r$, with $\rightarrow$ representing material implication, and the second, using the same principles, as $(p \rightarrow r) \vee (q \rightarrow r)$, then the inference seems licenced, as the second formula is a logical consequence of the first. (The trouble here has much to do with the circumstances that in the second formula $\rightarrow$ occurs within the scope of $\vee$.

For another illustration of the same general point consider the following little dialogue, which, we assume, occurs between Mr. and Mrs. des Tombes, who are planning their next soirée:

He: 'Should we invite ffrench?'

She: 'I am afraid that if we invite him he will snub us. But if I am wrong about that we defintely will invite him.'

The last of these three sentences has a natural interpretation according to which 'I am wrong about that' is short for 'it is not the case that if we invite him he will snub us'. This is an interpretation, moreover, which strikes one as intelligible: Mrs. des Tombes wants to invite ffrench only provided his reaction will be favorable. But when we formalize the sentence with the help of material implication **this sense** is

lost: The symbolization takes the form: $\neg(p \rightarrow q) \rightarrow p$ which is a tautology of truth functional logic. That is **not** what Mrs. des Tombes has said. (She may be a socialite, but she isn't daft!)

In this second case the loss of meaning which results from symbolizing **if** as $\rightarrow$ is, as far as I can see, irretrievable. No Gricean or other pragmatic components that one might be prepared to incorporate into a comprehensive theory of natural language would seem capable of recovering the sense that the symbolization has obliterated.

This is a long familiar ground. There is, however, a related point which to my knowledge is rarely made but which nevertheless deserves explicit notice. While the conditionals of natural language often resist symbolization by means of $\rightarrow$, material implication does nevertheless render extremly valuable service in logical symbolization. How, one feels compelled to ask, is this possible?

I do not know exactly how to answer this. But I strongly suspect that the answer must relate to the undeniable fact that many natural language condionals carry an implicit element of generality; they tend to involve generalization over all manners of entities, over situations, possibilities, times, places, etc. To borrow David Lewis' aptly bland phrase (*Lewis 1975, 3-15*), they tend to involve generalizations over 'cases'. The meaning of such conditionals can often be captured quite well by a symbolization which makes the relevant generalization explicit. Thus the sense of the conditional sentence

(1) If a farmer owns a tractor he is well-to-do.

is captured reasonably well by the symbolization:

(2) $(\forall x)\,(F(X) \,\&\, (\forall y)\,(T(y) \,\&\, O(x, y)) \rightarrow W(x))$.

Similarly

(3) Invariably, if it snows it is cold.

might be rendered as

(4) $(\forall t)\,(S(t) \rightarrow C(t))$,

with universal quantification over times and predicates S for 'it is snowing at ...' and C for 'it is cold at ...'.

Indeed, the most serious difficulties we encounter when translating natural language conditionals into the language of extensional logic seem to arise when we cannot lay our hands on a suitable parameter to which an explicit universal quantifier could be applied. The material condition can help to symbolize such natural language conditionals. But it won't be enough by itself. Part of meaning of

the symbolized sentence must be made explicit with the help of quantifiers. We should also note that when the universal element is made explicit in the symbolization the paradoxical effects of material implication tend to disappear. For instance, if we read the conditionals about the engine and the switches as involving quantification over times, and represent the two statements as

$$(\forall t)\,(p_t \,\&\, q_t \rightarrow r_t)$$

and

$$(\forall t)\,(p_t \rightarrow r_t) \vee (\forall t)\,(q_t \rightarrow r_t))$$

respectively, the second no longer follows from the first, and our intention that the inference is wrong is indicated. In contrast, the example about ffrench cannot be dealt with quite so easily, precisely because here it isn't clear what the parameter is over which one introduces explicit universal quantification in the symbolizing formula.

Directly connected with these observations is a further point. It is not just when we symbolize **if**, or near paraphrases of it, like **when** or those involving verbs such as **follow from** or **imply**, that the implication sign is needed. It is also used in the symbolization of sentences involving overt marks of universal quantification. For instance, according to the logical tradition the sentence

(5) Every farmer owns a tractor.

is symbolized as a formula of the form

(6) $(\forall x)\,(F(X) \rightarrow (\exists y)\,(T(y) \,\&\, O(x, y)$

The need for a conditional connective in the symbolization of sentences such as (5) results from a choice which Frege made in the formalization of logic he presented in the Begriffsschrift, and used subsequently in his formalization of arithmetic. Frege chose to represent such words as **every** and **some** as 1-place quantifiers, i.e. as operators which yield a new formula when applied to **one** other formula. Evidently the grammar of the particles in question - words like **every, all, some, no**, etc. - does not impose this choice. It does not even very much suggest it. An unprejudiced look at their syntactic and semantic function suggests rather that they act as operators which form sentences by combining **two** operands, one given by the (simple or complex) noun following the word (which typically has the syntactic status of a determiner) and the other given by the rest of the clause in which the noun phrase which combines determiner and noun occurs. Translated in the terminology current among logicians, they appear as operators that form new formulae by combining two **formulae** (each of which acts as predicate by virtue of

containing one or more free occurences of some variable which gets bound by the operator in the process of combination.) [1]

If **every, all** and their synonyms are represented by such a two-place quantifier, symbolization such as (5) no longer requires the use of a separate implication sign. For instance, if we symbolize **every** by means of the binary universal quantifier $\forall^2$ and adopt, analogously, a binary existential quantifier $\exists^2$ to symbolize **a**, we get as symbolization of (5) the formula

(7) $(\forall^2 x)\,(F(X), (\exists^2 y)\,(T(y), O(x, y))$.

Frege seems to have been well aware of this alternative. What moved him to choose the option which is now enshrined in the generally accepted formalism of predicate logic is not entirely clear: I suspect that he was led to this choice at least in part because of a conviction that a logic with unary quantifiers is simpler, in particular that it yields simpler and more perspicuous rules of proof.

2.

There nowadays exists, I think, an intuitive feeling among those acquainted with predicate logic that, if this was indeed one of Frege's motives, he was right. But to what extent this feeling is itself the result of habit, a habit for which Frege's choice is itself ultimately responsible, is another matter. In fact, the logic which we obtain when we replace the unary quantifiers by their binary counterparts is not all that much more complicated or unwieldy than the versions of predicate logic familiar to us. This should not be surprising given the fact the two systems - the one with the unary and the one with the binary quantifiers - are mutually interpretable via very simple definitions. The ordinary predicate calculus the 2-place quantifiers $\forall^2$ and $\exists^2$ can be defined by way of the schemata

(8) $(\forall^2 x)\,(\phi, \psi) = (\forall x)\,(\phi \rightarrow \psi)$

$(\exists^2 y)\,(\phi, \psi) = (\exists y)\,(\phi \,\&\, \psi)$

Conversely, if we take $\forall^2$ and $\exists^2$ as primitives then both $\forall$ and $\exists$, as well as the connectives & and $\rightarrow$ become definable, viz. by

(9) $(\forall x)\,\phi = (\forall^2 x)\,((\forall^2 x)\,(\phi, \psi), \phi)$,

$(\exists y)\,\phi = (\exists^2 y)\,((\forall^2 x)\,(\phi, \psi), \phi)$,

$(\phi \rightarrow \psi) = (\forall^2 x)\,(\phi, \psi)$,

$$(\phi \,\&\, \psi) \quad = \quad (\exists^2 y)\,(\phi, \psi),$$

where y is the first variable not occuring in either ϕ or ψ.

These definitions allow us to convert a proof procedure for one of these systems into one for the other. In particular, (9) transduces the familiar proof procedures for the predicate calculus into corresponding procedures for the language with $\forall^2$ and $\exists^2$. The proof procedures for the new system that result in this way may, though they are not much more complex than the procedures for the unary calculus from which they are thus derived, not be particularly pretty. However, quite elegant axiomatizations can be obtained easily enough reflecting directly upon the meanings of the binary quantifiers. [2]

The moral I want to draw from this brief foray into the history of predicate logic is this. One of the important insights that Frege brought to bear on his formalization of logic was that there is an intimate connection between existence and conjunction on the one hand and between generality and implication on the other. He exploited these insights in the formatization of logic he chose: analyzing existential and universal quantification by means of the 1-place quantifiers that are now standard was possible precisely because the conjunctive aspect of existential quantification could be rendered using &, and the implicational aspect of universal quantification by means of $\rightarrow$. It is somewhat ironic that the way Frege capitalized on this insight led subsequently to a somewhat distorted perspective on the relation between logic and language. By separating, in particular, universality and implication in the formalism he bequeathed to future generations, he allowed us to lose sight of the fact that generality and conditionalization are inseparable - that one of them tends to be present whenever the other is; and so that one may expect to find either element both in sentences which contain expressions that have traditionally been reckoned to express universality and in those that obtain words which the same tradition came to classifiy as indicators of conditionalization. All these words tend to convey by and large same complex idea of conditionalized generalization. As a matter of fact the English language has a word in which both the universal and the conditional aspect are ethymological explicit. This is the word **whenever**. But from the present perspective we should not expect a significant difference in logical form between sentences of the form: 'if A then B', sentences of the form:'whenever A then B' and sentences of the form: 'every F is a G'. To a considerable extent this is, I believe, true. To what extent is a question I shall briefly address below, but which can be answered fully only on the basis of more detailed work than I have carried out.

3.

It would be wrong to claim that the universal aspect of natural language conditionals has never been recognized. That an element of quantification over times is usually present in **when**-sentences is unlikely to have escaped anyone - even if it is a fact that few have found it worth their while to point out explicitly. As regards **if**-sentences, the acknowledgement that they too involve an element of universality is implied in much of the recent philosophical literature on conditionals.

Yet, while the insight is now firmly entrenched, it has found its way into contemporary logical consciousness via a somewhat tortuous route. Dissatisfaction with the material conditional as a formal analogue of our intuitive concept of implication led C.I.Lewis in the early parts of this century to develop a logic of modalities in which it would be possible to capture that concept more accurately. One could accomplish this, Lewis thought, by analyzing the conditional as 'strict implication', i.e. as the necessitation of the material conditional. Thus 'A strictly implies B' was to be analyzed as

(10) $\Box(A \rightarrow B)$

where $\rightarrow$ is, as before, the sign for material implication, and $\Box$ represents 'it is necessary that'. As it stands this analysis does not introduce an element of universality. In fact, Lewis' own development of modal logic does not provide any unequivocal basis for an interpretation of (10) which reads a universal element into it. The possibility of giving such an interpretation became available only with the advent of the semantics for modal logic that was developed during the late fifties by a number of logicians, in particular Hintikka, Kanger, Kripke and Montague. According to that semantics, to be necessary is to be true in all possible worlds, or in all possible worlds satisfying certain conditions. Thus, if we expand the formula $(A \rightarrow B)$ according to this semantics formula we obtain

(11) $(\forall w)$ ((w is a possible world and w satisfies condition C and A is true at w) $\rightarrow$ B is true at w).

In (11) the universal aspect of conditionalization has become explicit.

Even after possible world semantics had become an integral part of modal logic, the thesis that natural language conditionals are strict implications did not come to be seen generally as entailing that they contain a universal ingredient. Not everybody accepted the possible worlds interpretation as one that provides the

intuitively correct analysis of necessity and possibility. For many possible worlds semantics remained just a useful tool in study of modal logics metamathematical properties, not a theory that could tell them what necessity, or for that matter, conditionals really mean.

In any case the claim that conditionals typically involve quantification over possible worlds is not quite on the mark. It is too restrictive, in so far as many conditionals we encounter in ordinary discourse seem to involve quantification over other parameter than possible worlds, e.g. times. Moreover, many conditionals, while involving quantification over some other parameter, (say time), are nonetheless understood as pertaining to the actual world only. Such conditionals cannot be represented as material implications simpliciter, and yet they are 'extensional' in the loose sense that their truth values are determined exclusively by what is actually the case. Thus the strict implication account is able to deal with only one of the many guises in which the universal aspect of conditionals can manifest itself.

4.

What I have said about the function of words like **if, when, implies, each** and **every** might seem to imply that they all do the same job. Of course this isn't true. For one, a "quantifier word" such as **every, each** and **all** makes explicit, through its position in the sentence in which it occurs, what the quantification it stands for is 'over', i.e. what the domain of quantification is. The presence, on the other hand, of a 'conditionalizer' such as **if** or **when**, although it does normally point towards universal quantification of some kind, tends to leave it open what domain of quantification is.

This is a difference that has generally been recognized. However, there is also another, which traditional treatments tend to obscure, but which I nevertheless believe to be crucial to a proper understanding of the ways in which quantifier words and conditionalizers function. The difference between the logical functions of, say, **every** and **if** (to take one item from each of the two categories) relates, in far greater measure than has usually been acknowledged, to the difference between strict universality and genericity.

This is a distinction which formal semantics and logic have not so far been able to elucidate very well. In fact, established logical and semantic methods seem particularly unsuited to deal with the problems of genericity. This inadequacy is

connected with the fact that logical theory has been almost exclusively preoccupied with the study of deductive, as opposed to other types of inference - with that kind of inference, on other words, for which it is impossible that the conclusion be false while the premises are true.

Such forms of inference are nowadays often referred to as 'monotonic', to capture the fact that the inference relation - that which holds between a set of premises and a conclusion if the latter may be inferred from the former - is monotonic in its first term: once the relation holds between a set of premises A and a conclusion b, it continues to hold when more premises are added, i.e. when the premise set is enlarged.

But monotonic inference is not all that matters. In recent years it has become increasingly clear how crucially important non-monotonic inference is in the context of human cognition. This has happened partly as a consequence of the new developments in cognitive psychology, but mostly through the efforts, undertaken within artificial intelligence, to track down the computational complexities of many human tasks that, at earlier times, would have been considered too trivial to deserve scientific attention. Many of the inference mechanisms that play a decisive role on the execution of those tasks appear to be non-monotonic. According to present understanding they have heavy use of "default principles", principles whose application is limited to instances that are in some sense "typical". When such principles are exploited in inference the resulting conclusions tend to be provisional, as they depend on the tacit assumption that the case in question is typical in the sense the principle requires. If, after the principle has been applied, new information comes in which shows the case to have been non-typical after all, the application becomes null and void and its effects will have to be undone. Such forms of reasoning are evidently fraught with peril; but they are the only forms that will serve creatures who, like us, must find their way in a world which is full of approximate regularities but which obeys few recognizable laws that are entirely free of exceptions.

Modern symbolic logic, it should be admitted, has not neglected non-monotonic forms of inference altogether. Probabilistic inference for instance is not monotonic, but probability logic received serious attention as far back as the 20's and 30's and has been a serious topic of research since that time. And the same is true of the closely connected phenomenon of inductive inference. However, it appears that neither inductive nor probabilistic reasoning are very much like the default reasoning that has now been recognized to play such an important part in most manifestations of human intelligence; and so inductive and probability logics

are hardly better suited to give us any real insight into the structure of that kind of reasoning than the theory of deductive logic.

5.

To explain the relevance of this excursion to the concerns of the present paper I must say a little more about the term "generic". Within linguistics it is common to classify as "generic" certain sentences with a habitual, dispositional, frequentative or lawlike reading. Sentences can often be recognized as allowing, or even requiring, such readings by their syntactic form. Typical indicators of genericity are: certain tense forms, like the simple present in English or the continuous past in Romance languages (e.g. the imparfait in French); auxiliaries such as **used to, would, will**; frequency adverbs such as **usually, regularly, commonly, typically, as a rule**; and "generic" noun phrases such as bare plurals, bare mass nouns or indefinite descriptions. Examples or sentences that seem to have only a generic interpretation are

(12) Whales suckle their young.

(13) Moss grows in shadowy places.

(14) In the seventeenth century a man who got into debt (as a rule) went to prison.

(15) Until recently professors used to wear gowns.

(16) In south Italy a boy who invites a girl to dinner is expected to marry her.

Prominent among the sentences that invite generic interpretations are those which have subordinate clauses beginning with **if** or **when**. In particular, there are many such sentences which suggest or even demand a generic interpretation and whose subordinate clauses contain indefinites:

(17) If a farmer owns a donkey, he prospers.

(18) If a farmer owns a donkey, he beats it.

We will discuss sentences and especially those of the type exemplified by (19), at length in Section II.

To appreciate the difference in meaning between generic and strictly universal statements it may help to compare the conditionals (17) and (18) with universal

sentences that are often treated as having the same truth conditions, but whose meanings strike me as decidedly different:

(19) Every farmer who owns a donkey prospers.

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

Even if there were a farmer who owned a donkey but did not prosper or did not beat the donkley, (17), or (18) might still be defensible if the contrary case which the farmer and donkey constituted was a sufficient a-typical one. (19) and (20), on the other hand, would be irrevocably false. This difference can be understood if we see (17) and (18) as guiding principles in default reasoning, which are intended to cover only those cases that can be recognized as non-pathological. Once a case has been established as pathological it no longer threatens the generalization and the latter can still be upheld. (19) and (20) by contrast do not play that kind of role. The simply and plainly assert that all cases of a certain kind, described by the every-phrase, satisfy the condition that is expressed by the remainder of the sentence.

Which factors decide whether a sentence may or must be given a generic interpretation is a problem which, as far as I know, has not yet been solved in every detail. But, one feels, it is a problem that ought to be solvable, for after all we ourselves, as native speakers, do not know when a sentence can or must be given a generic reading. Let us assume that this problem can be solved; that we can define, that is, in grammatical terms which sentences can be given a 'generic' interpretation and which sentences must be so interpreted. The question which then remains is: What is the **meaning** of those generic interpretations?

This seems to be a very difficult question. Indeed, I suspect, that it may require a sort of answer quite different from those that have been current in formal semantics during the past 20 years or so. It has been one of the dogmas of modern semantic theory that to explain the meaning of a sentence one should specifiy the conditions under which is true. This paradigm has worked well for many semantic problems. But I am not sure it will work for the present one. The reason is this: Generic Sentences - and this brings us back to the discussion in I.4 - are typically used to express those generalizations which we exploit as default assumptions in non-monotonic reasoning. Inasmuch as this use is central, an account of the meaning of generic sentences cannot be divorced from an account of the mechanisms of non-monotonic inference in which the principles they express play their particular parts. Perhaps it will be possible after all to account for default reasoning in truth conditional terms, just as this turned out to be possible within the theory of deductive inference. Default reasoning has certain features that

make me think this doubtful. But, whether or not it can be explained in truth conditional forms, as long as no such account has been given, the true meaning of generic sentences must remain a mystery too.

As long as no satisfactory theory of genericity is in place, the correct explanation of the meaning of differences between such words as **every, all, each, if** and **when** will remain beyond our reach. As far as this point is concerned the theory to be presented in Section II is no improvement over its alternatives. In fact, it ignores the distinction between genericity and strict universality entirely. Its advantages (or what I see as its advantages) lie in a different direction. However, for all I can see it should be possible to incorporate these advantages without much difficulty into more refined theories which will, among other things, give the distinction between generics and strict universals its proper due.

6.

As I have said, I attribute the present awareness that non-monotonic reasoning is a centrally important aspect of human cognition to the comparatively recent insights of artificial intelligence. There exists however a substantial body of work on the logic of conditionals that clearly preceded this recent change in perception and that addresses one important aspect of default reasoning. I am referring to the cluster of theories of counterfactuals (and other conditionals) developed by Stalnaker, Lewis, Pollock, Kratzer, Veltman and others.→

In part 3 of this section I observed that modally based theories of conditionality eventually came to be seen as importing a universal element into the meaning of the conditional - at that point, to be precise, when the modalities themselves had received an explication in the now familiar terms of possible worlds semantics. As I put the matter there, however, this universal element appeared to be one of **strict** universality: 'if A then B' would be true only if B is true in **all** worlds in which A is true. In fact, these are the truth conditions of the "strict conditional", formally represented as $(A \rightarrow B)$. This importation of an element of strict universality into the meaning of conditional sentences would appear inadequate in the light of what I said in the preceding paragraphs about the generic aspect that we detected in conditional sentences. If what I said about the generic character of conditionals is right then the strict conditional won't do, for it cannot account for the default status of the principles they express.

It is important to note in this connection that this very observation was made some considerable time ago within the framework of possible worlds semantics itself. R. Stalnaker and, a little later, D.K. Lewis noticed that the theory according to which the conditionals of natural discourse are the strict conditionals of modal logic leads to strongly counterintuitive conclusions in connection with counterfactual conditionals. It would predict, for instance, that we woud infer from the not implausible premises

(21) If J. Edgar Hoover had been a communist he would have been a traitor.

and

(22) If J. Edgar Hoover had been born in russia he would have been a communist.

the conclusion

(23) If J. Edgar Hoover had been born in russia he would have been a traitor.

which does not seem as plausible as either premise, and certainly doesn't seem to follow from them. As a remedy Stalnaker and Lewis proposed that the truth of a counterfactual of the form "if it had been the case that A it would have been the case that B" is true provided B is true in one or more of the "least outlandish" worlds in which A holds. In other words, unusual or atypical situations that make A true are being ignored in the evaluation of the counterfactual: even were B to fail in some of those atypical A worlds, the counterfactual might still be true. These analyses of counterfactual conditionals build a default element into the meaning of conditionals in that they ignore the atypical realizations of the antecedent, and thus interpret the conditional as licencing the passage from antecedent to consequent provided the consequence holds for all the atypical situations in which the antecedent is true. One consequence of this approach is that while a conditional of the form 'if it had been the case that A then it would have been the case that B' is true, a conditional with strengthened antecedent: 'if it had been the case both that A and C then it would have been the case that B' may nonetheless be false. This might happen when C holds in none of the typical A-worlds but holds in case that B may nonetheless be false. This might happen when C holds in none of the typical A-worlds but holds in some of the outlandish A-worlds. In that case even the least outlandish (A & C)-worlds would be outlandish A-worlds; if B fails in some such (A & C)-worlds, the second conditional will fail; if at the same time B is true in all the typical A-worlds the first conditional will hold.

This all too brief discussion may suffice as an indication that the counterfactual conditionals of Stalnaker, Lewis and others function in much the way one would

expect of principles for default reasoning. In fact, it might well be argued that their conditional logics are the first systematic treatments that the logic of default reasoning ever received.

SECTION II

1.

The treatment of conditionals I will sketch in this section was conceived, independently, by Irene Heim and myself. (See *Heim 1982, Kamp 1981*). Heim presents the theory in a somewhat different format from that used in *Kamp (1981)*. Being more at home with the latter paper's way of doing things, I shall present the theory in that manner. But nothing much of what I wish to say here hangs, I think, on this choice. There are some slight notational differences between the earlier papers of mine I just cited and what the reader will find on the pages following; these differences, however, are strictly cosmetic.

I should like to emphasize that the theoretical framework within which my own version of the account fits, that of "Discourse Representation theory" (or, for short, 'DR theory') was not developed as a theory of conditionals per se. It started out as an attempt to come to grips with the semantics of discourse, and with certain aspects of verbal understanding and command. That it has application to the theory of conditionals at all was, from my own original perspective, a bonus, and at the same time some confirmation that the approach as a whole might be on the right track.

DR theory was developed as an attempt to reformulate model-theoretic semantics in such a way that it can take account of something that earlier forms of formal semantics ignored, viz. the ways in which information flows in the course of verbal communication. It strives to accomplish this without sacrificing the mathematical precision which has been a standard in the formal semantics of natural language since the work of Richard Montague. At the same time DR theory aims to provide a systematic analysis of the meaning of discourse, not just of the single sentence. In this regard too the theory distinguishes itself from more traditional forms of model-theoretic semantics: It is a well-known fact that the meaning of a cohesive piece of discourse or text depends partly on the way in which the various sentences which make it up hang together. But model-theoretic semantics of the sort one finds, say, in Montague Grammar is not very well equipped to take these connections into account.

The issues of information flow in verbal communication and of discourse meaning are intimately connected. When you hear or read a piece of discourse or text you continually exploit the information with which you have already been supplied to make sense of the sentence or sentence constituent you are currently perceiving. From the point of view of language comprehension this is the primary significance of text coherence: It allows the interpreter to exploit what he has got out of the sentences he has already processed to assign meaning to those which follow. Put slightly more abstractly, the earlier parts of the text provide him with a context for the interpretation for its later parts.

We may summarize these observations by noting that textual cohesion manifests itself in two ways: through the contributions it makes to the context of the text; and through the opportunities it offers for contextually guided interpretation. While superficially distinct these two manifestations are nonetheless two sides of the same coin, and a good theory should account for them in a manner which makes this duality transparent.

2.

Here is, in rough outline, how DR theory goes about this task. Central to the theory is the concept of a Discourse Representation Structure, or DRS. DRS's are used to characterize (in a way that makes contextually important properties explicit) the content of sentences and multisentential texts. The task of specifying meaning for sentences and texts thereby falls into two parts: (1) the theory must state what meaning is represented by each DRS; (2) it must specify how individual sentences and texts determine the DRS's which characterize their contexts. Task (1) the existing versions of DR theory address in the manner familiar from model theoretic semantics, viz. by giving a general recursive definition of the truth conditions which each DRS determines through its internal structure. Task (2) has no direct analogue in any other syntactic or semantic theories with which I am familiar. [3] Let me outline the procedure of going from a given text consisting of a sequence of sentences S_1, S_2, ..., S_n to the corresponding DRS. I will assume that each S_i is a declarative sentence, and acts within the discourse S_i, ..., S_n as an assertion. Existing versions of DR theory presuppose an underlying syntax which assigns to each well-formed expression a syntactic analysis (or 'parse'). It is to these analyses of the sentences S_1, S_2, ..., S_n that the procedure of conversion into DRS's applies. Thus, in the present case the procedure will operate on the sequence $<A_1, ..., A_n>$ where

A_i is the syntactic analysis (or, in the case of syntactic ambiguity, one of the several possible syntactic analyses) of S_i. The procedure deals with each of these syntactic analyses in turn, exploiting the DRS K_{i-1} it has constructed from the preceding sentence analyses A_1, ..., A_{i-1} as context when it deals with the analysis A_i. The processing of A_i takes the form of incorporating A_i into K_{i-1}, thereby converting that DRS into a new DRS K_i, which now incorporates the joint content of S_1, ..., S_{i-1}, S_i and can serve as context for the processing of A_{i+1}. The procedure composes the syntactic analysis A_i (which, according to the syntactic theory presupposed has the familiar form of a tree) in an approximately top-down fashion, applying to each tree node a rule triggered by the syntactic composition principle which that node represents. These rules are called the **(DRS-) construction rules**, and the algorithm that is constituted by these rules, together with a specification of the order in which they are to be applied, will be referred to as the **DRS-construction algorithm**. Much of the difficulty, interest and substance of DR theory lies in the correct formulation of this algorithm.

Though it will be necessary for what I want to say here about conditionals that we are quite explicit about at least some of the construction rules, I will refrain from providing a fully general and formally exact statement of them. [4] Instead I will illustrate how the rules function in application to particular examples. In combination with suitable explanatory comment this will give us as much precision as is wanted here.

Usually examples are the best means of explaining how a theory works. I have found this to be particularly true in the present case, and will proceed accordingly. Most of the examples presented here are identical with, or minor variants of, those that were used in the introduction to DR theory of *Kamp (1981)*. [5]

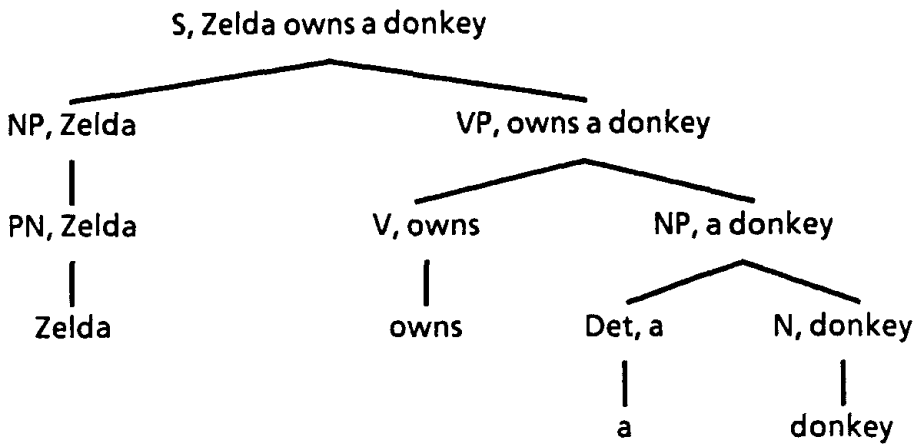
3.

To begin let us consider the two sentence discourse:

(1) Zelda owns a donkey. She adores it. [6]

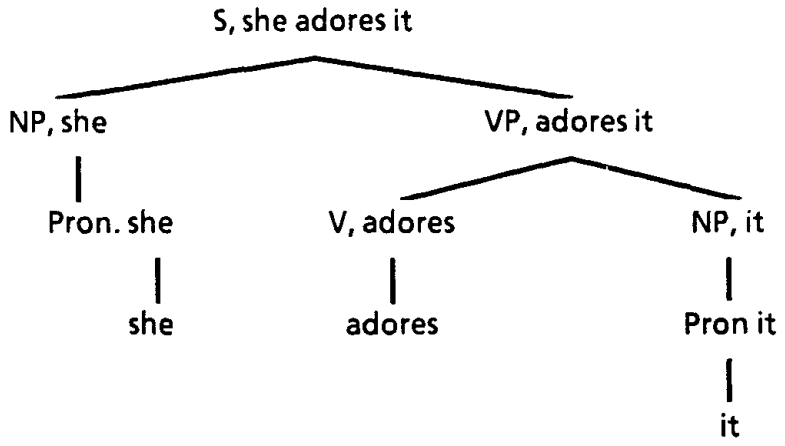
I will assume that the two sentences have the syntactic structures: [7]

(2)



and

(3)



Let us make the unrealistic, but pedagogically expedient assumption that the first sentence of (1) is interpreted without the benefit of antecedently established contextual information. Formally this means that the DRS K_0 that acts as 'context' for the interpretation of the sentence is empty - it contains no information whatever. (I will make this assumption throughout this paper: every single sample sentence, and the first sentence of any sequence, will be processed relative to such a 'tabula rasa'.)

The construction algorithm first applies to the top node (the 'root') of tree structure (2). The particular construction rule to be applied is selected in the light of the syntactic principle by which the expression associated with the top node - i.e. the entire first sentence - is put together from its immediate syntactic constituents. These are the expressions associated with the successor nodes, here the node for the (subject) NP and the one for the VP. What rule is to be selected depends in addition on the form of the NP. The rule we must use in the present case is one that is specific to proper names. When the NP is of different sort, e.g. a pronoun or an indefinite description, then, as we will see presently, slightly different rules come into play. Although distinct, all these different 'NP-rules', which correspond to syntactic principles that combine an NP with some expression with the semantic role of a predicate (a verb phrase, say, or a verb, or a preposition), have an important feature in common. Each of these rules introduces what we will call a 'reference marker'. [9] This reference marker acts as a 'representative' (in a sense to be explained shortly) for the constituent NP. The marker is introduced into the 'universe' of the DRS under construction; moreover we add to the second component of the DRS, its 'condition set', two 'conditions', which contain information 'about' the marker. The first condition expresses that what the marker stands for satisfies the verb phrase; the second that the marker stands for the bearer of the proper name. Schematically we can represent the result as:

(4)

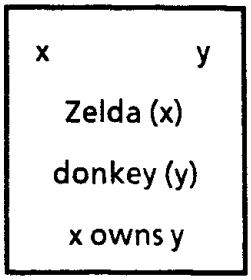
x	
Zelda (x)	(2)
x owns a donkey	(1)

where x is the chosen reference marker and 'x owns a donkey' and 'Zelda (x)' are the two conditions.

The next construction step - and the only other step the algorithm specifies for the analysis (2) - deals with the VP node. The syntactic composition principle associated with this node is again one that combines an NP with a predicate-like expression. But this time the NP is an indefinite description, not a proper name. The corresponding construction rule is much like the one we just applied. The only difference that is relevant here is that the second condition on the new reference marker now is to express that what that marker stands for satisfies the descriptive

content of the indefinite description - thus, for the case of our example, that it must be a donkey. The application of this rule transforms the DRS (4) into the structure

(4)



where y is the new marker and 'donkey (y)' expresses that what y represents is a donkey.

4.

What are reference markers? And what does a structure like (5) mean? These two questions are intimately connected and, more in particular, it would be misguised to try and answer the first in abstraction from an answer to the second. So let me answer the second one first.

The meaning of a DRS such as (5) is to be assessed primarily in terms of the truth conditions it determines, and those are determined in the following way. Speaking intuitively a DRS is **true** if it gives a correct description of some real 'situation'. We could adopt here the stance and framework of situation semantics (See e.g. *Barwise & Perry 1983*) and interpret the word 'situation' in the specific sense in which the notion is developed there. Then (5) would be true if the real world contains a situation consisting of the fact that two individuals a and b, where a is Zelda, and b is some donkey, are related by the relation of ownership. Or, alternatively (5) would be true, on a given occasion of use if the situation described on that occasion was one which the DRS gives a correct description. [10] I will however, as I did in *Kamp (1981)*, state this same idea in more traditional terms: (5) is **true**, in the actual world, (or in some possible world or in some model) [11] iff there is a way of associating with the reference markers x and y individuals a and b *from that world or model which satisfy, in their world or model*, the DRS's

conditions (which may be thought of in this connection as formulae containing x and y as free variables).

It is important to notice the existential character of this definition of truth: (5) is true if **there exists** a correlation of reference markers with individuals that satisfy the relevant conditions. As argued at greater length in *Kamp (1981)* it is this which is responsible for the appearent existential force of the indefinite **a donkey** in the first sentence of (1). It has often been thought that indefinite descriptions are devices of existential quantification of natural language. This, I believe, is a misconception which has been responsible in particular for the failure of earlier theories to deal with the so-called 'donkey sentence' problem to which we will come presently.

The first of the two questions I asked above was: What sorts of things are reference markers? One answer to that question is implied in what I said about DRS-meaning: The truth definition for DRS's shows the role reference markers play in determining the truth conditions of the DRS's in which they occur. In so far as reference markers are part of a theoretical apparatus for characterizing the content of sentences or texts, an explanation of their function within this machinery is all that can be asked for.

There is, however, a second function reference markers fulfill besides the contribution they make to DRS content. They also act as antecedents for anaphoric noun phrases. We will find this illustrated in the next step of the construction of DRS for (1). This is the first construction step triggered by the syntactic analysis (3). The rule that is to be applied in this step is again one which corresponds to a syntactic combination of an NP with some predicate-like expression. This time the NP is a pronoun.

The processing principle governing the interpretation of pronouns is that they always pick up an element that is salient in the context in which they are used. There are various ways in which an element can become contextually salient. One of these is that the speaker points at the element (an object in the environment) in a manner that draws the addressee's attention to it. Another way involves an earlier mention in the antecedent discourse, typically through the use of a suitable singular term. It is an interesting and important fact, however, that the earlier use of a singular term may provide a basis for the interpretation of a subsequent pronoun irrespective of whether the term really succeeds in referring or not. To run slightly ahead of where we are in our treatment of example (1), even if the first sentence is false and there is no donkey Zelda possesses, the pronoun **it** is still interpretable as referring to the 'element' the indefinite **a donkey** somehow

introduces into the context in which the second sentence is to be understood. This seems to point towards a discrepancy between the so-called **deictic** uses of pronouns, which get their reference via some demonstrative act, e.g. a pointing, and their anaphoric uses, where their referential function is determined via a connection with some other noun phrase from the sentence or discourse in which they occur: whereas the element that a deictic pronoun picks up must always be a *real world object*, this need not be so when the pronoun is anaphoric. In fact, the anaphoric possibilities of pronouns can be accounted for by the principle that the anaphoric must always pick up one of the **reference markers** contained in the DRS that serves as context in which the pronoun is interpreted: Whether these 'antecedent' reference markers have counterparts in the real world is immaterial to the possibility of anaphoric interpretation as such.

The apparent discrepancy we just noted between the deictic and the anaphoric use is in last analysis not as large as it might at first appear. It dissolves once we think of the context-DRS as incorporating information which stems not only from the preceding discourse but may come from other sources as well. Such a DRS may have reference markers for salient objects from the environment as well as markers whose introduction was prompted by earlier noun phrases. Once DRS's are made to play this more comprehensive contextual role, the referential function of both anaphoric and deictic pronouns can be analysed in terms of connections with reference markers that have found their way into the DRS in any one of a number of different ways. [12]

The upshot of all this is that the construction rule for anaphoric pronouns must not only introduce, like any other NP-rule, a new reference marker, but also establish an identifying link between that marker and one of the markers that are already present in the DRS. This last requirement, that of linking the new marker to what may be one of the substantial number of potential 'antecedent', raises the question: Which of those potential antecedents should it select? This is a notorious problem on which much time and effort has been spent, but which, in spite of all that time and effort, is still very far from being solved. One thing, however, that has become quite clear is that it cannot be solved by purely linguistic means alone. In fact, there seems to be no limit to the variety of considerations that human interpreters bring to bear on the anaphoric choices they make, and therefore only comprehensive theories of human knowledge and expectation (and not just of linguistic competence) would stand a chance of accounting fully for how such choices are made.

This does not mean that we could not build at least some of the factors that influence anaphoric interpretation explicitly into the construction rule for pronouns. However, such an inevitably partial solution would yield nothing that would be of intrinsic interest for the central topic of this paper. I will, therefore, here as in subsequent examples, link anaphoric pronouns to those antecedents to which English speakers would normally understand them to be linked, without trying to provide a theoretical justification for the particular choices I will make. 13] Thus we will assume that the rule for anaphoric pronouns simply stipulates that the reference marker which is introduced for an anaphoric pronoun is to be linked to some one of the already available markers, without specifying which. To summarize: The pronoun rule introduces a new reference marker for the pronoun, and adds as new conditions: i) the condition which results from replacing the pronoun by the new marker in the condition to which the rule applies; and ii) a condition which conveys the connection between the new marker and the one which is selected as anaphoric antecedent. Since this connection has the semantic significance of coreference we represent it by means of an equation.

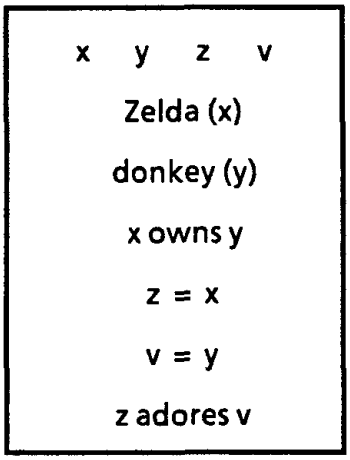
Applying this construction rule to the top node of (3), and choosing as antecedent for **she** the reference marker x we obtain the DRS

(6)

x y z
Zelda (x)
donkey (y)
x owns y
z = x
z adores it

One further construction step is necessary. It applies to the VP-node of (3), and involves the very same rule that we have just used. Identifiying **a donkey** as the antecedent of **it** we get from (6)

(7)



In the versions of the DR theory that have thus far been formulated this is the final result of the construction procedure. This accords well with the perspective familiar from formal semantics according to which such formulae as 'x owns y' count as 'atomic'. From the point of view of actual language interpretation, however, stopping at this particular point may seem somewhat arbitrary. Arguably interpretation of natural language by us humans often involves further lexical analysis of such conditions, typically in the light of the context in which the lexical item in question occurs. Moreover, the interpreter does not as a rule stop even there, but may go on to draw further inferences from the information already obtained - and all this may happen in that brief period which usually suffices for us to reach an understanding of a sentence we hear or read, a time so fleeting that we ourselves do not experience it as a duration at all. Ideally a theory of language should make explicit those further processes also; and I hope that it should be possible to do this in roughly the same form we have already employed here, viz. by formulating additional processing rules which expand or transform a DRS such as (7) further. Rules which take DRS's beyond the stage exemplified by (7) have, to my knowledge, not yet been articulated by anyone, and here is at the present still little systematic work that one could rely on in the development of these additional components of the construction algorithm. We must leave this as a topic for further investigation.

Applying the truth definition for DRS's to (7), and interpreting the conditions 'z = x' and 'y = v' in the obvious way (that is, an assignment of, say, c to z and a to x

satisfies 'z = x' if and only if c is identical with a) we see that the truth conditions of (7) are precisely those we intuitively associate with (1): (7) is true if and only if there are individuals a and b such that a is Zelda, b is a donkey, a owns b and a adores b.

5.

It is important to compare (7) with (5). (7) extends (5); it incorporates besides the information delivered by the first sentence of (1), which constitutes the entire content of (4), also the further information that is added to it by the second sentence. Consequently the content of (7) entails that of (5). This is entirely appropriate given what might be called the 'rethorical structure' of the minidiscourse (1): its first sentence posits a certain amount of information; and the second sentence simply adds some further information to that.

This cumulative connection between sentences of a discourse is common enough. But it is by no means the only way in which sentences can be connected. First, not all sentences we use are declaratives. We ask questions, give orders, o.fer pieces of advice, issue permissions, make apologies and so on. Such sentences cannot be connected among themselves or with declarative sentences in the way the first sentence of (1) is connected with the second, because they do not serve the function of simply conveying information in the first place. But even when both members of a pair of consecutive sentences are declarative their connection is often not a strictly cumulative one. For instance, in

(8) Siegfried is unhappy. He has received a C in the course.

we are inclined to take the second sentence as giving an **explanation** for Siegfried's unhappiness, or alternatively as specifiying the content of this unhappiness, or we take it in both these ways at the same time. We are prone to a similar interpretation if the two sentences are reserved, as in

(9) Siegfried has received a C in the course. He is unhappy.

This causal, explicative aspect of the connection between the sentences in (8) and (9) is not accounted for by DRS's constructed along the lines just sketched for (7). Ultimately the construction algorithm will have to be refined so that such aspects of the discourse can be encoded also. The need for such a refinement appears even stronger in connection with sentences in which the causal or explicative aspect is made explicit, e.g. by particles like **so**, **for**, therefore, etc. thus (8) conveys roughly the same sense as

(10) Siegfried is unhappy. For he has received a C in the course.

and (9) is similar in sense to

(11) Siegfried has received a C in the course. Hence he is unhappy. [14]

I will say no more here about the representation of these connections, nor about the difficult question what precisely is their semantic force. (A problem that would have to be clarified at the the point where we state under what conditions the more elaborate DRS's in which those connections have been made explicit would be true or what inferences one would be entitled to draw on their basis.) One fact about them is worth nothing however. In each of these examples the interpretation of second sentence can make use of information contained in the first sentence, and moreover that information is always exploited in the same way. In particular, the anaphoric connections between pronouns and their anaphoric antecedents are established according to precisely the same principles as we adopted in our analysis of (1).

6.

Here I wish to focus on another type of connection between successive sentential components of a discourse. In this connection the first of the two sentences involved is not a declarative sentence but a kind of imperative, viz. a sentence beginning with: 'Suppose that'. The second sentence is a declarative one (though its mode is something subjunctive). Samples of the kind of discourse I have in the mind are

(12) Suppose that Siegfried gets a C in the course. Then he will be unhappy.

(13) Suppose Siegfried were to get a C in the course. Then he would be unhappy.

(14) Suppose a cat and a dog meet near a tree. Then the cat will run up the tree.

The non-declaratives with which they begin notwithstanding, each of this three passages serves, as a whole, to convey a certain piece of information. The information comes roughly to this: Given that things are as described in the first sentence they also must be as described by the second sentence. It is not hard too see how this compound meaning comes about. In the first sentence the speaker invites his audience to suppose the world to be a certain way; he then continues by saying in the second sentence that such a world also satisfies some further conditions. Or, using the terminology of situation semantics, (See in particular *Barwise 1986*) the audience is in the first sentence invited to suppose there is a

situation of a certain kind and is then told in the second sentence that with this situation goes a situation of some other kind. The combination of the two sentences thus succeeds in conveying what Barwise and Perry have called a **Constraint** - i.e. a regularity, to effect that a situation of one type is accompanied by a situation of a second type.

Although the first sentence of (12), (13) and (14) are grammatically speaking imperatives, the contribution they make to the passages in which they occur is, because of the meaning of the particular verb they contain, viz. **suppose**, a quite special one. I see it therefore as legitimate to analyze the **suppose that's** of the first sentence together with the **then's** of those that follow them as expressing a discourse connection which, like such words as **so, hence, for**, etc., serves to combine a pair of declarative sentences into a declarative whole. Thus, according to this proposal the very same two linguistic elements that enter into the cumulative discourse (1) can, by means of '**Suppose that ... Then ...** ', be combined into the discourse

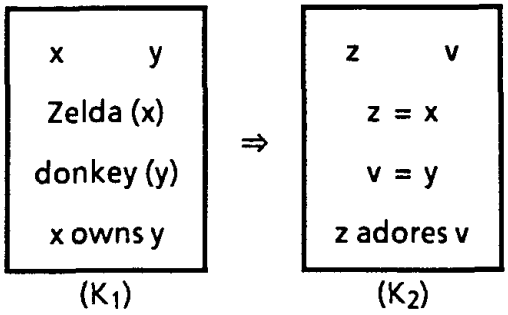
(15) Suppose that Zelda owns a donkey. Then she adores it.

The discourse connection which this complex particle 'Suppose that ... Then ...' establishes I will call the 'hypothetical connection'.

While the meaning of a discourse in which two sentences S_1 and S_2 are hypothetically connected is evidently different from what it would be had the connection been cumulative, the processing of such a pair parallels in almost all respects that of a corresponding pair of cumulatively connected sentences. The only difference is that the pieces of the resulting DRS that derive from the two components of the hypothetical pair are joined together in a new and different manner. In fact, because the hypothetical connection is not, in the way the cumulative connection is, a symmetric connection, it becomes important to make explicit in the DRS for the entire passage how it divides up into those two pieces.

The following diagram for the passage (15) constitutes one way of making this division explicit:

(16)



(K_1) (K_2)

The arrow between the two boxes is to represent the hypothetical connection between the two sentences from which they come. What contribution this arrow makes to the content of the structure that it is part of must be made explicit in the articulation of the truth conditions of DRS's like (16). As a first shot (the one and only shot I fired at this target in *Kamp 1981*) we might stipulate that (16) is true if and only if any way of associating objects with the reference markers in the first box (K_1) which ensures that the conditions of that box are all satisfied can be extended to an association of objects with markers in the second box (K_2) which guarantees satisfaction of the conditions of that second box. For the case at hand this amount to saying that for any objects a and b such that a is Zelda, b is a donkey and a owns b, it is the case that there are objects c and d such that c is the same as a, d is the same as b and c adores d - more succinctly, whenever a and b are objects such that a is Zelda, b is a donkey and a owns b then a adores b.

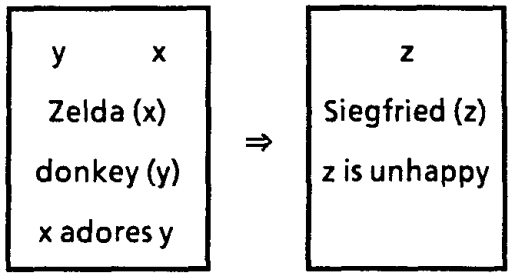
7.

Note that this articulation of the truth conditions of (16) imposes on the arrow which connects the boxes in essence the reading of material implication. This becomes perhaps clearer if we consider an example that does not involve the sort of anaphoric link that we find in (16) between **a donkey** and **it**. Consider

(17) Suppose Zelda adores a donkey. Then Siegfried is unhappy.

The construction algorithm I have sketched will transform (17) into the DRS:

(18)



Applying the truth conditions I proposed we get that (18) is true iff for any individuals a and b such that a is Zelda, b is a donkey and a adores b, there is an individual c, who is Siegfried and is unhappy. Evidently this is equivalent to saying that either there is no such pair of an a and b or else there is such a c, i.e. either the DRS displayed in the first box is false or the DRS displayed in the second box is true.

In connection with (17) this truth-functional account seems to be off the mark. Here, one may feel, there is something the hypothetical connection wants to convey but which the material conditional is missing. With (15) on the other hand this feeling is absent, or at any rate much weaker. This illustrates the first main point of Section I: even though the interpretation of the hypothetical connection in (16) is in essence that of the material conditional, the truth conditions which are thereby conferred upon (15) do not strike us as especially procrustean; and the reason is, once again, that (16) makes explicit a certain element of generality as well. This element enters into the truth conditions through the reference markers x, y, z and v and the links between them.

Even if there seems no need for stronger, "intensional", truth conditions for the hypothetically connected sentences in (15), there are other hypothetically connected sentence pairs, e.g. (17), which do seem to require such an intensional interpretation. In *Kamp 1981* I took it for granted that the familiar semantic methods for defining stronger conditional concepts can without any difficulty be adapted in the same way in which I just modified the standard definition of material implication. Subsequent reactions to that paper have since shown that this assumption was overly optimistic. So let me, on pain of being too obvious, belabour the point here. Above I said that a structure such as (16) is true in a world w iff every assignment to the markers of K1 of objects from w which satisfy the conditions of K1 in w can be extended to an assignment which assigns elements of w also to the reference markers of K2 so that the conditions of K2 are satisfied in w

as well. There is no problem whatever in replacing this stipulation by one which takes into account not only assignments and satisfaction in w but also assignment and satisfaction in other "possible" worlds. Thus, for instance, let us consider one of the familiar model structures for modal predicate logic, a structure M consisting of: a set of worlds W; an accessibility relation R between worlds; a function U which assigns to each world w in W the set Uw of individuals existing in W; and a function F which assigns to each w in W and each non-logical constant (i.e. predicate, etc.) C a suitable extension Fw(C) of C in w. It is common to define in relation to such model structures a notion of strict implication, $<$, by means of

> A $<$ B is true in M at w under the assignment f iff for each w' $\in$ W such that wRw' if A is true in M at w' relative to f then B is true in M at w' relative to f.

Evidently this definition can be recast in the spirit of Section II.6. For instance, we could stipulate that (16) is true in a model structure M at a world w iff for every w' W such that wRw' and every assignment f of elements of Uw' to the reference markers of K1 and that these elements satisfy the conditions of K1 and M at w' there is an extension of f to the markers of K2, again involving elements of Uw, so that the conditions of K2 are satisfied in M at w' also.

Any other definition of a conditional connection in terms of possible worlds, as one finds these e.g. in the work of *Lewis 1975*, *Stalnaker 1968* or any of the works cited on p. 77 could be adapted in a similar way.

8.

Hypothetical connections between successive parts of a discourse tend to be "local": They involve only a small section of the discourse. In the examples I have so far given the connection is local in the extreme; it involves only two sentences, the first one beginning with **suppose that** and the second the immediate successor to the first. It is not hard to find examples where more sentences are involved, e.g.

(19) Suppose Zelda owns a donkey. Suppose also she adores it. Then Siegfried will be unhappy. He will leave Zelda and turn all his attention to his Honda.

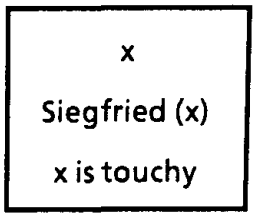
It remains true however that hypothetical connections do as a rule not involve all the sentences which make up a discourse or text. The DRS for a discourse that contains a hypothetical passage as a proper part must reflect this locality aspect of it.

Consider for instance the sequence:

(20) Siegfried is touchy. Suppose Zelda adores a donkey. Then he will be unhappy.

Applying the construction algorithm to the first sentence of (20) we get a DRS of the form

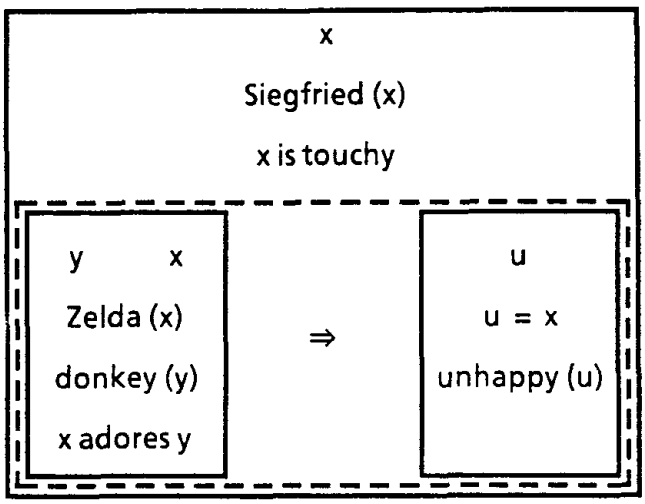
(21)



Moving to the next part of the discourse the algorithm will not only have to recognize the words **suppose that** as indicating the beginning of two hypothetically connected sequences, it will also have to be able to determine where the antecedent part ends and the consequent part starts; and finally it will have to be able to recognize where the consequent part ends. In the present case it is obvious what determines the first demarcation: it lies just before the sentence-initial **then**, which clearly marks the beginning of the consequent part. At the end of the consequent part can here only be the end of that last sentence, simply because that's all there is. In general, however, determining where the parts begin and end need not be such a simple matter. (This is equally true for parts that stand to each other in a causal, explicative or elaborative relation.) One of the problems of discourse analysis generally, and of DR theory in particular, is to uncover the principles by which such parts are delimited. This is an issue to which I have little to contribute at the present time.

But let us assume that these principles can be isolated and made available to the DRS construction algorithm. An algorithm so equipped would convert (21) into

(22)



In (22) the dotted line democrates the substructure of the DRS that represents the hypothetical part of (21).

We know intuitively what the truth conditions for (21), and thus for (22), ought to be: (21) is true iff some individual, Siegfried, is touchy, and is such that he is unhappy if another individual, Zelda, adores a donkey. In other words, if there is some individual a, who i) is Siegfried, who ii) is touchy and who iii) is such that if any individuals b and c have the properties that b is Zelda, c is a donkey and b adores c, then he is unhappy. This last phrasing of the truth conditions shows that the part within the dotted line can be thought of as playing a role similar to that of the conditions "Siegfried (x)" and "touchy (x)". And this is how I will treat it formally; that is, the structure consisting of the subordinate DRS's connected by the arrow will count as a single condition, on a par with "atomic" conditions such as "Siegfried (x)", "donkey (z)" or "x owns y". An assignment f of individuals to the reference markers in the universe of the DRS to which such a condition K1 ⇒ K2 belongs will **satisfy** that condition iff every extension g of f that assigns objects also to the reference markers of K1 and satisfies K1's conditions can be extended to an assignment h that takes the reference markers of K2 into account as well, and satisfies all the conditions of K2.

9.

It may seem a little peculiar that a passage consisting of several sentences (such as the last two sentences of (20)) contributes to the DRS a unit of the same "order of magnitude" as are contributed in other cases by small sentence parts, such as e.g. the individual noun phrase "Siegfried". But this isn't really as implausible as it may look at first. Quite often one or two words in a sentence serve to convey what may be regarded as a separate proposition. Thus compare:

(23) Mr. Jones was the last to arrive. The popstar was accompanied by a gorgeous brunette and his favorite puma.

(24) Mr. Jones was the last to arrive. The 19-year-old popstar was accompanied by a gorgeous brunette and his favorite puma.

The only difference between the two texts is the presence of the words **19-year-old** in (24). But these few words are enough to add the informatoion that Mr. Jones, the popstar, is 19 years of age. (This device of using a relative clause, or even a single adjective, to convey information that could also have taken a complete separate sentence appears to be particularly common in journalism where there is often a premium on conveying information with a minimum of words.)

It is even more obvious that what could be said by several sentences can often also be said by means of one. Thus a cumulative multisequence passage can be converted into an equivalent single sentence by simply gluing the several sentences together into one large coordinate conjunction. Moreover one can often achieve a similar effect by turning one or more of the sentences into subordinate clauses governed by **while** or **whereas**.

Just as these connectives mimic, within the confines of the single sentence, the cumulative connection, so the hypothetical connector is mimicked by particles like **if** and **when**. Sentences which contain sub-ordinate clauses beginning with such a particle - let us refer to them as "conditional sentences" - can convey on their own what it takes at least two sentences to express if we start off with **suppose that**. Thus

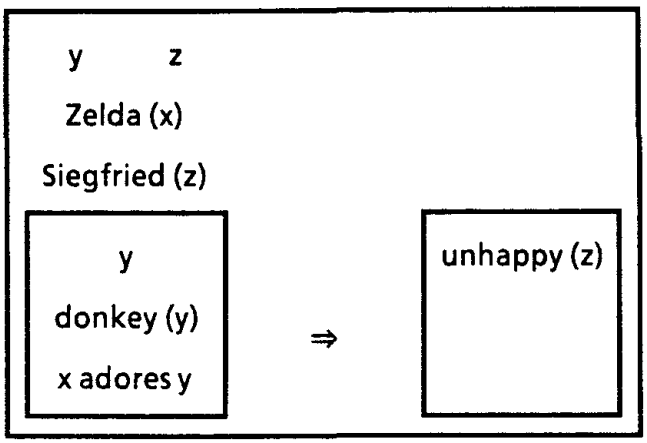
(25) If Zelda adores a donkey, Siegfried is unhappy.

is equivalent in content to the two sentence discourse:

(26) Suppose Zelda adores a donkey. Then Siegfried will be unhappy.

a content is captured by a DRS of the form

(27) [15]

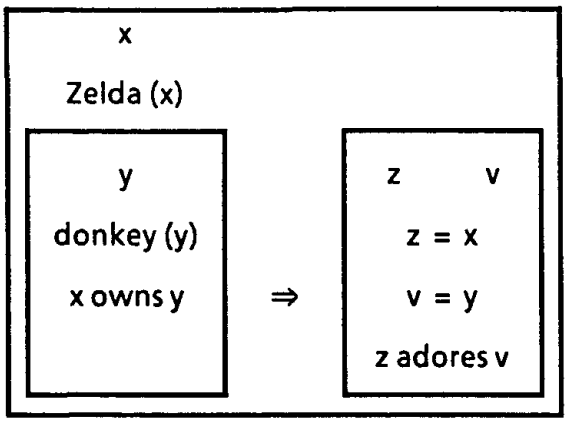


Similarly

(28) If Zelda owns a donkey she adores it.

expresses the same content as (15) and should, just as (15), yield a DRS of basically the same structure as (16).

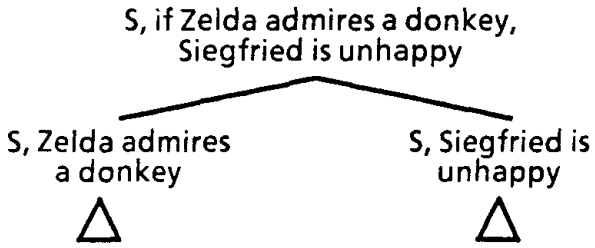
(29)



Once again we must address the question what construction steps lead from (28) to the DRS (29). This time we must consider in particular which rule gives rise to the conditional structure $K_1 \Rightarrow K_2$, where K_1 and K_2 are structures that get subsequently expanded to complete DRS's of the antecedent and consequent parts. I raised this problem already briefly in connection with (20), but there I deferred it to a future study. In relation to conditional sentences however I want to address it now.

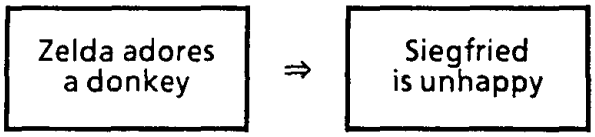
In *Kamp 1981* I offered the following treatment: A conditional such as (26) is assumed to have a syntactic analysis the top node of which is to represent a syntactic rule that combines the antecedent and consequent into a single conditional sentence, by prefixing the word **if** or **when** to the antecedent and placing the consequent behind the antecedent, with an optional **then** between the two. So (26) would have an analysis looking like this:

(30)



From such a syntactic analysis we can obtain (29) if we add to the construction rules already discussed one that corresponds to the syntactic combination of antecedent and consequent into the conditional, and which has the effect of initiating the construction of two DRS's K_1 and K_2, one for the antecedent and one for the consequent, which are combined into a complex condition by means of $\Rightarrow$. Applying this rule to the top node of (30) we get

(31)



the algorithm can then proceed to break down the antecedent and consequent separately in the ways that earlier examples illustrated. The resulting DRS is (27). [16]

There is a great deal more that ought to be said about the syntactic analysis of conditional sentences. For one thing there is a question of how the rule that combines subordinate clause and main clause relates to that (or those) which is (are) responsible for inflection. For another, how do sentences containing **if**- or **when**-clauses relate to those that have other types of subordinate clauses, e.g. clauses beginning with other particales such as **after**, **because**, or **although**? As these questions involve syntactic considerations with which I am not equipped to deal, I refrain from trying to tackle them. [17]

10.

Something like a 'solution' to the traditional 'donkey' problem (How could the indefinite in the antecedent in sentences like (28) "bind" the pronoun in the consequent?) seems to have come for free in our treatment of conditionals. Let me list the elements of the theory I have so far presented that are responsible for this solution.

We sketched a number of processing rules that are needed to convert texts such as (1) into DRS's. A separate definition specifies under what conditions such DRS's are true. Rules that we were obliged to introduce to deal with (1), and which turn out to have particular importance for the explanation of the donkey problem, are the one for singular indefinite noun phrases and the one for anaphoric pronouns. We then introduced further construction principles for hypothetically connected parts of texts and for conditional sentences. Combining these with the already established construction rules we obtained for a text such as (15) and a conditional sentence like (28) the DRS's (16) and (29); given one further stipulation for the satisfaction of the complex conditions which (16) and (29) contain, these DRS's then assign to (15) and (28) truth conditions that are at least approximately correct ('approximately' in view of the discrepancies between generics and universals discussed in Section I). It should be noted in particular that in the analysis offered here the **very same** construction rules (to wit the rule for indefinite descriptions and that for anaphoric pronouns) allow for the link between **it** and **a donkey** in the hypothetical passage (15) or the conditional sentence (28) on the one hand, and in a cumulative passage such as (1) on the other.

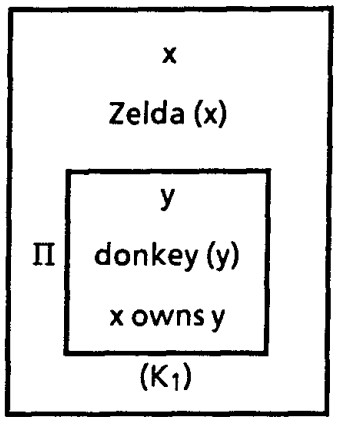
So innocent a solution for so notorious a problem may seem just too good to be true. In fact, matters aren't quite as simple as this. So far I have made it appear as if every marker that has already been introduced into the DRS is always available in principle as antecedent for any later pronoun. But in general this is not so. An example will make this clear:

(32) Zelda doesn't own a donkey. She adores it.

In (32) **a donkey** cannot act as antecedent for **it**. Intuitively the reason seems obvious: we have just been told in the preceding sentence that there is no donkey Zelda owns; so there is nothing for **it** to refer to. However, this can not be quite the right explanation, for as we saw (28) is perfectly acceptable and would not be judged ungrammatical ex post facto simply because, as it might turn out, Zelda doesn't own any donkeys.

The explanation DR theory offers for this difference between (28) and (32) runs as follows. A negated sentence, such as the first sentence of (32), introduces a complex condition which has one DRS-constituent, and that constituent is a DRS for the unnegated sentence. Thus the first sentence of (32) yields the DRS

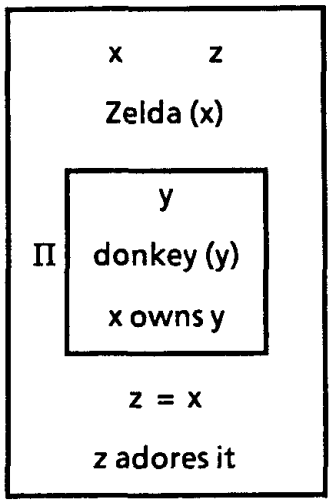
(33)



The second of the two conditions of (33) is the complex condition K_1. This condition is satisfied by an assignment f for the main DRS if there is no extension g of f to the markers in U_{K1} which satisfies the condition of K_1. It is easily verified that this gives the intuitively right truth conditions for the first sentence of (32).

Let us now try to complete (33) to a DRS for the whole of (32) by incorporating the second sentence into it. Of all the construction steps that this incorporation requires the one that matters in connection with our present concerns is that which deals with the pronoun **it**. When this rule applies, the pronoun is part of the condition 'z adores it' that is entered into the DRS when the construction algorithm deals with the subject **she**. In this situation, displayed in (34),

(34)



the anaphoric pronoun rule should not be able to link the marker furnished by the pronoun **it** to y. For otherwise we would obtain for (32) a reading which it evidently does not have. But what is it that prevents the rule from making this connection? Intuitively the marker y is inaccessible to the pronoun, because from the perspective of the position which the pronoun occupies y is not "free". y appears from that perspective more like a bound variable, one that is bound by the negation operator which governs the sub-DRS in whose universe it occurs. Thus, to stay with the familiar terminology of quantification theory, it is outside the scope of the operator by which y is bound.

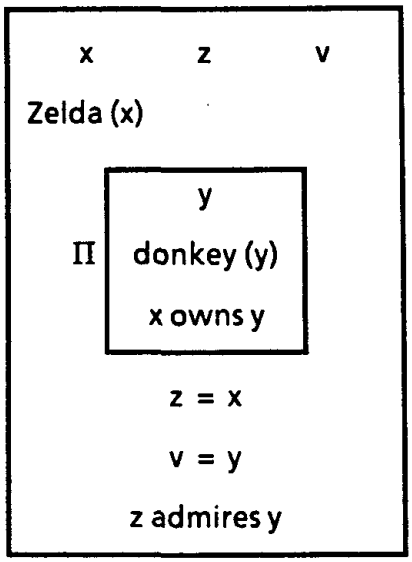
This, however, is only an intuitive explanation. It does not tell us when a marker is accessible to a pronoun. For instance, whereas the y of (34) is not accessible from the position of the pronoun **it**, the y of (29) has to be accessible from the relevant position of the pronoun **it** there, that is from the second subordinate DRS K_2. How are we to account for this difference?

There are really two problems here. One is to state exactly which reference markers in a DRS are accessible to which positions; and the second is to provide an **explanation** of why accessibility should hold between some positions and not between others, in particular, why it should hold between markers in the first and pronouns in the second embedded DRS of (29). In *Kamp 1981* I gave a strictly formal definition of accessibility, with some informal motivation for why that definition ought to be the way I had stated it. The paper also contains a number of further sample sentences which provide some forensic evidence that the definition makes

the correct predictions. The intuitive motivation for the principle, crucial to the construction of such DRS's as (16) or (29), that the refernce markers belonging to the universe of the first 'antecedent', DRS of a pair connected by ⇒ are accessible to the second ('consequent') DRS, ran roughly as follows: The point of a hypothetical claim is to put forward a situation of a certain type, and to say of such a situation that it has certain other features as well. Since the description of these other features is to be considered only in (hypothetical) contexts in which a situation of the first type exists it can rely upon the information given by the clause, or sentence, or bit of text, that describes the first situation type. In this regard the sequence (15) is similar to the sequence (1): In either case the second sentence serves as **further** description of a situation already partly described by the first sentence. And the relation between subordinate clause and main clause of the conditional sentence is, according to the present story, yet another instance of the same phenomenon. Evidently such an argument for accessibility does not apply to (32), for there the first sentence is used to assert that a certain situation, that characterized by the sub-DRS K_1 of (33), does **not** occur. In this case the second sentence cannot be understood as further describing the situation of the type characterized by K_1. Therefore its interpretation cannot rely on the situation description encoded in K_1, in the way it legitimately can in each of the passage (1), (15) and (28).

Whatever plausibility these informal considerations may have, some have found them less than satisfactory. However, *Chierchia & Rooth 1985* have shown that it is possible to do better: Even if we allow the construction rule for pronouns to link the it of (34) with the reference marker y, so that the DRS could be completed to one of the form

(35)



the truth definition will, when suitabley reformulated, filter such a DRS out as uninterpretable. The reason is that an assignment for the markers x, z, v fails to determine a satisfaction value for the condition v = y. [18]

Unfortunately a purely semantic account of these anaphoric phenomena (such as the possibility of an anaphoric link between **it** and **a donkey** in (1), (15) and (28), and the absence of this possibility in (32)) does not seem possible. For instance such an account cannot explain why anaphora is entirely felicitous in (28) but not, or barely, in

(36) Zelda adores it if she owns a donkey.

in which main clause and if-clause appear in reverse order. It is not clear to me whether this difference between (28) and (36) is due to a difference in syntactic structure or a manifestation of a certain left-right asymmetry that should be accounted for at the level of DRS construction. But in any case the difference appears to be one of form, not meaning. So neither the strategy of *Chierchia & Rooth 1984* nor the informal considerations of *Kamp 1981* could explain it. [19]

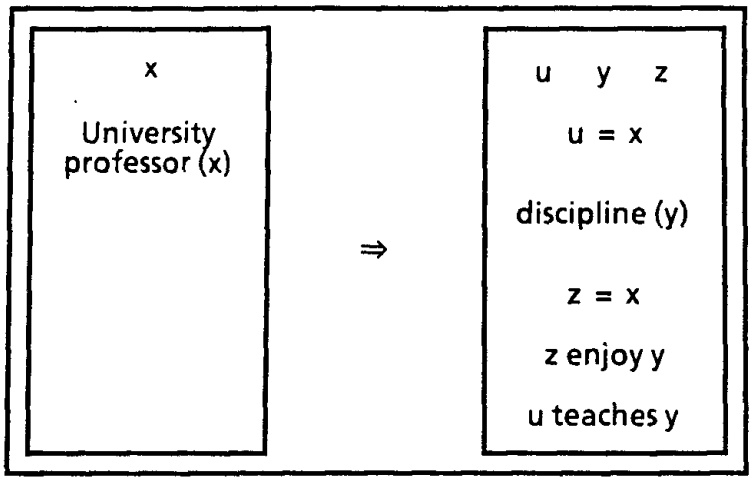
11.

Text fragments beginning with **Suppose that** are not the only ones that require a hypothetical interpretation. Another type of passage which produces a similar effect is that which begins with **Take a** or **Consider a**, as in

(38) Take a University professor. He teaches a discipline he enjoys. He teaches no more than six months out of twelve, and when he teaches he teaches at most 6 hours a week.

Such a text also conveys a generic claim, one to the effect that any typical university professor accomplishes his duties in the manner described in the second, third and fourth sentence. In (38) the first sentence provides once more the antecedent-DRS of the complex condition that should represent the entire passage and the remaining sentences supply the consequent-DRS. The structure induced by the first two sentences should look like:

(39) [20]



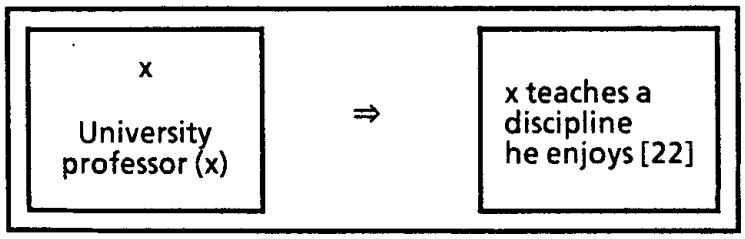
Once again it won't make an attempt to state the principles of discourse processing that would determine which sentences are to go into the antecedent part of the complex condition and which into the consequent part. In fact, my only reason for mentioning this particular form of discourse is to draw an obviuos parallel: Just as the sentence sequence (15) is synonymous with the single conditional sentence (28), so the first two sentences of (38) are together largely equivalent in meaning to the single sentence

(40) Every university professor teaches a discipline he enjoys.

We can moreover, articulate the relation between (38) and (40) in a manner reminiscent of that in which I described the similarity between (15) and (28). The first sentence of (38) can be thought to result from combining the words **take a** with the common noun phrase **university professor**. It invites the addressee to contemplate some arbitrary satisfier of that common noun phrase. The second sentence of (38) then asserts that this abritrary satisfier also satisfies some further condition. In the single sentence (40) the two functions are combined, and the combined functions are indicated by the particle **every**. [21]

It is straightforward to state the construction rule which deals with NP's of the form '**every N**' and which yields the correct semantic results. Ignoring the fine points of a strictly formal statement we may describe the new rule as follows: Suppose the rule is applied to a clause or condition of the form 'X every N Y'. Then it calls for the choice of a new reference marker, x say, and for the introduction of a complex condition $K_1 \Rightarrow K_2$, where K_1 is obtained by placing x into U_{K1} and introducing N(x) as its only condition; K_2 has an empty universe and has for its only condition X x Y. Applying this rule to the sentence (40) we obtain

(41)



As noted already in Section I the truth conditions we have associated with DRS's such as (39) and (41) are more appropriate to the sentence (40) than they are to the first couple of sentences of (38). Only (40) has the strictly universal interpretation which our truth definition captures; (38), in contrast, has the kind of generic meaning to which the truth conditional approach is inadequate.

Up to this point we have covered essentially the same ground as *Kamp 1981*. In what follows I want to discuss some issues relating to conditionals and universals that have been though to pose special problems for the kind of theory that I have sketched here. The first of these is so-called 'generic' use of indefinite descriptions.

12.

Whereas (40) does not quite coincide in meaning with the first two sentences of (38) there does exist a single sentence which would seem to capture the sense of that sentence pair exactly. This is the sentence

(42) A university professor teaches a discipline he enjoys. [23]

(42) should yield a DRS that is, barring minor details, like (39) and (41). It is not hard to form a plausible idea as to how such a DRS might be constructed; but it is equally easy to see that it cannot be obtained with the means of DRS-construction of which we have availed ourselves so far. What seems to be needed is an additional rule for dealing with NP's of the form 'a N', a construction rule which treats these NP's in the same way as the **every** rule treats the NP's to which it applies. Stating such a rule is, given what has gone before, a triviality; but the matter of its application is not. In fact the adoption of this second rule for a-phrases gives rise to a complication we did not yet encounter in this paper: how is one to choose between two construction rules each of which may be triggered by the same syntactic principle? The particular instance of this problem we are facing here - How do we distinguish the uses of indefinites from their non- generic uses? - is closely related to the problem of how one recognizes the sentences in which the indefinite occurs as a generic sentence. And this is part of the larger problem how sentences are recognized as generic sentences generally. I touched upon this larger problem already in Section I, where I implied that I do not have, and doubt there exists, a satisfactory solution to it at the present time. But even if we had a solution to that problem that would not give us automatically a solution to the present one. For the matter of deciding whether an indefinite description is to be interpreted as a generic or as a non-generic indefinite isn't always simply that of deciding whether the containing sentence must be given a generic reading. Even after a clause has been identified as generic it may still be an open question which of the indefinite NP's that it contains are to receive a generic and which a non-generic (existential) interpretation. Compare for instance

(44) A serious student appreciates a good dictionary.

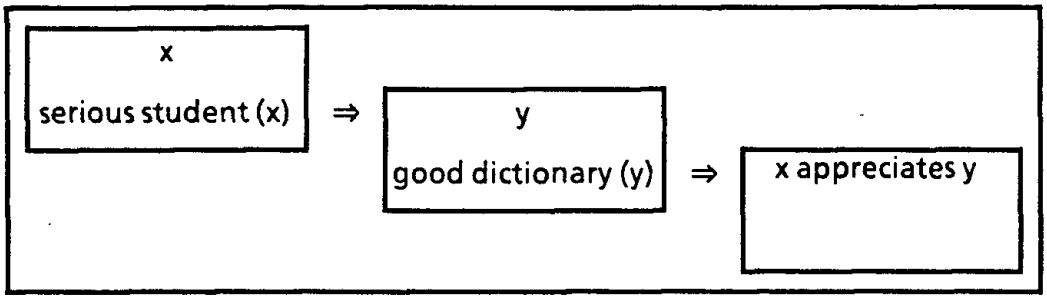
and

(45) A serious student owns a good dictionary.

The first is naturally interpreted as expressing that between serious students and good dictionaries there typically obtains the relation that the former appreciates

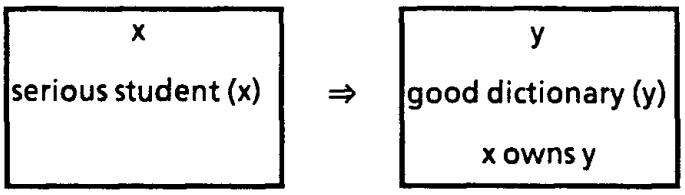
the latter. In contrast the most plausible interpretation of (45) is that serious students typically have the feature that they own a (that is: at least one) good dictionary. To obtain DRS's for (44) and (45) that would capture, or at least approximate, these readings we should apply the rule for generic indefinites to both subject and object of (44), but apply it in the case of (45) only to the subjec, while treating its object with the help of opur original rule for indefinites. In this way we would obtain, respectively

(46)



and

(47)



The contrast between the readings we are prone to assign to (44) and (45) in spite of their similarity is indicative of the difficulties which must be overcome by any attempt to articulate the principles that govern the choice between these two rules. The absence of precise canons for deciding between them is, it must be conceded, a non-trivial shortcoming for DR theory as it stands. One can only hope that future research may discover how to fill this gap.

Bad as this may be, it is not as bad as some thought it to be. Once or twice I have come across the contention that in connection with the account DR theory whishes to offer of the donkey problem the need to acknowledge generic uses of indefinite NP's and adopt a special construction rule tailored to this uses is embarrassing (an embarrassement that is heightened by the absence of a proper procedure for choosing betwen the two rules). 'For', so goes the argument, 'once one

acknowledge the occurence of generic indefinites anyway, why then not account for the indefinite antecedents of the donkey pronouns as generics also?'

The answer is: 'You can't!' First a piece of circumstantial evidence. It is generally possible to replace in the relevant indefinite descriptions of the typical donkey sentences, such as (28), - and the same applies to multisentential hypothetical passages such as (15) - the indefinite article **a** by the determiner **some** without appreciable change in meaning. But a similar substitution in simple generic clauses like (42), (44) or (45) alters the meaning radically, turning them from generic into existential claims.

There is however also a more formal reason why the indefinites of (15) and (28) cannot be treated as generic. Or, at any rate, why they could not be treated with the help of the construction rule we specifially introduced to deal with generic indefinites. To show that subjecting the indefinite of, say, (28) to that rule would yield the wrong result, I have to clarify a matter about which I have thus far failed to be fully explicit. In footnote 18, I noted that the reference markers proper names and some other NP's must go into the universe of the main DRS even if the NP itself stands at the point when the construction rule applies to it, within some subordinate DRS. This is a principle that distinguishes these NP's from other's, and in particular from indefinite NP's: An indefinite, as the DRS's for (15) and (28) illustrated already, introduces a reference marker into the universe of the very sub-DRS that contains the condition as constituent of which it is treated.

The rule for generic indefinites must be similarly restricted as regards the position that the marker it introduces can come to occupy. We already saw, in (46) and (47), that the rule introduces into the DRS containing the condition to which it applies a comlex condition $K_1 \Rightarrow K_2$ where U_{K1} contains the new reference marker. This principle, that the new condition K1 $\Rightarrow$ K2 replaces the condition to which the rule applies, holds true not only when the old condition is one of those of the main DRS, but equally when it occurs in a subordinate position.

To appreciate that the rule should be given in this form consider sentences which contain generic indefinites in subordinate positions. An example is the following conditional

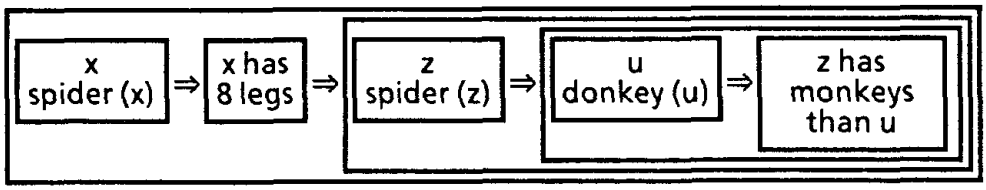
(48) If a spider has eight legs than a spider has more legs than a donkey.

Here both antecedent and consequent are naturally understood as generic clauses and their subjects as generic indefintes.

(Indeed, substitution of **some** for **a** leads to a radical change of meaning here.) By applying the rule for generic NP's to each of the two indefinites we obtain for

(48) the DRS (49), which (if we ignore once the difference between generics and strict universals) assign the right meaning:

(49)



It is worth nothing in this connection that a generic indefinite in the antecedent of a conditional cannot act as anaphoric antecedent to the pronoun **it** in the consequent. To see this compare (48) with

(50) If a spider has eight legs than it can run fast.

True, this sentence has a reading in which **it** is anaphoric to **a spider**. But according to that reading **a spider** is not generic in the sense in which it is generic in (48): the antecedent of (50) is no longer understood as making a general claim about spiders; it only states some conditions which enter as hypotheses into the generic claim that is made by the sentence as a whole.

13.

The dilemma illustrated by a pair of sentences (44) - (45) can be rephrased as follows. Suppose a sentence is recognized as having a conditional aspect. Then it is still a further question which parts of it are to be understood as belonging to the antecedent and which to the consequent. (44) and (45) illustrate the problem in so far as the descriptive content of the object phrase ends up as antecedent in the one case and as part of the consequent in the other; and as we saw, it is far from easy to articulate (in a way that is general enough to be of theoretical interest) what is responsible for this difference.

This problem, of how to devide the semantic material of a sentence between the antecedent and consequent parts of its logical form, arises not only in connection with indefinite descriptions, but with various other sentences forms as well.

Consider

(51) Siegfried gambles in monte Carlo.

This sentence can either mean that Monte Carlo is where Siegfried gambles, i.e. that when he gambles he does it in Monte Carlo; or it can mean that this is what Siegfried does in Monte Carlo: When he is in Monte Carlo he gambles. In spoken language the two readings are clearly disambiguated by the stress pattern.

(52) Siegfried gambles in Monte Cárlo.

unequivocally has the first interpretation, and

(53) Siegfried gámbles in Monte Carlo.

the second.

This is an ambiguity that we find not only in connection with generic sentences such as (51) but also with sentences containing frequency adverbs (**always, usually, sometimes**, etc.). [24]

The problem that generality and conditionality pose for an algorithmic theory of language interpretation is thus even more complex that we noted in Section I. Not only are we at present without an exhaustive analysis of what determines when a sentence must be understood as containing a conditional element, e.g. as we find it in generic, but not in non-generic readings of simple clauses; we also lack a satisfactory account of how those sentences that have been recognized as in some way conditional in meaning are to be separated into the two halves into which every conditional divides. Conditional sentences and the simpler sentences containing **every**-phrases are among those sentences with a conditional meaning component in which this division is clearly indicated by syntactic form. But it is important to keep in mind that because of this they constitute the less problematic cases of a much larger semantic class. [25]

14.

This is a paper about conditionals. And indeed conditionals have been virtually the sole subject of discussion. The only time I have spoken of sentences of discourse that did not have a conditional meaning was in the early parts of this section where the basic ideas od DR theory were explained in relation to "cumulative" texts such as (1), whose semantic analysis seemed to the inherently simpler than that of sentence sequences whose interpretation involves an element of conditionalization.

The reason why sentences and discourses of the former kind seem to present fewer problems to the kind of analysis I have proposed here is, I presume, clear from all that has been said in this section. Even so, I want to elaborate a little on

this point, and at the same time present it from a perspective that has emerged only gradually as we went along. Compare the single sentence

(56) Zelda owns a donkey she adores.

with the two-sentence discourse

(57) Zelda owns a donkey. She adores it.

The information provided by (57) falls into two easily separable parts, that conveyed by the first sentence and that conveyed by the second. However, for the truth conditions of the resulting DRS it is immaterial what information stems from the first sentence and what from the second. By the same token, no matter how one would divide the parts of (56) into a 'first' and 'second' component the truth conditions of the whole will thereby not be affected. For, as far as the truth conditions are concerned, all parts and up as conjuncts of the same representation anyway.

Thus the division that is crucial to the meaning of sentences which have conditional meaning components is something which we may apparently ignore when the different information components contribute to the whole as conjuncts. It should be noted however that this apparent simplicity of such sentences and texts is, for all we can tell an artefact of the preoccupation with conditions of truth which has dominated formal sentences in recent years.

When we study the behaviour of sentences within the context of cohesive discourse - and after all, that only in this direction there is hope for a satisfactory theory of meaning is a view to which DR theory explicitly subscribes [26] - we find that the division between 'old' (or 'known', or 'presupposed') and 'new' (or 'unknown', or 'asserted') information is relevant to the interpretation of almost every sentence, not just of those which have a universal or conditional meaning component. We find this to be true, in particular, for many sentences of what I have been calling the existential conjunctive type. Moreover (although this must at present time remain a speculation on my part) it appears that the lines along which those sentences are divided into 'old' and 'new' parts are similar to those along which sentences with conditional interpretation are divided into antecedent and consequent. Whether, and to what extent this is so further investigations will have to tell.

I want to conclude this paper with a more modest observation, but one which alos points to the conclusion that the difference between existential-conjunctive and universal conditional sentences ought not to be overstated. In fact, the description I just gave of the difference is in general not even tenable. For, and this,

is precisely the observation I want to make, there are sentences which are neither unequivocally of the one nor unequivocally of the other type, but rather, ambiguous between an existential-conjunctive and a universal-conditional reading. The contrasting pair consisting of the sentences (44) and (45) should already have alerted us to the fact that such sentences exist. True, (44) and (45) have themselves only readings that envolve conditionalization on at least one level. But they suggest that it should not be too hard to construct, using roughly the same recipe, sentences that are ambiguous in just the relevant sense. Here is a sentence that seems to me to display just that ambiguity:

(58) Zelda prefers a friend of mine to a friend of yours.

A related, though slightly different ambiguity can be found in a sentence type to which I have so far paid no explicit attention, although it is very close to the **if ... then**-sentences which have been prominent in this paper. These are sentences which have not an **if**-, but a **when**-clause. Almost all of what I have said about sentences with **if**-clauses is also applicable to sentences with subordinate clauses that begin with **when**. But there is nevertheless an important difference between them. Sentences with **when**-clauses are often ambiguous in a way sentences with **if**- clauses never are. The ambiguity is one which manifests only in the past or future tense - **when**-sentences in the present tense allow only for one, generic, reading. But provided the tense is past or future the ambiguity arises very commonly. By way of example, consider

(59) When Siegfried visited her Zelda was happy.

(60) When you go and see her she will be cheerful enough.

(59) can be used both to express a universal position: that Zelda was happy on each occasion on which Siegfried paid her a visit, and an 'existential' one: on some particular occasion - identified, perhaps, with the help of further contextual information - when Siegfried visited Zelda she was happy. (60) is equivocal in the same way. [27]

As I already said the ambiguity of sentences with **when**-clauses is not altogether the same as the one exemplified by (58). The difference is this: An indefinite description carries with the presupposition that what is being spoken of is novel to the recipient - this is one half of the familarity distinction between definite and indefinite NP's. Definite descriptions, on the other hand, and this is true of definite noun phrase in general, presuppose that their referents are already familiar, that the recipient can identify the referent uniquely from the information which NP gives him.

The distinction between novelty and familarity that divides the noun phrases neatly into the two categories of indefinite and of definite NP's is also of importance in relation to certain subordinate clauses - in paticular clauses which begin with a temporal conjunction such as **after**, before or **when**. But it does not apply to these clauses in quite the same way in which it applies to noun phrase. When a sentence containing such a clause is interpreted generally the subordinate clause functions much like an indefinite. But when the sentence remains a non-generic interpretation then the subordinate clause seems to function more like a definite noun phrase. Consider for instance our sample sentence (59). When this sentence is taken generically the **when**-clause is understood to range over arbitrary visits (within perhaps some contextually determined interval of past time). But when the sentence is given a non-generic interpretation it is typically taken as referring to some particular visit. If, in actual fact, Siegfried visited Zelda more than once then the interpreter will rely upon the context and the indexical or anaphoric mechanisms associated with tense to pick out a particula visit; or at least he will assume that the context could be expioited to yield one. This marks a difference between (58) on the one and (59) and (60) on the other hand. Whereas (58) is ambiguous between a generic and an **existential** reading, (59) and (60) are ambiguous between a generic and what, for lack of a better word, I will refer to as a 'definite' interpretation. Although (59) and (60) differ in this particular respect from (58) there is nonetheless also an important similarity between them. What they have in common, and what matters for the general issue this paper has made an effort to address, is best explained in connection with (59) and (60). It is evident that the information contained in the **when**-clauses of (59) and (60) is needed to arrive at a satisfactory interpretation of their main clauses. But it is also evident that this information enters into the information of the main clause irrespective of whether the sentence receives a generic or a definite interpretation: The way in which one part of the sentence provides contextual information for the interpretation of the other part is independent of the future question how the interpretations of those two parts are understood to be connected.

We have here yet another instance of the general principle that served as our starting point in this section: the principle that the rules of context-independent interpretation are orthogonal to those that distinguish between e.g. conditional and non-conditional interpretations. This general principle has already received so much attention in the preceding pages that it does not need, I trust, the additional support of this last illustration. There is one point, however, which may not have been fully transparent so far, but which (59) and (60) make quite clear. To interpret

a sentence correctly it is often necessary to know which parts should serve as contexts for the interpretation of which order parts; one must in these cases be able to divide the sentence into an 'old' and a 'new' part, and this as (59) and (60) show, may arise irrespective of whether the sentence serves a conditional, universal or generic interpretation.

From the vantage point of a theory which accounts for these divisions into 'old' and 'new' systematically the partition into antecedent and consequent part, which according to the present theory is the mark of conditionalization, may well come to appear as a special case of a more general phenomen. I should have liked to sketch at least the beginning of such a theory. And I hope that I may one day be able to make some contribution to it. But I am aware how much work will have to be accomplished before even the scaffoldings of such a theory can be erected. We would, for instance, need a much better understanding of such important but elusive notions as 'topic', 'focus' and 'component'. We have, in other words, come to a point from where the going will be much rougher than the journey hither.

ACKNOWLEDGEMENT

This paper arose out of an attempt to write comments on Tania Reinhart's contribution to the volume in which it was originally meant to appear: *A.G.B.Ter Meulen & E.Traugott (Eds.)*, **On Conditionals**, (to appear in *1986*). In the end the editors thought it preferable that those comments should appear elsewhere (a judgement with which I concur). Therefore all direct references to Reinhart's paper were eliminated from the present essay. However, I hope that it will nevertheless be plain to those who read both her paper and the present one, what connections exist between them. In an elaboration of the original draft of this essay, I will try to make these connections much more explicit, addressing in particular the question of how the mechanisms for dealing with pronoun binding and anaphora proposed by Reinhart compare with those offered by the theory sketched here. These issues are only tangentially connected with the analysis of conditionals as such.

I almost finished this paper in the summer of 1985, or so I then thought. Barbara Partee, the most perceptive as well as the most constructive of all critics, made it clear to me that I was mistaken. In the end it was not until the summer of 1986 that I was able to work on the paper again, by which time the last deadline for the collection **On Conditionals** had passed. I am grateful to the editor of the present volume for his willingness to give shelter to the manuscript after it had became homeless.

The present version is substantially different from the draft which has been circulating inofficially for some time. In particular, it is without the original Section III, which tried to address the question whether familiar donkey sentences carry elements of uniqueness. This seems implied in the analyses proposed by Evans and Cooper, but is ignored in the existing treatments within File Change Semantics and Discourse Representation Theory. I have been persuaded to turn that part into a separate paper, and also to rework it thoroughly.

I presented parts of the earlier version at a workshop on semantics at the University of Massachusetts, Amherst, in August 1985 and profited from the comments of several of those present. I would like to mention, in particular, Craige Roberts whose paper on Modal Subordination is a decisive contribution to our understanding of conditionals in natural language and which has influenced my thoughts on several issues that are closely related to those discussed here. None of the points the present paper attempts to make coincide fully with the concerns of

modal subordination. But the issues are closely intertwined and I reckon I may be more indebted to Roberts' work than I am myself aware of.

Shortly before the present version was written, I have benefitted considerably from the comments of Frank Veltman. Only once the paper was virtually completed did I have the opportunity to read Strigin's paper 'Eine Semantik für generische Sätze', which deals with the analysis of generic sentences within DR theory. I would have liked to give that paper its proper due, but found that too many changes in the nearly complete draft would have been necessary to do so in an adequate way. This is a shortcoming for which I am hoping to make up later.

Originally, this paper was prepared as a report to the Fraunhofer-Institut für Arbeitswirtschaft und Organisation.

FOOTNOTES

[1] In fact, this second analysis of quantification becomes inevitable when we consider determiners such as **most** which Frege chose to ignore; and for this reason, it has become the generally accepted model of quantification in the contemporary theories of generalized quantifiers. See e.g. *Barwise & Cooper, 1981; Keenan & Stavi* (forthcoming); *van Benthem, 1984; Zwarts, 1983.*

[2] It is a moderately amusing fact that in the presence of a necessarily false constant $\underline{\perp}$ only one of the two place quantifiers $\forall^2$ and $\exists^2$ suffices as a basis for the entire set of quantifiers and connectives of standard logic. Thus $(\forall^2 x)(\phi, \perp)$ can serve as definition of $\neg\phi$ provided x does not occur free in ϕ. With the defintions of -> and & we already gave in (9) this provides a set of operators from which the remaining ones are definable in familiar ways. For this parsimonious set of primitives we can formulate correspindingly simple deduction systems. For instance, adopting the style of natural deduction (e.g. that of the system by *Lemmon, 1965*) we can make do with the following rules:

(I) $$\frac{(\forall^2 x)(\phi(x), \psi(x)) \quad \phi(a)}{\psi(a)}$$

(II) $$\frac{\begin{bmatrix}\phi(a)\\ \psi(a)\end{bmatrix}}{(\forall^2 x)(\phi(x), \psi(x))}$$

(III) $$\frac{\underline{\perp}}{X}$$

(VI) $$\frac{\begin{bmatrix}(\forall^2 x)(\phi\underline{\perp})\\ \underline{\perp}\end{bmatrix}}{\phi}$$

In (I), the conclusion depends on everything on which the two premises depend. Similarly, in (III) the conclusion depends on all the lines on which depends its only premise. (II) is a rule whose "premise" is a subsidiary derivation, rather than a simple line. The explicitly mentioned premise rather

than a simple line. The explicitly mentioned premise of this derivation must be an assumption. In the transition from the conclusion of the subsidiary derivation, ψ (a), to the conclusion obtained through applying the rule (II), i.e. To $(\forall^2 x)$ ($\phi(x)$, $\psi(x)$), the lines in which the former depends are retained excpt for the asssumption that $\phi(a)$. The rule may be applied, moreover, only if a does not occur in any of the lines, other than the assumption $\phi(a)$, in which $\psi(a)$ depends. (IV) is similar to (II). Here the conclusion depends on the subderivation involviNg $(\forall x)$ (ϕ, $\underline{\perp}$) and $\underline{\perp}$. Again $(\forall x)$ (ϕ, $\underline{\perp}$) must be an assumption and, the conclusion ϕ depend on all lines on which the subsidiary conclusion depends$\underline{\perp}$, with the exception of that assumption. Furthermore x should, in the case of IV, not occur free in ϕ.

[3] Parallels that suggest themselves are the translation from syntactic analyses to intensional logic formulae in Montague Grammar and the transition from S-structure to LF in the theory of Government and Binding. But as we will see there are important differences what is needed in DR theory and the conversion procedures specified in these other theoretical frame works.

[4] For explicit statement see *Kamp 1981*; or the forthcoming 'SID Without Time or Questions'. CSLI Report. To appear 1986.

[5] I feel somewhat apologetic for so much repitition in print. However, I have over the past four years found no alternative examples that work as well. So I will simply reiterate what some readers may already have seen (nearly word for word) elsewhere. They should have no difficulty, I trust, in picking up the thread of the argument at the point where things begin to look less familiar.

[6] If I am using in many of the example that will appear below proper names which have become like signature tunes in the work of Tania Reinhardt, this is not just a hangover from the earlier version, (which as I said was consciously written as a commentary on a paper of hers). It is meant as a tribute to the important contributions she has made to our understanding of syntactic constraints on pronoun interpretation, and many other, related matters.

[7] To my knowledge these structures are not disputed: All substantive theories of generative syntax with which I am familiar seem to agree on the basic tree structures of sentences as simple as those in (1). For more complicated sentences, however, this will no longer be true: when one wants to apply DR theory to those sentence one is faced with a significant choice of underlying syntactic theory.

[8] The importance of this choice is often limited, as the particular syntactic analysis one opts for has no effect on the resulting DRS's, and only superficial

consequences for the form of the construction algorithm. Yet, the relation between DRS-construction procedure and underlying syntax raises important questions which require careful study. Important observations on the relationship can be found in *Roberts 1984*.

[9] *Kamp 1986* uses, following *Karttunen 1976*, the term 'discourse referent'. 'Reference marker' was suggested to me by Barwise and Perry, who pointed out that the word 'referent' evokes misleading associations. The term 'discourse referent' however persists, and I have been among those guilty of using the two expressions interchangeably.

[10] A situation, in other words, which instantiates the abstract situation they denote as <donkey, b, 1>, <own, Zelda, b, 1>.

[11] By a **model** I understand here a model for predicate logic which provides extensions for the relevant predicates, i.e. The 1-place predicate 'is a donkey' and 'is the bearer of the name 'Zelda''. and the 2-place predicate 'owns'. As DR theory gets applied to larger fragments of natural language it requires for the evaluation of its DRS's models of complexity. We will see the first signs of this later on this paper. Compare in this connection also *Kamp 1981*.

[12] If we extend the role of DRS's along these lines we can no longer see them as just characterizations of the contents of sentences and texts. Rather, they should now be considered characterizations of contextually relevant information generally. It is only one step from this to the notion that such DRS's can be used to characterize the actual belief state of the recipient. Taking this step leads to an extension of the DR theory that appears to be very fruitful not only in connection with various problems in the theory of reference, but also as the basis for a theory of the logic and semantics of propositional attitudes. (See e.g. *Asher 1987*; *Kamp 1985*; *1986*.) Though it is of some importance to keep this extension of the theory in mind, if only to better appreciate its underlying motivations, the extension itself will play no role in this paper. Nor will I have anything more to say in these pages about the phenomenon of deixis.

[13] As in *Kamp 1981* I will make one exception to this working principle. I will distinguish the available markers into those that are accessible (from the position of a given anaphoric pronoun) and those that are not.

[14] In written language one often uses the colon to indicate that there exists such a causal or explicative connection between the sentences it separates.

[15] Note that the reference markers x and z, which are introduced for the proper names 'Zelda' and 'Siegfried', occur in the universe of the main DRS, not

those of the sub-DRS's that make up the complex condition of (27). This is a general principle: The reference markers for proper names (and certain other 'definite' noun phrases such as deictically used pronouns and demonstratives) always end up in the universe of the main DRS irrespective of where the NP occurs at the point when it yields its marker. This principle reflects the intuitive notion that the referents of such NP's are fixed independently from all other components of the sentences or discourse in which the NP occurs. The construction rule for proper names I gave earlier must be reformulated so that the markers it introduces always end up in the universe of the main DRS. In view of this correction some of the earlier DRS's would need slight modifications. In (16) for instance the marker x should also be at the top rather than in the first of the two subordinate DRS's. See *Kamp 1981* and *Kamp 1986* for more extensive discussion.

[16] Using the adjusted construction for proper names. See preceding footnote.

[17] There are also somewhat more respectable reasons for bypassing these problems here. First, were we to go into them we would also have to enter into the complex problem of how to treat tense and aspect. In fact, a detailed account of tense and aspect within DR theory is now taking shape. (*Kamp & Rohrer 1983*; forthcoming) However, the complexities of that account are quite forbidding; even a sketch that would confine itself to those points that are relevant to the treatment of conditionals proposed here woulf take up a disproportionate amount of room. Second, we could hardly avoid the question what construction rules should be appropriate for other types of subordinate clauses (e.g. those beginning with **after, because** or **although**). But at the present time it is only for temporal conjunctions, such as **after**, that this problem has been seriously considered. As long as these matters have not been investigated more carefully the details of the treatment of conditionals I have sketched here cannot be taken as definitive. However, the central claim DR theory makes about such sentences is not, I think, dependent on the final word on the syntax of conditionals. For whatever that will turn out to be, it cannot alter the necessity that at some point in the syntactic generation of the conditional the **if-** or **when**-clause will have to be joined to the main clause. The syntactic principle that effects this combination can always be made to trigger the introduction of the complex condition $K_1 \Rightarrow K_2$.

[18] In *Heim*'s theory (*1982*) this way of explaining accessibility phenomena was built into the theory from the beginning.

[19] Such left-right asymmetry in the relation between anaphoric pronouns and their antecedents may seem unsurprising. After all it would seem plausible that when the pronoun comes before its intended antecedent it also has to be processed before that other NP and thus the construction step which deals with the pronoun cannot yet take advantage of the marker which that NP will eventually yield. Unfortunately this explanation cannot be quite right as it stand, for it would predict that, for instance.

(3) Zelda will be very angry with him if Siegfried doesn't apologize.

does not admit of a reading which interprets **him** as anaphorically linked to **Siegfied**. But such a reading for (37) seems perfectly acceptable.
Here is a conjecture of why there is this difference between (36) and (37). when a promoun is interpreted, some independently available reference marker must be found which can provide for its reference. Now, both in the case of (36) and in that of (37) the marker that comes directly from the putative antecedent won't be available at the point where it would be needed for the interpretation of the pronoun. However, it is a common 'back up' strategy in interpretation to hypothesize, in cases where the context initially does not permit the construction of a satisfactory reading for the expression you are trying to make sense of, that the speaker must have been presupposing a different context than the one you took yourself to be in, one which **would** make it possible to assign a reasonable interpretation to his utterance. In particular, when you try to interpret a pronoun, and the assumed contect does not contain a reference marker that can provide a suitable referent, you are inclined to assume that the context presupposed by the speaker is distinct from your own and that this conext does contain such a marker. You may then provisionally introduce a marker into your own context DRS and use it as 'antecedent' for the pronoun even though you have so far no further information about that marker, on the assumption that further information will presently become available. Such provisional interpretation procedures appear to be tolerable so long as the uncertainties they introduce are quickly resolved. In (37) the definite noun phrase **Siegfried** which follows immediately (it is even part of the same sentence!) can provide this resolution. But in (36) the situation is different. By using an indefinite NP (viz. **a donkey**) the speaker indicates that the element he thereby introduces is **not** yet part of the context. (This is the so-called 'familarity-novelty' contrast between definite and indefinite noun phrases. See in particular *Heim 1982*.) Therefore the marker for the

subsequent NP **a donkey** cannot be the same as the marker which the interpreter provisionally introduced to provide a link for the pronoun. For the latter must have been part of the intended context at the point where the indefinite is and the former must be distinct from all markers which that context contained. It is an interesting question to what extent differences such as that between (36) and (37) can be accounted for by explanations of the sort attempted here, and to what extent they derive from syntactic constraints for which there is no obvious further semantic or pragmatic underpinning. More about this and similar questions will be found in *Kamp 1986*.

[20] The construction of (39) involves one further construction principle which we have not yet considered in this paper. It concerns noun phrases that contain restrictive relative clauses. Intuitively the descriptive content of such an NP has the form of a conjunction of two predicates, one given by the head noun and one by the relative clause. Accordingly, when such an NP is processed its content yields two conditions, one representing the content of the head and one representing that of the relative clause. There are several ways of formulating the construction procedure for such complex NP's, which all yield this same final result. For one way see *Kamp 1981*. As this issue is tangential to the concerns of the present paper, I omit the details.

[21] It might be objected that the relation between (38) and (40) differs from that between (15) and (28) in so far as the second sentence of (38) contains the pronoun **he** needed to 'pick up' the arbitrary satisfier introduced by the first sentence, while (40) contains no such pronoun. In contrast no corresponding anaphoric element seems to be present in the second sentence of (15). Even if the observation made in this last sentence were correct this would not, I think, seriously affect the point of the parallel. But in fact I am not certain that the observation is valid. For it is arguable that the word **then**, which typically initiates the consequent-part of hypothetical passages such as (15), has an anaphoric function not unlike thaat of **it** in (38). (Note in this connection that **then**, as it is used in (15), seems to have just the same effect that would be carried by **in that case** were it to occur in the same position. The anaphoric role of this latter expression is a special instance of the evident fact that demonstartives can play an anaphoric as well as deictic role. (See e.g. *Kamp 1985*.)

[22] In the present application X = ∅ and Y = **teaches a discipline he enjoys**.

[23] More naturally in this case would probably be the corresponding bare plural

(43) University professors teach disciplines they enjoy.

Which generic sentences sound more felicitous when their generic terms occur in the plural, and which are better, or equally good, with singulars, is a matter I do not understand. Since the treatment for plurals (in DR theory or elsewhere) is a highly complicated matter that raises a number of difficulties orthogonal to the theme of this paper, I have decided to confine attention to sentences containing only singular NP's - even where this leads, as in the case under consideration, to some strain.

[24] The phenomenon seems moreover closely related to ambiguities that one finds in sentences containing such particles as **only**, even, still and a few others. Consider e.g.

(54) Siegfried { only / even } introduced Zelda to Rósa

as opposed to

(55) Siegfried { only / even } introduced Zélda to Rósa

A thourough and perspective treatment of these pehenomena can be found in *Roth 1985*.

[25] Rooth's dissertation, mentioned in footnote 24, develops a mechanism for deriving the division fromfacts about syntactic structure and, although this is not made entirely precise, phonological aspects such as stress. That mechanism does not help with the decisions that have been made to arrive at the intuitively preferred readings of (44) and (45). Indeed we could not expect it to help with the problem these sentences present, for the choices we make in interpretating them are evidently determined by lexical differences. However, these are not the only cases in which Rooth's theory doesn't determine how the choice is to be made. The phenomenon according to which a sentence requires for its interpretation that the information it contains be divided into two halves turns out to be very common and compatible with a wide variety of syntactic structures. The general question of how we are able to partition the information the sentence contains in all cases where interpretation demands such a partition appears to be one of the considerable complexity, and for which it may well turn out to be possible to give a single unified solution.

[26] The view that this is the direction in which semantic theory should move is of course by no means new. Among the many who have defended it should

mention in particular the members of the Prague group - Renesova, Hajicová, Sgall - among others, in whose work this conviction has occupied an especially prominent place.

[27] The ambiguity of certain **when**-sentences is in more than one way peculiar to English. First there are languages, such as German or Dutch, which require different particles for the universal and the existential prepositions (German: **wenn** (universal) - **als** (existential); Dutch: **wanneer** (universal) - **toen** (existential). Moreover, in certain languages that have particles which match **when** in both contexts - e.g. French, which uses both **quand** and **lorsque** in these capacities - the means of disambiguation do not coincide with those available in English. Thus the French distinction between Imparfait and Passé Simple/Passé Composé disambiguates between the two readings of (59) and (60), which translate, respectively, into

(61) Quand Siegfried venait la voir, Zelda était contente.

(universal) and

(62) Quand Siegfried { vint / est venu } la voir, Zelda était contente.

Only when they are combined with the furture tense do **quand** and **lorsque** produce the same ambiguity that we noted in both (59) and (60).
Other English sentences types that are ambiguous in this manner:

(63) Last week Siegfried had bacon and eggs.

(63) too is ambiguous between a universal reading (on every day of last week Siegfried had bacon and eggs for breakfast) and an existential one (Siegfried had bacon and eggs at least once) an interpretation which we might be prepared to give to the sentence when we get it as part of a reply to an inquiry into all the things Siegfried has been eating during the past fortnight. (Imagine, if you like, Siegfried in a coma with intestinal poisoning of a quite unusual sort and a mystified medical team attending him.)
I am not sure whether there are other sentence types, significantly different from those I have mentioned already, which show this same equivocation between an existential and a general interpretation.