

## NOMINAL AND TEMPORAL ANAPHORA\*

## I. INTRODUCTION

A number of parallels between temporal and nominal anaphora were noted in Partee (1973); there I tried to account for them by invoking explicit variables over times and treating the tense morphemes *Present* and *Past* as directly analogous to pronouns. I now believe that a much better explanation of the parallels is available as the result of recent work on the formal semantics and pragmatics of temporal discourse and of pronominal anaphora. One key ingredient is the incorporation of a version of Reichenbach's notion of 'reference time' into a formal semantic framework, as developed by Bäuerle (1977) and further extended by Hinrichs (1981). In these accounts reference time is at the heart of temporal anaphora, as has been argued in less formal accounts (e.g. Smith (1978)), and the similarity between tense morphemes and pronouns can be seen as a derivative phenomenon. A second crucial ingredient is the unified treatment of pronouns provided by the theory of discourse representations of Kamp (1981a) or the 'file-card' semantics of Heim (1982). The task of unifying these advances is carried out to a large extent in Hinrichs (1981); in this study I draw heavily on the work of Hinrichs and show how it can be extended to cases of temporal quantification and temporal analogs of 'donkey-pronouns'.<sup>1</sup>

Among the data to be accounted for, described more fully in Section II, are temporal analogs of deictic pronouns, anaphoric pronouns with definite and indefinite antecedents, 'bound-variable' pronouns, and 'donkey-sentence' pronouns. The unified treatment of all these uses of pronouns provided by the frameworks of Kamp and Heim is reviewed in Section III. In Section IV I describe and slightly modify Hinrichs' treatment of tenses, adverbs, and temporal anaphora in simple linear discourse and in sentences with *when*-, *before*-, and *after*-clauses. In Hinrichs' treatment, events, processes, and states are taken as primitives rather than instants or intervals of time, following Kamp (1979), (1980) (cf. also Bach (1980), (1981)); 'reference events' are added to take over the function of earlier authors' 'reference times'. Hinrichs' overall framework fits into Kamp's theory of discourse representation structures, allowing 'discourse events' to be treated similarly to 'discourse entities'. Section V summarizes the explanation provided by these accounts for the parallels between temporal and nominal anaphora in the deictic case and

the case of definite and indefinite antecedents. In Section VI I offer an extension of Hinrichs' treatment to cover temporal quantification as represented by *whenever*-clauses and the combination of a *when*-clause with an *always* in the main clause. This extension offers an immediate account of the temporal analogs of donkey-sentences as well, completing the account of the parallels described in Section II. The final section offers conclusions and some open problems for further research.

Insofar as the resulting explanation of the parallels between temporal and nominal anaphora is an improvement over previous accounts, it supports an important shift in perspective within the tradition of formal semantics as developed from Montague's work towards a point of view which has been independently argued for from outside that tradition, e.g. by W. S. Cooper (1978), Seuren (in press), and Bosch (1983), among others. This perspective, emphasized in Heim (1982), regards semantic interpretation as a dynamic process mapping partial models plus contexts onto new partial models plus contexts, as opposed to the classical logical view of semantic interpretation as a (static) specification of truth conditions relative to a given model and a given context.<sup>2</sup> This shift in perspective and accompanying enrichment of formal 'semantics-cum-pragmatics' should make it easier for linguists and other students of language from different traditions to draw profitably on each other's insights.

## II. PARALLELS BETWEEN TEMPORAL AND

### NOMINAL ANAPHORA

In this section we review the data from Partee (1973) that suggest that there is a parallel between temporal and nominal anaphora to be accounted for. (Some of the examples have been replaced, but all the types are still represented.)

#### A. Non-linguistic 'antecedents'

Partee (1973) noted that a past tense may be used to refer to an understood particular time not introduced by previous linguistic context, as in (1a) uttered while driving down the freeway; a similar use of a pronoun can be seen in (1b) uttered as the first sentence of a conversation.

- (1) (a) I didn't turn off the stove.
- (b) She left me.

Pronouns can be used without linguistic antecedents when their referent is

understood to be salient to the hearer; there is no analog to salient physical presence with past tenses, but a particular past time can well be presently salient while one is looking at vacation snapshots or watching family movies. (Comparable 'derivative' demonstrative uses of pronouns are also common with pictures.) The past tense in these uses is like a third person pronoun; a genuinely temporal present tense in a simple sentence is like a first person pronoun in that both are 'indexical' or 'token-reflexive', normally referring to the time of utterance and the utterer respectively (but see Kratzer (1978)).

#### B. Definite anaphors with definite antecedents

In traditional treatments of anaphora, the paradigm case is that in which there is an antecedent noun phrase that refers to a particular individual, and a subsequent pronoun which refers to the same individual, as in (2a) below.

- (2)(a) Sam is married. He has three children.

There are several potential analogs for such cases in the temporal domain. listed in (2b-d).

- (2)(b) Sheila had a party last Friday and Sam got drunk.
- (c) When John saw Mary, she crossed the street.
- (d) At 3 p.m. June 21st, 1960, Mary had a brilliant idea.

In (2b) a time is specified in the first clause and the second clause is most naturally understood as referring to the same time. In (2c), we might view the *when*-clause as providing an antecedent for the past tense of the main clause. In (2d), a simple temporal adverb may be similarly viewed as the antecedent of the past tense. Postponing particulars of the analysis, it seems safe to say that in all of the temporal examples considered so far, the past tense can be viewed as an anaphoric element inasmuch as it is not understood as meaning 'at some time in the past', but as referring to some relatively definite past time, the specification of which is provided by a non-linguistic or linguistic antecedent.

#### C. Indefinite antecedents

Considerable attention has been paid in recent studies of anaphora to cases in which the antecedent of a pronoun is indefinite as in (3a), from Kamp (1981a).

- (3)(a) Pedro owns a donkey. He beats it.  
 We will say more about such cases in Section III, but for now note that the antecedent of a past tense may be similarly indefinite in the sense of not specifying a particular time, as in (3b).
- (3)(b) Mary woke up sometime during the night. She turned on the light.

The first sentence of (3a) is presumably true if Pedro owns at least one donkey, and the first sentence of (3b) similarly true if Mary woke up at least once during the night. The problem is then to say how the ‘it’ of (3a) or the past tense of the second sentence of (3b) gets its reference when the antecedent is apparently not referential but existentially quantified. (Case (2b) of the previous section might be argued to belong here insofar as the antecedent does not specify *when* on Friday the party *was*.)

#### D. Bound variables

Typical uses of pronouns as bound variables are illustrated in (4a–b); apparently comparable cases of temporal bound variable cases are given in (5a–d).

- (4)(a) Every woman believes that she is happy.  
 (b) No woman fully appreciates her mother.
- (5)(a) Whenever Mary telephoned, Sam was asleep.  
 (b) When Mary telephoned, Sam was always asleep.  
 (c) Whenever Mary wrote a letter, Sam answered it two days later.  
 (d) Whenever John got a letter, he answered it immediately.

#### E. ‘Donkey-sentences’

The famous “donkey-sentences” introduced by Geach (1962) are given (in the versions of Kamp (1981a) in (6a–b), along with possible temporal analogs in (6c–d); discussion of the problem raised and possible solutions to them is deferred to subsequent sections.

- (6)(a) If Pedro owns a donkey, he beats it.  
 (b) Every farmer who owns a donkey beats it.  
 (c) If Mary telephoned on a Friday, it was (always) Peter that answered.  
 (d) Whenever Mary telephoned on a Friday, Sam was asleep.

There is also an apparent parallel in negative data that we will account for:

- (7)(a) \*If every man owns a donkey, he beats it.  
 (b) \*If Sheila always walks into the room, Peter wakes up.  
 (cf. (b) If Sheila walks into the room, Peter always wakes up.)
- All of the data above are at this point only suggestive; we have not yet offered any arguments for giving similar analyses of nominal and temporal anaphora, and there are clearly many differences between them. In the remaining sections of the paper, we show how Kamp’s ‘discourse representation’ approach, which offers a unified treatment of nominal anaphora, if taken together with an approach to tense, aspect, and time adverbials which takes ‘eventualities’ rather than (or possibly in addition to) times as basic and incorporates the notion of reference time, provides a framework in which the parallels observed above receive a natural explanation.

### III. DISCOURSE REPRESENTATIONS

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

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

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

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

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

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

DR <sub>1</sub> (8)	$u$	$v$
	.	.
Pedro owns a donkey		
$u = \text{Pedro}$		
$u \text{ owns a donkey}$		
donkey ( $v$ )		
$u \text{ owns } v$		

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

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

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

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

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

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

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

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

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

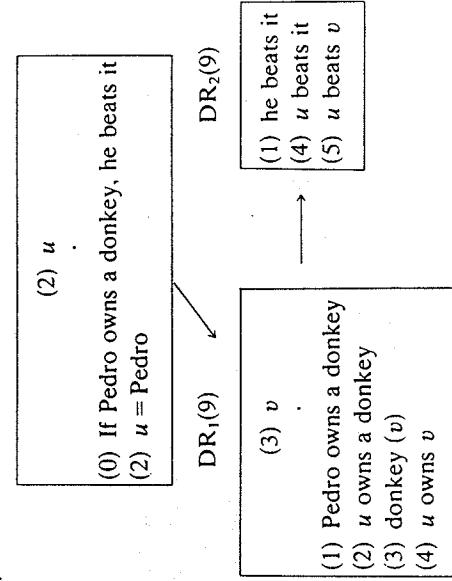
- (9) If Pedro owns a donkey, he beats it.

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

**DR<sub>0</sub>(9)** If Pedro owns a donkey, he beats it

Since the *if-then* rule was the last rule applied in the construction of the sentence, the corresponding DRS construction rule is the first to be applied. That rule creates two additional DR's, DR<sub>1</sub>(9) and DR<sub>2</sub>(9), with DR<sub>1</sub>(9) containing the antecedent clause and DR<sub>2</sub>(9) the consequent, and with the stipulation<sup>10</sup> that DR<sub>1</sub> is subordinate to DR<sub>0</sub> and DR<sub>2</sub> is subordinate to DR<sub>1</sub>. (The subordination relation that holds among DR's does not correspond directly to the syntactic notion of subordination; it does play a crucial role in determining the accessibility of discourse entities for pronoun assignment.) Each of the two DR's is then processed in the usual way, antecedent first, with the following proviso: when a discourse entity is introduced for a proper noun, it and its identity condition are placed in the top DR of the whole current DRS (making it available for assignment to any subsequently processed pronoun), but when an indefinite noun phrase is processed, the newly introduced entity is placed in the DR being processed (and therefore accessible to pronouns only in the same or subordinate DR's). The complete DRS for (9) is then as follows (from Kamp (1981a, p. 315); I have added arrows marking the subordination relation; numbers in parentheses indicate steps in the processing sequence).

DRS(9):



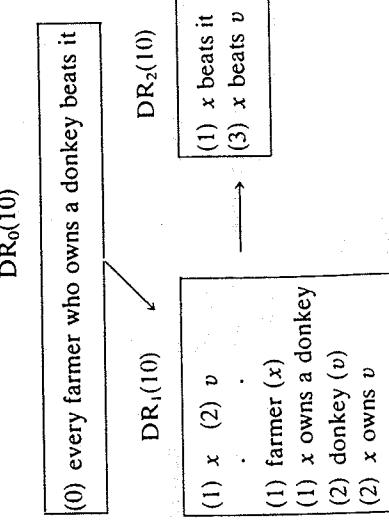
In steps (4) and (5) we are able to assign the entities *u* and *v* to the pronouns because DR<sub>2</sub> is subordinate to both DR<sub>1</sub> and DR<sub>0</sub>.

The embeddability condition for DRS's resulting from the *if-then* construction rule is roughly as follows (see Kamp (1981a) for full details of this and other rules): DRS(9) is embeddable in M if there is a mapping which satisfies the atomic conditions in DR<sub>0</sub> (i.e. which assigns *u* to Pedro) such that every extension of it which satisfies DR<sub>1</sub> also satisfies (or can be extended to satisfy) DR<sub>2</sub>.

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

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

DRS(10):



The embeddability condition for *every*-constructions is the same as that for *if-then* sentences: every embedding that satisfies DR<sub>1</sub> must be extendable to an embedding that satisfies DR<sub>2</sub>. I will refer to such DRS configurations henceforth as universal/conditional structures.

Note that while the construction of DRS's is determined (up to the

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

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

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

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

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

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

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

#### IV. THE TEMPORAL SYSTEM

For our treatment of tenses and adverbs, we draw on the work of Bach (1980, 1981) and Kamp (1979), who have argued for taking what Bach calls 'eventualities' (events and processes, and perhaps states) and relations of precedence and overlap between them as primitive, rather than starting from moments or intervals of time as primitive. (Kamp (1979) shows how moments and intervals can then be reconstructed by a technique

that traces back to Russell and to Wiener.) Hinrichs (1981) has worked out a detailed treatment of a substantial fragment of English in the framework of Kamp's discourse representation structures, focussing on the temporal structure of the past tense narrative discourse. Since Hinrichs' fragment contains much of what we need, we will use it as a starting point, describing its essentials in this section and then in Section VI showing how it could be extended to include bound variable cases and temporal analogs of donkey-sentences. As a simplifying assumption which we will follow, Hinrichs takes whole tenseless clauses as atomic, classified as activities, states, achievements, and accomplishments.<sup>14</sup> (These are respectively processes, states, instantaneous events, and extended events in the terminology of Bach (1981), which we will follow here. Our examples will just involve states and events.) He treats progressive as a sentence operator which applies to a process-sentence or an extended-event sentence and gives a new category of progressive sentence (which patterns with process-sentences and state-sentences in his rules). Past and past perfect are sentence operators which apply to any of the other five kinds, giving 'past-sentences' and 'past perfect sentences' as a result. (A more complete treatment would require paying more attention to the internal structure of verb phrases and probably treating tense and aspect as verb phrase operators (Bach, 1980).) Hinrichs' fragment also includes 'frame adverbials' (Bennett and Partee (1978)) like 'on Tuesday' and 'last week' and *when*, *before*-, and *after*-clauses.

To illustrate the general approach with an example, consider the following stretch of narrative.

- (14) John got up, went to the window, and raised the blind.  
 $e_1 \quad e_2 \quad e_3$   
 It was light out. He pulled the blind down and went back to bed.  
 $s_1 \quad e_4 \quad e_5$   
 He wasn't ready to face the day. He was too depressed.  
 $s_2 \quad s_3$

The clauses labelled  $e_1$ – $e_5$  describe events, while  $s_1$ – $s_3$  describe states. In narratives with a simple linear structure and all clauses in the simple past tense, it has been observed that the event sentences move the action forward in time, while the state sentences do not, but rather describe how things are at the time of the last-mentioned event.<sup>15</sup>

We can represent this in a DR for (14) as follows, using ' $<$ ' for the relation of complete precedence between events, '0' for overlaps and  $r_s$  for the speech time. 'John get up ( $e_1$ )' is to be understood as what signals the condition that in a proper embedding of DR (14) into a model,  $e_1$  must be

an event of John's getting up.<sup>16</sup>

DR(14)	$e_1 \ e_2 \ e_3 \ e_4 \ e_5 \ s_1 \ s_2 \ s_3 \ r_s$
.	.
.	.
.	.
.	.
$e_1 < e_2 < e_3 < e_4 < e_5 < r_s$	
John get up ( $e_1$ )	
:	
John go back to bed ( $e_5$ )	
$s_1 \ 0 \ e_3$	
$s_2 \ 0 \ e_5$	
$s_3 \ 0 \ e_5$	
It be light out ( $s_1$ )	
:	
John be too depressed ( $s_3$ )	

The main oversimplification we have made in this example is in ignoring Hinrichs' use of 'reference time' (Reichenbach (1947)). For one thing, the first sentence of the discourse is not interpretable without some understood past reference time (Partee (1973), Bäuerle (1979), Hinrichs (1981)), so we need to assume that there is a past reference time  $r_p$  specified at the start of the discourse, and that the introduction of new event sentences moves the reference time forward.<sup>17</sup> Furthermore, Hinrichs has noted that the states and processes introduced need not always be understood as overlapping the last-mentioned event, as illustrated in (15) below (Hinrichs' example (108), p. 66).

- (15) Jameson entered the room, shut the door carefully,  
 $\quad \quad \quad e_1 \quad \quad \quad e_2$   
 $\quad \quad \quad e_3$  and switched off the light. It was pitch dark around him,

because the Venetian blinds were closed.

From the fact that there are conditions requiring reference times to include events ( $e_2 \subseteq r_1$ , etc.) and to be included within states, i.e. within some period for which a given state holds ( $r_3 \subseteq s_1$ , etc.) it follows that reference times must be construed as protracted events or bounded intervals. Hinrichs construes them as events with no descriptive content stipulated, but as far as I can see we could just as well think of them as intervals for present purposes, given Kamp's way of reconstructing instant and interval structures from event structures. In any case, the embedding conditions for DR(15) will simply require that there be *some* events (or intervals)  $r_1, r_2, r_3$  which satisfy the specified ordering relations. The net effect of the ordering specifications in DR(15) is that  $e_1 < e_2 < e_3 < r_s$ , and  $s_1$  and  $s_2$  must both overlap some time 'just after'  $e_3$ ; they may but need not

DR(15) as a first illustration of the introduction of reference times; in subsequent examples we will be more explicit about the order of construction steps, particularly about the dynamics of the shifting 'current reference time'. The notation in DR(15) combines elements from Kamp and Hinrichs; ' $\subseteq$ ' stands for the relation of temporal inclusion, which is definable in terms of ' $<$ ' and O(overlap), and the specification of the events and states by means of DR-boxes follows Kamp (1981b) and can be read as  $e_i$  is an event-token of the event-type given in the box following. (In subsequent examples we will carry out the internal processing of such boxes.) We assume that we start with a given past reference time  $r_0$  and present reference time  $r_s$ ; the other reference times  $r_1, r_2$ , and  $r_3$  are introduced during the construction.

DR(15)

$r_0 \ e_1 \ r_1 \ e_2 \ r_2 \ e_3 \ r_3 \ s_1 \ s_2 \ r_s$
.
.
.
.
$e_1 \subseteq r_0$
$e_1 < r_1 < r_s$
$e_2 \subseteq r_1$
$e_2 < r_2 < r_s$
$e_3 \subseteq r_2$
$e_3 < r_3 < r_s$
$r_3 \subseteq s_1$
$r_3 \subseteq s_2$
$e_1; \boxed{\text{Jameson enter the room}}$
.
$e_2; \dots$
.

overlap  $e_3$  itself. The content of (15) would tend to make it likely that  $s_1$  does not overlap  $e_3$ , and that  $s_2$  overlaps all of  $e_1$ ,  $e_2$ , and  $e_3$ , but none of this is required by DR(15).<sup>18</sup> The conditions represented formally at this level include only those constraints deemed to follow from the structure (including the event/state distinction) independently of particular content. Whether the particular conditions given are the correct ones is of course open to debate.<sup>19</sup>

Reference times thus play a crucial role in temporal anaphora. A simple sentence with a past tense is interpreted with respect to a reference time; if it is a state or process sentence, the corresponding state or process must hold or go on at the current reference time, while if it is an event sentence, the event must occur within that reference time, and a new reference time following the event is introduced. (As Hinrichs notes, not all past tense discourses follow such a neat linear sequence. If two successive event sentences have different subjects, the events may well be understood as simultaneous or overlapping. And a sentence describing a 'big' event may well be followed by sentences describing some of its subevents as in our earlier example (2b).) The proposal of Partee (1973) that past tenses be taken as directly analogous to pronouns, referring to the time specified by a preceding clause or adverb, is incompatible with the moving forward of time in successive event sentences (it would be as if pronouns referred to the *father* of the last mentioned individual!).<sup>20</sup> I still believe it is reasonable to characterize tenses as anaphoric, or more broadly as context-dependent, but I would no longer suggest that this requires them to be viewed as 'referring' to times as pronouns 'refer' to entities, or to treat times as arguments of predicates.<sup>21</sup>

To complete the relevant background, we need to consider the interaction of temporal adverbials and tense. This is an issue which raises a host of well-known problems for any attempt to relate semantic interpretation systematically and explicitly to syntactic form (see Dowty (1979) and Bäuerle (1979) for good discussions of some of the principal problems). We will not address all of those problems here; but I believe that the use of reference times is helpful in this respect as well, as argued by Bäuerle (1977, 1979), Kratzer (1978), and Hinrichs (1981). I will use Hinrichs' treatment as a basis for the generalizations to quantificational temporal adverbs to be made in Section VI. In the remainder of this section I will describe his treatment of sentences containing *when*-, *before*-, and *after*-clauses. As before, we are limiting our attention to sentences in narratives in which only simple past tenses occur, with clauses describing either events or states (thereby bypassing a number of issues that would be important for a more comprehensive treatment).

One of the main problems in accounting for the interaction of tenses and adverbs is the fact that a past tense seems redundant if there is an explicit adverb but not redundant when there isn't;<sup>22</sup> how can this be accounted for with a uniform interpretation for the past tense? If we try to let the past tense be a sentence operator meaning 'at some time in the past' and say that an adverb like 'yesterday' or 'two days later' is simply a more specific operator, we run into problems with either possible scope of applying such operators (Dowty (1979)). It is possible by judicious use of lambda's to achieve the effect of putting both operators on in parallel rather than in series, so to speak (Parsons (1980), Bach (1980)). But given the arguments in Partee (1973) and Bäuerle (1979) for treating a simple past tense sentence without adverbs as anchored to a reference time rather than as existentially quantifying over past times, we will not pursue the 'conjoined operator' approach here.

Hinrichs' approach can be characterized as follows. A simple past tense clause must be interpreted relative to a current 'past' reference time, which may have been provided by non-linguistic context or by preceding discourse. If a sentence begins with a past adverb<sup>23</sup> (or just a possibly past adverb if we are in the context of a past tense narrative), that adverb is processed before the main clause and serves to update the current reference time. Thus it's optional that there be an adverb, but if there is one it overrides the prior context. The main clause is interpreted by the same rules in either case, in terms of current reference time. The adverb itself, whether phrasal or clausal, provides a descriptive characterization of the new reference time; it may identify it completely ('at 3 o'clock on June 12') or simply put bounds on it, as with 'frame adverbials' like 'in June'. (Cf. the treatment of the context-dependence of modals in Kratzer (1978) and the role of *if*-clauses in augmenting the relevant context.)

Besides providing for a uniform treatment of main clauses with and without adverbs, Hinrichs' treatment accounts neatly for the asymmetry of function of main and subordinate clauses. Traditional treatments of sentences with *when*-, *before*-, and *after*-clauses have tended to simply yield truth-conditions that treat the two clauses on a par (much as the standard semantics of relative clauses makes no distinction between 'A man who loves Mary hates Susan' and 'A man who hates Susan loves Mary'). Hinrichs' treatment is compatible with the traditional truth conditions, but distinguishes the role of main and subordinate clauses with respect to the dynamics of reference time. The main clause, as we have noted, is interpreted with respect to a reference time descriptively characterized by the subordinate clause; and by the usual rules, if the main clause is an event-clause, the last step in its processing is the resetting of

the reference time to a time 'just after' the main clause event. Thus the reference time in effect after the complete sentence is processed depends on which clause was the main clause; this corresponds with the informal observation that it is main clauses that carry the main story line along in a narrative. We will show this asymmetry with examples involving *before* and *after* further below, and first consider Hinrichs' basic treatment of *when*-clauses.

Suppose we are interpreting a simple past tense narrative, our most recently established past reference time is  $r_1$ , and the next sentence begins with a *when*-clause. The *when*-clause triggers the updating of the reference time to a new value, let's say  $r_2$ , and the content of the *when*-clause puts conditions on  $r_2$ . (It is also required that  $r_2$  follows  $r_1$ , a stipulation that we will try to justify and generalize later.) The main clause is then interpreted with respect to  $r_2$  just as it would have been if it were a simple sentence with the reference time  $r_2$  provided by previous context. For illustration consider the little narrative (16), which includes example (2c) from Section II as a subplot.

- (16) Mary turned the corner. When John saw her, she crossed the street.

The following discourse representation, DRS(16), incorporates Hinrichs' treatment into a Kamp-style diagram, with parenthesized numbers showing the order of construction steps. Because Hinrichs' rules refer to 'the current reference time  $r_p$ ', which changes in the course of the construction, I have used square brackets to enclose the conditions which update the reference time (' $r_p = r_0$ ', ' $r_p = r_1$ ', etc.), only the most recent of them is in effect at any given point in the construction of the representation.<sup>24</sup> The DRS construction rules which depend on reference time make reference only to ' $r_p$ ', i.e. to whatever is the current reference time. In showing the effects of applying the construction rules I have filled in the values,  $r_0$ ,  $r_1$ , etc., according to what the current reference time was at the corresponding point in the construction. The (past) reference time at the beginning of the processing is  $r_0$ ; the reference times  $r_1$ ,  $r_2$ , and  $r_3$  are introduced in the course of processing. The resulting DRS is in a sense then a dynamic representation rather than a static one; in the long run we clearly need a more systematic representation of how the relevant context-parameters, of which reference time is just one, change in the process of interpretation.

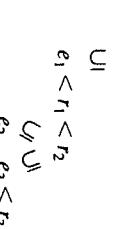
In this and subsequent DRS's, I have used 'now' rather than ' $r_s$ ' for the present reference time, simply for mnemonic convenience.

### DRS(16)

(0) $r_0$ (0) now (2) $e_1$ (2) $r_1$ (5) $u$ (8) $e_2$ (8) $r_2$ (11) $v$ (13) $e_3$ (13) $r_3$
$[(0)r_p = r_0]$
(1) Mary turned the corner
(2) $e_1 < \text{now}$
(2) $e_1 \subseteq r_0$
(2) $e_1 < r_1$
(2) $r_1 < \text{now}$
$[(3)r_p = r_1]$
(4) $e_1:$
(4) $e_1:$ (6) $w$
(4) Mary turn the corner
(5) $u$ turn the corner
(6) $w = \text{the corner}$
(6) $u$ turn $w$
(5) $u = \text{Mary}$
(7) When John saw her, she crossed the street
(8) $e_2 < \text{now}$
(8) $r_2 < \text{now}$
(8) $r_1 < r_2$
$[(9)r_p = r_2]$
(10) $e_2 \subseteq r_2$
(10) $e_2:$
(10) $e_2:$ (10) John see her
(11) $v$ see her
(11) $v$ see $u$
(12) $v$ see $u$
(11) $v = \text{John}$
(13) $e_3 < \text{now}$
(13) $r_3 < \text{now}$
(13) $e_3 \subseteq r_2$
(13) $e_3 < r_3$
$[(14)r_p = r_3]$
(15) $e_3:$ (17) $z$
(15) she cross the street
(16) $u$ cross the street
(17) $z = \text{the street}$
(17) $u$ cross $z$

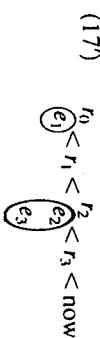
We can extract the relevant temporal conditions from DRS (16) and summarize them as follows, omitting the condition "before now", which applies to all the introduced events and reference times.

(17)



According to (17), both  $e_2$  and  $e_3$  follow  $e_1$ , but no constraints are imposed on the relation between  $e_2$  and  $e_3$ ; all that is required is that both occur within the reference time  $r_2$ . The final reference time  $r_3$  follows  $e_3$ , but  $e_2$  could in principle follow both  $e_3$  and  $r_3$ , since  $r_3$  is not required to follow  $r_2$ .

I think we can improve this picture somewhat if we add some auxiliary premises relating to the idea of 'linear narrative'. First of all, we can suppose that in construing a piece of narrative as linear, we assume that the successively introduced reference time strictly follow one another. (Hinrichs' conditions permit  $r_0$  to overlap or include  $r_1$ ,  $r_2$ , and  $r_3$ , and  $r_2$  to overlap or include  $r_3$ .) This would give the conditions pictured in (17'), where circles now represent inclusion.



Secondly, we can question Hinrichs' decision not to impose any relative ordering on  $e_2$  and  $e_3$ , the events of the *when*-clause and main clause of the second sentence. Hinrichs gives examples (as have others) that show that the event in the main clause does not always have to follow the event in the *when*-clause when both are in the simple past.

The *when*-event can include the main-clause event, as in (18a), or even follow it, as is possible in (18b) (Hinrichs' examples, adjusted to keep the surface order of the two clauses constant).

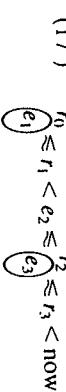
- (18)(a) When John wrecked the Pinto, he broke his arm.  
 (b) When the Smiths threw a party, they invited all their friends.<sup>25</sup>

But we already know that such conditions can obtain between successive simple sentences as well; simple linear progression is just one mode of discourse organization. Let us assume then that 'simple linear progression' is one possible value, probably the unmarked one, of a higher-order parameter of discourse structure (a parameter which can have different

values for different subparts of a discourse), and that when it is in effect, it applies to *when*-clause constructions as well as to concatenations of sentences.<sup>26</sup> We can then generalize the idea that in the simple linear case an event-clause moves the narrative forward by bringing in a new reference time that is 'just after' the given event, and characterize the reference time introduced by a *when*-clause in that way as well:<sup>27</sup> a (preposed) *when*-clause in a linear narrative triggers the introduction of a new reference time located 'just after' the event described in the *when*-clause.

We then obtain the following picture (17''), where  $\leqslant$  now represents 'just after' and  $<$  represents precedence with no assumption of proximity.

(17'')



The overt marking of 'just after' as distinct from simple precedence is a departure from Hinrichs' treatment, but one which I believe is consistent with the spirit of his analysis. The analyses differ on just how a *when*-clause characterizes the new reference time it introduces. Hinrichs lets the *when*-clause be either stative or eventive and puts the reference time within or surrounding it respectively. I require the *when*-clause to be eventive (if superficially stative, then interpreted as inchoative), and put the reference time just after it. Without 'just after', the reference time would not be sufficiently constrained by the *when*-clause and I would be treating *when* as if it meant *after*.<sup>28</sup>

The two proposals now cover slightly different ranges of data; Hinrichs' analysis covers more of the data, my suggested modification of it gives a more unified account of the introduction of reference times in the linear case. Further comparison and evaluation would require trying to embed both variants in more comprehensive theories.

The modifications I have suggested would entail some slight revisions to DRS(16) with respect to the conditions surrounding the introduction of  $r_2$  by the *when*-clause; rather than redraw the whole diagram, I will mention the revisions in a note<sup>29</sup> and follow the modified system in subsequent examples. The resulting picture (17'') is consistent with the idea that the primary function of a *when*-clause in simple linear narrative is to provide a new reference time for the associated main clause. Even in a simple linear narrative under the assumptions made above, an event described in a *when*-clause differs from one in a simple sentence in that it is not constrained to occur within the then-current reference time, but rather serves to provide a descriptive anchor for the next-introduced reference

time. Compare the anomalous discourse (19) with the normal (20).

- (19) People began to leave. The room was empty. The janitors came in.  
 (20) People began to leave. When the room was empty, the janitors came in.

Discourse (19) is anomalous, presumably because we don't expect the state of the room being empty to hold 'just after' people begin to leave, but state-expressing sentences cannot by themselves move the action forward. The *when*-clause of (20), on the other hand, signals the introduction of a new, later, reference time; we interpret the janitors came in' with respect to a time which is after people began to leave and just after the room became empty.<sup>30</sup> The asymmetry between main and subordinate clause is even clearer in the case of *before* and *after*. Sentences with *before*- or *after*-clauses also make it particularly clear that the account of temporal anaphora cannot be directly in terms of the tense morphemes in the main and subordinate clauses, as proposed in Partee (1973). Truth-conditionally, 'after A, B' and 'before B, A' are equivalent (except possibly for the non-factivity of *before*-clauses, which we will return to below), but in simple linear narratives they can be seen to have different effects on the establishment of reference time and hence on the temporal interpretation of the discourse as a whole. To appreciate the difference, we need a three-sentence discourse. We begin by extending (16) to (21) as a basis for comparison with (22) and (23).

- (21) Mary turned the corner. When John saw her, she crossed the street. She hurried into a store.  
 (22) Mary turned the corner. Before John saw her, she crossed the street. She hurried into a store.  
 (23) Mary turned the corner. After she crossed the street, John saw her. She hurried into a store.

We will not construct complete DRS's for these examples, but consider just the sketches of the resulting temporal conditions in the manner of (17'). Here again I am departing from Hinrichs in not putting the subordinate-clause event *within* any reference time of its own; to dispense with the additional reference time that he uses for *before-* and *after-* clauses, I have to claim that what is within the *before*- or *after*-clause cannot be a state or process. I believe that is correct, and that apparent state or process descriptions in such clauses have to be interpreted as events – again usually inchoatively, sometimes, especially with *after*, 'terminatively'.<sup>31</sup> See also Bach (1981). In all other respects I believe the

sketches below, (21')–(23'), conform to Hinrichs' analysis. The events have been given mnemonic names instead of numbers. In the actual processing rules the subordinate clause is always processed before the main clause and introduces the reference time with respect to which the main clause is interpreted. In each case, presumably as a result of the simple linear progression mode, the reference time  $r_2$  introduced by the subordinate clause comes after the previous reference time  $r_1$ , regardless of which subordinating conjunction introduces the clause. If we break the subordinating clause into its conjunction (*before*, *after*, or *when*, which I'll abbreviate collectively as BAW) and its clause, we can say that the clause characterizes an event type and BAW tells where the new reference time  $r_2$  is located relative to some event of that type.

$$\begin{array}{c} r_0 \qquad r_2 \qquad r_3 \\ (21') \textcircled{e_{\text{turn}}} \leqslant r_1 < e_{\text{sec}} \leqslant \textcircled{e_{\text{cross}}} \leqslant \textcircled{e_{\text{hurry}}} \leqslant r_4 \\ r_0 \qquad r_2 \qquad r_3 \\ (22') \textcircled{e_{\text{turn}}} \leqslant r_1 < \textcircled{e_{\text{cross}}} \leqslant \textcircled{e_{\text{hurry}}} \leqslant r_4 \\ < e_{\text{sec}} \end{array}$$

$$\begin{array}{c} r_0 \qquad r_2 \qquad r_3 \\ (23') \textcircled{e_{\text{turn}}} \leqslant r_1 < e_{\text{cross}} < \textcircled{e_{\text{sec}}} \leqslant \textcircled{e_{\text{hurry}}} \leqslant r_4 \end{array}$$

The striking difference between the *before*-clause case and the others is that the event in the *before*-clause does not end up in the linear order at all; it helps to describe the temporal location of  $r_2$  and hence of the crossing event, but is not otherwise connected, even in the context of a simple linear narrative. This seems to be a natural reflection of two factors, iconicity of order in simple linear narratives and the dynamics of successive introduction of reference times in the interpretation process.<sup>32</sup>

Why does the *before*-clause event not end up linearly ordered with the other events of the discourse, while the events of the *when*-clause and the *after*-clause do? If we process just the first two sentences of each discourse and leave out the reference time  $r_3$  introduced in the final steps of that part, we have the following structures, all linear.

$$\begin{array}{c} r_0 \qquad r_2 \\ (21'') \textcircled{e_{\text{turn}}} \leqslant r_1 < e_{\text{sec}} \leqslant \textcircled{e_{\text{cross}}} \\ r_0 \qquad r_2 \\ (22'') \textcircled{e_{\text{turn}}} \leqslant r_1 < \textcircled{e_{\text{cross}}} < e_{\text{sec}} \\ r_0 \qquad r_2 \\ (23'') \textcircled{e_{\text{turn}}} \leqslant r_1 < e_{\text{cross}} < \textcircled{e_{\text{sec}}} \end{array}$$

The difference arises because the next reference time,  $r_3$ , is introduced in

the processing of the *main clause* of the second sentence; in each case  $r_3$  is required to be after  $r_2$ . For (21) and (23), this continues the linear order, since the main clause event was the last event so far. But for (22), this leaves us with  $r_3$  and  $e_{\text{see}}$  both following  $r_2$  and no specified relation between them. Subsequent reference times follow  $r_3$ , since it is the reference times that move the narrative linearly forward, and  $e_{\text{see}}$  is left 'dangling'.

While Hinrichs does not claim to have an account of non-factive *before* (cf. Heinemaki (1974)), the isolation of the *before-clause* event from the linear structure in even this simple case accords well with the ease with which we construe such events as not part of the 'real' event structure at all.

One could question the simple linearity of the *after-structure*, (23), as well. It is a matter of stipulation in Hinrichs' original work and even more so in the modification I have suggested that the event<sup>17</sup> in the *after-clause* must strictly follow the last current reference time ( $r_1$ ). (If I try to make it follow by strengthening my claim about the general effect of the linear progression mode to require that not only all reference times but all *events* in such a discourse be linearly ordered, I would have to retract the previous remark about the *before-case*.) Mats Rooth (personal communication) has provided examples like (24) that suggest that the event in the *after-clause* can overlap the previous event; what's hard to decide is whether such cases fall within the linear order mode or amount to a shift to a different mode (e.g. 'adding details').

- (24) Mary crossed the street. After she reached the middle of the street, John saw her.

I would like to think that in the simple linear mode, such cases 'really' want a past perfect in the *after-clause*, and can occur in simple past only because past perfect is hardly ever obligatory in ordinary English. Otherwise they would present a problem, since at the point at which the *after-clause* is processed, the current reference time (see (23)) is  $r_1$ , not  $r_0$ , so there is no nice way to state a condition which would let the event in the *after-clause* overlap the previous event without letting it reach arbitrarily far into the past, which I don't think it can.

Leaving further details and open questions aside, the most important point about the parts of Hinrichs' analysis that we have reviewed here is that the phenomena of temporal anaphora which I tried in Partee (1973) to account for by treating the tense morpheme itself as a pronoun-like variable over times appear to be much more elegantly handled through the intermediary reference times, as argued by Bäuerle (1979). Reference

times are not directly denoted by any part of the sentence; they are more like a part of the necessary context for interpreting tensed sentences (Krämer, 1978), akin to the kind of locative frame of reference needed to interpret *left* and *right* and other locative expressions. And like the locative case, they are not bound to the actual context of the utterance but can be 'constructed' and shifted in the course of interpretation. Although Kamp's and Hinrichs' proposals and those they build on are certainly just first steps toward the construction of a formal framework integrating such contextual frame features with a model-theoretic semantics, their work can be neatly combined and extended to account for temporal analogs of bound variable and 'donkey' pronouns as well.

Before turning to these extensions in section VI, we should pause to take stock of how much of the explanation of the parallels noted in Section II is already available.

## V. THE FIRST THREE PARALLELS EXPLAINED

The first three of the five parallels discussed in Section II were pronominal and temporal anaphors with (A) non-linguistic antecedents, (B) definite antecedents, and (C) indefinite antecedents. Both in Kamp's and Heim's treatment of pronouns and in Hinrichs' treatment of temporal anaphora there is no special distinction between cases (B) and (C) – that distinction mainly reflects the fact that in earlier treatments (B) seemed straightforward and (C) was a problem. In this section we review the account of the parallels that can be provided from the proposals discussed so far.

### A. Non-linguistic 'antecedents'

The pronominal 'deictic' case was discussed briefly at the end of Section II. Kamp speaks in unpublished work of 'anchored' discourse referents; the notion of 'anchoring' is also found in the work of Barwise and Perry. Whatever the exact mechanism, it is apparent that personal pronouns can get their values from the non-linguistic context. As Heim (1982) puts it, it is a precondition on the interpretation of a sentence containing a non-anaphoric pronoun that the context provides an appropriate value for the pronoun. Hinrichs similarly requires that the context already provide a past reference time in order to interpret a simple past sentence (without temporal adverbs; with an adverb like 'in May', the context must already provide a year, but need not specify a more particular reference time). The discourse representation level (or Heim's 'file card' semantics) helps to unify this case with the anaphoric cases by providing a level in which contribution<sup>18</sup> from context can be represented overtly (whether intro-

duced spontaneously or via a process of accommodation in Lewis's sense) without having to arise as translations of actual constituents of the sentences of the discourse. Treating pronouns as variables has some plausibility and a considerable tradition; but 'reference time', which appears to lie at the heart of temporal anaphora, does not correspond uniformly to any single constituent of the sentence, so there does not seem to be any reasonable way to introduce it systematically in a direct model-theoretic interpretation of the syntax.

### B. Definite anaphors with definite antecedents

The pronominal case was illustrated with proper name antecedents in Section III. In the temporal cases discussed in Section IV, the 'definite antecedent' was the reference time introduced in the processing of the previous sentence or clause. This is more like the<sup>25</sup> case of a definite description antecedent (see Heim (1982)) than a proper noun antecedent; a closer analog to the latter would be a sentence like (25).

(25) At 3 p.m. June 21st, 1960, Mary had a brilliant idea.

Hinrichs treats the adverb in such cases as serving to fix the reference time (replacing any previously current reference time) with respect to which the rest of the sentence is interpreted; the adverb thus functions much like a proper noun antecedent for a pronoun, although in the temporal case we do not have a common syntactic category of expressions denoting the antecedent and the anaphor as we do in the nominal case.

### C. Indefinite antecedents

The treatment of pronouns with indefinite antecedents was one of the main innovations in Kamp's and Heim's proposals. In the temporal case the contrast between definite and indefinite is not always clearly marked; a newly introduced reference time might be thought of as definite in those cases where its introduction is accompanied by a condition that it be 'just after' some uniquely specified event, and indefinite in those cases where it is introduced with conditions that merely constrain it to be before, after, or within some given event or interval, or 'just after' an event whose description is not uniquely specifying. But the distinction is not marked by any obligatory grammatical signals (at least in English); our temporal system is in that respect more like the nominal system of languages that lack the definite and indefinite article, and Kamp's and Heim's unified treatment of these cases (see especially Heim's work on this point)

therefore makes it much easier to account for the parallels between nominal and temporal anaphora in English as well as for the existence of article-less languages.

The examples with *before* and *after* in Section IV were in effect cases of indefinite antecedents, since the conditions on the reference times introduced by such clauses amounted to 'at some time (after the previous reference time and) before/after such-and-such.' An indefinite antecedent can also be introduced via an indefinite adverb, as in (3b), repeated here as (26).

(26) Mary woke up sometime during the night. She turned on the light.

We show below a DRS for (26) which conforms to Hinrichs' construction. Hinrichs does not treat the specific locution 'sometime during the night' but does give explicit rules for other 'frame adverbs' like 'on Friday', 'in 1976', and the permissible complex adverbs that can be built up by combining appropriately nestable simple ones. We assume that 'sometime during the night' would work similarly, yielding the condition  $r_1 \subseteq i_1$  in DRS(26), and we also leave definite NP's like 'the night' and 'the light' unanalyzed. We have parenthesized the initial past reference time  $r_0$  and the conditions that pertain to it; following the observations of Smith (1978), Hinrichs provides both for frame adverbs like *two days later* which can only be interpreted in a context which includes a current  $r_p$  and ones like *in June 1970* which do not require such a context. The present example requires contextual support for the expression *the night*, but that could in principle come either from having the night available as an entity already introduced or from a reference time which specified a given period only containing one night. A similar example with 'the night of June 21st 1960' would not require any  $r_0$  present in the context, so there would be otherwise parallel DRS's with and without the parts parenthesized in DRS(26). I introduce an interval-variable  $i_1$  for 'the night', but perhaps it could just as well be viewed as a protracted event (cf. 'during the fight'). In DRS(26) it is the reference time  $r_1$  that plays the role of 'indefinite antecedent'. The parallels to Kamp's treatment of pronouns with indefinite antecedents should be clear: the role of  $r_1$  in the subsequent processing of the two clauses is exactly the same as it would have been if it had been specified 'definitely', e.g. 'at 3 a.m. on the night of . . .' just as the role of a discourse entity is the same for the interpretation of subsequent pronouns regardless of whether that entity is characterized by a definite condition like ' $u = \text{Pedro}$ ' or an indefinite one like 'farmer ( $u$ )'.

To complete the account of the parallels between temporal and nominal

anaphora, we need to extend Hinrichs' treatment to cover temporal quantification, to which we now turn. The treatment of 'donkey-tenses' will fall out as a direct consequence of the treatments of quantified cases and indefinite antecedent cases, just as it did in the pronominal case for Kamp and Heim.

DRS(26)

(0) now ((0) $r_0$ ) (2) $i_1$ (2) $r_1$ (4) $e_1$ (4) $r_2$ (6) $u$ (9) $e_2$ (9) $r_3$
((0) $r_p := r_0$ )
(1) Mary woke up sometime during the night.
(2) $i_1 \subseteq r_0$
(2) $r_1 \subseteq i_1$
(3) $r_p := r_1$
(4) $e_1 < \text{now}$
(4) $e_1 \subseteq r_1$
(4) $e_1 \leqslant r_2$
(4) $r_2 < \text{now}$
(5) $e_1$ :
(5) Mary wake up
(6) $u$ wake up
(6) $u = \text{Mary}$
((7) $r_p := r_2$ )
(8) She turned on the light
(9) $e_2 < \text{now}$
(9) $e_2 \subseteq r_2$
(9) $r_3 < \text{now}$
(9) $e_2 \leqslant r_3$
(10) $e_2$ :
(12) $v$
(12) .
(10) she turn on the light
(11) $u$ turn on the light
(12) $v = \text{the light}$
(12) $u$ turn on $v$
(13) $r_p := r_3$

VI. GENERALIZING TO QUANTIFICATION OVER EVENTS

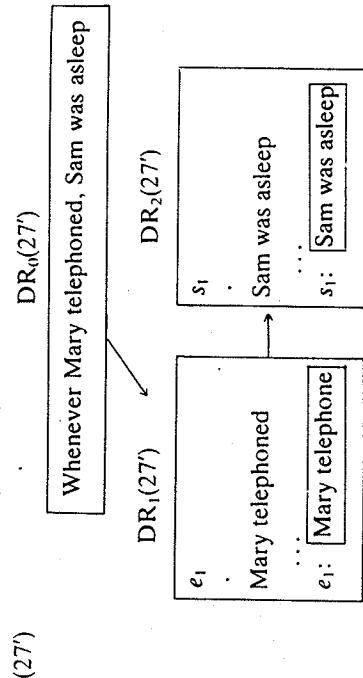
David Lewis, in his paper 'Adverbs of Quantification' (Lewis, 1975), noted that frequency adverbs like *always*, *sometimes*, *usually*, etc. are used not only for temporal quantification but more generally for quantifying over cases (as in 'The sum of two odd numbers is always even'). Kamp's treatment of ordinary quantifiers like *every* yields structures which are naturally construed as quantification over cases, so it is not surprising that his approach is readily generalizable to temporal (and other) kinds of quantification. We will limit our treatment here to simple event and state clauses in constructions with (temporal) *whenever*, *always*, etc.

There are at least two ways to express universal quantification over eventualities, either by using *whenever* to introduce the subordinate clause or by using a plain *when* (or *before*, *after*, etc.) and putting *always* in the main clause. Even with a simple *when*-clause and no adverb in the main clause a sentence may be interpreted universally (or more likely generically); this is probably to be attributed to implicit modalization in the main clause rather than to an ambiguity in *when*, since (a) a main clause alone can have a similarly generic or habitual reading, and (b) the same phenomenon occurs with *before*, *after*, etc., which have no counterparts with *-ever* and for which there is no independent reason to posit ambiguity. Heim (1982) includes extensive discussion of the 'unselective quantifier' force of various main adverbs, modals, and other sentence operators, and shows the parallels between her treatment of quantification and Kratzer's explanation of the interaction of *if*-clauses with main clause modals (the parallels extend in relevant respects to Kamp's treatment). Kamp and Heim both treat *every* and *if*-clauses in a unified manner, as we illustrated for Kamp in Section III, and very differently from *a* or *the*. Following their lead, and without providing rules for an explicit fragment, we will assume that both a *whenever*-clause and a main-clause *always* trigger the same sort of DRS-splitting as an *if*-clause or an *every*. In both cases, the content of the 'antecedent' box in the DRS (using Kamp's version) has the same internal form as in a simple indefinite case; the universal quantification arises in the statement of the embeddability conditions for the whole DRS conditional/universal substructure.

To see how we can put the ideas of Sections III and IV together, let's consider an example. Example (5a) from Section II is repeated below as (27).

(27) Whenever Mary telephoned, Sam was asleep.  
The basic idea of the construction is to end up with a DRS roughly of the

form (27), analogous to DRS(9) for the conditional example in Section III.

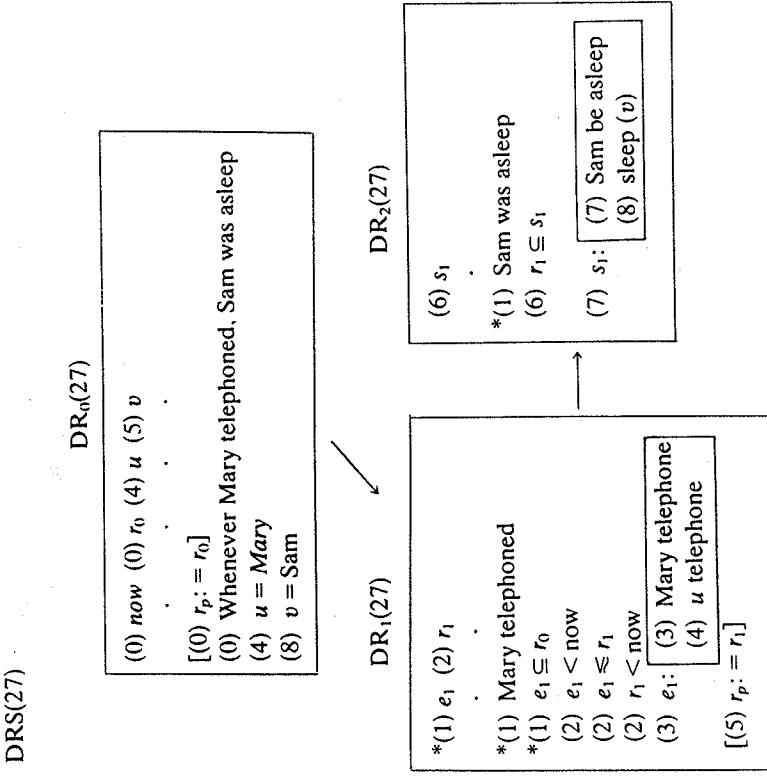


(Here  $s_1$  is a discourse state.) One new factor we have to deal with is that although we are still considering an example with simple past tenses in both clauses, we are not dealing with a simple linear narrative anymore. The antecedent clause cannot be anchored to a single specific reference time as it was in the simple *when*-clause cases, yet the whole sentence does presumably have to be interpreted relative to some (sufficiently large) reference period. (The whole sentence should be characterized as describing a state, and the DRS should perhaps have a big box around it labelling the whole thing as a state (Gennaro Chierchia, personal communication), but I will ignore that factor here.) We can handle that by assuming that there is a reference time  $r_0$  already current in the top box and that the discourse event  $e_1$  in the antecedent box is introduced with a condition that it fall *within* the current reference time. (That has to be part of what happens in the initial box-splitting step triggered by *whenever*, since the clause that follows *whenever* is internally just like any other subordinate clause, and should therefore be processed within its box by the normal rules.)

The embedding conditions for the whole configuration will be just like those for the *if*-clause and the *every* construction: the whole sentence is true just in case every proper embedding of the antecedent part can be extended to a proper embedding of the combination of the antecedent part and the consequent part. The main thing missing from the rough sketch in (27) is the indication of temporal connectedness between the antecedent and the consequent. When I discussed such sentences in Partee (1973), I didn't see any way to capture such 'bound variable' temporal cases without an explicit variable over times in the representation. But the abstract

notion of reference time (or reference event or situation) together with the general embeddability conditions conditions just described can do the job just as well, as we will now show.<sup>33</sup>

Here is a more complete picture of the DRS for (27), with parenthesized numbers showing the order of construction. Asterisks signal the application of the one new rule needed for this construction: the new rule is a straightforward adaptation of Kamp's rule for universal/conditional sentences. The remaining steps follow the rules of Kamp and/or Hinrichs (continuing with the modification of Hinrichs' treatment introduced with (17') in Section IV).<sup>34</sup>



It is important to recall at this point that the representation of the consequent box  $DR_2(27)$  is an abbreviation for a fuller representation which incorporates all of the contents of the antecedent box,  $DR_1(27)$  and

adds the new material to that. This is particularly crucial for step (6), which follows the same rule that applies to all simple past state-describing clauses, namely that the state described overlaps the current reference time  $t_p$ . In step (5)  $t_p$  was set to  $r_1$ , and it is therefore that reference time that is current at step (6). The embeddability conditions for the whole conditional structure thus require, as desired, that for every choice of an event  $e_1$  of Mary's telephoning and reference time  $r_1$  'just after' it, there is a state of Sam's being asleep that surrounds  $r_1$  (and hence may overlap or surround  $e_1$ ).<sup>35</sup> The treatment of this case thus comes out exactly parallel to the treatment of *if*-clauses in Kamp's system.

Extending the parallel, we can design a rule that is sensitive to the conjoint presence of *always* and a *when*-clause (just as Kamp's *every*-rule takes a relative clause into account at the same time) to produce exactly the same DRS for sentence (5b), repeated here as (28).

- (28) When Mary telephoned, Sam was always asleep.

Although this may look suspicious because the *when*-clause and the *always* do not form a surface constituent, I believe that there are sufficient arguments in Stump (1981) and Kratzer (1981) for viewing similar cases of clausal sentential adjuncts as modifying main clause sentence operators; neither of their treatments takes the same form as Kamp's and the different approaches deserve careful comparison, but the similarities seem sufficient to justify treating the *when*-clause and the adverb *always* as in construction with each other (perhaps indirectly through the use of lambdas, if one wants to maintain a surface-syntax compositional treatment).

The construction as described also extends straightforwardly to the rest of the 'bound variable' cases described in Section II, including cases where the main clause describes an event rather than a state and/or contains anaphoric adverbial like 'two days later' or 'immediately'. Again we don't need to introduce invisible time-variables into such expressions, but can simply treat them as interpretable only relative to a given reference time; the interpretation proceeds just the same whether such a clause is used in isolation with a contextually supplied reference time or whether it follows a *whenever*-clause with the reference time introduced as in DRS(27). That takes care of sentences like (29) and (30).

- (29) Whenever Mary wrote a letter, Sam answered it two days later.  
 (30) Whenever John got a letter, he answered it immediately.

The construction does *not* extend straightforwardly, however, to cases like (31). If we adapted Hinrichs' rules for *before*- (and *after*-) sentences to the quantified case in the same way we have done for *when*-sentences, we would end up with the erroneous interpretation that John is lighting a cigarette at *all times preceding each phone call*, rather than that he lights a cigarette *sometime before each phone call*.<sup>36</sup> The meaning of the sentence is approximately the same as that of (32); we seem to need to insure somehow that the condition setting the reference time to a time

- (32) When John makes a phone call, he always lights up a cigarette beforehand.

before the (each) phone call ends up in the consequent box, not the antecedent box.

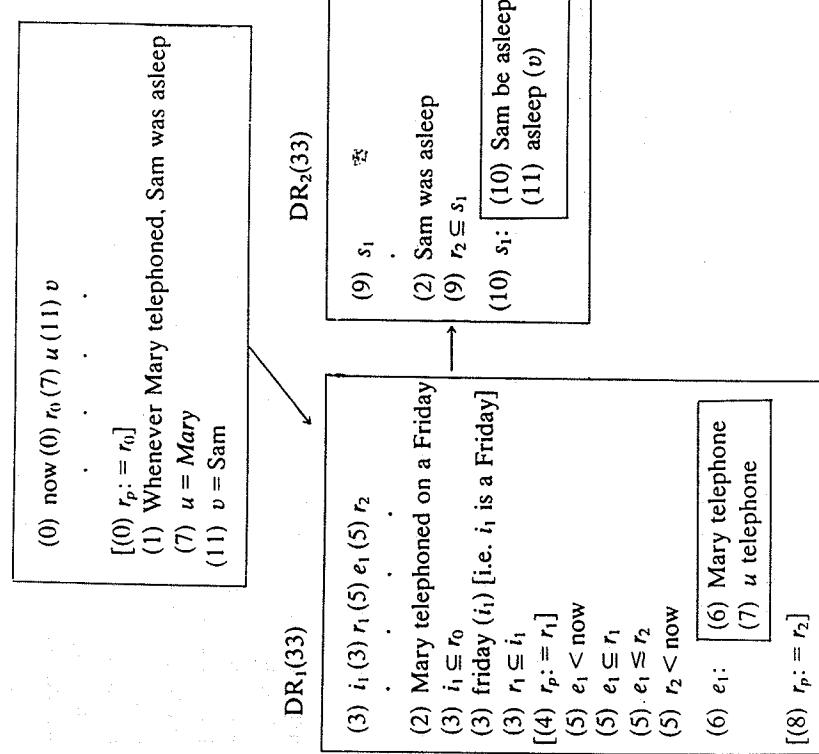
Sentence (32) itself does not fit into the pattern of linear sequencing we have been dealing with, suggesting that the problem of accommodating cases like (31) would be better dealt with in the context of discourse segments in which one clause introduces an event (or more generally a topic) and subsequent clauses fill in details. (And these examples further illustrate the need for a clearer articulation of what it is to quantify over 'cases').

The treatment of donkey-sentences on Kamp's approach is a direct consequence of his treatment of indefinite antecedent cases together with his treatment of *every* and *if*. Similarly, the treatment of the 'temporal analogs of donkey-sentences follows directly from Hinrichs' treatment of the indefinite antecedent cases together with our extension of his analysis to sentences with *whenever* or *always*. We illustrate by constructing a DRS for sentence (6d), repeated here as (33), which differs from sentence (27) only by the addition of the indefinite temporal adverb 'on a Friday' in

- (33) Whenever Mary telephoned on a Friday, Sam was asleep.

the antecedent. As in the nominal case, the net effect of the embedding rules operating on DRS(33) explains the apparent 'wide scope universal' reading of the indefinite adverb as well as the apparent 'binding' of the time in the consequent clause to the times on Fridays when Mary called.

DRS(33)

DR<sub>0</sub>(33)

On Kamp's account of (7a) the occurrence of *every* in the antecedent will trigger (as always) the introduction of a pair of DRS's, subordinate in this case to the DR for the *if*-clause. Because of the subordination structure, the discourse entity corresponding to 'every man' will not be an accessible value for the *he* in the main clause. (See also the discussion of examples (11) and (12) in Section III.) A similar account for (7b) can be given, since the *always* in the antecedent will trigger a similar DR-split, with the new DR's subordinate to the *if*-clause DR, and the *always* absorbed into their embeddability conditions, so to speak. Only a reference time introduced at the level of the *if*-clause as a whole will be accessible for the main clause interpretation; the 'variable' reference time corresponding to *always* will not be.

We thus see that the proposals of Kamp (and Heim) and Hinrichs generalize straightforwardly to an account of quantified temporal anaphora. It should be reemphasized that the distinction between 'bound variable' cases and 'donkey sentence' cases, like that between cases of definite and indefinite antecedents, has no theoretical status in this approach but merely reflects the earlier descriptive classification of Partee (1973). This unification is particularly welcome in the temporal case, where the distinctions in question are quite artificial.

## VII. CONCLUSIONS AND OPEN PROBLEMS

This completes our account of the parallels between temporal and nominal anaphora. I consider this a much more satisfying account than the one offered in Partee (1973), which in retrospect can be seen to have suffered from two inadequacies: (i) the lack of a unified treatment of pronominal anaphora, which did not become available until the work of Kamp and Heim; and (ii) the claim that tenses themselves acted like pronouns and the consequent belief that they therefore had to correspond to explicit time variables in a logical representation. Intuitively, noun phrases 'refer' and 'tenses don't'; nominal anaphora can be viewed as involving a generalization and explication of the notion inaccurately but intuitively labelled 'coreference'. Temporal anaphora is more subtle because of the categorial variety of the expressions involved – tenses, adverbs, adverbial clauses, and main clauses (including the aspectual classification of the clauses themselves into event-like and state-like). It is still fair to say that tenses, like pronouns, are anaphoric, and like pronouns can be construed with either linguistic or non-linguistic antecedents; but it doesn't follow that they 'refer' to times to the degree that pronouns 'refer' to individuals. Two general points deserve mention here.<sup>37</sup> Kamp motivated the level

of DRS's with two separate sets of phenomena: the behavior of pronouns (in the non-temporal domain) and the interpretation of aspectual matters in the temporal domain (Kamp 1979, Kamp and Rohrer 1983). The fact that these two uses of DRS's can be so neatly combined to explain the parallels between temporal and nominal anaphora without having to treat 'tenses as pronouns' provides further support for such an approach.

The other general point relates to the integration of Reichenbach's and Prior's treatments of the past tense operator. On Prior's treatment, which has become standard tense logic, *Past*  $\phi$  is true at time  $t$  iff  $\phi$  is true at some  $t' < t$ : the past operator thus amounts to 'at *some* time in the past'. On Reichenbach's treatment, a sentence *Past*  $\phi$  is only interpretable with respect to a given past reference time  $R$ , and is true iff  $\phi$  is true at  $R$  ('event time = reference time'); the past operator thus amounts to 'at *that* time (in the past)'. In effect, Hinrichs' analysis and those of Kratzer and Bäuerle before him incorporate aspects of both analyses. In a simple past tense event sentence, the event is not required to coincide with the past reference time, as in Reichenbach, but to occur within it (a distinction that only became available with the advent of interval semantics). Thus the existential quantifier over past times is still explicitly there, but restricted to times within the past reference period. In narrative discourse of the sort considered by Hinrichs, reference intervals are typically quite small, since the focus is on the succession of individual events. In other sorts of discourse, reference intervals may be small and specific ('I didn't turn off the stove'), or large, vague, and possibly even irrelevant ('Who killed Julius Caesar?' – I don't have to know when it happened to know who did it, given that it could only have happened once if it happened at all). In the latter kind of case, the reference time could potentially be the whole of the past, leaving only 'at some time before now' as the consequence of the condition ' $e \sqsubseteq t_p$ '. The Reichenbachian and Priorian past tenses can then both be seen as special cases of the Kratzer-Bäuerle-Hinrichs account: The Reichenbachian one results if both reference time and event time are instants, the Priorian if the reference time is all of the past.

The account given here suffices to explain the parallels with which we began, but is still very crude. Part of this is just the result of my over-simplified presentation of Hinrichs' system,<sup>38</sup> but it is also clear that there are many major open questions in this area that need to be explored. I will close by mentioning several that seem particularly pressing.

- (i) In the DRS's for temporal anaphora cases, we put 'discourse events' for events described by tensed clauses into the representation on a par with discourse entities for individuals; but then what's the difference between

an event-describing clause like 'Mary telephoned John' and a nominalization like 'Mary's telephoning John', which has more claim to referring to an event. Would the strategy followed here require us to posit a discourse referent for the whole proposition expressed by a sentence to account for the 'sentence-pronoun' *it* if the next sentence is 'But John doesn't know it'? Where would that discourse referent go? Presumably not within the DRS for the sentence (proposition) it refers to on pain of circularity. Clearly a general treatment of anaphora has to involve both things (including events, situations, propositions, etc.) directly expressed or referred to in a discourse and things that become salient as a result of the occurrence and interpretation of the discourse; but it is not so clear that everything potentially relevant should be entered into a DRS in the same way, especially given the fact that there are 'pure anaphors' which can only have linguistically expressed antecedents and 'pure deictics' which can only have contextually supplied values, as well as cases like the pronouns and tenses which can have either. (Both Kamp and Heim are aware of these problems, but as far as I know neither they nor anyone else has a general solution to offer.) The questions that need to be answered here concern both ontology and levels of representation.

(ii) Another pressing need is for a better articulated theory of context and its interaction with semantic interpretation. 'Reference times' probably belong to context rather than to semantic content, but if Hinrichs' treatment of temporal anaphora and my extension of it are on the right track, we can only move reference time to a separate context dimension if we have a framework in which context both affects and is affected by the process of semantic interpretation, which in turn seems to have to be viewed in some sense dynamically rather than statically (cf. the crucial role of the 'updating' of the past reference time  $t_p$  in the account of temporal anaphora).<sup>39</sup> Just as we can now see that we don't need variables over times in the object language to account for temporal anaphora and temporal quantification, it is to be hoped that with a better theory of context we will not have to put reference times into DRS's on a par with other discourse referents to capture their involvement in the parallels between nominal and temporal anaphora.

(iii) Another major issue, already mentioned, is how to generalize further to quantification and anaphora involving 'cases' in the sense of Lewis (1975). *Whenever*-clauses are not always literally temporal, nor are *whenever*-clauses always locative; how do we tell what we are quantifying over? The problem noted earlier in this section about constructions with a *before* or *after* clause accompanied by an *always* is the main clause is one example of a much broader problem of determining what belongs in the

'antecedent box' in a conditional/universal DRS. Closely connected with this is a problem of interpreting the embedding condition for conditional DRS's, namely how to individuate proper embeddings of the antecedent part. This problem is perhaps best illustrated by the problem that arises in trying to extend Kamp's treatment to *most* or *almost every*, noted by Heim (1982). Whereas (34) and (35) have the same truth-conditions (at least in the respects relevant here), (36) and (37) seem not to: (37), but not (36), seems to be falsified by a situation in which just one donkey-owner fails to beat any of his donkeys but he owns most of the donkeys.

(34) Every man who owns a donkey beats it.

(35) { Always }  
       { In all cases }, if a man owns a donkey, he beats it.

(36) Almost every man who owns a donkey beats it.

(37) { Almost, always }  
       { In almost every case }, if a man owns a donkey, he beats it.

Intuitions seem to be sharper with event-clauses (perhaps since it's not so clear what a 'case' of a state holding is). The difference in truth-conditions between (38) and (39) seems more certain than that between (36) and (37) (although still conceivably disputable).

(38) Almost every man who swam the channel took more than 12 hours.  
 (39) In almost every case, if a man swam the channel, he took more than 12 hours.

The difference evidently arises because in the case where the quantifier is combined with *man* we have to count men, and in the other case we have to count cases of channel swimmings and the same man may be involved in many swimmings. As Scha (1983) argues, when we have to deal with quantification with a complicated and possibly uncertain underlying ontology, we need to specify a 'sort' (for the quantifier to 'live on' in the sense of Barwise and Cooper (1981)) separately from whatever further restrictions we want to add (perhaps in terms of 'cases') about which instances of the sort we are quantifying over. In terms of Kamp's framework this means that we have to worry not only about what belongs in the antecedent box but also how to distinguish a substructure within it that plays the role of sortal (the head noun in the NP case).

This is turn relates to the syncategorematicity of *every* in Kamp's treatment and the corresponding treatment of *always* in this paper. How, for instance, can *almost* modify *always* or *every* if they are not part of the semantic representation? I suspect that many of the ingredients for a

better articulation of how the meanings of the various parts combine in these cases could be gotten out of a combination of the proposals in Stump (1981) for the treatment of free adjuncts in combination with frequency adverbs, Kratzer (1978) for the treatment of *if*-clauses and modals, Heim (1982) for a more Kratzer-like treatment of the quantifier cases, and the ideas of Kamp and Hinrichs presented here. But it is important to recognize that the source of these problems for the Kamp and Heim frameworks is their abandonment of Montague's unified treatment of noun phrases as generalized quantifiers, in which determiners can be assigned a uniform semantic type and modifiers of determiners could be added straightforwardly.

I don't see how to incorporate Montague's elegant treatment of compositionality into the framework followed in this paper, nor do I see how to reproduce within Montague's theory the unified and explanatory account of nominal and temporal anaphora provided by these extensions of Kamp's, Heim's, and Hinrichs' work. So the next task is to try to construct a theoretical framework which incorporates the insights of both approaches.<sup>40</sup>

#### ACKNOWLEDGEMENTS

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I gratefully acknowledge the following support for the period in which the paper actually got written: a fellowship from the National Endowment for the Humanities, the hospitality of the Max-Planck-Institute for Psycholinguistics in Nijmegen, and a sabbatical leave from the University of Massachusetts.

#### NOTES

<sup>1</sup> All references to Hinrichs' work in this paper are based on Hinrichs (1981); Hinrichs has now written a paper in English on this topic, Hinrichs (1982), which I have not seen.

<sup>2</sup> Among other approaches which have emphasized a dynamic view of semantic interpretation are Hintikka's game-theoretical semantics and procedural semantics (Isard 1973); attention to dynamic aspects of context has been standard in studies of the semantics of programming languages.

<sup>3</sup> There are acceptable sentences of the form (7b), such as (i) below, from Emmon Bach.

(i) If Sheila always worked late, Peter got angry.  
But the *always* in the antecedent is then interpreted with 'narrow scope' and does not 'bind' the time of the main clause; we could paraphrase (i) as (ii):

If Sheila always worked late over a period of time, Peter got angry during that period.

This corresponds to the fact that *if*-clauses containing *every* are perfectly all right as long as the scope of the *every* remains within the *if*-clause.

<sup>4</sup> Kamp does not treat *the*; Heim (1982) treats it extensively. Van Eijck (1982) offers an extension of Kamp's work treating *the*.

<sup>5</sup> Kamp (1981a) uses the term 'discourse referent' which traces back to Karttunen (1976); in some later unpublished work he uses 'reference marker'. I use 'discourse entity' for parallelism with 'discourse event' and 'discourse state' (also Kamp's terms).

One might ask why *Pedro* is entered via a 'variable' discourse entity rather than directly as a 'named' element. I don't know Kamp's answer, but one answer might be that it leaves the way open to abstract over that 'variable' in extending the fragment to handle VP-deletion,

<sup>6</sup> For simple cases, 'accessible' just means 'already in the DR'; more complex cases will be discussed below and the notion of accessibility correspondingly sharpened. See also Note 8.

<sup>7</sup> See Webber (1978) for an earlier statement of a similar approach in a computational framework, and Karttunen (1976) for a still earlier introduction of the idea of 'discourse referents'.

<sup>8</sup> We ignore here issues of 'suitability' (e.g. gender agreement), as well as the issues of disjoint reference and of reflexive pronouns. These are, of course, important issues for a complete treatment, but I believe they are independent of the concerns of this paper.

<sup>9</sup> I have a terminology problem in the rest of this paper because of the 'paradigm shift' that comes from Kamp's and Heim's work. Henceforth, when I use expressions like 'bound variable anaphora', even without scare quotes or caveats, I mean 'cases of anaphora which were classified as bound variable cases in earlier treatments'.

<sup>10</sup> Eventually one will want to find general principles governing both the introduction of additional DR's and the subordination relations among them. Since the function of both is clearly semantic, it will be interesting to see how far one can go with the assumption that the rules which introduce them are sensitive only to syntactic structure and the presence of particular (closed-class) lexical items like *every* and *if*.

<sup>11</sup> It has long been observed that there is an intimate connection between *every* and *if* and clauses be derived from conjunctions or *if*-clauses depending on the determiner of the head noun (although that very dependence weakened the attractiveness of the proposals from a syntactic perspective). In PTO Montague built an *if* into the meaning of *every* and an *and* work on conditionals and modals (Kratz's (1978, 1981) can be viewed as an important foreunner of such an idea; her work also suggests that the quantifier implicitly associated with an *if*-clause may not always be universal. See discussion of the problem of *most* in the last section of this paper.)

<sup>12</sup> The truth conditions assigned to (9) and (10) amount to giving the embedded *a* a wide scope universal reading. This is not uncontroversial; an apparent counterexample is (i):

(i) If you have a credit card, you should use it here instead of cash.

But (i) might be construable as having a wide-scope universal reading for 'a credit card' if we paraphrase it with *any* rather than *every*.

## NOMINAL AND TEMPORAL ANAPHORA

In an earlier proposal for a unified treatment of pronouns, Cooper (1979a) treated them all as context-dependent definite descriptions. Cooper's treatment has the advantage of extending naturally to 'paycheck' sentences, but would predict anomalousness for Heim's 'sage plant' example (ii), for which Kamp and Heim correctly predict a wide-scope universal reading.

(ii) Every customer who bought a sage plant bought eight others with it.

See Heim (1982) for a good discussion of these and related issues.

<sup>13</sup> Kamp (in unpublished work) and Heim (1982) both make proposals along these lines. Not all problematic cases of pronouns are covered by the mechanisms discussed here; but this covers all of the kinds of nominal anaphora that were compared to temporal anaphora in Partee (1973), and all the types discussed in Kamp (1981a), so we will not try to speculate on further extensions to cover e.g. Karttunen's 'paycheck' pronouns (Karttunen (1969)). Crit Cremer (personal communication) suggested to me that these may have temporal analogs as well. Possible examples might be (i) and (ii):

(i) When John got married, he had a good job and money in the bank. Bill had no job and a pile of debts.

(ii) Some people, when they got a divorce, remarry within a few months. Other people don't remarry until years later.

I thank the anonymous referee for the following:

(iii) The man who left town when he was fired was wiser than the man who sued the management.

<sup>14</sup> I received a copy of Dowry (1982) just as I was putting the finishing touches on this paper.

Dowry challenges Kamp's discourse representation approach and Hinrichs' application of it on just this point: the classification of sentences into aspectual types plays a crucial role in discourse representation construction rules but would itself be determined by the compositional semantic interpretation of the parts of the sentence in a fuller treatment, since much more than the aspectual type of the main verb plays a role. Unless all the relevant factors are encoded in the syntax, as in Verkley (1972), there is then a conflict. Dowry argues, between the use of DRS's as intermediate constructs between syntax and model-theoretic interpretation and the role of the model-theoretic interpretation in determining properties of the sentence on which DRS construction rules depend. I believe this is indeed a serious problem, possibly a representative of a large family of such problems. I shall, however, proceed without either solving the problem or revising the paper in the belief that the proposals about anaphora that are central here are robust enough to survive whatever theoretical changes may be needed. See also Note 19.

<sup>15</sup> This is an oversimplification which will be rectified shortly.

<sup>16</sup> We will say more about both the construction and the interpretation of such DR's as we proceed. See also Kamp (1981b), Kamp and Rohrer (1983).

<sup>17</sup> As with other kinds of contextual preconditions or presuppositions, it is not literally required that a past reference time is already available to the hearer – one will be added or assumed via the general process of accommodation if doing so does not create any conflicts with the prior context.

<sup>18</sup> The reader may wonder (as one referee did) why I haven't added a helpful graphic display of the resulting structure with little circles along a time line, as in some examples in Kamp and Rohrer (1983). The reason is that Kamp's and Hinrichs' rules in general provide only partial information about precedence and inclusion among the introduced events and states, and it is in many cases difficult or impossible to draw a graphic display that contains only the information provided in the DRS. In the case of DR(15) it is the information about *s*<sub>1</sub> and *s*<sub>2</sub> that is hard to draw.

The relation between DRS's and graphic representations of ordered event structures has

not been addressed explicitly in any work that I know of; the question is potentially important for theories of language comprehension. Discussion of related issues in other domains, e.g. discourse about spatial relations, can be found in Johnson-Laird (1983). Johnson-Laird has conducted experiments to study differences in comprehension strategy for discourses like (i), which can be mapped into a determinate partial model and those like (ii) which cannot.

- (i) A is to the right of B. C is to the right of A.
- (ii) A is to the right of B. C is to the right of B.

<sup>19</sup> In particular, Dowry's arguments described in Note 14 challenge the inclusion at this level of any conditions that depend on aspectual distinctions (here simplified to the event/state dichotomy). I believe that a potential resolution may lie in a clearer articulation of the dynamic aspects of DRS-construction and the corresponding dynamic aspects of context change as it both affects and is affected by interpretation. To make this more concrete, note that there are just two points in Hinrichs' DRS construction rules where the event/state dichotomy makes a difference: (i) in the choice between the conditions ' $e_i \sqsubseteq r_p$ ' and ' $r_p \sqsubseteq s_j$ ' relating a given event/state description to the current reference time, and (ii) whether a new reference time is introduced or not at the end of processing a simple clause. For the first, we could let the syntax-driven DRS construction rules introduce a free context-dependent variable over temporal relations, whose value will be determined as ' $\sqsubseteq$ ' or ' $\supseteq$ ' from the context after the clause has been interpreted; for the second, the syntax-driven rules could in effect just say 'reset ' $r_p$ ' at the end of each simple clause, deferring until further interpretation of the clause in context the decision as to whether the reference time has moved forward or not. I am not at all sure of the best way to articulate the implement such suggestions, however.

<sup>20</sup> See the chapters on 'egocentric logic' in Prior and Fine (1977) for discussion of a totally different logically possible (but linguistically implausible) way of assimilating pronouns to tenses, treating both as operators.

<sup>21</sup> Another principal shortcoming of the proposal of Partee (1973), not to mention its inexpressiveness about the mapping from syntax to semantics, was its failure to extend from *when*-clauses to *before*- and *after*-clauses, a direct consequence of the attempt, in effect, to make direct anaphoric connection to 'event times' without the intermediary of 'reference times'. It also failed to account for a number of uses of past perfect. Hinrichs includes extensive treatment of past perfect, which I am ignoring here for simplicity.

<sup>22</sup> See Cooper (1979) for discussion of both this problem and a similar problem concerning subject-agreement markers in languages where the subject is only optionally present, so that the agreement marker may be redundant or not. Cooper notes that such phenomena may be particularly numerous in polysynthetic languages; his suggested solution for such cases invokes the notion of 'rule clusters' and requires in the temporal case that the past tense operator and the time adverb be added by a single syntactic rule when both are present, and thus differs from the approach of Bach and Parsons discussed below and that of Hinrichs.

<sup>23</sup> Hinrichs treats postponed and proposed temporal adverbs alike; I would rather restrict this account to proposed adverbs and leave internal and final adverbs out of consideration in this paper. See Note 32.

<sup>24</sup> I am following a suggestion of Ewan Klein in making the form of the 'update' statements purposely resemble variable assignment statements used in programming languages.

<sup>25</sup> A referee suggested that a clearer example of main-clause events preceding the *when*-clause event might be (i):

- (i) When Smith spoke, Jones introduced him.

Actually, it seems to me that in both (1b) and (i), there is a strong tendency to interpret the *when*-clause event description broadly so that the main-clause event occurs within it; throwing a party can include planning and sending invitations, and the introduction of the speaker can be counted as part of a speaking event. The fact that we automatically construe

spoke in (i) as 'making a speech' supports this idea.

<sup>26</sup> I recognize that this is a controversial assumption, one that will probably have to be replaced by a more elaborate theory of the interaction among content, context, inference, and implicatures. Perhaps all that the grammar determines in the initial stages of DRS construction is a free relation variable connecting the eventuality-referent with the newly introduced reference time, and the setting of specific values like 'just after' is the result of subsequent processes involved in integrating the information in the DRS with background knowledge and contextual information. In any case, I believe that the 'just after' condition

will turn out to be parallel in the *when*-clause constructions and strings of simple sentences. <sup>27</sup> To make this change, we must claim that sentence-initial *when*-clauses within discourses in the linear progression mode must be event-clauses and not state-clauses, since we could not otherwise characterize the introduced reference time as 'just after' the *when*-clause event. We will argue for this claim below in connection with examples (19) and (20).

<sup>28</sup> Ewan Klein has suggested the following formal characterization of my notion of 'just after', which I accept: ' $e'$  is 'just after  $e$ ' iff ' $e$ ' is after  $e$  and there is no contextually relevant ' $e'$ ' between  $e$  and  $e$ . See also Note 35.

<sup>29</sup> The only changes in DRS (16) to yield the ordering shown in (17<sup>a</sup>) are the replacement of the three conditions numbered (8) by the condition(s) ' $r_1 < e_1 \leq r_2 <$  now and the deletion of the condition ' $e_2 \sqsubseteq r_2$ ' in step (10).

<sup>30</sup> Both Hinrichs' original treatment and my modification of it account for the difference between (19) and (20). Closer inspection of (20) shows one of my reasons for the modification: on Hinrichs' account, since 'the room was empty' describes a state, that state should surround the event of the janitors coming in, which it cannot. I believe we have to reinterpret states as inchoatives to fit them into *when*-clauses (at least preposed ones in linear narrative); then on my account the reference time is characterized as a time just after the room emptied, which seems correct.

<sup>31</sup> The ontological status of states remains unclear, but I can try to elucidate what I have in mind. States can be temporally unbounded, but with those which are bounded on at least one end one could associate a corresponding event of beginning-to-hold (inchoative) or ending (terminative). With those which are bounded on both ends one can in principle associate a corresponding event coinciding with the state ('holistic'). 'After Mary was in the hospital', for instance, is ambiguous: it can mean after she began to be in the hospital (inchoative), or after her whole hospital stay (which could be analyzed as either terminative or holistic). *When*-clauses in general can contain state and process descriptions, but not (I am claiming) in linear narrative. There, as in (20), it seems that an inchoative reading is always imposed. I leave as open problems the best way to characterize these effects and the existence of 'terminative' and/or 'holistic' readings; the existence of inchoative readings is already widely accepted.

<sup>32</sup> As noted earlier, Hinrichs always processes the subordinate clause first, even when it follows the main clause. I have limited my examples to cases where the subordinate clause comes first, because I don't believe the order of the clauses is irrelevant. There is more relevant literature than I care to try to cite – but one would have to consider issues of real-time processing, within-sentence temporal iconicity, topic-focus structure, backwards anaphora, S versus VP-attachment of temporal adverbial clauses, and restrictive versus non-restrictive adverbial clauses. I believe that sentence-internal adverbs can help characterize event types; see Bach (1980). Some preposed temporal adverbs are probably topicalized VP-adverbs; I leave them out of consideration here.

<sup>33</sup> And in fact if we didn't have independent reasons to invoke the notion of reference time we could also achieve an appropriate linking with a condition ' $e_1 \sqsubseteq s_i$ ' in the consequent box, since  $e_1$  and  $s_i$ , like discourse entities, can also end up having either particular or 'variable' referents depending on the embedding condition of the DRS's in which they occur.

<sup>34</sup> The requirement that  $e_1$  precede 'now' is in this case redundant, given the condition ' $e_1 \sqsubseteq r_0$ ' and the specification of  $r_0$  as a past reference time, but is included since it is

automatically generated by the rules processing the first clause.

<sup>35</sup> Since  $r_1$  is in the antecedent, it is important to require that it be 'just after'  $e_1$ , or else the resulting truth conditions will be too weak, requiring only that Sam be asleep sometime after Mary telephoned, and that could be true if he only slept after the last of her phone calls. The notion of 'just after' needs to be explicated; it must clearly be a vague notion with its values constrained by context. If we tried to dispense with the reference times and require that  $s_1$  surround or overlap  $r_1$  directly, we would meet the argument from discourse (15) again in the shape of sentences like (i) and (ii)

- (i) Whenever John turned off the light, it was pitch dark in the room.
- (ii) Whenever John took all he wanted, there was nothing (left) for the rest of us.

Remko Scha (personal communication) suggests that the introduced reference time is typically understood as including the end of the given event (and the beginning of the associated 'resultant state' if there is one). This suggestion would appear to generalize nicely to a treatment of shifting 'reference location' for locative anaphora, where the resultant reference location at the end of processing a motion sentence is typically the end location ('goal') of the mover ('theme').<sup>36</sup>

The only difference between the when-rule and the rules of before and after-clauses is the relation between the introduced reference time and the event described by the clause, where DR, (27) has  $e_1 \leq r_1$ , an analogous DR, for (31) would have  $r_1 < e_1$ , and the one for after would have  $e_1 < r_1$ . The embedding conditions for universal/conditional DRS's universally quantify over the discourse events and reference times in the antecedent box. In the when case, each instantiation of  $e_1$  effectively determines a corresponding time  $r_1$  (just after it), but in the before and after cases, there would be many possible values of  $r_1$  for each instantiation of  $e_1$ , and the embedding conditions would quantify over all of them. 'Just before' or 'ten minutes before' would work fine, since then there would be a determinate ' $r_1$ ' for each instantiation of  $e_1$ ; but 'sometime before' wouldn't work, and I don't see any basis for arguing that 'before' means 'just before' rather than 'sometime before' in sentences like (31).

<sup>37</sup> I am indebted to Johan van Benthem for the first of these points and for raising the question which is discussed in the second.

<sup>38</sup> In particular I have completely omitted the parts of Hinrichs' system designed to account for discourses and multi-clause sentences containing mixtures of past and past perfect, and I have not seriously investigated the question of whether my suggested modifications of his system are compatible with those parts of it.

<sup>39</sup> Hinrichs himself does keep reference time apart as part of a 'conversational scoreboard' in the sense of Lewis (1979). But I could not see how to extend his treatment of the quantificational and 'donkey-sentence' case without including the reference times explicitly within the DRS representation.

<sup>40</sup> During the final stages of revision, I received a copy of Chierchia and Rooth (to appear), which addresses the issue of whether the configurational stipulation of subordination on which anaphoric accessibility in DRS's depends is really essential. The paper argues convincingly that it is not, and that the same results can be derived from the recursive definition of proper embeddability. Chierchia and Rooth show how the language of DRS's can be reformulated to more closely resemble the language of first-order predicate logic, bringing out parallels between discourse entities and variables and showing how 'accessibility' for pronouns follows from the semantics just as it follows from the semantics of first-order logic which variables are bound by which quantifiers. They discuss the present paper as well and show that their results can be carried over to this treatment of discourse events and reference times.

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