

# TENSE AS DISCOURSE ANAPHOR

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In this paper, I consider a range of English expressions and show that their context-dependency can be characterized in terms of two properties:

1. They specify entities in an evolving model of the discourse that the listener is constructing;
2. The particular entity specified depends on another entity in that part of the evolving "discourse model" that the listener is currently attending to.

Such expressions have been called *anaphors*. I show how tensed clauses share these characteristics, usually just attributed to anaphoric noun phrases. This not only allows us to capture in a simple way the oft-stated but difficult-to-prove intuition that *tense* is *anaphoric*, but also contributes to our knowledge of what is needed for understanding narrative text.

## 1 INTRODUCTION

In this paper, I consider a range of English expressions and show that their context-dependency can be characterized in terms of two properties:

1. They specify entities in an evolving model of the discourse that the listener is constructing;
2. the particular entity specified depends on another entity in that part of the evolving "discourse model" that the listener is currently attending to.

Two types of expressions have previously been described in these terms: definite pronouns and certain definite noun phrases (NPs). Researchers in computational linguistics and in artificial intelligence have called these expressions *anaphors* (cf., Woods 1978, Sidner 1983, Bobrow 1977, Hirst 1981, Webber 1983).

Linguists, however, have used this term somewhat differently. Many have restricted its use to expressions (usually pronouns) that can be treated analogously to variables in a logical language (Chomsky 1980). A view in linguistics that comes somewhat closer to the AI model can be found in a paper by Sag and Hankamer (1984), who distinguish what they call *deep* (or *model-interpretive*) anaphora from what they call *surface* anaphora (or *ellipsis*). Under the former, they include personal pronouns, sentential "it," and null-complement anaphora, and under the latter, verb phrase (VP) ellipsis, sluicing, gapping, and stripping. The two types are distinguished by whether they make reference to the interpretation of an antecedent—i.e., some object in a

model of the world constructed by the interpreter of the sentence of discourse (deep anaphora)—or whether they are interpreted with respect to a previous logical form (surface anaphora). While their deep anaphors include pronouns, Hankamer and Sag do not consider other expressions like NPs in discourse that might also be described in similar model-interpretive terms, nor do they describe in any detail how model interpretation works for the expressions they consider.

To avoid confusion then, I will use the term *discourse anaphors* for expressions that have these two properties.<sup>1</sup> My main point will be that tensed clauses share these properties as well, and hence should also be considered discourse anaphors. This will capture in a simple way the oft-stated, but difficult-to-prove intuition that *tense is anaphoric*.

To begin with, in Section 2, I characterize the dependency of an anaphoric expression  $X_b$  on a discourse entity  $E_a$  in terms of an anaphoric function  $\alpha(X_b, E_a)$ , that itself depends on 1. the *ontology* of the specified entity  $E_a$  and 2. *discourse structure* and its *focusing* effect on which  $E_a$  entities the listener is attending to. With respect to definite pronouns and NPs, this will essentially be a review of previous research. However, I will argue that some indefinite NPs should also be considered discourse anaphors in just this same way. In Section 3, I will move on to tensed clauses and the notion of *tense as anaphor*, a notion that goes back to at least Leech in his monograph *Meaning and the English*

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Verb (1987). I will review previous attempts to make the notion precise, attempts that require special-purpose machinery to get them to work. Then I will show, in contrast, that the notion can more simply be made precise in terms of a set of similar anaphoric functions that again depend on ontology and discourse structure. Making clear these dependencies contributes to our knowledge of what is needed for understanding narrative text.

## 2 BACKGROUND

### 2.1 DISCOURSE MODELS AND SPECIFICATION

The notion **specify** that I am using in my definition of discourse anaphora is based on the notion of a **Discourse Model**, earlier described in Webber (1983). My basic premise is that in processing a narrative text, a listener is developing a model of at least two things: 1. the entities under discussion, along with their properties and relationships to one another, and 2. the events and situations under discussion, along with their relationships to one another (e.g., consequential relations, simple ordering relations, elaboration relations, etc.). The representation as a whole I call the listener's **Discourse Model**.<sup>2</sup>

In this section, I will focus on NPs. (In Section 3, I will turn attention to tensed clauses.) NPs may **evoke** entities into the listener's Discourse Model corresponding to individuals (Example 1), sets (Example 2), abstract individuals (Example 3), classes (Example 4), etc.<sup>3</sup>

1. a. Wendy gave Eliot a T-shirt for Christmas.  
b. Unfortunately, (*it, the T-shirt*) had the logo "You ate it, Ralph".
2. a. Wendy gave each boy a T-shirt.  
b. (*They, The T-shirts*) each had a different logo on the front.
3. a. *The vice president* must be over 35 years old.  
b. *He or she* must also be able to count.
4. a. The dachshund down the block bit me yesterday.  
b. *They're* really vicious beasts.

An NP which **evokes** a discourse entity also **specifies** it.<sup>4</sup> One way an NP would be considered anaphoric by the above definition would be if it specified an entity  $E_a$  in the model that had already been evoked by some other NP. (In that case, one would say that the two NPs **co-specified** the same entity.) This basic arrangement is illustrated in Examples 1–3 above and is shown in Figure 1a.<sup>5</sup> Formally, one could say that there is an anaphoric function  $\alpha$ , whose value, given the anaphoric noun phrase  $NP_b$  and the discourse entity  $E_a$ , is  $E_a$ —that is,  $\alpha(NP_b, E_a) = E_a$ . This can also be read as  $NP_b$  *specifies*  $E_a$  by virtue of  $E_a$ . Definite pronouns are most often anaphoric in just this way.

The other way an NP would be considered a discourse anaphor would be if it used some existing discourse entity  $E_a$  to evoke and specify a new discourse entity  $E_b$ , as in

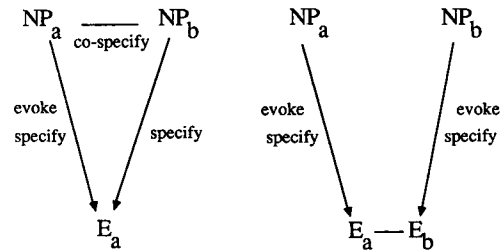


Figure 1. Evoke, specify, and co-specify.

5. a. A bus came round the corner.  
b. I signaled to *the driver* to stop.

where  $NP_b$ —*the driver*—makes use of the entity associated with the bus mentioned in 5a to specify a new entity—*the driver of that bus*.

Here the anaphoric function is of the form  $\alpha(NP_b, E_a) = E_b$ . In cooperative discourse, there have to be constraints on the value of  $\alpha(NP_b, E_a)$ , since only  $NP_b$  is given explicitly. In short, a cooperative speaker must be able to assume that the listener is able to both infer a possible  $\alpha$  and single out  $E_a$  in his/her evolving Discourse Model.<sup>6</sup> (This is illustrated in Figure 1b.) I will consider each of these two types of constraints in turn.

Speakers assume listeners will have no problem with  $\alpha$  when  $\alpha(NP_b, E_a) = E_a$ . Inferring  $\alpha$  in other cases follows in large part from the **ontology** of the entities specified by NPs—i.e., the ontology of our concepts of individuals, sets, mass terms, generics, etc. We view these as having parts (e.g., car: the engine, the wheels), having functional relations (e.g., car: the driver), having roles (e.g., wedding: the bride), etc. These needn't be necessary parts, relations, roles, etc. Our ontology includes possible parts, relations, etc., and these too make it possible for the listener to infer an  $\alpha$  such that  $\alpha(NP_b, E_a) = E_b$  (e.g., room: the chandelier; car: the chauffeur; wedding: the flower girl). Such inferences are discussed at length in the literature, including Clark and Marshall 1981, and Hobbs 1987.<sup>7</sup>

Before closing this section, there are two more things to say about NPs. First, the above definition of discourse anaphor does not apply to all definite NPs: a definite NP can be used to refer to something unique in the speaker and listener's shared spatio-temporal context (e.g., the telephone—i.e., the one that they both hear ringing) or their shared culture (e.g., the government), to the unique representative of a class (e.g., the duck-billed platypus), to an entire class or set (e.g., the stars), or to a functionally defined entity (e.g., the

largest tomato in Scotland). None of these would be considered discourse anaphoric by the above definition.

Secondly, though the definition implies that one must consider some indefinite NPs to be discourse anaphors, since they are essentially parasitic on a corresponding anaphoric definite NP, as in the following example:

6. a. The driver stopped the bus when *a passenger* began to sing, "Aida".
- b. The driver stopped the bus when *the passengers* began to sing "Aida".

The indefinite NP *a passenger* in (6a) can be paraphrased as *some one of the passengers*, and thus is parasitic on the anaphoric definite NP *the passengers* mentioned explicitly in (6b). This does not imply that all indefinite NPs are discourse anaphors. In *Mary met a boy with green hair* or *Fred built an oak desk*, the indefinite NPs do not need to be interpreted with respect to another discourse entity and some inferrable relationship with that entity, in order to characterize the discourse entity they specify.

In the next section, I will discuss the second kind of constraint on the function  $\alpha(\text{NP}_b, \text{E}_a)$  necessary for cooperative use of an anaphor—constraints on identifiable  $\text{E}_a$ s. These involve notions of **discourse structure** and **discourse focus**. Before I close, though, I want to point to where I'm going vis-à-vis the anaphoric character of tense and tensed clauses. In contrast with previous accounts of tense as pronoun or tense as loosely context-dependent, I am going to claim that, like an anaphoric definite NP,

- a tensed clause  $C_b$  may either **specify** an existing event or situation  $\text{E}_b$  in the listener's Discourse Model, or it may both **evoke** and **specify** a new entity.
- As with anaphoric NPs, there are constraints on possible anaphoric functions and on the  $\text{E}_a$ s that can participate in them at any one time.
- These functions are sensitive to that part of a tensed clause  $C_b$  called by Reichenbach (1947) **point of reference** (here abbreviated RT), as well as its relationship to Reichenbach's **point of the event** (ET).
- These functions can be defined in part in terms of an independently justifiable ontology of events proposed (independently) by Moens and Steedman (this volume) and Passonneau (this volume).
- The constraints on  $\text{E}_a$  are tied in with a temporal analogue of discourse focus that I have called **temporal focus** (TF), and through TF, with discourse structure as well.

## 2.2 DISCOURSE FOCUS AND DISCOURSE STRUCTURE

The ideas presented in this section have been formulated and developed by Barbara Grosz and Candy Sidner, originally independently and later in joint research. It is not a summary of their work:<sup>8</sup> it is limited to those of their ideas that are necessary to the concept of anaphor that I am advancing here and the concept of tense as anaphor, in particular.

Sidner's thesis (1979, 1983) presents an account of understanding definite pronouns and anaphoric definite NPs that reflects the ease with which people identify the intended specificand of definite pronouns (except in highly ambiguous cases), as well as the intended specificand of anaphoric definite NPs.

With respect to noun phrases (but not clauses), Sidner makes the same assumption about evoking, specifying, and co-specifying in a Discourse Model that I have made here. To understand anaphoric expressions, Sidner postulates three mechanisms:

1. a current discourse focus (DF)
2. an ordered list of potential foci (PFL) for the next utterance
3. a stack for saving the current DF and resuming it later.

The DF corresponds to that entity the listener is most attending to. Pronouns can most easily specify the current DF, slightly less easily a member of the PFL, and with slightly more difficulty, a stacked focus. Specifying an entity pronominally can shift the listener's attention to it, thereby promoting it to be the next DF. Anything else specified in the clause ends up on the PFL, ordered by its original syntactic position. (Sidner introduced a separate "agent focus" to allow two entities to be specified pronominally in the same clause, but it was not a critical feature of her approach.) As for anaphoric definite NPs, they can specify anything previously introduced (whether on the PFL, a stacked focus, or anything else) or anything related in a mutually inferrable way with the current DF or a member of the PFL. In terms of the constraints I mentioned above, it is only those discourse entities that are either the DF or on the PFL that can serve as  $\text{E}_a$  for an anaphoric definite NP.<sup>9</sup>

In Sidner (1983) DFs always are stacked for possible resumption later. In Grosz and Sidner (1986) it is an entire **focus space** (FS) (Grosz 1977) that gets stacked (i.e., the collection of entities  $L$  is attending to by virtue of the current **discourse segment** (DS)) but only when the **purpose** of the current DS is taken to **dominate** that of the one upcoming. **Dominance** relations are also specified further according to the type of discourse. In Grosz and Sidner, they are defined for task-related dialogues and arguments. For example, in arguments, one DS purpose (DSP) dominates another if the second provides evidence for a point made in the first. When the dominated DSP is satisfied, its corresponding FS is popped. This stack mechanism models the listener's **attentional state**. The relations between DSPs constitute the **intentional structure** of the text. Getting a listener to resume a DS via the stack mechanism is taken to require less effort on a speaker's part than returning to elaborate an argument or subtask description later on.

The significance of Sidner (1983) and Grosz and Sidner (1986) for the current enterprise is that:

- Sidner essentially shows how DF can move gradually among the discourse entities that make up a focus space, as the listener is processing its associated discourse segment;
- Grosz and Sidner show how DF can make a radical jump to a different (possibly newly evoked) discourse entity as the listener moves to process the next discourse segment.<sup>10</sup>

I reinterpret this in the current framework in terms of the anaphoric function  $\alpha(NP_b, E_a)$ . Within a discourse segment, the entity that is the DF is the most likely  $E_a$ . Over the discourse segment, other discourse entities in the segment's focus space may in turn become DF. With a change in discourse segment, however, the DF can change radically to an entity in the focus space associated with the new segment.

To hint again at what is to come: in Section 3.2, I will propose a temporal analogue of DF, which I have called **temporal focus** (TF). In Section 3.3, I will show how gradual movements of the TF are tied in with the ontology of what a tensed clause specifies—i.e., an ontology of events and situations—while more radical movements reflect the effect of discourse structure on TF.

### 3 TENSE AS ANAPHOR

Tense may not seem *prima facie* anaphoric: an isolated sentence like *John went to bed* or *I met a man who looked like a basset hound* appears to make sense in a way that a stand-alone *He went to bed* or *The man went to bed* does not. On the other hand, if some time or event is established by the context (i.e., either by an event or situation described in the previous discourse or by a temporal adverbial in the current sentence—cf. Passonneau, and Moens and Steedman, this volume), tense will invariably be interpreted with respect to it, as in:

7. a. After he finished his chores, John went to bed.
- b. John partied until 3 am. He came home and went to bed.

In each case, the interpretation of John's going to bed is linked to an explicitly mentioned time or event. This is what underlies all discussion of the anaphoric quality of tense.

#### 3.1 BACKGROUND

The assumption that tense is anaphoric (i.e., that its interpretation is linked to some time or event derived from context) goes back many years, although it is not a universally held belief (cf. Comrie 1985). Leech seems to express this view in his *Meaning and the English Verb*:

- 63 INDEFINITE TIME Whereas the Present Perfect, in its indefinite past sense, does not name a specific point of time, a definite POINT OF ORIENTATION in the past is normally required for

the appropriate use of the Simple Past Tense. The point of orientation may be specified in one of three ways: (a) by an adverbial express of time-when; (b) by a preceding use of a Past or Perfect Tense; and (c) by implicit definition; i.e., by assumption of a particular time from context.

- 73 The Past Perfect Tense has the meaning of past-in-the-past, or more accurately, 'a time further in the past, seen from the viewpoint of a definite point of time already in the past'. That is, like the Simple Past Tense, the Past Perfect demands an already established past point of reference. (Leech: 47)

Leech did not elaborate further on how reference points are used in the interpretation of simple past tense and past perfect tense, or on what has become the main problem in the semantics and pragmatics of tense: reconciling the (usual) forward movement of events in narratives with a belief in the anaphoric (or context-dependent) character of tense.

The first explicit reference I have to tense being anaphoric like a definite pronoun is in an article by McCawley (1971:110), who said:

However the tense morpheme does not just express the time relationship between the clause it is in and the next higher clause—it also refers to the time of the clause that it is in, and indeed, refers to it in a way that is rather like the way in which personal pronouns refer to what they stand for.

McCawley also tried to fit in his view of tense as pronoun with the interpretation of tense in simple narratives. Here he proposed that the event described in one clause serves as the antecedent of the event described in the next, but that it may be related to that event by being either at the same time or "shortly after" it. He did not elaborate on when one relation would be assumed and when the other.

Partee (1973) also noted the similarities between tense and definite pronouns. However, she subsequently recognized that taking simple past tense as directly analogous with pronouns was incompatible with the usual forward movement of time in the interpretation in a sequence of sentences denoting events (Partee 1984). Her response was a modification of the claim that tense is anaphoric, saying:

I still believe it is reasonable to characterize tense 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 (256).

The particular context-dependent process she proposes for interpreting tensed clauses follows that of Hinrichs 1986, briefly described below.

The examples presented above to illustrate the anaphoric quality of tense were all simple past. However, as Leech notes (see above), the past perfect also makes demands on having some reference point already estab-

lished in the context. Thus it cannot be in terms of the event described in a tensed clause that tense is anaphoric. Instead, several people (Steedman 1982, Hinrichs 1986, Bauerle 1979) have argued that it is that part of tense called by Reichenbach (1947) the **point of reference** (here abbreviated RT) that is anaphoric. This can be seen by considering the following example:

8. a. John went to the hospital.
- b. He had twisted his ankle on a patch of ice.

It is not the **point of the event** (here abbreviated ET) of John's twisting his ankle that is interpreted anaphorically with respect to his going to the hospital. Rather, it is the RT of the second clause: its ET is interpreted as prior to that because the clause is in the past perfect (see above).

I will now review briefly Hinrichs's proposal as to how tensed clauses are interpreted in context, in order to contrast it with the current proposal.

In Hinrichs 1986, Hinrichs makes the simplifying assumption that in a sequence of simple past sentences, the temporal order of events described cannot contradict the order of the sentences. This allows him to focus on the problem of characterizing those circumstances in which the event described by one sentence *follows* that described by the previous one (Example 9—Hinrichs's Example 15) and when it overlaps it (Example 10—Hinrichs's Example 21):

9. The elderly gentleman wrote out the check, tore it from the book, and handed it to Costain.
10. Mr. Darby slapped his forehead, then collected himself and opened the door again. The brush man was smiling at him hesitantly.

Hinrichs bases his account on the *Aktionsart* of a tensed clause (i.e., its Vendlerian classification as an accomplishment, achievement, activity, or state—including progressives). Assuming an initial reference point in a discourse, the event described by a tensed clause interpreted as an accomplishment or achievement will be included in that reference point and will also introduce a new reference point ordered after the old one. Events associated with the other *Aktionsarten* include the current reference point in the event time. This means that given a sequence of two clauses interpreted as accomplishments or achievements, their corresponding events will follow one another (cf. Example 9). On the other hand, given a sequence with at least one tensed clause interpreted as an activity or state (including progressive), their corresponding events will be interpreted as overlapping each other (cf. Example 10).

Hinrichs relates his reference point to that of Reichenbach. (Thus, the anaphoric character of tense is based on RT and not on the events directly.) However, Hinrichs's notion and Reichenbach's differ with respect to the time of the event described in the tensed clause. While Reichenbach talks about ET and RT being the

same for nonprogressive past-tense clauses, in Hinrichs's account the reference point can fall after the event if a nonprogressive past is interpreted as an accomplishment or an achievement. This is necessary to achieve the forward movement of narrative that Hinrichs assumes is always the case (his simplifying assumption) but it is not the same as Reichenbach's RT. It also leads to problems in cases where this simplifying assumption is just wrong—where in a sequence of simple past tenses, there is what appears to be a “backward” movement of time, as in

11. a. For an encore, John played the “Moonlight Sonata”.
- b. The opening movement he took rather tentatively, but then . . .

where the second clause should be understood as describing the beginning of the playing event in more detail, not as describing a subsequent event.

In the account given below, both forward and backward movement of time fall out of the anaphoric character of tensed clauses, and the dependency of discourse anaphora on discourse structure.<sup>11</sup>

### 3.2 TENSE AS DISCOURSE ANAPHOR: IN WHAT SENSE “SPECIFY”?

With that background, I will now show how tensed clauses share the two properties I set out in Section 1 (repeated here) and hence are further examples of discourse anaphora:

1. Anaphors specify entities in an evolving model of the discourse that the listener is constructing;
2. the particular entity specified depends on another entity in that part of the evolving Discourse Model that the listener is currently attending to.

To do this, I need to explain the sense in which tensed clauses specify and the way in which that specification can depend on another element in the current context.

Recall that I presume that a listener's developing discourse model represents both the entities being discussed, along with their properties and relations, and the events and situations being discussed, along with their relationships with another. For the rest of this paper, I want to ignore the former and focus on the latter. This I will call **event/situation structure**, or **E/S structure**. It represents the listener's best effort at interpreting the speaker's ordering of those events and situations in time and space. One problem in text understanding, then, is that of establishing where in the evolving E/S structure to integrate the event or situation description in the next clause.

In this framework, a tensed clause  $C_b$  provides two pieces of semantic information: (a) a description of an event or situation, and (b) a particular configuration of ET, RT, and **point of speech** (abbreviated ST). (Here I may be departing from Reichenbach in treating ET, RT, and ST explicitly as elements of linguistic semantics, quite distinct from entities of type “event” in the

Discourse Model.)  $C_b$  then specifies an entity  $E_b$  in the Discourse Model whose temporal relationship to other events in the model follows (in part) from  $C_b$ 's particular configuration of ET, RT, and ST. Both the characteristics of  $E_b$  (i.e., its ontology) and the configuration of ET, RT, and ST are critical to my account of tense as discourse anaphor.

The event ontology I assume follows that of Moens and Steedman (this volume) and of Passonneau (this volume). Both propose that people interpret events as having a tripartite structure (a "nucleus" in Moens and Steedman's terminology) consisting of a preparatory phase (**prep**), a culmination (**cul**), and a consequent phase (**conseq**)—as in Figure 2. This tripartite structure permits a uniform account to be given of aspectual types in English and of how the interpretation of temporal adverbials interacts with the interpretation of tense and aspect. For example, the coercion of clauses from one interpretation to another is defined in terms of which parts of a nucleus they select and how those parts are described.<sup>12</sup>



Figure 2. Tripartite ontology of events.

The ET/RT/ST configuration is significant in that, like Steedman 1982, Dowty 1986, Hinrichs 1986, and Partee 1984, I take RT as the basis for anaphora. To indicate this, I single it out as an independent argument to anaphoric functions, here labelled  $\beta$ . In particular, the following schema holds of a clause  $C_b$  linked anaphorically to an event  $E_a$  through its RT:

$$\beta(C_b, E_a, RT_b) = E_b$$

The relationship between  $E_b$  and  $E_a$  then falls out as a consequence of 1. the particular ET/RT/ST configuration of  $C_b$ ; and 2. the particular function  $\beta$  involved.

One possibility is that  $\beta$  links  $RT_b$  directly to  $E_a$ —i.e.:

$$\beta_0(C_b, E_a, RT_b) = E_b$$

In this case, the relationship between  $E_b$  and  $E_a$  then depends on the configuration of  $RT_b$  and  $ET_b$ . If  $ET_b = RT_b$ , then (minimally)  $E_b$  is taken to coincide in some way with  $E_a$ . This is shown in Figure 3a. If  $ET_b < RT_b$  (as in the perfect tenses),  $E_b$  is taken to precede  $E_a$ . This is shown in Figure 3d.

Alternatively,  $\beta$  may embody part of the tripartite ontology of events mentioned earlier:  $\beta_{prep}$  links  $RT_b$  to the preparatory phase of  $E_a$  (as shown in Figure 3b)—i.e.:

$$\beta_{prep}(C_b, E_a, RT_b) = E_b$$

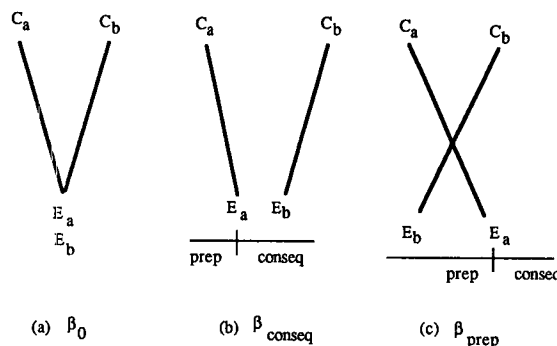


Figure 3. Anaphoric relations for tensed clauses where ET = RT.

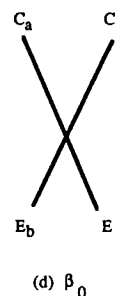


Figure 3 (continued). Anaphoric relations where ET < RT.

while  $\beta_{conseq}$  links  $RT_b$  to the consequent phase of  $E_a$  (as shown in Figure 3c)—i.e.:

$$\beta_{conseq}(C_b, E_a, RT_b) = E_b$$

(There is a third possibility—that  $RT_b$  links to the culmination of  $E_a$ —but it is not clear to me that it could be distinguished from the simpler  $\beta_0$  function given above, which links  $RT_b$  to  $E_a$  itself. Also, while  $\beta_{prep}$  and  $\beta_{conseq}$  relations for  $RT_b$  might theoretically be possible for a perfect, it is not clear to me that these cases could be distinguished from the simpler  $\beta_0$ . In the case of perfects therefore, the relation between  $E_b$  and  $E_a$  is correspondingly indirect.<sup>13</sup>)

The following example illustrates the case where  $\beta = \beta_0$  and  $ET_b = RT_b$ .

- 12. a. John played the piano.
- b. Mary played the kazoo.

Sentence 12a. evokes a new event entity  $E_a$  describable as the event of John playing the piano. Since the tense of (12b) is simple past,  $ET_b = RT_b$ . Given  $\beta_0(C_b, E_a, RT_b) = E_b$ , then  $E_b$  is interpreted as coextensive with  $E_a$ . (Whether this is further interpreted as two simultaneous events or a single event of their playing a duet depends on context and, perhaps, world knowledge as well.) This is illustrated in Figure 4. Example 8 (repeated here) illustrates the case  $\beta_0$  where  $ET_b < RT_b$ .

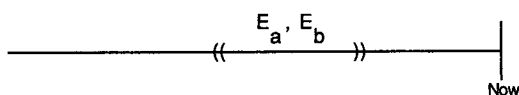


Figure 4. Co-extensive events.

- 8. a. John went to the hospital.
- b. He had twisted his ankle on a patch of ice.

Clause 8a. evokes an entity  $E_a$  describable as John's going to the hospital. Since 8b is past perfect,  $ET_b < RT_b$ . Thus if  $\beta_0(C_b, E_a, RT_b) = E_b$ , the event  $E_b$  described by 8b is taken to be prior to  $E_a$ . As Moens & Steedman (this volume) point out, the *consequences* of an event described with a perfect tense are still assumed to hold. Hence the overlap shown in Figure 5:

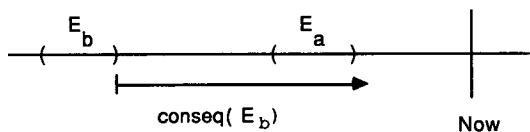


Figure 5. Ordered events.

The next example illustrates  $\beta_{conseq}$ :

- 13. a. John went into the florist shop.
- b. He picked out three red roses, two white ones and one pale pink.

Clause 13a evokes an entity  $E_a$  describable as John's going into a flower shop. Since Clause 13b is simple past,  $ET_b = RT_b$ . Thus given  $\beta_{conseq}(C_b, E_a, RT_b) = E_b$ , event  $E_b$  is taken as being part of the consequent phase of  $E_a$ . That is, John's picking out the roses is taken as happening after his going into the florist shop. This is shown in Figure 6. The next example illustrates the case of  $\beta_{prep}$ :

- 14. a. John bought Mary some flowers.
- b. He picked out three red roses, two white ones and one pale pink.

Since 14b is simple past,  $ET_b = RT_b$ . Thus given  $\beta_{prep}(C_b, E_a, RT_b) = E_b$ , event  $E_b$ —the event of picking out some roses—is taken as being part of the preparatory phase of the event  $E_a$ , which when completed, can

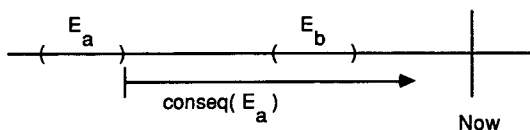


Figure 6. Consequent-phase relation.

be described as having bought some flowers. This is shown in Figure 7.

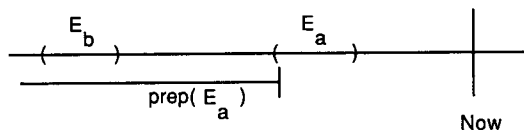


Figure 7. Preparatory-phase relation.

To summarize, I have claimed that: 1. the notion of **specification** makes sense with respect to tensed clauses; 2. one can describe the anaphoric relation in terms of the RT of a tensed clause  $C_b$ , its ET/RT configuration, and an existing event or situation entity  $E_a$ —that is,  $\beta(C_b, E_a, RT_b) = E_b$ ; and 3. there are (at least) three  $\beta$  functions—one,  $\beta_0$ , linking  $RT_b$  to  $E_a$  itself, the other two ( $\beta_{prep}$  and  $\beta_{conseq}$ ) embodying parts of a tripartite ontology of events. In the next section, I will discuss constraints on the second argument to  $\beta(C_b, E_a, RT_b)$ —that is, constraints on which entities in the evolving E/S structure the specification of a tensed clause can depend on.

### 3.3 TEMPORAL FOCUS

Recall from Section 2.2 that Sidner introduced the notion of a dynamically changing **discourse focus** (DF) to capture the intuition that at any point in the discourse, there is one discourse entity that is the prime focus of attention and that is the most likely (although not the only possible) specificand of a definite pronoun. In parallel, I propose a dynamically changing **temporal focus** (TF), to capture a similar intuition that at any point in the discourse, there is one entity in E/S structure that is most attended to and hence most likely to stand in an anaphoric relation with the RT of the next clause. That is,  $\beta(C_b, TF, RT_b) = E_b$ . If  $C_b$  is interpreted as part of the current discourse segment, after its interpretation there are three possibilities:

1. With  $\beta_0$ , the TF will stay where it is, independent of whether  $ET = RT$  or  $ET < RT$ .
2. With  $\beta_{conseq}$ ,  $RT_b$ 's link to the consequent phase of the TF locates event  $E_b$  there, shifting the TF forward (to  $E_b$ ). This is the "natural" forward progression of narrative.
3. With  $\beta_{prep}$ ,  $RT_b$ 's link to the preparatory phase of the TF locates  $E_b$  there, shifting the TF backward to ( $E_b$ ). This is used to elaborate an event or situation in more detail.

These relationships, which I will call **maintenance** and **local movement** of the TF, correspond to Sidner's DF moving gradually among the discourse entities in a discourse segment. (They cover the same phenomena as the **micromoves** that Nakhimovsky describes in his paper (this volume).) More radical movement of TF correspond to changes in discourse structure. (These

cover similar phenomena to the **macromoves** described in Nakhimovsky, also this volume.) In cases involving movements into and out of an embedded discourse segment, either 1. the TF will shift to a different entity in E/S structure—either an existing entity or one created in recognition of an embedded narrative; or 2. it will return to the entity previously labeled TF, after completing an embedded narrative. Such movements are described in Section 3.3.2. Other movements, signaled by temporal adverbials and *when* clauses, are not discussed in this paper.<sup>14</sup>

**3.3.1 TEMPORAL FOCUS: MAINTENANCE AND LOCAL MOVEMENT**

The following pair of examples illustrate maintenance and local movement of TF within a discourse segment and its link with E/S structure construction. The first I discussed in the previous section to illustrate  $\beta_{conseq}$ . The second is a variation on that example:

- 13. a. John went into the florist shop.
- b. He picked out three red roses, two white ones and one pale pink.
  
- 15. a. John went into the florist shop.
- b. He had promised Mary some flowers.
- c. He picked out three red roses, two white ones, and one pale pink.

First consider Example 13. The first clause (13a) evokes an event entity  $E_a$  describable as *John's going into the florist shop*. Since its tense is simple past,  $E_a$  is interpreted as prior to ST. Since it begins the discourse, its status is special vis-à-vis both definite NPs and tensed clauses. That is, since no previous TF will have been established yet, the listener takes that entity  $E_a$  to serve as TF.<sup>15</sup> This is shown in Figure 8:

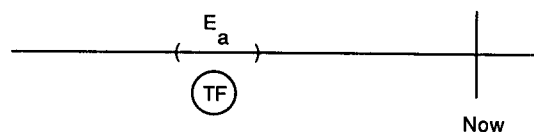


Figure 8. E/S structure after processing Clause 13a.

If Clause 13b is interpreted as being part of the same discourse segment as (13a) it must be the case that  $\beta(C_{13b}, TF, RT_{13b})$ . Assume the listener takes  $\beta$  to be  $\beta_{conseq}$  on the basis of world knowledge—that is,  $\beta_{conseq}(C_{13b}, TF, RT_{13b})$ . Since the tense of (13b) is simple past, its RT and ET coincide. Thus (13b) specifies a new entity  $E_b$ , located within the consequent phase of the TF—that is,  $E_a$ —and hence after it. I assume that, following the computation of the anaphoric function, TF becomes associated with the event entity located at  $RT_b$ . In this case, it is  $E_b$ , and TF thereby moves forward (cf. Figure 9). As noted, this is the gradual forward movement of simple narratives that Hinrichs,

Partee, and Dowty were out to achieve. Here it falls out simply from the discourse notion of a TF and from the particular anaphoric function  $\beta_{conseq}$ .<sup>16</sup>

Now consider Example 15 (repeated here) whose first clause is the same as Example 13a and hence would be processed in the same way.

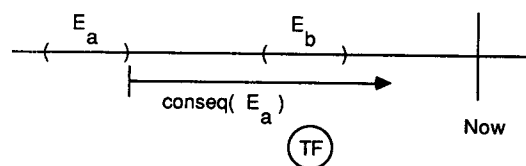


Figure 9. E/S structure after processing Clause 13b.

- 15. a. John went into the florist shop.
- b. He had promised Mary some flowers.
- c. He picked out three red roses, two white ones, and one pale pink.

The tense of the next clause (15b) is past perfect. As I noted above, the only anaphoric function on  $RT_{15b}$  and an event entity that makes sense for perfect tenses is  $\beta_0$ —that is,

$$\beta_0(C_{15b}, TF, RT_{15b}) = E_{15b}$$

Given that perfect tenses imply  $ET < RT$ , the event  $E_b$  specified by (15b) will be interpreted as being prior to  $E_a$ . Moreover, since (15b) is past perfect, the consequent phase of  $E_b$  is assumed to still hold with respect to  $RT_{15b}$ . Hence the consequent phase of  $E_b$  overlaps  $E_a$ . Finally since TF is associated with the event entity at  $RT_b$ , it remains at  $E_a$ . E/S structure at this point resembles Figure 10:

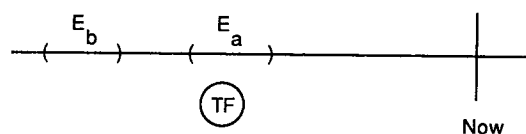


Figure 10. E/S structure after processing Clause 15b.

Now Clause 15c is the same as (13b), and TF is the same as it was at the point of interpreting (13b). Thus not surprisingly, 15c produces the same change in E/S

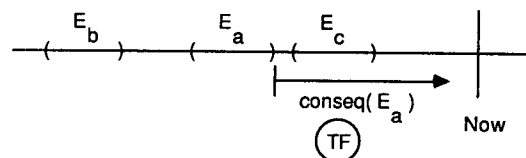


Figure 11. E/S structure after processing Clause 15c.



structure and in the TF as (13b), resulting in the diagram shown in Figure 11.

3.3.2 TEMPORAL FOCUS: DISCOURSE-STRUCTURE MOVEMENTS

To illustrate the effect of discourse structure on TF, consider the following variation on Example 15, which had the same structure vis-à-vis sequence of tenses.

- 16. a. John went into the florist shop.
- b. He had promised Mary some flowers.
- c. She said she wouldn't forgive him if he forgot.

The first two clauses (a) and (b) are the same as in Example 15 and lead to the same configuration of event entities in E/S structure (as shown in Figure 10). But the most plausible interpretation of (16c) is where the "saying" event is interpreted anaphorically with respect to the "promising" event—that is, where (16b–c) are taken together as (the start of) an embedded discourse, describing an event prior to John's going to the florist's.

To handle this, I assume, following Grosz and Sidner 1986, that when the listener recognizes an embedded discourse segment, s/he stores the current TF for possible resumption later.<sup>17</sup> However, I also assume the listener recognizes the embedding *not* when s/he first encounters a perfect-tensed clause  $C_b$ , since it needn't signal an embedded discourse, but *later*, when an immediately following simple past tense clause  $C_c$  is most sensibly interpreted with respect to the event entity  $E_b$  that  $C_b$  evoked.<sup>18</sup> At this point, the listener moves TF from its current position to  $E_b$ , caching the previous value for possible resumption later. Following this gross movement,  $\beta(C_c, TF, RT_c)$  will be computed. If  $\beta$  is then interpreted as  $\beta_{conseq}$  or  $\beta_{prep}$ , there will be a second movement of TF.<sup>19</sup>

Coming back to Example 16, if Clause 16c is taken as being part of a single discourse segment with (16a–b), *she saying something* would have to be interpreted with respect to the current TF ( $E_a$ )—John's going to the florist. This is implausible under all possible interpretations of  $\beta$ .<sup>20</sup> However, under the assumption that  $E_b$  is part of an embedded narrative, the listener can *a posteriori* shift TF to  $E_b$  and consider the anaphoric relation

$$\beta(C_{16c}, TF, RT_{16c}) = E_{16c}$$

with  $E_b$  as TF. At this point, the listener can plausibly take  $\beta$  to be  $\beta_{conseq}$  based on world knowledge. Since (16c) is simple past,  $ET_c = RT_c$ , the "saying" event  $E_c$  is viewed as part of the consequent phase (and hence following) the "promising" event  $E_b$ . As in the first case, TF moves to the event located at  $RT_c$ —i.e., to  $E_c$ . This is shown roughly in Figure 12. Notice that this involved *two* movements of TF—once in response to a perceived embedded segment and a second time, in response to interpreting  $\beta$  as  $\beta_{conseq}$ .

Now consider the following extension to (16):

- 17. a. John went into the florist shop.
- b. He had promised Mary some flowers.
- c. She said she wouldn't forgive him if he forgot.
- d. So he picked out three red roses, two white ones, and one pale pink.

As before, Clauses 17b–c form an embedded narrative, but here the main narrative of John's visit to the florist shop, started at (17a), is continued at (17d). To handle this, I again assume that TF behaves much like Sidner's DF in response to the listener's recognition of the *end* of an embedded narrative: that is, the cached TF is resumed and processing continues.<sup>21</sup>

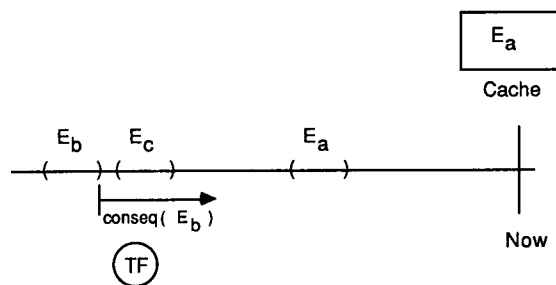


Figure 12. E/S structure after processing Clause 16c.

Under this assumption, Clauses 17a–c are interpreted as in the previous example (cf. Figure 12). Recognizing Clause 17d as resuming the embedding segment,<sup>22</sup> the previously cached TF ( $E_a$ —the *going into the florist shop* event) is resumed. Again assume that the listener takes the anaphoric function to be  $\beta_{conseq}(C_d, TF, RT_d) = E_d$  on the basis of world knowledge. Since Clause 17d is simple past ( $ET = RT$ ), the *picking out roses* event  $E_d$  is viewed as part of the consequent phase and hence following the *going into the florist shop* event. This is shown roughly in Figure 13:

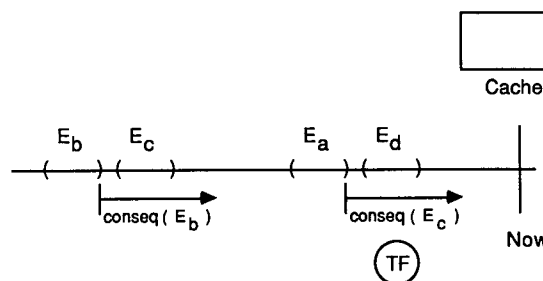


Figure 13. E/S structure after processing Clause 17d.

Now getting the listener to interpret a text as an embedded narrative requires providing him/her with another event or situation that TF can move to. One way in English is via a perfect-tensed clause, which

explicitly evokes another event, temporally earlier than the one currently in focus. Another way is by lexical indications of an embedded narrative, such as verbs of telling and NPs that themselves denote events or situations (e.g., ones headed by de-verbal nouns).

This is illustrated in Example 18. Even though all its clauses are simple past ( $ET = RT$ ), Clauses 18c–d are most plausibly interpreted as *indirect speech* describing an event that has occurred prior to the “telling” event. I assume that in response to recognizing this kind of embedded narrative, the listener creates a new node of E/S structure and shifts TF there, caching the previous value of TF for possible resumption later. The temporal location of this new node vis-à-vis the previous TF will depend on information in the tensed clause and on the listener’s world knowledge.

18. a. I was at Mary’s house yesterday.
- b. We talked about her sister Jane.
- c. She spent five weeks in Alaska with two friends.
- d. Together, they climbed Mt. McKinley.
- e. Mary asked whether I would want to go to Alaska some time.

Notice that, as with embedded narratives cued by the use of a perfect tense, caching the previous TF for resumption later enables the correct interpretation of Clause 18e, which is most plausibly interpreted as following the *telling about her sister* event.

An NP denoting an event or situation (such as one headed by a noun like *trip* or by a de-verbal noun like *installation*) can also signal the upcoming possibility of an embedded narrative that will elaborate that event or situation (past, upcoming, or hypothetical) in more detail, as in Example 19. In this case, the original NP and the subsequent clause(s) will be taken as co-specifying the same thing. The question here is how and when TF moves.

19. a. I was talking with Mary yesterday.
- b. She told me about her trip to Alaska.
- c. She spent five weeks above the Arctic Circle with two friends.
- d. The three of them climbed Mt. McKinley.

After interpreting Clause 19b, the TF is at the “telling” event. I claim that the NP *her trip to Alaska*, while evoking a discourse entity, does not affect the TF. If Clause 19c is interpreted as the start of an embedded narrative (as it is here), TF moves to the event entity  $E_c$  it evokes (caching the previous value  $E_b$ ). At this point, using additional reasoning, the listener may recognize an anaphoric relation between Clause 19c and the discourse entity evoked by *her trip to Alaska*. Support for this, rather than assuming that an event-denoting NP sets up a potential focus, just as I claim a perfect-tensed clause does, comes from the reasoning required to understand the following parallel example, where I would claim TF does not move.

20. a. I was talking with Mary yesterday.
- b. She told me about her trip to Alaska.
- c. She had spent five weeks above the Arctic Circle with two friends.
- d. The three of them had climbed Mt. McKinley.
- e. She said that next year they would go for Aconcagua.

The event described in Clause 20c is the same as that described in Clause 19c, and should be interpreted anaphorically with respect to the entity *her trip to Alaska* in the same way. If this is the case, however, then the anaphoric link does not follow from the movement of TF.

### 3.3.3 TEMPORAL FOCUS: MISCELLANY

Example 20 above illustrates one case of an anaphoric function on an NP and a tensed clause, specifically  $\beta(C_b, E_a, RT_b)$  where the entity  $E_a$  has been evoked by an NP rather than a clause. Another possibility is that  $\alpha(NP_b, E_a) = E_b$ , where  $NP_b$  is definite by virtue of an entity evoked by a clause rather than an NP—that is,  $E_b$ , is associated with either the preparatory/culmination/consequent structure of  $E_a$ , as in

21. a. Mary climbed Mt. McKinley.
- b. *The preparations* took her longer than *the ascent*.

or its associated role structure, as in

22. a. John bought a television.
- b. Although he had intended to buy a 13” b/w set, *the salesman* convinced him to buy a 25” color, back-projection job.

where *the salesman* fills a particular role in the buying event.

Next, notice that ambiguities arise when there is more than one way to plausibly segment the discourse, as in the following example:

23. a. I told Frank about my meeting with Ira.
- b. We talked about ordering a Butterfly.

Here it is plausible to take Clause 23b as the beginning of an embedded narrative, whereby the “talking about” event is interpreted against a new node of E/S structure, situated prior to the “telling Frank” event. (In this case, *we* is Ira and me.) It is also plausible to take (23b) as continuing the current narrative, whereby the “talking about” event is interpreted with respect to the “telling Frank” event. (In contrast here, *we* is Frank and me.)

Finally, consider things from the point of view of generation. If some event  $E_b$  is part of the preparatory phase of some event  $E_a$ , and a description of  $E_a$  has just been generated using the simple past tense, then  $E_b$  could be described using either the simple past, as in Example 24 or past perfect, as in Example 25.

24. a. John went to the hospital.  
b. He took a taxi, because his car was in the shop
25. a. John went to the hospital.  
b. He had taken a taxi, because his car was in the shop.

In the case of Example 24, the listener/reader recognizes that  $E_b$  is part of the preparatory phase of  $E_a$  and that  $E_b$  therefore precedes  $E_a$ . In the case of Example 25, the listener would first recognize that  $E_b$  precedes  $E_a$  because of the past perfect, but then recognize  $E_b$  as part of the preparatory phase of  $E_a$ .

On the other hand, if  $E_b$  simply precedes  $E_a$ , but a description of  $E_a$  has been generated first, then  $E_b$  must be described with a past perfect (Example 26): simple past would not be sufficient (Example 27).

26. a. John went to the hospital.  
b. He had broken his ankle, walking on a patch of ice.
27. a. John went to the hospital.  
b. \*He broke his ankle, walking on a patch of ice.

#### 4 CONCLUSION

In this paper, I have presented a uniform characterization of discourse anaphora in a way that includes definite pronouns, definite NPs, and tensed clauses. In doing so, I have argued that the successful use of discourse anaphors depends on two different things: 1. speakers' and listeners' (mutual) beliefs about the ontology of the things and events being discussed, and 2. speakers' and listeners' (mutual) focus of attention. The former implicates semantics in the explanation of discourse anaphora, the latter, discourse itself. It is important that we as researchers recognize these as two separate systems, as the properties of discourse as an explanatory device are very different from those of semantics.

#### ACKNOWLEDGMENTS

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8. Nor does it indicate wholesale acceptance of their theory of discourse as has so far emerged. I believe that they would be the first to admit that it's a "theory in progress".
  9. Grosz, Joshi, and Weinstein (1983) have reinterpreted part of Sidner's work in terms of their theory of centering. Her DF becomes their "backward-looking center"  $C_b$  and her PFL becomes their ordered list of "forward-looking centers"  $C_f$ . They have proposed heuristics for which entities ( $C_b$  and/or  $C_f$ s) will be specified pronominally (when specified at all) and for the consequences for such specification on subsequent  $C_b$  and  $C_f$ s.
  10. This jump is not necessary: the DF can stay the same over discourse segments—for example, discussing the same entity from different points of view.
  11. Dowty 1986 gives an account similar to Hinrichs's in its *a priori* assumption of the non-backward-movement of time in simple narratives and its focus on how different *aktionsart* lead to interpretation of co-temporal versus subsequent events. The two accounts differ in how the latter is achieved. Dowty's account avoids some problems that Hinrichs's cannot, but still cannot deal with the fact that time sometimes "moves backwards" even in sequences of simple past tense.

## NOTES

1. Computationally, these properties imply particular things about processing. For example, in interpreting an NP, one may always have to consider the possibility—probably in parallel with other possibilities—that it is a discourse anaphor. For this alternative, the processor will need to (a) keep track of entities whose specification the NP may depend on and (b) make appropriate inferences with respect to these entities. Other forms of context dependencies will have other implications for processing. In this paper, I will touch on processing issues for discourse anaphora, but not other context-dependent phenomena.
2. In earlier work, it was only the former that I discussed under the concept of Discourse Model. The notion is not all that different from Kamp's "Discourse Representation Structures" (Kamp 1984) or Heim's "File Cards" (Heim 1982).
3. This does not mean that all NPs evoke entities in the listener's Discourse Model: for example, I would not want to say that a predicate nominal (as in "John is a neuro-surgeon.") evokes a separate entity. On the other hand, I do assume that NPs in a quantified context evoke discourse entities that are accessible as long as that context holds. For example, "Whenever a philosopher debates a computer scientist, *the philosopher* turns out to have a naive idea of what *the computer scientist* is doing. Of course, *the computer scientist* always does her best to explain." (I thank Rich Thomason for the example.) Keith Stenning has also discussed examples such as this one.
4. In this use of "specify", I am following Sidner, who used it to mean, essentially, *refer in a model*, as opposed to *refer in the outside world* (cf. Sidner 1983).
5. Note that a discourse entity may or may not stand for some real-world individual or set. Whether it does or doesn't, however, is irrelevant to these model-based notions of evoke, specify, and co-specify.
6. As with any aspect of discourse that relies on the speaker making assumptions about the listener's knowledge, those assumptions may in some cases be wrong. Listeners, for their part, try to do their best in making sense anyhow—for example, hoping that the further discourse will provide enough information to work things out.
7. The inferability of  $\alpha$  in other cases follows from the ontology of entities specified clausally. This I will touch upon in Section 3. Often a speaker can assume that  $\alpha$  relates an individual to the generic class it belongs to, as in Example 4, or the intension of a definite description to its extension—or vice versa—as in "The President is elected by the Electoral College. In the 1964 election, he got all but two of the votes." I am not claiming that all inferrable  $\alpha$ 's follow from ontology—only that ontology sanctifies a great many.
12. The ontology of an event/situation also includes its role structure. This latter appears to play a part in possible anaphoric relations between an NP and an event entity, but not between a tensed clause and an event entity.
13. I have not considered other aspectual types in English (such as progressive) vis-à-vis possible anaphoric relations. Integrating the current account with work on aspect and *Aktionsarten*, [cf. Moens & Steedman, Passonneau, Hinrichs, Nakhimovsky—this volume] is left to future work.
14. I should also note that Rohrer 1985 suggests that there may exist a set of possible temporal referents, possibly ordered by saliency, among which the tense in a sentence may find its reference time, but doesn't elaborate how. That is the only thing I have seen that comes close to the current proposal.
15. This is similar to the listener's response to the definite NP *the florist shop*, which in the middle of a discourse would have to be taken anaphorically. At the beginning of a discourse, the listener will just create a new discourse entity.
16. In parallel with this, given  $\beta_{\text{prep}}$ , TF will move incrementally back into the preparatory phase of the event that was the previous TF. Given  $\beta_0$ ,  $RT_b$  is at the TF and TF does not move.
17. While Sidner and thereafter Grosz & Sidner assume a stack of focus spaces with their associated DFs, each of which is resumable, I do not have evidence that the listener can keep track of more than one other node of E/S structure in addition to the TF. Resuming any other node seems to require more effort—such as using a *when* clause. Hence I assume a single item cache for the previous value of TF.
18. One could say, in parallel with Sidner 1983, that this  $E_b$  was a potential focus (PF). However, I do not postulate a Potential Focus List as in Sidner, because I do not think there is ever more than one PF that one can shift to without using a temporal adverbial.
19. This is clearly an inertial strategy: it assumes that the listener will prefer to interpret clauses as being in the same discourse segment, unless forced to do otherwise, say by a continuation such as (16c) or a lexical item that signals a possible embedded narrative. This I will discuss later on. In spoken text, the speaker might give an intonation to (16b) that conveys that it and the following clauses should be understood as an embedded discourse segment. This would be what breaks the inertia and causes the listener to shift the TF.
20. It is rarely the case that one cannot come up with a story linking two events and/or situations. Thus it would be impossible to reject a hypothesis on grounds of inconsistency. All one can say is that one of such stories might be more plausible than the

others by requiring, in some sense not explored here, fewer inferences. Crain and Steedman 1985 make a similar argument about prepositional phrase (PP) attachment. For example, it is not impossible for a cat to own a telescope—e.g., by inheritance from its former owner. Thus *a cat with a telescope* is not an inconsistent description. However, it must compete with other plausible interpretations like *seeing with a telescope* in *I saw a*

*cat with a telescope*. Thus I assume that interpretations are computed in parallel, with the most plausible prediction being the one that ends up updating both E/S structure and the TF.

21. Recall my prediction that if any but the most recently cached TF is to be resumed, a cooperative speaker will explicitly indicate this with a temporal adverbial or a *when* clause.
22. *So* is one cue. In spoken discourse, intonation would be another.