University of Pennsylvania

ScholarlyCommons

Technical Reports (CIS)

Department of Computer & Information Science

9-1-1989

Deictic Reference and Discourse Structure

Bonnie L. Webber
University of Pennsylvania, bonnie@inf.ed.ac.uk

Follow this and additional works at: https://repository.upenn.edu/cis_reports

Deictic Reference and Discourse Structure

Abstract

Research on the factors and processes involved in pronoun interpretation has to date concentrated on anaphoric pronouns. Results have supported the now widely-held view that discourse understanding involves the creation of a partial, mental model of the situation described through the discourse. Anaphoric pronouns are taken to refer to elements of that model (often called *discourse referents* or *discourse entities*), usually ones that have, at the moment of referring, some special focus status.

This paper examines *deictic pronouns* - in particular, ones that refer to the interpretation of one or more clauses. I argue that referents for these pronouns must come from the interpretations of *discourse segments* on the *right frontier* of an evolving structure representing the discourse. Under the assumption that reference is always to an individual, this implies that discourse segment interpretations must also be part of the evolving *discourse model*. I discuss this in the last section of the paper.

Comments

Deictic Reference And
Discourse Structure

MS-CIS-89-55
LINC LAB 159

Bonnie Lynn Webber

Department of Computer and Information Science
School of Engineering and Applied Science
University of Pennsylvania
Philadelphia, PA 19104-6389

September 1989

Deictic Reference and Discourse Structure

Bonnie Lynn Webber
Department of Computer and Information Science
University of Pennsylvania
Philadelphia PA 19104-6389*

September 11, 1989

Abstract

Research on the factors and processes involved in pronoun interpretation has to date concentrated on anaphoric pronouns. Results have supported the now widely-held view that discourse understanding involves the creation of a partial, mental model of the situation described through the discourse. Anaphoric pronouns are taken to refer to elements of that model (often called *discourse referents* or *discourse entities*), usually ones that have, at the moment of referring, some special *focus* status.

This paper examines *deictic pronouns* – in particular, ones that refer to the interpretation of one or more clauses. I argue that referents for these pronouns must come from the interpretations of *discourse segments* on the *right frontier* of an evolving structure representing the discourse. Under the assumption that reference is always to an individual, this implies that discourse segment interpretations must also be part of the evolving *discourse model*. I discuss this in the last section of the paper.

short title: Deictic Reference and Discourse Structure

1 Introduction

Research on the factors and processes involved in pronoun interpretation has concentrated on anaphoric pronouns. Results have contributed to the now widely held view that text understanding involves the creation of a partial, mental model of the situation being described by the text. Anaphoric pronouns are taken to refer to elements of the model (often called *discourse referents* or *discourse entities*) rather than to things in the world or the text itself, for example:

Example 1

>   Wendy gave an apple to each of her brothers.
>   *They* thanked *her* for *them*.

> | |
> |---|
> | they $\equiv$ Wendy's brothers |
> | her $\equiv$ Wendy |
> | them $\equiv$ the set of apples, each of which Wendy |
> | gave to one of her brothers |

where $\equiv$ indicates coreferring expressions.

This paper examines *deictic pronouns* – in particular, ones that refer to the interpretation of one or more clauses, for example:

Example 2

>   It's always been presumed that when the glaciers receded, the area got very hot. The Folsum men couldn't adapt, and they died out. *That's* what is supposed to have happened. It's the textbook dogma. But it's wrong.

Example 3

>   The Fed hasn't full freedom of action. The American monetary system has been globalized. The U.S. dollar is no longer the world's anchor currency – the currency to which the British pound, Japanese yen, German mark, French franc and other currencies tie. Fed policies on interest rates are conditioned by what goes on in the foreign-exchange markets. *That's* a big change, a global change. *Philadelphia Inquirer*, 9 July 1989, E-1

The phenomenon in question has been called, by some, *event reference*, after one interpretation that groups of clauses often receive, and, by others, *deictic reference*, after the type of pronoun often used to refer to clausal interpretations (in English, the pronouns *this* and *that*, in Italian, *questo*, and in German, *das*).[1] Though other forms of reference are used,[2] I have adopted the latter term here because my primary thesis concerns the *source* of the referents for these pronouns rather than their *semantics*.

While all the data and examples I will use in this paper are drawn from English, English is (not surprisingly) not the only language in which this phenomenon occurs, as Di Eugenio (1989) has shown for Italian and Bäuerle (1988), for German.

I will start with a brief review of current theories of anaphoric reference in order to show that such theories do not provide plausible interpretations for deictic pronouns that refer to the complete sense of one or more clauses. However, I will then try to show that more general current theories of discourse understanding do offer a basis for an adequate theory of deictic pronoun interpretation – that is, one based on notions of *discourse segment* and *attentional state*. The theory of deictic reference that I then present reveals an interesting relationship between two main elements of many current discourse theories – that is, *discourse entities* and *discourse segments*. What this implies is that *discourse models* must incorporate the recent *structure* of the discourse as well as its *content*. In Section 5, I suggest how this can be done.

2   The Interpretation of Anaphoric Pronouns

There are several excellent surveys of past and current theories of how anaphoric pronouns receive their interpretations in inter-sentential reference, including (Hirst, 1981; Garnham 1987a, 19887b). Here I just want to sketch out enough of the general form of current theories to show that they do not provide an adequate account of pronouns that refer to the sense of one or more clauses, such as those given above.

Current theories of anaphoric pronoun interpretation generally have two parts:

* an account of what it is that pronouns can refer to;
* an account of how a particular pronoun is correctly interpreted .

```
┌─────┐
│ x y │
├─────┴────────────────┐
│ name-of(x, john)     │
│ donkey(y)            │
│ own(x,y)             │
└──────────────────────┘
```
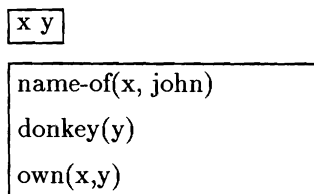
Figure 1: Discourse Representation Structure

The first is usually discussed in terms of what has been called a *discourse entity* or *discourse referent*, and the second, in terms of some kind of notion of *focus*.

2.1 Discourse Referents

The notion of a *discourse referent* was first introduced by Lauri Kartunnen (1976), to provide a uniform way of explaining what it is that noun phrases (including pronouns) in a discourse refer to. Rather than taking them as referring to things in the world, he took them as referring to (mental) entities in a listener's evolving model of the discourse, often called simply a *discourse model*, as in Webber (1983). Sentences are interpreted as attributing properties to discourse referents, or as specifying their relationships with other entities. (It is for this reason that Bill Woods once called them "conceptual coathooks".) Discourse entities may correspond to something in the outside world, but they do not have to.

Current theories of discourse continue to associate discourse entities with a listener's interpretation of the noun phrases in a text. For example, in Kamp's *Discourse Representation Theory* (Kamp, 1981), each successive sentence in a discourse, by virtue of its context-dependent interpretation, augments the current *discourse representation structure* or *DRS*, and transforms it into a new one, ready for interpreting the next sentence. A *DRS* has two components: a set of *reference markers* corresponding to the individuals that things are predicated of, and a set of *conditions*, corresponding to what is predicated of them.

Example 4

John owns a donkey.

He feeds *it* Cheerios.

In Example 4, the first sentence would result in a *DRS* containing two reference markers, x and y, and three conditions: that x is named John, that y is a donkey, and that x

owns y (Figure 1). The pronouns *he* and *it* in the second sentence would then refer to the entities introduced by the noun phrases *John* and *a donkey* of the first sentence.

Heim's theory of *file change semantics* (Heim, 1983) also echoes this view. In her theory, discourse referents have the form of *file cards*, which are either started or updated in response to noun phrases in the discourse. A *file* of such cards corresponds to a Kamp *DRS*.

In all of these theories, discourse referents are introduced into the model by noun phrases and are subsequently used in interpreting anaphoric pronouns and noun phrases. Bäuerle (1988) has recently proposed some elegant extensions to Kamp's *Discourse Representation Theory* to cover a restricted range of deictic reference to events and propositions, a proposal which I will discuss in detail in Section 2.3.

2.2 Focus

Anaphoric pronouns themselves give little clue as to their intended referent. In discussing how pronouns are correctly interpreted, current theories usually appeal to notions of *focus*. Such notions of *focus* have been proposed, at least in part, to account for patterns of concept verbalization – for example, when the pronunciation of concept descriptions can be attenuated, when concepts can be specified using explicit pronouns or zero-anaphors, when an unmodified definite noun phrase can be used to refer to a concept, when particular intonation structures and/or marked syntactic constructions like clefts are appropriate, etc.

Many factors have been cited as contributing to what is in focus, including frequency of mention, the linguistic form of the noun phrase first (or most recently) used to refer to a discourse entity, and the physical or syntactic position of the most recently referring noun phrase. Again I refer the reader to excellent surveys of focus in (Hirst, 1981; Garnham, 1987a, 1987b). The common thread that runs through all these accounts is that, at the point of interpreting a particular pronoun, there is a small set of discourse referents that are *focussed* (*active*, in Chafe's terminology (Chafe, 1987); *centered*, in the terminology of Grosz, Joshi & Weinstein (1983)) which are offered, in some prescribed order or in parallel, for various types of consistency checks with the given pronoun and the role that its referent is meant to play in the sentence. Where there is more than one acceptable candidate, accounts differ as to how the choice between them is made.

2.3 Extensions to Handle Deictic Pronouns

I am aware of three attempts to extend theories of anaphoric pronoun interpretation to handle the deictic pronouns *this* and *that* as well – two which depend on notions of *focus* (Linde, 1979; Sidner, 1983), and the other of which is an extension of Kamp's *DRT* (Bäuerle, 1988).

The earliest account is (Linde, 1979), which is based on oral descriptions of apartment layouts – people giving an imaginary tour through their current or previous apartment. She observed that both *it* and *that* were often used to refer to what were semantically the same sort of things. She therefore tried to attribute differences in their use to features of the surrounding discourse – in particular, a notion of *focus of attention*, which she defined with respect to tree structures underlying the layout descriptions. (Nodes were taken to correspond to room descriptions, with left-to-right branch order corresponding to presentation order and dominance encoding nearness of the room to the physical start of the tour.) Paired with a tree structure was a moving pointer marking the current focus of attention. When a new room was mentioned, a new branch was added to the tree and the pointer shifted to that node. When a room was re-mentioned, the pointer would shift without the addition of a new node.

Linde claimed that when a room was referenced *inside* the focus of attention, the pronoun *it* was used – for example (numbering from (Linde, 1979)),

Example 5

> (12) On the right was a little kitchenette which means that *it* was just like one wall with kitchen appliances.

When a room was referenced that was *outside* the focus of attention, *that* was most often used – for example,

Example 6

> (17) You enter a tiny hallway, and the kitchen was off *that*.

In the second clause of (17), the focus of attention has changed from the hallway to the kitchen. Thus *that* is used to refer to the hallway, which is no longer the focus of attention.

Linde herself notes a number of problems with the view of *it* referring to "in focus"

items and *that* referring to "out of focus" items: cases where *it* could only be interpreted as referring across nodes, where *that* referred within a node[3], and where after *that* was used to refer to something, *it* was used to refer to it right afterwards. Finally, while Linde does note cases of *that* being used to refer to "the preceding statement taken as a statement" (Linde, 1979, p.344), she does not attempt to tie this in with her *focus* explanation of *it* versus *that*. She takes it as something else entirely.

Later Sidner (1983) proposed a focus-based account of deictic pronouns and noun phrases, in connection with her theory of anaphoric pronouns and definite noun phrases. The elements of this theory[4] comprised a current *discourse focus* (DF), an ordered list of *potential foci* for the next utterance (the PFL), and a stack for saving the current *discourse focus* while discussing something else, then "popping" back to resume it later. Anaphoric pronouns can most easily specify the current DF, slightly less easily a member of the PFL, and with more difficulty, a *stacked focus*. With minor exceptions, specifying something pronominally promotes it to be the next DF. Anything else specified in the clause (including the verb phrase predication itself) would end up on the PFL, ordered by their original syntactic position.

Sidner proposed that the difference between deictics and anaphorics was primarily in their relationship with the DF. In particular, she proposed that

1. a *this* noun phrase used in contrast with a *that* noun phrase allows the speaker to keep two things in focus simultaneously – either the current DF and a member of the PFL or the current DF and a previously stacked DF;

2. a *this* noun phrase used alone allows the speaker to specify the DF, while optionally providing additional information about it (e.g., "On my left pinkie, I wear a gold ring. I inherited *this heirloom* from my grandmother.")

3. the pronoun *this* allows the speaker to indicate a preference for the verb phrase predicate on the PFL, thereby changing the DF to this item;

4. a *this* noun phrase within a quantified phrase allows the speaker to indicated that it co-specifies the quantified variable, without moving the DF;

5. a *that* noun phrase can either introduce a new discourse referent or re-mention one without then becoming the DF.

Like Linde, Sidner proposes a purely focus-based account of deictic reference, and therein

lie two problems: in addition to not being directly extensible to the phenomenon considered here, there is separate evidence against a purely focus-based account of deictic reference in general. Such evidence comes from Passonneau (1989), who reports on 678 instances of *it* and *that* drawn from conversational interactions that refer to entities introduced into the discourse model by noun phrases and other sentential constituents. Passonneau found not one, but two independent factors that strongly predicted whether subsequent reference would be via *it* or via *that*: one she called *persistence of grammatical subject*, the other, *persistence of grammatical form*. The first indicates whether both antecedent and pronoun were subjects of their respective clauses: if so, the pronoun *it* was strongly favored. This is what focus-based theories would predict. However, the latter factor involves the *form* of the antecedent: if it were anything else but a pronoun or a canonical noun phrase headed by a noun – for example,[5]

Example 7

> so in some ways, I'd like to be my own boss, so *that's* something that in some way appeals to me very much.

Example 8

> I don't think each situation is inherently different from the other, at least, *that's* not the way I look at it

then the pronoun *that* was strongly favored, whatever its syntactic role or the syntactic role of its antecedent. Thus, even restricted to single sentence constituents, focus alone, without reference to the kind of thing referred to is insufficient. On the other hand, as I shall argue in subsequent sections, there is a sense of focus that is involved in the interpretation of deictic pronouns.

The third attempt I am aware of is Bäuerle's proposed extensions to Kamp's *Discourse Representation Theory (DRT)* to cover reference to events and propositions. His work, done on German, is more recent and closer to the current proposal. Starting with examples like the following:

Example 9

> Diesen Monat stürzte ein Flugzeug. *Das* war in Paris.
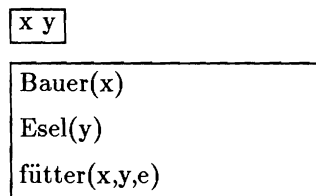> (This month a plane crashed. *That* was in Paris.)

```
┌─────┐
│ x y │
├─────┴──────────┐
│ Bauer(x)       │
│ Esel(y)        │
│ fütter(x,y,e)  │
└────────────────┘
```

Figure 2: Adding event variables to predicates in DR Structures

```
┌───────┐
│ x y e │
├───────┴────────┐
│ Bauer(x)       │
│ Esel(y)        │
│ e < t₀         │
│ fütter'(e)     │
│ Agent(e,x)     │
│ Object(e,y)    │
└────────────────┘
```
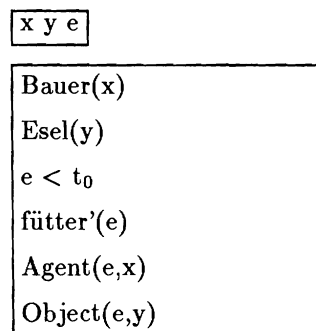
Figure 3: Distinguishing thematic roles in DR Structures

Example 10

    Peter fiel vom Rad. Mir wäre *das* nicht passiert.

    (Peter fell off the bike. *That* wouldn't have happened to me.)

Example 11

    Pele erzielte ein Tor. *Das* überraschte mich nicht.

    (Pele scored a goal. *That* didn't surprise me.)

Bäuerle argues first that extending *DRT* representations through the use of *event variables* in predicates – for example, representing the interpretation of "A farmer feeds a donkey" as in Figure 2 supports only subsequent reference to the particular event token described and not reference to a related event type. Thus it cannot account for the referent of *das* in examples like 10. Bäuerle proposes instead a decomposed, conjoined predicate-argument representation in which the relationship of each participant to the event is asserted separately, as in Figure 3. Reference to event types can then be supported through lambda-abstraction on a

subset of the conjuncts from a description.

Bäuerle then argues that *DRT* also cannot support reference to one or more *propositions* because its structures do not distinguish the contribution of individual sentences: the only structures it separates out are the subordinate representations required for the interpretation of negation, conditionals, universal quantifiers and propositional attitudes. Bäuerle proposes instead the notion of a conjoined *Discourse Representation Structure* (*DRS*), in which context is represented not just by embedded *DRS*s, but a sequence of coordinated *DRS*s (which may, of course, contain embedded structures). This does not alter the semantics of *DRT*, while allowing Bäuerle to formulate an accessibility rule for propositional reference in which any immediately preceding subsequence of *DRS* conjuncts is a possible anchor for pronominal reference. (As I will discuss in Section 3, conjoining the interpretations of a sequence of utterances is an operation common to most theories of discourse segmentation. What I will argue though is that there is at least one other operation that contributes to determining the possible source of referents for deictic pronouns.)

3 Discourse Segments and the Interpretation of Deictic Pronouns

Any model-based theory of pronoun interpretation can be characterized in terms of three separate features:

* the type(s) of pronoun it handles — Does the theory provide an account of the interpretation of anaphoric pronouns like *he*, *she* and *it*, deictic pronouns like *this* and *that*, zero-anaphors, etc.?

* the source of its pool of possible referents — Does the theory consider as possible referents only the interpretations of noun phrases, or does it consider in some way the interpretations of clausal material? Does it only consider previously introduced referents or does it allow for referents "accommodated" into the model at the point of reference because a referent of a particular type is needed?[6]

* features of the model from which referents derive — Is the model structured in some way? If so, what does the structure represent? e.g., the structure of the situation/world being described, the structure of the discourse conveying that description, scope of quantfiers, modality, belief, etc.

With respect to these features, my intention is to develop a theory of deictic pronouns in discourse, one driven by the fact that they can and do refer to the interpretation of (or an interpretation derivable from) one or more clauses. I have so far argued that theories of anaphoric pronouns that refer to the interpretation of one or more noun phrases does not suffice.

On the other hand, I noted in Section 1 that I believe that current discourse theories do provide a basis for an adequate account of this type of pronominal reference — namely, in terms of *discourse segmentation* and *attentional state*. So let me now review these notions and their relationship to features of the model from which referents derive — the third dimension mentioned above.

3.1 Discourse Segments

It is a widely held that discourses are formed of smaller sequences of related clauses or sentences called *discourse segments*, although as James Allen has noted:

> ... there is little consensus on what the segments of a particular discourse should be or how segmentation could be accomplished. One reason for this lack of consensus is that there is no precise definition of what a segment is beyond the intuition that certain sentences naturally group together (Allen, 1987, pp.398-9)

Bases that have been proposed for grouping utterances into segments include conversation role (Hinds, 1979; Fox, 1987), common discourse purpose with respect to a speaker's plans (Grosz & Sidner, 1986); common meaning (Hobbs, 1988); common perspective in describing a single event (Nakhimovsky, 1988), and common modality (e.g., hypothetical, counterfactual, belief, etc.) While these factors are diverse, there seems to be no reason to suppose that there has to be a single basis for segmentation: different types of texts (e.g., instructions, arguments, narratives, expositions, etc.), may well support different criteria for viewing sentences as a group. What is significant about discourse segments is why researchers are interested in them.

One early computational reason for interest in them was as a domain of locality for definite noun phrases (Grosz, 1977, 1981), to account in part for the fact that the same definite noun phrase may refer to different discourse entities at different points in the discourse.

Segmental locality would say that a definite noun phrase would be interpreted as referring to an entity mentioned in the same segment rather than one mentioned elsewhere, even if the latter were mentioned more recently. For example, consider the following sequence uttered by a single speaker:

Example 12
       a. Do you think I can borrow your tent?
       b. The one I took on my last hike leaked,
       c. and I haven't had time to replace it.
       d. I would of course have *the tent* cleaned before returning it to you.

The speaker uses *the tent* in sentence 12d to refer to the one she has requested in 12a, and not the leaky one mentioned in 12b-c. This can be explained in terms of segmental locality, by saying that clauses 12b-c make up a discourse segment explaining the request made in 12a. While 12d belongs to the discourse segment made up of 12a-d, it is outside the embedded segment. Thus its object noun phrase *the tent* would not be interpreted as the leaky tent mentioned in the embedded segment that 12d doesn't belong to, but the requested tent mentioned in the segment that it does.[7]

Often (as above) *discourse segments* are taken to be recursive structures, such that either a discourse segment is a minimal segment[8] or it comprises a sequence of embedded discourse segments.[9] As so defined, the recursive structures of interest are *trees*. Note that this does not mean that a discourse necessarily forms one big recursive structure, just that there may be parts of a discourse that evince an embedding structure, and that this structure has interesting properties.

3.2   Recursive Discourse Segmentation

If a tree structure is to represent something, then its two basic structuring relations – *parent-of* and *right-sibling-of* – must have some meaning in the domain represented.

For example, as noted earlier, in the tree structures representing Linde's apartment layout descriptions (Linde, 1979), *parent-of* means that the room corresponding to the parent node is closer to the physical start of the tour than that corresponding to the child. *Right-sibling-of* corresponds to presentation order.[10]

12

In Robin Cohen's work on the structure of argumentative discourse (Cohen, 1983; Cohen, 1987), *parent-of* means that the claim made by the child provides evidence for the claim made by the parent. *Right-sibling-of* corresponds to the linear order of claims that provide evidence for the same conclusion. Cohen's goal is to understand how structured arguments are transmitted through a linear sequence of clauses. She presents three common *transmission forms* that enable minimal effort reconstruction of the structure underlying an argument: pre-order, post-order and a mixed pre- and post-order.[11] They require minimal effort because of the severe restrictions they place on what an incoming clause can stand in a parent/child or sibling relation to. Cohen shows how "clue words" can be used to provide enough information to enable departures from these expected transmission forms and still produce comprehensible arguments.

Scha & Polanyi (1988) have as their goal the development of a semi-deterministic, on-line procedure for building up a hierarchical structural description of an unfolding discourse. They take the nodes of such trees to be any of a variety of types of *discourse constituent units* or *DCUs*. *Discourse constituent units* differ from one another in two ways: (a) how they derive their semantic attributes from those of their constituents, and (b) the "accessibility" of their constituents to things like anaphoric reference. (The three types of *DCU* discussed in (Scha & Polanyi, 1988) are subordinations, binary coordinations, and n-ary coordinations, each of which has several subtypes. For example, lists and narratives are types of n-ary coordinations.) Given the variety of node types, while *parent-of* has a uniform meaning over the tree – i.e., that one *DCU* is a constituent of another, the meaning of *right-sibling-of* varies, depending on the type of common parent node. For example, *right-sibling-of* in a narrative n-ary coordination has a temporal aspect to its meaning, which it doesn't in a simple list n-ary coordination.

Grosz & Sidner (1986) take a more abstract criterion for establishing structural relations in discourse. The *parent-of* relation they call *domination* (DOM), and the *sibling-of* relation, *satisfaction-precedes*. They take these relations to hold between what they call *discourse segment purposes* or DSPs, rather than between discourse segments directly. A segment's DSP specifies how it contributes to achieving the overall discourse purpose. If the DSP of one segment serves to satisfy that of another, the latter *dominates* (or stands in a *parent-of* relation to) the former. If one DSP must be satisfied before another (in satisfying some larger purpose), than the former *satisfaction-precedes* or is a *right-sibling-of* the latter. Grosz & Sidner call the resulting hierarchy of DSPs the *Intentional Structure* of a discourse. It

13

is only one of three structures that they associate with a discourse. Another of the three, *Attentional State*, I will discuss later.

In what follows, I am going to make the very simple assumption that the only things relevant to discourse structure are *meaning composition* and *linear order*. (By *meaning* I refer not only to *sense semantics*, but also to *discourse function* – e.g., that a segment is to function as evidence, as an argument, as a claim, etc. To avoid potential confusion, I will use the term *discourse meaning* instead.) While this assumption clearly misses the richness of structuring relations evident in the Scha/Polanyi and the Grosz/Sidner models, it provides a sufficient skeleton on which to hang the argument that discourse structure provides a basis for interpreting deictic reference. So in the context of my simplifying assumption, two discourse segments will be said to stand in a *parent-of* relation, if the meaning of the former is a function of the meaning of the latter, while they will be said to stand in a *right-sibling-of* relation if their meanings both contribute directly to the same parent, and the latter follows the former in the discourse. Examples of both relations will be found in the next section.

3.3 Algorithms for Recursive Discourse Segmentation

Having specified meanings for both the *parent-of* and *right-sibling-of* relations, a theory of discourse segmentation that is to be used on-line must also specify the operations that can be used in growing a recursive structure from a linear sequence of elements.[12]

For example, Cohen's pre-order transmission format for arguments (Cohen, 1983; Cohen, 1987) uses a single operation: *attach as daughter*, which makes an existing node the *parent-of* the node corresponding to the new clause. Her post-order transmission format uses a second operation: *attach as parent*, which can apply to subordinate one node or a set of nodes as daughters of the node corresponding to the new clause. Her hybrid strategy makes use of both these operations.

While characterizing the process of on-line recognition of a recursive discourse structure is an active area of research (Grosz & Sidner, 1986; Hirschberg & Litman, 1987; Cohen, 1987; Reichman, 1985), my purpose here in describing two simple operations for growing a tree based on meaning composition and linear order is to ground the notion of its *right frontier* – and to show how it can change from one utterance to the next. I shall argue in Section 4 that, at any point in the discourse, the only segments that can provide referents
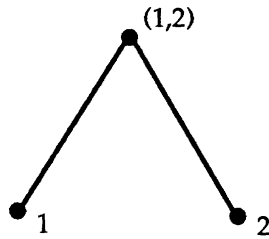
Figure 4: Multi-branching non-terminals

for deictic pronouns are ones on this *right frontier*.

The trees I will use to illustrate the two proposed operations *attachment* and *adjunction* will be labelled as followed:

* terminal nodes (leaves), which correspond to single-clause discourse segments, are labelled with the number of the clause they represent (e.g., 1, 2, etc.);

* non-terminal nodes, which corresponds to segments whose discourse meaning is a function of those of one or more other segments (i.e., those it stands in a *parent-of* relation to), are labelled with a list of the labels of the sements that contribute to its meaning.

For example, Figure 4 represents the discourse structure corresponding to each of the following texts:

Example 13

   a1. John eats yoghurt for breakfast,

   2. and Fred eats Cheerios.

   b1. When John ate an amanita,

   2. he became very ill.

   c1. John was taken to the Emergency Room,

   2. where doctors pumped his stomach.

This illustrates my point about the *parent-of* relation indicating meaning composition *per se*, even though the particular meaning composition function (and hence, the resulting discourse meaning) is different in each case: simple non-temporal conjunction in Example 13a, causal contingency in Example 13b[13], and temporal order in Example 13c.
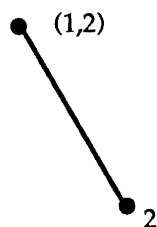
Figure 5: Single-branching non-terminals

In a perhaps non-standard move, I will take complementizers like "John thinks" in sentences like

Example 14

1. John thinks
2. that Fred eats Cheerios for breakfast.

as just indicating the meaning composition function, much like a modal, not as a separate segment. Thus Example 14 would yield the single-branching structure shown in Figure 5.[14]

The process of on-line discourse structure recognition begins with the first clause of a discourse. When the first clause is processed, an initial root node is established. (This will not necessarily be the final root node after segmentation is complete.) Two operations are used in processing subsequent clauses: *attachment* and *adjunction*. A clause is *attached* as the rightmost daughter of an existing discourse segment if its discourse meaning contributes directly to that of the segment so far (i.e., it composes with those of the segment's other daughters). It doesn't matter what discourse meaning a clause contributes, since *parent-of* merely indicates *meaning composition*: as mentioned earlier, Example 13a and b would both yield the same structure (Figure 4). This does not, of course, imply that their discourse meanings are the same: it is just that *structure is not used to encode discourse meaning*. The operation of *attachment* is shown in Figure 6.[15]

Adjunction is a somewhat more complex operation which creates new non-terminal nodes (composite discourse meanings) rather than just adding leaves to (i.e., augmenting the discourse meaning of) existing non-terminals. A clausal segment is adjoined to an existing segment S_i if its discourse meaning combines directly with that of S_i to form a discourse meaning different from the latter's current parent. Because structurally a tree has three different types of nodes – root, non-terminal and leaf – there are three varieties of *adjunction*.
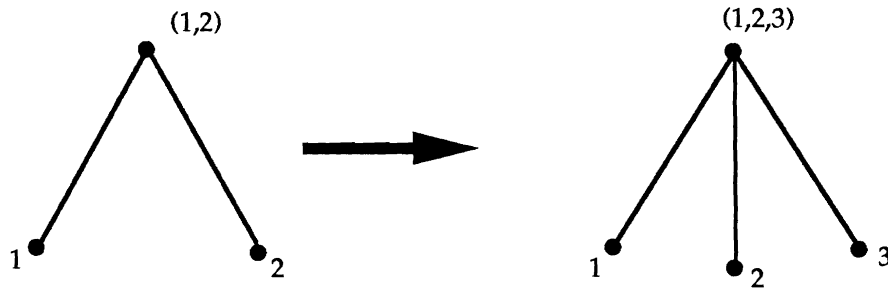
16

Figure 6: Addition of Nodes by Attachment

A clausal segment C_k is *adjoined* to the current root node if its discourse meaning is taken to combine with that of the root to form a larger unit of discourse meaning. For example,

Example 15

    a. Here's how to make Bechamel Sauce.

    ...

    k. Now, if you are not going to use the sauce right away,

    ....

Assuming that after processing clauses 15a through k-1, the root node has a composite discourse meaning on the order of "instructions for making Bechamel Sauce for immediate use". The discourse meaning of clause 15k does not add to that meaning: rather, it combines with it to form a composite discourse meaning on the order of "making Bechamel Sauce for use any time". Structurally, this corresponds to adjunction to the current root node, yielding a new root whose leftmost daughter is the old root and whose rightmost daughter is the as yet unspecified instructions for extending the life of the sauce. The process of adjunction to a root node is illustrated in Figure 7.

A clausal segment C_j can *adjoin* to an existing terminal node C_i if it is their composite discourse meaning that contributes to the discourse meaning of the C_i's parent rather than the independent discourse meanings of C_i and C_j. For example,

Example 16

    a. Here's how to make Bechamel sauce.

    b. Make a roux.

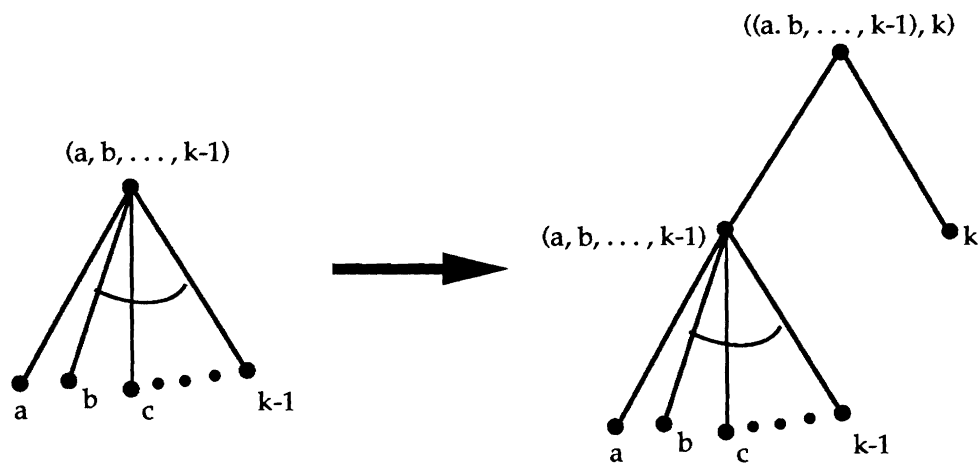   c. Melt 4 T. of butter in a pan....

17

Figure 7: Adjunction to the Root Node

16a-b can be taken to form a composite discourse meaning to which 16b contributes the first step of the procedure named in 16a. The segment will have a binary structure like that in Figure 4. If 16c is then understood with respect to 16b – i.e., their composite discourse meaning being (partial) instructions for making roux, it will be adjoined to 16b, as shown in Figure 8.

Finally, a clausal segment can also adjoin to an internal non-terminal node S_i if together they form a "unit of discourse meaning" separate from the parent of S_i but which then contributes to the discourse meaning of that parent. For example,

Example 17

     a. Here's how to make Bechamel sauce.

     b. Make a roux.

     c. Melt 4T of butter in a small pan.

     d. Add 4T of flour,

     e. and stir over heat for 2 minutes.

     f. That's the easy part.

Assuming that 17b-e form a segment S_2 with a composite discourse meaning (instructions for making roux) and that this has been taken as contributing directly to the discourse meaning of the root S_1 (instructions for making Bechamel sauce), the interpretation of 17f
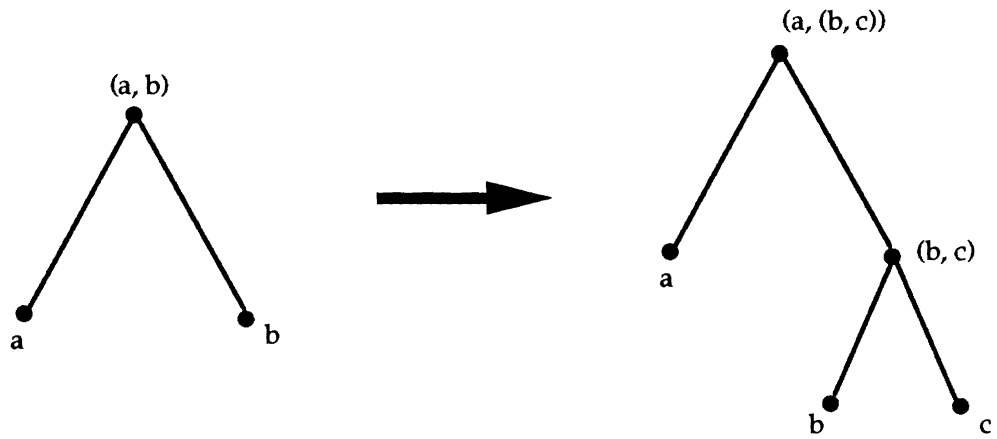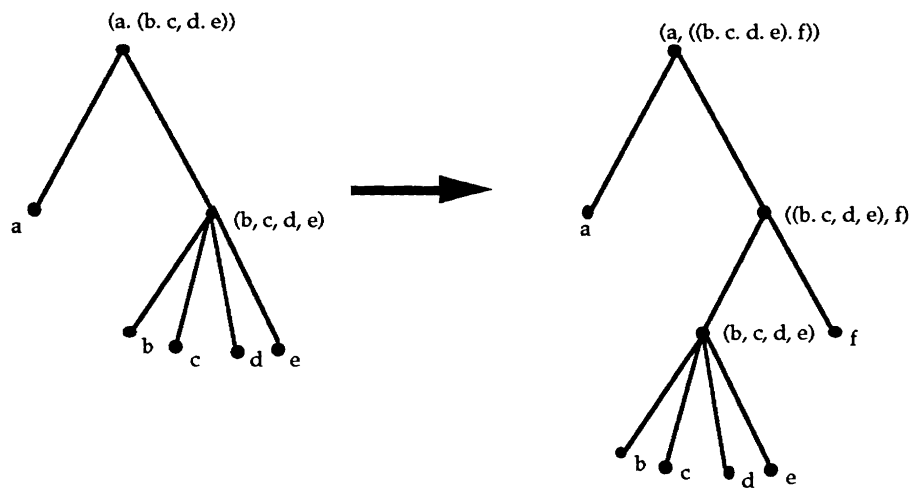
Figure 8: Adjunction to a Leaf

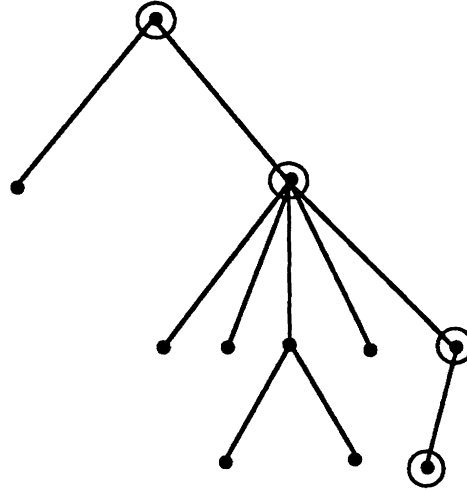Figure 9: Adjunction to a Non-Terminal Node

Figure 10: Right Frontier

appears to combine with that of S_2 rather than contributing to the discourse meaning of either S_2 (as a daughter) or S_1. Thus it is adjoined rather than attached, as in Figure 9.

There is an additional assumption that I am making about the operations of *attachment* and *adjunction*: I assume that the only nodes that they can apply to are ones on the *right frontier* of the evolving structure. The *right frontier* of a tree comprises those nodes along the path from root to tip defined by the sequence of rightmost daughters, starting at the root. (In Figure 10, nodes on the *right frontier* are circled.) The same assumption – that integration of the discourse meaning of the next clause only takes place at the *right frontier* of the discourse structure – is made by Polanyi (1986) and Scha & Polanyi (1988). Note that this is not to say that other elements of the discourse model do not provide a *context* for interpreting the next clause – only that the discourse meaning of a segment (especially what Grosz & Sidner (1986) call its *Discourse Segment Purpose*) only forms a unit with the discourse meaning of segments on the *right frontier*.

Note that, in general, a tree construction algorithm does not *require* that only a subset of its nodes be available for subsequent growth: provided operations are defined, any node can host further growth. Moreover, even tree-construction algorithms that restrict growth to a *frontier* do not require it to be the *right frontier*: for example, standard breadth-first algorithms restrict new growth to the current terminal nodes – what is often called the *fringe* of the tree. Nevertheless, the significance of the *right frontier* for the current work lies with notions of attention, the next topic of discussion.

3.4 Recursive Discourse Structures and Attention

In Grosz & Sidner's model (1986), a listener's attention at any point correlates with the perceived structure of the discourse. In particular, they associate a *focus space* with each discourse segment, as well as the *discourse segment purpose* or DSP noted earlier. Corresponding to the evolving *Intentional Structure* (a tree of DSPs), they propose a stack of *focus spaces* which represents the listener's *Attentional State*. A segment's focus space is pushed on the stack when its DSP is taken to contribute to that of the segment whose focus space is at the top of the stack. Focus spaces will be popped from the stack prior to a push until the top focus space is one whose associated DSP can be taken to *dominate* that associated with the focus space about to be pushed. Focus spaces may also be popped from the stack if the next utterance cannot be interpreted as part of the current segment (e.g., if it contains a definite noun phrase whose referent is not in the top focus space, as discussed further below). Another way to put this is that the stack contains the focus spaces of segments whose "purposes" can still receive support.

Grosz & Sidner hypothesize that a concept's activation correlates with its focus space's position in the stack: ones in the focus space at the top of the stack are most "active". So the stack of focus spaces defines a structured domain of locality for the interpretation of unmodified definite noun phrases (cf. Section 3.1). Such a noun phrase is more likely to pick up its referent from a focus space closer to the top of the stack than from one further down. Picking up a referent further down may, in fact, indicate that the segments associated with focus spaces higher up the stack can now be taken as "closed", with attention shifting back to a more inclusive segment. (Other work that associates *activation* with segmentation for the purpose of interpreting definite noun phrases and anaphoric pronouns includes (Reichman, 1985; Fox, 1987).)

There is a close relationship between the notion of *right frontier* presented in the previous section and Grosz & Sidner's (1986) stack representing *Attentional State*. This derives not only from the fact that any directed path through a tree from root to tip (such as the *right frontier*) can be mapped directly to a stack, but also from the fact that the nodes on the *right frontier*, like the segments whose focus spaces are on the stack, are the only ones whose discourse meanings can combine with the discourse meaning of an incoming clause to form a new (discourse meaning). Thus the *right frontier* of discourse structure can be said to reflect discourse participants' *attention* on a changing set of discourse structures and meanings.

4 Segments and Right Frontier in the Interpretation of Deictic Pronouns

The point of reviewing notions of discourse segmentation and recursive segmentation procedures is to argue in Section 5 that the interpretations of such segments provide referents for deictic pronouns. What I have to demonstrate now is that the interpretation of deictic pronouns is constrained by the structure of discourse segments, rather than by the structure of the world being described. In particular, I will argue that the referent of *this* and *that* must come from the interpretation of a discourse segment on the *right frontier*.[16]

Recall that the phenomenon under consideration is the following – the use of deictic pronouns to refer to the interpretation of multi-clause segments of texts, as in

Example 18

It's always been presumed that when the glaciers receded, the area got very hot. The Folsum men couldn't adapt, and they died out. *That*'s what is supposed to have happened. It's the textbook dogma. But it's wrong. They were human and smart. They adapted their weapons and culture, and they survived.

Example 19

The tools come from the development of new types of computing devices. Just as we thought of intelligence in terms of servomechanism in the 1950s, and in terms of sequential computers in the sixties and seventies, we are now beginning to think in terms of parallel computers, in which tens of thousands of processors work together. *This* is not a deep, philosophical shift, but it is of great practical importance, since it is now possible to study large emergent systems experimentally. (Hillis, 1988, p.176)

Looking at Example 18, whether one takes *that* to refer to:

* the Folsum men's dying out;
* the Folsum men's inability to adapt and therefore dying out;
* the area getting very hot, the Folsum men being unable to adapt and therefore dying

out;

* the glaciers' receding, the area getting very hot, the Folsum men being unable to adapt and therefore dying out

it does not refer to a discourse entity introduced into the listener's discourse model by a noun phrase. The same goes for *this* in Example 19. The stuff of their interpretation – which comes from material introduced clausally – is the phenomenon I shall now try to characterize more precisely.

(In what follows, I am confining myself to written (primarily objective) expositions rather than considering spoken texts. The reason is that spoken texts often make use of stress – in particular, contrastive stress – to alter what a referring phrase can be used to refer to. Since the purpose of this paper is to argue what is *necessary* for an account of *this* and *that*, not for what is *sufficient*, it seems reasonable to confine the investigation in this way for the present.)

I now want to argue that not only can the deictic pronouns *this* and *that* refer to a segment's worth of information, but that segmental structure is more important in constraining both the scope and the source of possible referents than any structure deriving from world knowledge of the things being discussed. To see this, consider the following example:

Example 20

There's two houses you might be interested in:

House A is in Palo Alto. It's got 3 bedrooms and 2 baths, and was built in 1950. It's on a quarter acre, with a lovely garden, and the owner is asking $425K. But *that* 's all I know about it.

House B is in Portola Vally. It's got 3 bedrooms, 4 baths and a kidney-shaped pool, and was also built in 1950. It's on 4 acres of steep wooded slope, with a view of the mountains. The owner is asking $600K. I heard all *this* from a real-estate friend of mine.

Is *that* enough information for you to decide which to look at?

What I want to show is that *that* in the second paragraph of this passage does not re- fer to House A (although all instances of *it* do) or all known information on House A, but

rather, to the import of an immediately preceding segment – information about House A. Similarly *(all) this* in the third paragraph does not refer to House B (although again, all instances of *it* do): it refers to the import of an immediately preceding segment – information about House B. *That* in the fourth paragraph refers to the import of one of its preceding segments – information about the two houses together.

That in each case it is the import of an immediately preceding segment that *this* and *that* are accessing, can be seen by presenting the same information in an interleaved fashion, a technique often used in discourse when comparing two items:

Example 21

There's two houses you might be interested in:

House A is in Palo Alto, House B in Portola Valley. Both were built in 1950, and both have 3 bedrooms. House A has 2 baths, and B, 4. House B also has a kidney-shaped pool. House A is on a quarter acre, with a lovely garden, while House B is on 4 acres of steep wooded slope, with a view of the mountains. The owner of House A is asking \$425K. The owner of House B is asking \$600K. #*That*'s all I know about House A. #*This/That* I heard from a real-estate friend of mine.

Is *that* enough information for you to decide which to look at?

I claim that *that* and *this* fail to refer successfully in the second paragraph to the same referents as in Example 20. I claim that this is because it is not the houses being referred to or what one has learned about them from the text, but rather a plausible interpretation of some coherent unit of information – a discourse segment. In Example 21, there is only one discourse segment containing information about both houses: the reader does not have immediately available the information attributable to House A alone or to House B. The only deictic that refers easily and successfully is the final *that*, which refers to the interpretation of the entire segment – information about both houses.

I now want to argue that the structure of segments is as important to the interpretation of deictic pronouns as the segments themselves. Recall from the previous section that a *discourse segment* can be taken to be a recursive structure, with smaller segments as constituents. Thus, at any time, more than one segment may still be "open" and under construction – segments at different levels of embedding. These "open" segments constitute the *right frontier* of discourse structure. What I want to show is that every segment on the

current *right frontier* is capable of providing a referent for a deictic pronoun. To see this, consider the following quote from (Hillis, 1988):

Example 22

> ...it should be possible to identify certain functions as being unnecessary for thought by studying patients whose cognitive abilities are unaffected by locally confined damage to the brain. $\{_1$For example, binocular stereo fusion is known to take place in a specific area of the cortex near the back of the head. $\{_2$Patients with damage to this area of the cortex have visual handicaps but $\{_3$ [they] show no obvious impairment in their ability to think.$_3\}_2\}$ *This*$_i$ suggests that stereo fusion is not necessary for thought.$_1\}$ *This*$_j$ is a simple example, and the conclusion is not surprising.... (Hillis, 1988, p.185)

I have added brackets to indicate discourse segments, with subscripts indicating the depth of embedding. The most likely interpretation of *this*$_i$ is the observation that visual cortex-damaged patients have visual handicaps but no impairment to their thinking abilities (i.e., the interpretation of Segment 2), while the most likely interpretation of *this*$_j$ is the whole "brain damage" example (i.e., the interpretation of Segment 1).

Finally, I want to argue that not only must *this* and *that* be able to refer to the import of a segment on the *right frontier*, but that these are the only segments whose import they can refer to. Consider the following variation of Example 20. (The clauses are numbered for later discussion.)

Example 23

(1) There's two houses you might be interested in:

(2) House A is in Palo Alto. (3) It's got three bedrooms and two baths, and was built in 1950. (4) It's on a quarter acre, with a lovely garden, and (5) the owner is asking $425K.

(6) House B is in Portola Vally. (7) It's got three bedrooms, four baths and a kidney-shaped pool, and (8) was also built in 1950. (9) It's on 4 acres of steep wooded slope, with a view of the mountains. (10) The owner is asking $600K. (11) I heard all *this* from a real-estate friend of mine. (12) #But *that*'s all I know about House A.

(13) Is *that* enough information for you to decide which to look at?

What is at issue is the interpretation of *that* in clause (12). The rest of the clause constrains the interpretation of *that* to be information about House A. However its position in the text is only compatible with its being interpreted in one of very few ways, including:

* something related to clause 11, as in "But *that*'s all she said." (where *that* is interpretable as referring to the same thing as "all this about House B that I heard from a real-estate friend of mine");
* something related to the interpretation of clauses 2-11 (the information regarding both houses, similar to the perceived interpretation of *that* in clause 13).

Schematically, one might represent the discourse segmentation at the point in the processing *that* roughly as in Figure 11. The oddity of Example 23 comes from the conflicting demands of text position and clause predication in the process of resolving *that*.

Again let me emphasize that I am only considering written text and unstressed instances of *this* and *that*. It is well-known that stressing a pronoun can shift its preferred referent. In the case of clause (12), stressing *that*, reinforced by information conveyed by the rest of the sentence, allows it to be interpreted as the block of information about House A, even though that sequent is no longer being attended to.

Notice that even if it is true that unstressed *this* and *that* must be identified with a discourse segment on the right frontier, there is still an ambiguity as to which segment.
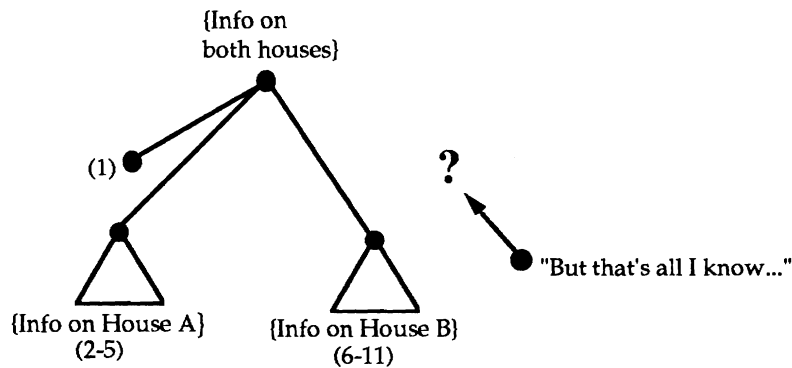
Figure 11: Discourse Segmentation at the point of processing "But that's all ..."

To see this, consider the first part of the Hillis' example (repeated here) as a "discourse completion task".

Example 24

...it should be possible to identify certain functions as being unnecessary for thought by studying patients whose cognitive abilities are unaffected by locally confined damage to the brain. For example, binocular stereo fusion is known to take place in a specific area of the cortex near the back of the head. Patients with damage to this area of the cortex have visual handicaps but show no obvious impairment in their ability to think. *This* ....

At this point in the discourse, there are many possible ways of completing the last sentence, among them –

Example 25

　　a. *This* is obvious when they are asked to solve word problems presented orally.

　　b. *This* suggests that stereo fusion is not necessary for thought.

　　c. *This* is only a simple example, and the conclusion is not surprising.

In (a), *this* can be interpreted as the fact that patients with damage to the area of the cortex near the back of the head show no obvious impairment in their ability to think. In (b) the referent of *this* must be the more inclusive claim that patients with damage to the particular area of the cortex near the back of the head have visual handicaps but show no obvious impairment in their ability to think. (It is this that shows that one doesn't need stereo fusion in order to think.) Finally, in (c) *this* is clearly the entire example about

binocular stereo vision. Which discourse segment interpretation provides the referent for *this* depends on what is compatible with the discourse meaning of the rest of the sentence. As with other types of ambiguity, there may be a default preference (e.g., based on recency, position, etc.) in a "neutral" context but, if there is one, it can easily be over-ridden by the demands of context (Crain & Steedman, 1985; Steedman, 1989).

This ambiguity as to which segment interpretation a deictic pronoun is referring to seems very similar to the ambiguity associated with the use of deixis for pointing within a shared physical context. Both Quine (1971) and Miller (1982) have observed in this regard that all pointing is ambiguous: the intended demonstratum of a pointing gesture can be any of the infinite number of points "intersected" by the gesture or any of the structures encompassing those points. (Or, one might add, any interpretation of those structures.) The ambiguity here – how inclusive a segment on the right frontier is providing an interpretation for *this* or *that* – seems very similar.

5 Discourse Models, Discourse Entities and the Interpretation of Deictic Pronouns

I have claimed that deictic pronouns in English[17] take their referents from the interpretations of *discourse segments* on the *right frontier* of discourse structure. However, I would still like to consider the *discourse model* as the locus of reference in a discourse. In this section, I would like to show how.

Recall from Section 2.1 that *discourse models* are generally viewed as consisting of *entities* introduced by referential noun phrases, and the *properties* and *relations* between them introduced by predicates. A discourse model grows as a discourse is processed, with new entities added and/or new properties and relations asserted of them.

Suppose one assumes that reference is always to an individual: any individual can be referenced, and whatever can be referenced is an individual. It follows from this that the entities in a discourse model all belong to the domain of *individuals*.

With respect to domains, a view that is gaining currency in formal semantics is that the domains involved in any model of Natural Language[18] have a very rich sub-structure (Link, 1983, 1984; Partee, 1987; Schubert & Pellatier, 1987). In particular, the domain of

individuals has been claimed to contain (at least) sub-domains of singular individuals, plural individuals (Link, 1983), groups (Link, 1984), "kind" individuals (Schubert & Pellatier, 1987), portion-of-stuff individuals, event-type individuals (Link, 1987), etc.

What I want to suggest is that discourse segment interpretations also belong to the domain of *individuals*. Some of these individuals belong to the sub-domain of event-tokens, some to the sub-domain of event-types, propositions, etc. – the same as if they had been evoked by noun phrases whose interpretations belonged to these sub-domains. So even though a discourse segment may be associated with all the discourse entities, properties and relations mentioned therein, its interpretation must also be considered an individual and, as such, correspond to its own *discourse entity*.

I want to return and consider the *form* of reference to these discourse segment interpretation individuals. There is a very common pattern of use in which reference using *this* or *that* is followed by co-reference using *it*[19], for example

Example 26

> It's always been presumed that when the glaciers receded, the area got very hot. The Folsum men couldn't adapt, and they died out. *That*'s what is supposed to have happened. *It*'s the textbook dogma. But *it*'s wrong. They were human and smart. They adapted their weapons and culture, and they survived.

Example 27

> Here's another thing we could do. We could continue to develop both systems in parallel and in isolation from one another. But I don't think *this* can be taken seriously either. *It* would mean in effect that we had learned nothing at all from the evaluation, and anyway we can't afford the resources *it* would entail.[20]

One could attribute this pattern of changing referring forms to *focus*, as Linde (1979) and Sidner (1983) originally assumed (Section 2.3). One could say, roughly, that even though particular discourse entities within a discourse segment were *focussed*, the entity associated with its interpretation was not. It would follow that they could not be referenced with an anaphoric pronoun. However, once referenced by *this* or *that*, especially in subject position, these discourse entities would become *focussed* and hence could subsequently be referenced anaphorically.

In this regard, it is interesting to note that at least in English text, the deictic pronouns *this* and *that* most commonly appear in first noun phrase position (i.e., subject in standard SVO clauses, topic in topicalized sentencees): of 81 clausally-referring instances of *this* and *that* in the corpus reported on here, $\sim 77\%$ were first NPs – 60 in subject position in standard SVO clauses and 2 preposed adverbials. For whatever reason – whether because it is most "given" or the first of the "forward-looking centers" (Grosz *et al.*, 1983) – the common way to refer to the subject of the preceding clause is with an anaphoric pronoun (Passonneau, 1989).

There may be problems with developing a purely focus-based account though, over and beyond the evidence presented in (Passonneau, 1989) and discussed in Section 2.3. First, anaphoric pronouns can be used in English to refer to discourse segment interpretations, even though it happens less often than the use of deictics (cf. Footnote 1). Secondly, the subject of the previous sentence can be referenced with a deictic, in ways that seem inter-changeable with an anaphoric pronoun:

Example 28

John and Mary each did a wonderful job on the exam. But $\left\{ \begin{array}{l} that\text{ 's} \\ they\text{'re} \end{array} \right\}$ who I would have expected to do well.

Of course, there may be something special about these deictic+copula constructions, since *that* as the subject of non-copula verbs cannot be used to refer to animate individuals or sets thereof.[21]

The commonness of the *that* /*it* pattern does not mean that one can not refer deictically to the same thing more than once:

Example 29

They wouldn't hear to my giving up my career in New York. *That* was where I belonged. *That* was where I had to be to do my work. [Peter Taylor, *A Summons to Memphis*, p.68]

Example 30

> By this time of course I accepted Holly's doctrine that our old people must be not merely forgiven all their injustices and unconscious cruelties in their roles as parents but that any selfishness on their parts had actually been required of them if they were to remain whole human beings and not become merely guardian robots of the young. *This* was something to be remembered, not forgotten. *This* was something to be accepted and even welcomed, not forgotten or forgiven. [Peter Taylor, *A Summons to Memphis*, p.217]

While this pattern is clearly marked,[22] it must still be explained. From the point of view of focus, one might say that while *centered* entities can be referenced anaphorically, they don't have to be: that reference via other forms like names, definite NPs and deictic pronouns will succeed although they will sound markedly strange, as is the case here.

6 Conclusion

In this paper I have argued for an account of reference to the interpretation of one or more clauses, which in English is usually done via a *this* or a *that*, based on current views of discourse structure. In particular, I argued that what provides referents for these expressions are the interpretations of discourse segments on the *right frontier* of discourse structure. This requires there be a closer relationship between discourse structure and the discourse model. I suggested how the discourse model might incorporate the interpretations of segments on the *right frontier* of discourse structure as individuals and hence as discourse entities. Thus discourse segments contribute two different sorts of entities to the discourse model: ones corresponding to noun phrase interpretations in context and ones corresponding to their own interpretations.

What I have discussed in this paper is only part of the story of deictic reference: another part concerns the semantic nature of these clausal interpretations. As many examples like the following show, interpretations can easily slip from one sort to another (in this example, from a proposition – the object of "believe" – to an eventuality – the object of "welcome").

Example 31

> I believe that these two activities will become less distinct in the future, an influence of the new sciences of complexity. I welcome *that*. (Pagels, 1988)

This other part of the story I discuss in a companion paper (Webber, forthcoming).

Footnotes

1. I informally analyzed 177 consecutive instances of pronominal reference using *it*, *this* and *that*, distinguishing those that could be taken to co-refer with some noun phrase and those that could only possibly be taken to refer to the interpretation of one or more clauses. There were 96 instances of the latter. Of those, only 15 (~16%) used the pronoun *it* while the other 81 (~84%) used either *this* or *that* (19 instances of *that* and 62 instances of *this*). Of the 81 that co-referred with a noun phrase, 79 (~98%) used *it* while only 2 (~2%) used *this* or *that*. My data comes from *Summons to Memphis* by Peter Taylor, Ballentine Books, 1986; W.D. Hillis' essay, "Intelligence as as Emergent Behavior", *Daedalus*, Winter 1988, pp.175-189; an editorial from *The Guardian*, 15 December 1987; two reviews in *TLS*, 23-29 October 1987, pp.1163-1164 and 20-26 November 1987, p.1270; and a technical report "An Architecture for Intelligent Reactive Systems" by Leslie Kaebling, SRI Int'l, Menlo Park CA., 1987.

2. DiEugenio (1989) has shown that, as well as *questo*, a zero-anaphor can be used in subject position to refer to clausal interpretations in Italian. In German, both anaphoric and deictic pronouns can be used in this way, though I do not know whether German shows as strong a preference for the use of deictic pronouns for reference to clausal interpretations as English.

3. Linde attributes this to the speaker's desire to contrast two items.

4. a strong influence on Grosz, Joshi & Weinstein's later *centering* theory of coherence and reference (Grosz *et al*, 1983)

5. examples from (Passonneau, 1989), numbering my own

6. e.g., to produce a referent for *it* in "Either there's no bathroom on this floor or *it's* in a very strange place."

7. This is clearly only part of the story because noun phrases can also be definite by association with some focussed element. Therefore a definite noun phrase can change its referent by just postulating a change in *focus*, rather than a change in segment – for example,

Example 32
> a. This morning, I noticed that the front tires of my car looked soft.
> b. But when I tried to get my tire gauge from the trunk, I found that *the lock* was frozen so *the key* wouldn't work.
> c. Then I remembered that I had another gauge in the shed out back.
> d. But when I got there I found I had forgotten *the key*, so I couldn't get *the lock* open.

Here *the lock* and *the key* have different referents in 32b and 32d. Even without postulating a segment boundary between them, it is clear that while the car trunk is the focus (or at least one of the foci) of 32b, the shed has taken its place by 32d. In this case, a change in focus is sufficient to explain the change in referent.

8. Theories also differ as to the minimal discourse segment. Hobbs takes it to be a sentence (Hobbs, 1988), and Polanyi (1986), a clause. Grosz & Sidner seem to take a sentence as the minimal segment needed to express a single purpose, but do not assume that every sentence constitutes a distinct discourse segment.

9. As Passonneau has pointed out (personal correspondence), this ignores the possibility of interpreting a stretch of text as belonging to two adjacent segments in a sequence, serving essentially as a transition between them. Including this possibility complicates what it would mean to have a *sequence* of discourse segments, but would not alter the recursive nature of the definition itself.

10. Linde does not mention any examples of rooms described more than once, each time when reached by a different path. She just notes that even when apartments offer the possibility of different tours, because rooms are multiply connected, the descriptions given one route or another: they don't take listeners around a loop.

11. The first two have the same meaning as when applied to tree traversal algorithms.

12. This is true whether the elements are sequences of words, sentences, or the integers used to illustrate the *binary search tree* and *B-tree* construction algorithms found in every elementary algorithms textbook.

13. See (Moens & Steedman, 1988) for discussion of *contingency* rather than *termporal order* as the interpretation of the relationship between when-clause and main clause.

14. I thank Barbara Di Eugenio for calling the need for this structure to my attention.

15. Attachment is similar to the DRS coordination proposed by Bauerle (1988) and discussed in Section 2.3.

16. While I say "must", it is well-known that there are no absolutes in discourse interpretation: people are such accommodating listeners, that it is rare that they cannot recover the intended meaning of an an utterance. However, given the choice, one would probably want a Natural Language generation system to produce referring expressions (both anaphoric and deictic) that require as little "puzzle-mode" processing as possible.

17. null subjects and deictics in Italian, and anaphoric and deictic pronouns in German

18. Here, I am using *model* in its formal sense of what provides a semantics for a language. I will use *discourse model* when I mean the partial model grounding the semantics of a particular discourse. I assume that the ontology grounding a discourse model is the same as the ontology grounding any model of the language used in the disocurse.

19. Passonneau (1989) reports on this common pattern of usage under the name "pronoun chains".

20. This pattern of reference is common, independent of what the deictic pronoun is taken to refer to – to the interpretation of a discourse segment, to a non-human individual, to a proposition, etc. For example,

Example 33
> We could think about getting a Volvo. *That*'s the kind of car my father usually drives. *Consumer Reports* describes *it* as "tediously safe".

21. DiEugenio (1989) reports that one can refer to the interpretation of a discourse segment in Italian with a null pronoun, but *only* in restricted contexts such as when it is the subject of a copula or a verb like "happen" or "mean". Other verbs requires the use of *questo.*

22. In both examples, it does not even appear to matter what order the clauses are in, which is not the case in the more common *that/it* pattern.

References

[1] Allen, J. *Natural Language Understanding.* Menlo Park CA: Benjamin/Cummings Publ. Co., 1987.

[2] Bäuerle, R. Aspects of Anaphoric Reference to Events and Propositions in German. (English version to appear. Also appears as Evénements et propositions: quelques aspects de la référence anaphorique en allemand. In *Recherches sur la philosophie et le langage 10* (Cahier du groupe de recherches sur la philosophie et le langage, Université des Sciences Sociales de Grenoble), Pascal Engel (ed), 1989.

[3] Chafe, W. Cognitive constraints on information flow. In *Coherence and Grounding in Discourse*, R. Tomlin (ed.), Philadelphia: John Benjamins, 1987, pp. 21-52.

[4] Cohen, R. *A Computational Model for the Analysis of Arguments.* PhD thesis, Technical Report 151, Computer Systems Research Group, University of Toronto, 1983.

[5] Cohen, R. Analyzing the Structure of Argumentative Discourse, *Computational Linguistics* 13(1-2):11-24, 1987.

[6] Crain, S. and Steedman, M. On not being led up the garden path: the use of context by the psychological parser. In *Natural Language Parsing*, D. Dowty, L. Karttunen & A. Zwicky (eds.), Cambridge: Cambridge University Press, 1985.

[7] Di Eugenio, B. Clausal Reference in Italian. *Proc. Penn Linguistics Conference*, University of Pennsylvania, February 1989.

[8] Fox, B. *Discourse Structure and Anaphora.* Cambridge: Cambridge University Press, 1987.

[9] Garnham, A. *Mental Models as Representations of Discourse and Text.* Chichester: Ellis Horwood Ltd., 1987.

[10] Garnham, A. Understanding Anaphora. In *Progress in the Psychology of Language, vol. 3*, A.W. Ellis (ed.). Lawrence Erlbaum Associates, 1987.

[11] Grosz, B. The Representation and Use of Focus in a System for Dialog Understanding. Technical Report 151, SRI International, Menlo Park CA, 1977.

[12] Grosz, B. The Representation and Use of Focus in a System for Understanding Dialogs. In *Elements of Discourse Understanding*, A. Joshi, B. Webber & I. Sag (eds.), Cambridge: Cambridge Univ. Press, 1981. (Reprinted in *Readings in Natural Language Processing*, B. Grosz, K. Sparck Jones & B. Webber (eds.), Los Altos: Morgan Kaufmann Publ., 1986.)

[13] Grosz, B. & Sidner, C. Attention, Intention and the Structure of Discourse. *Computational Linguistics*, 12(3), July-Sept. 1986, pp.175-204.

[14] Grosz, B., Joshi, A. & Weinstein, S. Providing a unified account of definite noun phrases in discourse. *Proc. 21st Annual Meeting, Association for Computational Linguistics*, 1983, pp.44-50.

[15] Heim, I. File Change Semantics and the Familiarity Theory of Definiteness. In *Meaning, Use and Interpretation of Language*, R. Bäuerle, C. Schwarze and A. von Stechow (eds.). Berlin: de Gruyter, 1983.

[16] Hillis, W.D. Intelligence as an Emergent Behavior, *Daedalus*, Winter 1988, pp.175-190.

[17] Hinds, J. Organizational Patterns in Discourse. In T. Givon (ed.) *Syntax and Semantics 12: Discourse and Syntax*, New York: Academic Press, 1979.

[18] Hirschberg, J. & Litman, D. Now Let's Talk about Now: Identifying Cue Phrases Intonationally. *Proc. 25th Annual Meeting, Association for Computational Linguistics*, Stanford Univ. Stanford CA, July 1987.

[19] Hirst, G. *Anaphora in Natural Language Understanding: A Survey*. Berlin: Springer, 1981.

[20] Hobbs, J. , Stickel, M., Martin, P. & Edwards, D. Interpretation as Abduction. *Proc. 26th Annual Meeting, Association for Computational Linguistics*, SUNY Buffalo, Buffalo NY, June 1988, pp.95-103.

[21] Johnson-Laird, P. *Mental Models*. Cambridge MA: Harvard University Press, 1983.

[22] Kamp, H. A Theory of Truth and Semantic Representation. In *Formal Methods in the Study of Language*, J. Groenendijk, T. Janssen and M. Stokhof (eds.). Amsterdam: Mathematical Center Tracts, 1981.

[23] Karttunen, L. Discourse Referents. In *Syntax and Semantics*, Volume 7, J. McCawley (ed.). New York: Academic Press, 1976.

[24] Linde, C. Focus of Attention and the Choice of Pronouns in Discourse. In T. Givon (ed.) *Syntax and Semantics 12: Discourse and Syntax*, New York: Academic Press, 1979.

[25] Link, G. The Logical Analysis of Plurals and Mass Terms: A lattice-theoretical approach. In R. Bäuerle *et al.* (eds.) *Meaning, Use and the Interpretation of Language*, Berlin: de Gruyter, 1983, pp.302-323.

[26] Link, G. Hydras: On the logic of relative clause constructions with multiple heads. In Landman & Veltman (eds.), *Varieties of Formal Semantics*, GRASS 3, Dordrecht: Foris, 1984.

[27] Link, G. Algebraic Semantics for Event Structures. In Groenendijk, Stokhof & Veltman (eds.), *Proc. 6th Amsterdam Colloquium ITLI*, Amsterdam, 1987.

[28] Miller, G. Problems in the Theory of Demonstrative Reference. In R. Jarvella & W. Klein (eds.), *Speech, Place and Action*. New York: Wiley, 1982.

[29] Moens, M. and Steedman, M. Temporal Ontology and Temporal Reference. *Computational Linguistics*, 14(2):15-28, 1988.

[30] Nakhimovsky, A. Aspect, Aspectual Class and the Temporal Structure of Narrative. *Computational Linguistics*, 14(2):29-43, 1988.

[31] Pagels, H. *The Dreams of Reason*. New York: Bantam Books, 1988, p.14.

[32] Partee, B. Noun Phrase Interpretation and Type-shifting Principles. In *Studies in Discourse Representation Theory and the Theory of Generalized Quantifiers*, J. Groenendijk, D. de Joongh & M. Stokhof (eds.) Dordrect: Foris, 1987.

[33] Passonneau, R. Getting at Discourse Referents, *Proc. 27th Annual Meeting, Association for Computational Linguistics*, Univ. British Colubia, Vancouver, Canada, June 1989.

[34] Polanyi, L. The Linguistic Discourse Model: Towards a formal theory of discourse structure. TR-6409. BBN Laboratories Incorp., Cambridge MA, November 1986.

[35] Quine, W. The Inscrutability of Reference. In D. Steinberg and L. Jacobovits (eds.), *Semantics: An Interdisciplinary Reader*. Cambridge: Cambridge University Press, 1971. pp.142-154.

[36] Reichman, R. *Getting Computers to Talk like You and Me*. Cambridge MA: MIT Press, 1985.

[37] Scha, R. & Polanyi, L. An Augmented Context Free Grammar for Discourse. *Proceedings of the 12th International Conference on Computational Linguistics*, August 1988, Budapest Hungary.

[38] Schubert, L., & Pelletier, F. Problems in the Representation of the Logical Form of Generics, Plurals, and Mass Nouns. In *New Directions in Semantics*, London: Academic Press, 1987, pp.385-451.

[39] Sidner, C. Focusing in the Comprehension of Definite Anaphora. In M. Brady & R. Berwick (eds.), *Computational Models of Discourse*. Cambridge MA: MIT Press, 1982, pp.267-330.

[40] Steedman, M. Grammar, Interpretation and Processing from the Lexicon. In W. Marslen-Wilson (ed.), Cambridge MA: MIT Press (Bradford Books), 1989.

[41] Webber, B. So What can we Talk about Now? In M. Brady & R. Berwick (eds.), *Computational Models of Discourse*. Cambridge MA: MIT Press, 1982, pp.331-371.

[42] Webber, B. Deictic Reference and the Ontology of Discourse Models. Forthcoming.