9-16-1990

Structure and Ostension in the Interpretation of Discourse Deixis

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

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

Recommended Citation


This paper is posted at ScholarlyCommons. http://repository.upenn.edu/cis_reports/581
For more information, please contact libraryrepository@pobox.upenn.edu.
Structure and Ostension in the Interpretation of Discourse Deixis

Abstract
This paper examines demonstrative pronouns used as deictics to refer to the interpretation of one or more clauses. Although this usage is frowned upon in style manuals such as (Strnnk and White, 1959), who say "This. The pronoun this, referring to the complete sense of a preceding sentence or clause, cannot always carry the load and so may produce an imprecise statement."

it is nevertheless very common in written text. Handling this usage poses a problem for Natural Language Understanding systems. The solution I propose is based on distinguishing between what can be pointed to and what can be referred to by virtue of pointing. I argue that a restricted set of discourse segments yield what such demonstrative pronouns can point to in the discourse model and a restricted set of what Nunberg (1979) has called referring functions yield what they can refer to by virtue of that pointing.

Comments
Structure and Ostension In The Interpretation of Discourse Deixis

MS-CIS-90-58
LINC LAB 183

Bonnie Lynn Webber

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

August 1990
Structure and Ostension in the Interpretation of Discourse Deixis

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

September 16, 1990

Abstract

This paper examines demonstrative pronouns used as deictics to refer to the interpretation of one or more clauses. Although this usage is frowned upon in style manuals such as (Strunk and White, 1959), who say

"This. The pronoun this, referring to the complete sense of a preceding sentence or clause, cannot always carry the load and so may produce an imprecise statement."

it is nevertheless very common in written text. Handling this usage poses a problem for Natural Language Understanding systems. The solution I propose is based on distinguishing between what can be pointed to and what can be referred to by virtue of pointing. I argue that a restricted set of discourse segments yield what such demonstrative pronouns can point to in the discourse model and a restricted set of what Nunberg (1979) has called referring functions yield what they can refer to by virtue of that pointing.

short title: Discourse Deixis
1 Introduction

1.1 The Phenomenon

This paper sets out to explicate a use of demonstrative pronouns illustrated in the following examples:

Example 1

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 2

Using microscopes and lasers and ultrasound, he removes tumors that are intertwined with children's brain stems and spinal cords. There is only the most minute visual difference between the tumors and normal tissue. Operations can last 12 hours or more. The tiniest slip can kill, paralyze or leave a child mentally retarded. This is the easy part of his job. (New York Times, 11 August 1990, p.27)

In these examples, a demonstrative pronoun is used to refer to something other than the referent of a previous noun phrase. It is not, however, referring to a previous section of text – what Lyons (1977, p.668) has called pure textual deixis – as in,

Example 3

A: The combination is 7-4-1-5.
B: I'm sorry I didn't hear you. Could you repeat that?

In Example 1, the referent of that must be something that can happen. In Example 2, it must be something that can be part of a job. Sections of text – i.e., strings of words – can be neither. On the other hand, sections of text can have such events or actions associated with them. My goal in this paper is thus straightforward: to show how sections of text can yield referents for demonstrative pronouns.

The paper proceeds as follows: First I discuss terminology and assumptions. I then try to show (Section 2.1) that it is not any arbitrary sequence of clauses in a text that can yield referents for demonstrative pronouns, but rather, only those that correspond to what have been called discourse segments in many current discourse theories. I then try to show that, at any point in the text, only certain discourse segments can yield referents for demonstrative pronouns – in particular, only those segments whose contribution to the discourse model is currently in focus.

To make this sense of focus precise, I present in (Section 2.3) a simple incremental tree construction algorithm which is meant to serve as a formal analogue for text processing. This algorithm specifies precisely (1) the positions at which new nodes can be inserted into a tree and (2) the particular insertion operations that can be used. I then associate
with these positions (the current right frontier of the tree) the set of discourse segments whose contribution to the discourse model is in focus. I claim that it is just these discourse segments that can yield referents for demonstrative pronouns. In support of this claim, I provide empirical evidence (Section 3) that segments corresponding to nodes no longer on the right frontier can no longer provide such referents.

Thirdly, I argue against the view that it is the structure of the world rather than how a speaker chooses to describe it that is the primary constraint on what deictic pronouns can refer to in discourse. I conclude in Section 4 with a description of the indirect process by which I believe discourse segments yield referents for demonstrative pronouns through their contribution to the discourse model. This process draws on Nunberg's exploration into polysemy and demonstrative reference (Nunberg, 1979) and current theories of what has been called natural language metaphysics (Bach, 1989).

1.2 A Name for the Phenomenon

Phenomena need names. Lyons, recognizing the difference between pure textual deixis (see above) and the phenomenon under discussion here, called this phenomenon impure textual deixis. It was "deixis" because

The term 'deixis' (which comes from a Greek word meaning "pointing" or "indicating") is now used in linguistics to refer to the function of personal and demonstrative pronouns, of tense and of a variety of other grammatical and lexical features which relate utterances to the spatio-temporal co-ordinates of the act of utterance. (Lyons, 1977, p.636)

It was "textual" because it had to do with the utterance itself, and "impure" because what was being indicated was not the utterance as a thing but what it expressed.

I think a better name is called for. The terms reference to events and reference to propositions used by Bäuerle (1989) reflect the semantic sort of the thing referred to. My problem with these terms are that (1) events and propositions are only two of the many sorts of things that demonstrative pronouns can refer to in discourse and (2) the separate names may be seen as implying that there are separate processes involved in reference to events and in reference to propositions. I do not believe this. I try to show here that only a single process need be involved. Another possible name is discourse deixis, previously used by Lakoff (1974). This is the name I favor: it labels the phenomenon as an instance of deixis, and grounds the source of its referents in the discourse.

As for a name for the referring phrases, when Lyons begins his discussion of this and that, he uses the locution the English demonstratives 'this' and 'that', used as deictics (Lyons,
1977, p. 655) acknowledging the fact that demonstrative pronouns are used for other functions as well. Shortly thereafter, he contracts this locution to *deictic pronoun* –

In so far as the very fact of pointing to something commits the person who is pointing to a belief in the existence of what he is pointing at, the use of a deictic pronoun carries with it the implication or presupposition of existence. (Lyons, 1977, p. 656)

One reason for promoting this phrase is that it turns out that in several languages, including Italian and even English, zero-pronouns (Ø) can be used in the same way as demonstrative pronouns. (See Di Eugenio (1989) for a discussion of discourse deixis in Italian.) In English, this occurs in instructions, where it is common to find ellipsed direct-objects (Sadock, 1974). However, the referent of this ellipsis need not be a physical object. Consider the following example drawn from a Frigidaire assembly and repair manual

**Example 4**

Check the door seal by closing the door on a 1” wide strip of paper. A slight drag should be felt when the paper is pulled from between the gasket and the cabinet.

Repeat Ø around all four sides of the door.

Here the zero-pronoun refers to the process described in the preceding section of text. This reference would ordinarily be achieved explicitly using a demonstrative – “Repeat this (or this process) around all four sides of the door.” Thus the term *deictic pronoun* can serve to denote any pronoun (zero-pronoun, demonstrative pronoun, or even personal pronoun) that serves this same function.

### 1.3 Terminology and Other Assumptions

I assume that in processing a text, a listener is constructing a *model* that supports it and that evolves with the text. Lyons (1977, p.670) has called this model the *universe-of-discourse*. I and others have called it a *discourse model*. A discourse model is clearly a mental construct, but as long as the participants in a discourse believe they understand one another, they assume that their models are consistent. Discourse models may correspond to particulars of the real world, if the real world is the subject of the discourse, but they need not. (This is not to say that people do not use their beliefs about the real world and how it works, in interpreting texts and constructing discourse models. It just says that the particulars of the two need not be the same. The only thing essential for successful discourse is that the participants believe their models are consistent with one anothers’.)

A discourse model contains *entities* to which are ascribed the properties and relationships predicated of them in the text. (Bill Woods once referred to them as “conceptual
coathooks"). More sober names that have been used include discourse referents (Kartunnen, 1976), reference markers (Kamp, 1981), and file cards (Heim, 1983). I have called them discourse entities (Webber 1979, 1982), and will continue to do so in this paper. Discourse entities ground referring phrases. They may or may not correspond to particular entities in the real world.

As in many recent theories of discourse including Discourse Representation Theory (DRT) (Kamp, 1981; Bäuerle, 1989; Roberts, 1989), Grosz and Sidner's theory of discourse (1986) and that of Polanyi (1986), I assume that a discourse model is structured into regions in a way that reflects the recent structure of the evolving text. Utterances seen as part of the same segment of text (for any of the reasons noted in Section 2.1) will be taken by the listener to contribute to the same region of the model. Likewise, clauses in the text that are understood as contributing to the same region of the model will be seen as part of the same segment of text. Regions of the model may be embedded in other regions, reflecting substructures in the text. In DRT, these regions corresponds to contexts. As in recent work in DRT (Asher, 1987; Bäuerle, 1989), I assume that each context has a discourse entity that "stands proxy" for its propositional content. This discourse entity will come into play in Section 4, when I explain how discourse segments can indirectly yield referents for deictic pronouns through their associated regions of the discourse model.

Like Nunberg (1979) and others, I assume an approach to ostensive acts (such as in the use of deictic pronouns) that distinguishes what is pointed to (the demonstratum), and what is referred to (the referent). These two entities may be the same, but they do not have to be. What is of interest is the link between them, which Nunberg (1979) has called a referring function. Referring functions apply to demonstrata to produce referents. In the approach that I present in Section 4, referring functions apply to discourse entity "proxies" for regions of the discourse model corresponding to discourse segments, thereby yielding referents for deictic pronouns. The range of possible referents follows directly from the range of referring functions possible in a given circumstance. In the following example, at least four are possible:

**Example 5**

Hey, management has reconsidered its position. They've promoted Fred to second vice president.

(a.) That's a lie.

(b.) That's false.

(c.) That's a funny way to describe the situation.

(d.) When did that happen?

In (a), the referenced interpretation is the specific speech act (only speech acts can be lies); in (b), the proposition conveyed by the segment; in (c) the description expressed by
the segment; and in (d), the particular event denoted by the segment. Since in the rich ontology advocated by Bach (1990) and others, all of these are sorts of individuals, I take it that the act of ostension performed by deictic pronouns in discourse can add new discourse entities into the model that were not present prior to the ostensive act. As such, ostension can have the same effect as what has been called accommodation (Lewis, 1979).

That is, in the simplest case, a referring phrase is taken to refer to an entity already in the discourse model. However, it can also cause the listener to add a new entity to the model to which s/he can ascribed the indicated properties or can set in the indicated relations. The addition of a new entity in response to an indefinite noun phrase is a common case. Where new entities are added in response to definite noun phrases, the process has been called accommodation because the use of a singular definite is felt to presuppose that there is already an unique entity in the context with the given description that will allow a truth value to be assigned to the utterance. For example,

**Example 6**

I walked up to the first house on my list. I noticed that the side door was wide open.

Houses do not necessarily have side doors. However, in response to “the side door”, the listener accommodates a new entity in his/her discourse model corresponding to the mentioned side door of the house in question (“mentioned”, because the text is consistent with there being more than one side door). Deictic pronouns can have the same effect as such definite noun phrases.

Finally, I assume that one can identify (at least, a posteriori) what a speaker and listener are attending to – what is immediately salient – at any point in the discourse. Items so identified are considered in focus, although other terms have been used to distinguish particular theories. Notions of focus have been proposed, at least in part, to account for patterns of “efficient” 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. Among the sorts of things that are felt to be able to have some sort of “focussed” status are discourse entities (Grosz et al., 1983; Sidner, 1982), open propositions (Wilson and Sperber, 1979; Prince, 1986; Steedman, 1990), and “focus spaces” (Reichman, 1985; Grosz and Sidner, 1986).

I will use the notion of focus to distinguish those regions of the discourse model that, at a given point in the discourse, can yield referents for deictic pronouns. The main feature of focus that is relevant here is that it changes in fairly predictable ways, as each new clause
While I will discuss focus with respect to which regions of the model can yield referents for deictic pronouns, when there is more than one, as in the following minimal pair, I will have nothing to say here about how the choice between them is made.

**Example 7**

a. Segal, however, had his own problems with women: he had been trying to keep his marriage of seven years from falling apart; when *that* became impossible . . .

b. Segal, however, had his own problems with women: he had been trying to keep his marriage of seven years from falling apart; when *that* became inevitable . . .

In Example 7a., it is the region associated with “(Segal’s) keeping his marriage of seven years from falling apart” that yields a referent for *that*, while in Example 7b., it is that associated with “his marriage of seven years falling apart” that does so.

### 1.4 For the Record

It is important for the reader to be clear that there are *three* structures under discussion here (Figure 1): the structure of the text (in terms of discourse segments), the structure of the discourse model (in terms of regions), and a tree structure which, by virtue of its associated insertion procedure, serves as a *formal record* of the *process* by which the discourse model grows and the structure changes, in response to the text and its perceived structure.

The value of having such a formal analogue lies in being able to make use of its properties, including how it can legally change over time, to pin things down and avoid hand-waving. (In Section 2.4, I discuss what I believe is the close relationship between these three structures and those proposed by Grosz and Sidner.)

I should also note that there this is not the first attempt to provide an account of demonstrative pronouns in discourse (nor do I expect it will be the last). Both Linde (1979)
and Sidner (1983) tried to extend theories of anaphoric pronoun interpretation to account for demonstrative pronouns as well. Both these accounts are in terms of the focus status of different objects and actions mentioned in the discourse. More recently though, Passoneau (1989) analyzed 678 instances of *it* and *that* found in conversational interactions, where these pronouns are interpreted as referring to entities introduced into the discourse model by noun phrases and other sentential constituents. She found 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. By the first factor, if both antecedent and pronoun were subjects of their respective clauses, the pronoun *it* was strongly favored. By the second factor, if the antecedent noun phrase was other than a pronoun or a canonical noun phrase headed by a noun, then the pronoun *that* was strongly favored. Unlike the current study, Passoneau's analysis is limited to pronouns whose antecedents were constituents within single sentences.

There are also at least two attempts to extend Kamp’s *Discourse Representation Theory* (1981) to handle the phenomenon of reference to events and to propositions (Bauerle, 1988; Asher, forthcoming), but as I will try to show, it is more than just events and propositions that deictic pronouns can refer to in discourse, so that a richer interpretive process is called for.

## 2 Discourse Segments

### 2.1 Background

I hope that a simple example will convince the reader that not every previous sequence of clauses in a text can yield referents for deictic pronouns. Consider the following:

**Example 8**

a. For his part in their joint project, John built a two-armed robot.
b. He had learned about robotics in CSE391.
c. For her part, Mary taught it how to play the saxophone.

It is easy to come up with a subsequent utterance in which the referent of *that* derives from just the previous clause (c), for example

\[ d. \text{That took her six months.} \]

It is also easy to come up with a subsequent utterance in which the referent of *that* derives from the previous three clauses (a-c), for example

\[ d'. \text{That earned them both As.} \]
However, it does not seem possible to come up with a subsequent utterance in which the referent of *that* derives from just the previous two clauses (b-c). This fact seems to follow from the fact that they are not interpreted together as a unit, independent of a.

If not every sequence of clauses in a text has an interpretation accessible to deictic reference, which ones do? There is a widely held view that discourses are formed of smaller sequences of related clauses or sentences called *discourse segments*, although as James Allen has noted:

\[\ldots\] 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)

Among the bases that have been proposed for grouping utterances into segments are: common 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 (Roberts, 1989). As for what constitutes a minimal discourse segment, theories differ. Hobbs (1988) takes it to be a sentence, and Polanyi (1986), a clause. Grosz and Sidner (1986) seem to take a sentence as the minimal segment needed to express a single purpose, but unlike Hobbs and Polanyi do not assume that every sentence constitutes a distinct discourse segment.

Characterizing what is involved in recognizing that utterances share a common subject, viewpoint, modality and/or purpose (and doing so in a manner amenable to computer implementation) is both an unsolved problem and an active area of research. To date, particular lexical and syntactic cues have been identified as signalling segmental changes (Cohen, 1987; Grosz and Sidner, 1986; Nakhimovsky, 1988; Reichman, 1985), as have specific intonational changes at segment boundaries (Hirschberg and Litman, 1987).

That is not the whole story, however. Also needed is a characterization of how listeners bring their beliefs about the world and about speakers’ intentions to bear on recognizing common subject or purpose, since this cannot be done on the basis of surface and syntactic cues alone. Here there are fewer research results to date. For this paper, I will have to assume, like Cohen (1987), the existence of an oracle that can decide with which, if any, existing segment the next utterance in a text shares a common subject, viewpoint, etc. If doing so leads the reader to abandon the paper at this point, so be it. My feeling is that existing evidence that discourse segments play a role in text understanding makes it worthwhile to continue, in parallel, efforts at characterizing recognition procedures and efforts like the present one that assume such recognition.
What roles have discourse segments been seen to play in discourse understanding? One early computational reason for appealing to the notion of discourse segment 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. The claim is that a definite noun phrase would be interpreted as referring to an entity mentioned in the same segment rather than one mentioned anywhere else, even if the latter were mentioned more recently. For example, consider the following sequence uttered by a single speaker:

Example 9

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.

By the tent in sentence 9d, the speaker is referring to the one she has requested in 9a, and not the leaky one she has mentioned in 9b-c. This can be explained in terms of discourse segments, by saying that clauses 9b-c make up a segment embedded in the larger one (9a-d). As a whole, the segment constitutes a request, with 9b-c functioning as its explanation. Because 9d is outside the embedded segment, its object noun phrase the tent would be interpreted as referring to the one mentioned in the segment that it belongs to (i.e., the outer one).

Another use to which the notion of discourse segment has been put is in the interpretation of tensed clauses in narrative text (Nakhimovsky, 1988; Webber, 1988). For example, the unmarked interpretation of a sequence of simple past tense clauses in English narrative is that the events described happen at the same time or in temporal sequence. But this is not always the case, as in the following example.

Example 10

a. I was over at Mary’s house yesterday.
b. She told me about her brother Harold.
c. He went to Alaska with two friends.
d. Together they climbed Mt. McKinley.
e. She asked me whether I was interested in going some time.

Clearly the event described in clauses c-d happened before the event described by a,b and e, even though all the clauses use the same simple past tense. Postulating an embedded segment and a temporal focus that can reset at segment boundaries (Webber, 1988) allows one to retain a notion of simple simultaneity or temporal progression in the unmarked case.
2.2 Relations between Discourse Segments

Often (as above) discourse segments are taken to be recursive structures, such that either a discourse segment is a minimal segment or it comprises a sequence of embedded discourse segments. As so defined, the recursive structures of interest are trees. This does not mean that a discourse corresponds to a single tree, just that there may be parts of the discourse that evince an embedding structure, and that this structure has interesting properties.

Now, if a tree structure is to represent the relationship among (certain) segments, then so must its two basic structuring relations – parent-of and right-sibling-of. For example, in Robin Cohen's work on the structure of argumentative discourse (Cohen, 1983, 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. These tramission forms 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.

In Scha and Polanyi's proposal (1988) for a semi-deterministic, on-line procedure for building a structural description of an unfolding discourse, they take the nodes of discourse structure 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 and 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.) For all these node types, parent-of means uniformly that one DCU is a constituent of another one. However, 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 list n-ary coordination.

Grosz and Sidner (1986) take a more abstract criterion for establishing structural relations in discourse. The parent-of relation they call domination (DOM), and the right-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 the latter (or, alternatively, the latter is the right-sibling-of the former). Grosz and Sidner call the resulting hierarchy of DSPs the Intentional Structure of a discourse. It is only one of three structures that they associate with a discourse. Another of the three, Attentional State, I will discuss in Section 2.4.

2.3 Incremental Tree Construction

Having specified the two tree-structuring relations parent-of and right-sibling-of, there is still a variety of ways that a tree can be grown incrementally from elements added to it in sequence, depending on the insertion operator(s) used and the nodes that insertion can apply to. Here I will show how the same initial tree and input sequence result in two different final trees, by different employing insertion operations.

First consider a Binary Search Tree (a tree with a maximum of two branches on each node and a restriction that (1) the value of any node on a left subtree is less than the value of its root and (2) the value of any node on a right subtree is greater than the value of its root). Here there are two simple operators attach as left daughter and attach as right daughter, where the position at which a new node is attached depends on how its value compares with the values of existing nodes on a path from root to leaf. These operators can insert new nodes only at the fringe of the tree. Thus the root of the tree can never change, nor can the relation between any existing node and the root. (Figure 2 illustrates the incremental change in a BST as two new elements, whose values are 50 and 25, are added in sequence.)

Now consider another data structure, the AVL tree. An AVL tree must satisfy the
same constraints as a BST, as well as one additional constraint: an AVL tree must be kept balanced around each node. (A tree is considered balanced if the heights of its left and right subtree do not differ by more than one.) Again, new nodes can only be added at the fringe of the tree, but the insertion operations are more complex, often leading to a restructuring of the tree (via rotation) to keep it balanced. (See (Reingold and Hansen, 1983) or any standard text in data structures, for more detailed discussion.) Figure 3 illustrates the incremental change in the same initial tree— which also qualifies as an AVL tree—as the same two elements, 50 and 25, are added in sequence. Notice that the root node of the AVL has changed by virtue of the insertions, as has the fringe and the right frontier. (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.)

No one has claimed that Binary Search Trees or AVL trees are relevant to discourse understanding. However, they can provide a basis for understanding other procedures that have been proposed for discourse understanding. For example, Cohen's pre-order transmission form (Cohen, 1983, 1987) uses a single operation—attach as rightmost daughter. Her post-order transmission format makes use of a different operation—attach as parent—which subordinates a node or set of nodes as daughters of the node corresponding to the new clause. Her hybrid strategy makes use of both operators. At any point, there is a set of nodes that these operators can apply to. When an operator applies, it may change the tree such that different nodes are available as points of attachment. As noted, Cohen allows for linguistic clues to redirect operators to other nodes in the tree.

What I want to propose is a somewhat different, incremental procedure that makes use of two operations—attach as rightmost daughter (or simply, attach) and adjoin. After describing the operators, where they apply, and how they change the shape of the evolving tree, I will try to explain in discourse terms what the two operators are meant to correspond to. I then offer evidence in Section 3 in support of the claim that it is regions of the discourse model corresponding to nodes on the right frontier of a tree created by such a procedure.
that can yield referents for deictic pronouns.

First, the operations. *Attach* is the simple operation *attach as rightmost daughter* discussed previously. (Because nodes do not have explicit values as in the BST and AVL trees, I will label leaf nodes in the order of their incorporation and non-terminal nodes, with a list of their children in left-to-right order.) *Adjunction* is a somewhat more complex operation which creates new non-terminal nodes rather than just adding leaves to existing non-terminals. When a new node is *adjoined* to one already in the tree, both become children of the same (new) parent node, with the new one being the right-sibling of the old. As I will show in the next section, adjunction applies slightly differently to root, non-terminal and leaf nodes. However, it always adds two nodes to a tree, whereas attachment adds only one.

In the procedure described here, *attachment* and *adjunction* are limited to nodes on the right frontier of the evolving tree structure. (In Figure 4, nodes on the right frontier are shaded.) If this were really an independent procedure I was describing, I would now have to specify how the choice would be made as to (a) *where* on the right frontier to add a new node and (b) *how* to do so (i.e., by *attachment* or *adjunction*). However, since my purpose is just to use the procedure to enable the reader to visualize what happens during text processing to the right frontier of this Discourse Structure (or *DS*) Tree, I will describe these choices in discourse terms.

### 2.4 Discourse Segments and Incremental Tree Construction

I will start by assuming a 1-to-1 mapping between discourse segments and tree nodes, with a clause constituting the minimal segment. When the next clause in a text is taken (for whatever reason mentioned in Section 2.1) to be included in an existing discourse segment,
the corresponding tree operation is *attachment* of a new node at the node corresponding to that segment. For example, when the third clause is processed in the following example, it corresponds to a node being attached to the root of the same tree (Figure 5).

**Example 11**

1. John eats yoghurt for breakfast,
2. Fred eats Cheerios,
3. and Mary eats muffins.

At the level of the discourse model, attachment means that the region of the discourse model comprising the entities, properties and relations conveyed by the new clause is included in the same region of the model as those associated with the rest of the segment. Both the entire region and the new subregion correspond to nodes on the right frontier of the current DS tree. It is these regions – ones corresponding to nodes on the right frontier of the current DS tree – that will be taken to be in focus (cf. Section 1.3).

Now for the discourse correlate of *adjunction*. When a discourse segment $S_i$ is taken as being directly embedded in another segment $S_j$, the assumption is that the former contributes *directly* to the meaning or purpose of the latter. Suppose clause C comes along, causing the listener to realize that it is not $S_i$ that contributes directly to $S_j$, but rather it is the combination of $S_i$ and C. That is, $S_i$ and C form a segment directly embedded in $S_j$. This is the discourse correlate of *adjunction* to a non-terminal or leaf node. If C is seen as contributing along with the top-level segment (corresponding to the current root of the tree) to some more encompassing meaning or purpose, this is the discourse correlate of *adjunction to the root*. The general case of adjunction to the root is shown in Figure 6.

Discourse processing that correlates with *adjunction to the root* is actually a common case, since it happens whenever the meaning or purpose of the second clause in a discourse is taken to combine with that of the first clause to form a more encompassing meaning or purpose, such as when the second clause of Example 11 is processed. This simple common case of adjunction to the root is shown in Figure 7.

To understand the discourse correlate of *adjunction to a leaf node*, consider the following text at the point at which the reader has finished processing the clause, “John hates snakes”.

![Figure 5: Addition of Nodes by Attachment](image)
Example 12

a. John hates snakes.
   b. His next-door neighbor had kept snakes,
   c. and he had hated his neighbors.

In processing the second clause (12b), the reader may decide that it provides an explanation for the situation described in the first clause and that the two thereby constitute a segment. (This correlates with the *adjunction to the root* operation described above. It is shown in step 1 of Figure 8.) However, in processing the third clause (12c), the reader may recognize that it is the situation described *jointly* by b and c that explains the situation described in 12a. This re-analysis of the relationship between the situations conveyed by a and b correlates with the tree restructuring operation of *adjunction to a leaf*—in particular, to the
terminal on the right frontier. This second step corresponds to step 2 of Figure 8. Notice how the right frontier of the tree has changed, and thus which regions of the discourse model will be taken to be in focus.

Finally, to get a feel for the discourse correlate of adjunction to a non-terminal node, consider the following continuation of Example 12.

Example 13

a. John hates snakes.
b. His next-door neighbour had kept snakes,
c. and he had hated his neighbors.
d. Later in college, his roommate had kept snakes.

Having decided that it is the situation described in b-c that provides evidence for a, the reader in processing 13d. may decide that it is the combination of situations (one described in b-c, and the other described in d) that provides evidence for a. This reanalysis of the relationship between situations correlates with the tree restructuring operation of adjunction to a non-terminal. This third step corresponds to step 3 of Figure 8. As in step 2, the right frontier of the DS tree has changed, and thus, the regions of the discourse model that are taken to be in focus.

Note that since operations only apply to the right frontier of the DS tree, the rest of the tree becomes irrelevant. In this light, one can easily suppose that the only segments of the discourse and regions of the discourse model that retain their identity are those that correspond to nodes on the right frontier. When they no longer do so, the only thing that needs to persist, for a listener to be said to have understood the discourse, are the entities, propositions and relations predicated of them.

Finally note that a similar 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 and Polanyi (1988). There is also a close relationship between the notion of right frontier presented here and Grosz and Sidner's (1986) stack of focus spaces representing Attentional State.

In Grosz and 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 its discourse segment purpose (DSP). A focus space contains discourse entities, along with the properties and relations predicated of them. 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. Another way to put this is that the stack contains the focus spaces of segments whose "purposes" are still open to additional support.

Drawing on Grosz's earlier work (Grosz, 1977, 1981), Attentional State serves as a structured domain of locality for the interpretation of definite noun phrases. Resolution algorithms can then prefer to resolve a definite noun phrase against a referent in a focus space closer to the top of the stack than in 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 to be taken as "closed", with attention shifting back to a more inclusive segment.

The right frontier of the DS Tree discussed here is closely related to Grosz and Sidner's Attentional State. First, there is a simple mechanical relationship: Any directed path through a tree from root to leaf node can be mapped directly to a stack, with the element corresponding to the leaf at the top. Attach and adjoining then correspond exactly to the simple push and the sequence of pops followed by a push that Grosz and Sidner use to manage the stack. (That is, attaching a new leaf node corresponds to pushing a new element on the stack. Adjoining a new node $S_k$ to a node $S_i$ corresponds to popping all the stack elements through that corresponding to $S_i$ and pushing that corresponding to $S_k$ onto the top of the stack.)

There is also a functional relationship: nodes on the right frontier of the DS Tree correlate with regions of the discourse model taken to be in focus – substructures that resemble Grosz and Sidner's focus spaces. In fact, by positing a single tree structure and insertion algorithm to serve as a formal analogue of both on-line recognition of discourse structure and changes in participants' attention on regions of the discourse model, one can eliminate Grosz and Sidner's stack as now redundant, while retaining their insight into the usefulness of distinguishing text structure, intentional structure and attentional state.

3 The Referents of Deictic Pronouns

The point of reviewing notions of discourse structure and incremental tree construction algorithms is to allow me to argue that it is only regions of the discourse model corresponding to nodes on the right frontier of the DS Tree – those regions that are in focus – that can yield referents for deictic pronouns. Before doing so, I want to demonstrate that it is the structure of discourse segments (and hence, that of the discourse model) that constrains the referents of deictic pronouns rather than the world being described.

Evidence that the primary constraint on possible referents of the deictic pronouns is the presentation of information (not simply what that information is about) comes from the fact that, presented differently, the same information about a situation gives rise to
different referents. To see this, consider the following example, focussing on the referents of the deictic pronouns in paragraphs 2-4:

**Example 14**

1. There's two houses you might be interested in:
2. 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.
3. 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.
4. Is *that* enough information for you to decide which to look at?

That in each case it is an immediately preceding segment that, through its contribution to the discourse model, yields the referent of the deictic pronoun, can be seen by presenting the same information in an interleaved fashion, a technique often used when comparing two items:

**Example 15**

1. There's two houses you might be interested in:
2. House A is in Palo Alto, House B in Portola Vally. 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.
3. Is *that* enough information for you to decide which to look at?

The two examples clearly have different segmental structures (at a gross level, one that corresponds to the structure of the paragraphs). The question that readers should ask themselves is whether the deictic pronouns in paragraphs 2-3 of Example 15 have the same referents as they do in Example 14. I believe they do not, and that this is because it is not the houses being referred to, but a distinct chunk of information one has been told about the houses. Example 15 does not contain separate segments describing what the speaker knows about house A and about house B. Rather, there is only one discourse segment containing information about both houses. The only deictic that refers easily and successfully is the final *that*, which successfully refers to the information conveyed about both houses through the entire segment.

Another piece of evidence that it is focussed regions of the discourse model that yield referents for deictic pronouns comes from the (partially) recursive nature of discourse structure (cf. Section 2.1). At any given point in a discourse, segments embedded at different
depths can yield referents for deictic pronouns. To see this, consider the following quote from (Hillis, 1988):

**Example 16**

...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. \{\footnote{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 \{\footnote{they} show no obvious impairment in their ability to think.}\} This suggests that stereo fusion is not necessary for thought. This is a simple example, and the conclusion is not surprising.... (Hillis, 1988, p.185)

(I have added brackets to indicate some of discourse segments at the points where deictic pronouns occur, with subscripts indicating the depth of embedding.) The most likely referent for this is the fact that visual cortex-damaged patients have visual handicaps but no impairment to their thinking abilities. This comes from Segment 2. The most likely referent for this is the whole “brain damage” example. This comes from the more inclusive Segment 1.

Not only do deictic pronouns get their referents from regions of the model corresponding to nodes on the right frontier of the current DS Tree. These are the only regions that can provide such referents. Consider the following variation of Example 14. (Here, the individual clauses are numbered for later discussion.)

**Example 17**

(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 referent of (unstressed) that in clause (12). The rest of the clause constrains the referent of that to be information about House A. However its position in the text is only compatible with its referring in one of three ways:

- It can co-refer with all this in clause (11), as in “But that’s all she said.” (In this paper, I do not discuss deictic pronouns that refer to NP-evoked entities.)
- It can refer to something associated with clause (11), such as its corresponding asser-
Figure 9: Discourse Segmentation at the point of processing “But that’s all . . .”

- It can refer to something associated with 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 9. The oddity of Example 17 comes from the conflicting demands of text position and clause predication in the process of resolving that.

Let me emphasize here 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, can force its referent to be the block of information about House A, even though its corresponding region of the discourse model is no longer in focus.

Notice that even if it is true that the referents of unstressed this and that must come from focussed regions of the model (ones corresponding to nodes on the right frontier of the DS Tree), there is still an ambiguity as to which region. To see this, consider the first part of the Hillis example (repeated here) as a “discourse completion task”.

**Example 18**

...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 19

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* refers to 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) *this* must refer to 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. (This is what shows that one doesn't need stereo fusion in order to think.) Finally, in (c) *this* clearly refers to the entire example about binocular stereo vision.

Which discourse segment provides the referent for *this* depends on what is compatible with the meaning of the rest of the sentence, as I noted in Section 1.1, in connection with the following example:

Example 20

a. Segal, however, had his own problems with women: he had been trying to keep his marriage of seven years from falling apart; when *that* became impossible . . .

that \( \equiv \) keeping his marriage from falling apart

b. Segal, however, had his own problems with women: he had been trying to keep his marriage of seven years from falling apart; when *that* became inevitable . . .

that \( \equiv \) his marriage falling apart

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 where a deictic pronoun takes its referent 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. The ambiguity here – how inclusive a region yields a referent for *this* or *that* – seems very similar.
4 Referring Functions and the Interpretation of Deictic Pronouns

Having set up what I hope is all the necessary groundwork in the previous three sections, I hope now to pull it together and show how deictic pronouns get their referents. The solution I propose is based on distinguishing between what can be pointed to (the demonstratum) and what can be referred to by virtue of pointing (the referent). I claim that it is focussed regions of the discourse model that deictic pronouns can point to (via the discourse entity "proxies" of those segments), and that it is possibly new discourse entities that they can refer to by virtue of that pointing. What links the two, I claim, are what Nunberg (1979) has called referring functions.

Nunberg (1979) introduces the notion of a referring function in connection with some rather extreme examples of demonstratum/referent pairs, such as in (17) below (Nunberg's numbering).

For example, a restaurant waiter going off duty might remind his replacement:

(16) The ham sandwich is sitting at table 20.
And in just those contexts, he could equally well point at a ham sandwich and say,

(17) He is sitting at table 20. (Nunberg 1979, p.149)

Here, the ham sandwich serves as the demonstratum of the pointing act and the guy who ordered the ham sandwich serves as the referent of the associated pronoun "he". Formally, referring functions map demonstrata into intended referents.

\[ f: D \rightarrow R \]

where \( f \) is the referring function, \( D \) is the domain of demonstrata and \( R \), the range of intended referents. The problem for the listener, given the ambiguity of pointing mentioned in Section 3, is to simultaneously constrain the demonstratum and the referring function, such that the intended referent results.

Aiding the listener are factors that Nunberg takes as constraining the referring functions that can be used in a particular case. These include:

- that \( R \), the range of the referring function, intersect "the set of things that the speaker might rationally be construed as intending to refer to in a given context", where the latter is determined by "the nature of the predication, by the morphology of the demonstrative pronoun, and by such contextual considerations at 'topic of conversation'" (Nunberg, 1979, p.157);
that it be possible for the listener to determine, in practice, just what stands in that relationship. (For example, if one wants to refer to a particular place by pointing to a particular object, the listener should recognize what place is salient to that object. A wine bottle labelled "Medoc" may make the Medoc a salient place, while a bottle of Coca Cola may not make any place salient.)

that it be a more likely referring function, under the circumstance, than any other.

Similar assumptions are made by Hirschberg (1986) with respect to which scales a speaker can use to make scalar implicatures in a given case.

To see that these assumptions make sense, consider the "ham sandwich" example given earlier. Here, R must intersect with males (given the pronoun "he") who are able to sit at a table (given the verb phrase). The listener can be expected to figure out which particular person stands in that relation, because it must be a man sitting at table 20. Finally, the circumstances of an order waiting in the kitchen to be delivered make it more likely that f is "the man who ordered the ham sandwich" than "the man who made it".

I claim that the same approach can be extended to cover discourse deixis as well as external ostension, simply by taking a different domain D of demonstrata. Specifically, I noted in Section 1.3 that I was making the same assumption as that made in DRT (Asher, 1987; Bäuerle, 1989) that each context region of the discourse model has a discourse entity that "stands proxy" for its propositional content. If one takes D to comprise the discourse entity "proxies" of those regions of the discourse model that are currently in focus — those corresponding to (and whose discourse segments correspond to) nodes on the right frontier of the DS Tree, then everything else can proceed as before.

To illustrate this approach, I will apply it to the first examples given in the paper (repeated here, with the initial clauses numbered).

**Example 21**

(1) It’s always been presumed that (2) when the glaciers receded, (3) the area got very hot. (4) The Folsom men couldn’t adapt, and (5) they died out. (6) That’s what is supposed to have happened. It’s the textbook dogma. But it’s wrong.

**Example 22**

(1) Using microscopes and lasers and ultrasound, (2) he removes tumors (3) that are intertwined with children’s brain stems and spinal cords. (4) There is only the most minute visual difference between the tumors and normal tissue. (5) Operations can last 12 hours or more. (6) The tiniest slip can kill, paralyze or leave a child mentally retarded.

(7) *This* is the easy part of his job. (New York Times, 11 August 1990, p.27)
First consider Example 21. Here at least four regions of the discourse model can be said to be in focus at the point in the discourse at which that appears:

- the region associated with clause 5
- the region associated with clauses 4-5
- the region associated with clauses 2-5
- the region associated with clauses 1-5.

Thus D, the domain of f, will comprise at least their four "proxies". R, the range of f, should be a subset of event tokens (i.e., things that can happen). It is easy to imagine a function that could apply to each of the first three proxies to yield an event token, since their propositional content can be taken to convey a particular event. The intended referent could be any of these, but given the rest of the story (Tony Hillerman's Dance Hall of the Dead), it is probably either the second or third.

Now consider Example 22. Here at least two regions of the discourse model can be said to be in focus:

- the region associated with clause 6
- the region associated with clauses 1-6.

Thus D will comprise at least their two proxies. I assume that it is intentional act types that are parts of jobs, so that R will intersect this set. It is hard to associate an intentional act type with the first proxy. (If clause 7 has been something like "This would paralyze some people into inaction," where R would comprise (probably difficult) situations, it would be easier to associate such a referent with the first proxy.) So the intended referent of that in clause 7 most likely derives from applying f to the second proxy – most likely paraphrasable as "removing these difficult tumors".

Notice that this approach in terms of referring functions avoids a problem that Bäuerle (1989) cannot, since he approach requires separate mechanisms to handle each of event token reference, event type reference and proposition (token) reference. That is, the current approach does not require introducing yet a fourth mechanism to handle deictic reference to proposition types (not discussed in Bäuerle's paper) such as the following:

Example 23

A: Fred and Amy always cheat on their homework.

B: Well, I'd believe that of Fred, but not Amy.

Finally, let me stress both the similarities and the differences between this account of discourse deixis and the process called accommodation, earlier mentioned in Section 1.3.
Like *accommodation*, this account of discourse deixis postulates that new individuals – new entities in the discourse model – can be introduced by virtue of a referring action. These entities have the same status in the model as any introduced through the use of an indefinite noun phrase. That event tokens, event types, facts, descriptions, actions, etc. introduced this way can be individuals in their own right seems in line with the view gaining currency in formal semantics that the domain of the type *individual* has a very rich sub-structure (Bach, 1989; Link, 1983, 1985; Schubert & Pelletier, 1987).

However, one should maintain a distinction between discourse deixis and the more general process of *accommodation*, since the former is more constrained. In accommodating a definite noun phrase, the discourse context must provide the listener with a discourse entity with which *s/he* can presume to associate a unique individual that satisfies the descriptive content of the noun phrase. Understanding definite noun phrases can thus be said to require all of a listener’s world knowledge. Unlike a definite noun phrase however, a deictic pronoun has no descriptive content of its own. Thus what the discourse context must provide is a small set of entities that can be pointed to, whose propositional content is the source of new intended referents. Finding an appropriate referring function and intended referent in this case seems to be a less comprehensive task.

## 5 Conclusion

In this paper I have argued for an account of discourse deixis, based on current views of discourse structure. In particular, I argued that what provides referents for these expressions are the interpretations of discourse segments corresponding to nodes on the *right frontier* of a formal tree structure analogue. I also argued that the manner by which these expressions get their referents could be viewed as an extension of Nunberg’s use of referring functions. For natural-language understanding systems, what lies ahead now is more work on discourse-level semantics, so that (1) systems can build appropriately structure discourse models in response to a text and (2) they can identify intended demonstrata and reference functions and thereby resolve this interesting class of referring forms.
Footnotes

* This work was partially supported by ARO grant DAA29-884-9-0027, NSF grant MCS-8219116-CER and DARPA grant N00014-85K-0018 to the University of Pennsylvania. I would like to thank Mark Steedman, James Allen, Becky Passonneau, Ethel Schuster, Craige Roberts, Jerry Hobbs, Annie Zaenen, Mark Gawron, John Nerbonne, Steve Levinson, Barbara Di Eugenio, Robin Cohen, Dick Oehrle and William Marslen-Wilson for their helpful comments on earlier versions of this paper. A preliminary version was presented at the 26th Annual Meeting of the Association for Computational Linguistics, Buffalo NY, June 1988.

1. Dick Oehrle has pointed out that these instructions literally specify five tests: it is only three additional repetitions that are needed. But how much in life would get done if people insisted on following instructions literally?

2. It is not necessary to suppose that a particular sub-structure persists indefinitely. Later, in Section 2.4, I will note how long it is needed in order for the current approach to work.

3. 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.

4. 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 an 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 Kaelbling, SRI Int'l, Menlo Park CA., 1987.
References


