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DEICTIC CENTERS IN NARRATIVE:
AN INTERDISCIPLINARY
COGNITIVE-SCIENCE PROJECT

G.A. Bruder, J.F. Duchan, W.J. Rapaport,
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Department of Computer Science

TECHNICAL REPORT

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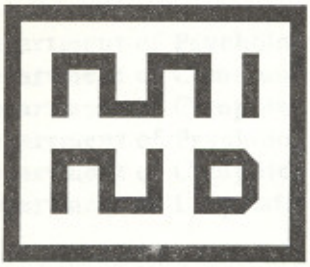

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ABSTRACT

This research program consists of a group of projects whose goals are to develop a psychologically real model of a cognitive agent's comprehension of deictic information in narrative text.

We will test the hypothesis that the construction and modification of a "deictic center"—the locus in conceptual space-time of the characters, objects, and events depicted by the sentences currently being perceived—is important for comprehension.

To test this hypothesis, we plan to develop a computer system that will "read" a narrative and answer questions concerning the agent's beliefs about the objects, relations, and events in the narrative. The final system will be psychologically real, because the details of the algorithms and the efficacy of the linguistic devices will be validated by psychological experiments on normal and abnormal comprehenders.

This project will lead to a better understanding of how people comprehend narrative text, it will advance the state of machine understanding, and it will provide insight into the nature of comprehension disorders and their potential remediation.

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PROJECT DESCRIPTION

DEICTIC CENTERS IN NARRATIVE: AN INTERDISCIPLINARY COGNITIVE-SCIENCE PROJECT

1. OVERVIEW OF THE PROJECT.

1.1. OBJECTIVES.

The goal of our project is to develop a partial model of a cognitive agent's comprehension of narrative text.[1] Our model will be tested on a computer system that will represent the agent's beliefs about the objects, relations, and events in narrative as a function of the form and content of the successive sentences encountered. In particular, we shall concentrate on the role of spatial, temporal, and focal-character information for the cognitive agent's comprehension.

We propose to test the hypothesis that the construction and modification of a *deictic center* (cf. Fillmore, 1975; Traugott, 1978) is important for comprehension of narrative. We see the deictic center as the locus in conceptual space-time of the objects and events depicted or described by the sentences currently being perceived. At any point in the narrative, the cognitive agent's attention is focused on particular characters (and other objects) standing in particular spatial and temporal relations to each other. Moreover, the agent "looks" at the narrative from the perspective of a particular character, spatial location, or temporal location. Thus, the deictic center consists of a WHERE-point, a WHEN-point, and a WHO-point.[2] In addition, reference to characters' beliefs, personalities, etc., is also constrained by the deictic center. We propose that the deictic center is an appropriate and useful data structure for representing and integrating this information and is thus a useful construct for studying how local sentence interpretation is integrated into more global comprehension of narrative text.

We plan to develop a computer system that will "read" a narrative and answer questions about the deictic information in the text. To achieve this goal, we intend to carry out a group of projects that will allow us to discover the linguistic devices in narrative texts that affect the deictic center, test their psychological reality for normal and abnormal comprehenders, and analyze psychological mechanisms that underlie them. Once we have the results of these individual projects, we will integrate them and work to build a unified theory and representational system that incorporates the significant findings. Finally, we will test the system for coherence and accuracy in modeling a human reader, and modify it as necessary.

1.2. SIGNIFICANCE.

This project will lead to a better understanding of how people comprehend narrative text, it will advance the state of machine understanding, and it will provide insight into the nature of comprehension disorders and their potential remediation. Results of these studies will add to our body of knowledge in Cognitive Science.

- Drawing from linguistics research, we will develop a cognitive model of the deictic center that integrates the study of diverse grammatical phenomena that have previously been viewed as unrelated (e.g., zero-anaphora, aspect, and topicalization). This unifying model will also lead to the discovery of additional deictic devices.
- Text comprehension depends in part on an interpretation of individual sentences. Psychological research suggests that for humans local interpretation of sentences within text depends on

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[1] We intend 'cognitive agent' to include both normal and language impaired humans, as well as non-human or artificial agents. The agent might be a reader or a listener of the narrative.

[2] The WHO-point is characteristically a human (thus 'who', not 'what'); however, it is possible for an animal, or even an inanimate object, to be the major WHO of a narrative.

context of various sorts. We intend to show that contextual knowledge obtained while reading narrative includes spatial, temporal, and focal-character information. We propose that people use the deictic center to integrate local and global contextual information as they process narrative.

- We anticipate that the deictic center model will allow us to understand comprehension disorders and will suggest approaches for diagnosing and remediating problems in this area.
- Finally, based on this work, we intend to implement and modify a computer system that will use the concept of a deictic center as a data structure in the interpretation of narrative text.

By focusing on a single issue, our project integrates the contributions of researchers trained in various disciplines, thus advancing an integrative discipline of Cognitive Science.

1.3. GENERAL METHODOLOGY.

In earlier work by members of our group, a semantic network processing system (SNePS; Shapiro, 1979) has been used as a belief-representation system (Maida and Shapiro, 1982; Rapaport and Shapiro, 1984; Rapaport, 1984; Shapiro and Rapaport, 1985). When used in this way, the system models the mind of a cognitive agent—"Cassie" (*C*ognitive *A*gent of the *S*NePS *S*ystem, an *I*ntelligent *E*ntity)—who has beliefs about various objects. We plan to extend Cassie to model an agent understanding a narrative text. Cassie will thus need to be able to represent and reason about such things as spatial and temporal relations among objects and events, identification of the focal character, and the relations between characters' beliefs and the narrative's reality. The system will operate as follows:

(1) Initially, Cassie will be provided with beliefs about the representation and functioning of spatial and temporal information (together with whatever background "world knowledge" is needed for the specific text being read). The spatial and temporal knowledge will be developed by the several components of the project (Sects. 2.1-2.4).

(2) Cassie reads and interprets the first sentence of the narrative. The sentence will be parsed by an ATN grammar (Woods, 1970; Shapiro, 1982) that will build a SNePS semantic-network representation. This representation will be determined by the sentence along with Cassie's initial knowledge. The representation will include a deictic center data structure containing the current WHERE-, WHEN-, and WHO-points (with default values if necessary).

(3) Cassie continues to read and interpret the succeeding sentences of the narrative. Each succeeding sentence's representation will be determined by:

   (a) the sentence
   (b) Cassie's current state of mind, including:
      (i) her initial knowledge
      (ii) the representations built as a result of processing the previous sentences
      (iii) the current deictic center

   As a result, Cassie's state of mind will change; in particular, the deictic center may be updated. Independent deictic centers will be created if the narrative does not proceed linearly. For instance, two deictic centers might be needed if the story switches back and forth between two scenes.

There are some general principles about the behavior of the deictic center that we expect will be borne out by our research:

— Typically, Cassie will update the deictic center on the basis of linguistic or other cues indicating that it should be changed or maintained.

— The deictic center can be thought of as a "window" on a currently active fragment of Cassie's memory. This window is "moved along" by changes in the WHERE-, WHEN-, and WHO-points. Thus, we shall have a notion of *activation*: parts of Cassie's memory outside the scope of the active window should be less accessible, but can be activated if needed for interpretation.

— The WHO-point often may be identified as the character whose beliefs and actions Cassie is currently following, and the WHERE- and WHEN-points can be identified in terms of the WHO.[3] But, on other occasions, Cassie might be able to determine the WHO-point by consulting the other components of the deictic center. For instance, if the focal character moves, often so will the WHERE and WHEN. Conversely, if WHERE and WHEN move, the focal character can be assumed to have moved along with them, unless there are explicit cues to the contrary in the text.

The precise sequence of interpretation, the nature of the linguistic devices, and the details of how the deictic center is used in understanding the narrative will be supplied by the linguistic, psychological, and language-disorders investigations. The details of the representation and processing of this information is the task of the AI investigators. Once the proposed mechanisms are tested by human and machine cognition, they will be refined, and naturally occurring text will be surveyed to see whether the new formulations are consistent with natural phenomena.

Since the concept of deictic center is quite new, we do not have a great amount of information as to which devices are available to communicate deictic movement and which ones are actually used to do so. The specification of such linguistic devices requires a linguistic analysis of text. We plan to study narrative text to find locations where the deictic center advances and moves. By considering different potential wordings, we shall generate hypotheses as to which devices are controlling this movement.

Once potential devices have been specified, we need to determine whether people actually use them. This will involve careful psychological experimentation to determine to what extent manipulation of these devices affects comprehension of the narrative in general and of deictic information in particular.

We must incorporate the devices identified by the linguistic analysis and validated by psychological experimentation into our computer model. We have reason to believe that a major stumbling block in natural-language understanding programs is that they have not generally controlled the dynamics of linguistic expression. Terms that refer to objects and events are affected by the local context (e.g., definite descriptions and pronouns). We believe that a major component of that local context is the deictic center. Cassie will interpret text, in part, as a function of how the sentences relate to the deictic center. A semantic network constrained in such a way should be able to represent the meanings in the text more accurately than one not so constrained. Since the point of such a program is to retrieve the same information that a human reader does, psychological investigation of the representation of deictic information will be particularly useful in building the semantic network.

As is evident in the previous discussion, one way to test our model is by the extent to which it comprehends narrative the way normal humans do. Another way that a theory can be tested is by finding out whether the structures that have been identified break down in a systematic way (Obler and Menn, 1982). Suppose we can find subjects who show systemic errors relating to such movement. The extent to which Cassie's behavior can be made to exhibit such cognitive disorders (rather than more normal behavior) will be an indication of the success of our interpretation.

The linguistic, artificial intelligence, and normal and abnormal psychological components of the research program will continually cross-fertilize one another. Proposed devices from the linguistic analysis will be used as input to the knowledge structure upon which Cassie depends and to design experiments to test whether they are being used to understand narrative. Simplified texts will be constructed and Cassie's understanding of them will be tested.

In this way, our project is truly a Cognitive Science project: each team of investigators will depend on the data and theories developed by the others. Moreover, the final system will be

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[3] The focal character should not be confused with the protagonist of the narrative as a whole or with the narrator's or audience's point of view (which for us is an informal notion that we are formalizing as part of the deictic center).

"psychologically real", because the details of the algorithms will be supplied by linguistic and psychological investigations with normal and abnormal human processing of narratives.

1.4. RELATED WORK.

The study of mechanisms, structures, and processes involved in comprehension of text have involved the talents of computer scientists, linguists, neuroscientists, philosophers, psychologists, and researchers in language pathology to a greater and greater degree over the last quarter century (Quine, 1960; Chomsky, 1965; Lenneberg, 1967; Minsky, 1968; Bobrow & Collins, 1975; Gunderson, 1975; Halle, Bresnan & Miller, 1978; Joshi, Webber & Sag, 1981; Norman, 1981; Maida & Shapiro, 1982; Obler and Menn, 1982; Barwise & Perry, 1983; Johnson-Laird, 1983; Greenspan and Segal, 1984).

One of the more important distinctions that seems to have emerged is whether or not the researcher considers text comprehension to involve *constructive* processes over and above the interpretation of the expressed text (Bransford, Barclay, and Franks, 1972). That is, does the researcher focus on those aspects of comprehension that depend strictly on the rules of the language (an interpretive or "closed" system)? Or does the researcher go beyond the text and consider how the comprehender brings general knowledge, knowledge of the context, or inferencing to bear on comprehension (a constructive or "open" system)?

With very few exceptions (Wittgenstein, 1953; Bartlett, 1932), most studies prior to 1970 assumed that words and sentences had a language-determined meaning and that comprehension was a representation of, or a response to, that meaning. This research style continues into the 1980's as researchers work at discovering the processes, rules, or structures by which sentence strings map onto their interpretations (Bresnan, 1978; Kintsch and VanDijk, 1978; Gazdar, 1979; Maida and Shapiro, 1982).

The strictly interpretive approach is sometimes sufficient. Problems of reference and of the identity of the agents and recipients of actions can be resolved by the linguistic relations among the words in the text. But not always. For example:

(1a) John and Mary saw each other in the restaurant.
(1b) He crossed the room to give her a check.

Following sentence (1a), sentence (1b) has no ambiguity with regard to the referent of 'he'. But the context of sentence (2a) does not disambiguate the pronoun 'he' in (2b).

(2a) John and Tom saw each other in the restaurant.
(2b) He crossed the room to give him a check.

In order to resolve this type of ambiguity, researchers have studied inferencing as an additional mechanism used by the comprehender (Haviland and Clark, 1974). For example, if an additional context sentence occurs before (2a) and (2b), such as 'John went to the restaurant to pay back a loan', John becomes the more likely interpretation of 'He'. Inferencing extends the capability of the comprehender somewhat, but still leaves some problems unresolved. What if no such disambiguating sentence is present in the text?

Knowledge about the topic or domain of the text can facilitate comprehension. Psychologists have shown that subjects comprehend certain text material better when the context domain from which the text is derived is presented prior to the presentation of the text (Dooling and Lachman, 1971; Bransford and Johnson, 1972). There are situations where linguistic strings cannot be fully interpreted independent of their context. Thus, comprehension of text requires the use of knowledge and information that neither occur in, nor are directly implied by, the text itself.

Various macrostructures have been proposed to account for the influence of domain knowledge, including such theoretical concepts as frames (Minsky, 1975), scripts and MOPs (Schank and Abelson, 1977; Schank, 1982), and story grammars (Rumelhart, 1975; Mandler and Johnson, 1977). For example, researchers have linked story grammars with comprehension and memory of text (Thorndyke, 1977). In our example with sentences (2a) and (2b), we can appeal to the notion of scripts to supply

information to disambiguate 'He'. If we are told in a previous sentence that 'Tom was a waiter in the restaurant', we can apply a restaurant script that would indicate that the waiter usually gives a customer a check, and conclude that Tom is the 'He' in sentence (2b).

To date, neither story grammars nor scripts have dealt in detail with the dynamic interplay of contextual and sentential cues as a comprehender progresses through the narrative. For example, how does a comprehender determine from the text which events end with an episode, which characters are involved or evoked in an episode, and where the characters are located in relation to one another? Researchers have begun to take a dynamic approach in studying how context related constructive processes work. For instance, the work of Polanyi and Scha (1984) is concerned with the overall structure of discourse and narrative—the cues that signal shifts in topic or episode, as is the work of Grosz (1981) and Kamp (1984).

If we change our example as follows:

(2a) John and Tom saw each other in the restaurant.
(2c) After John waved at Tom, he crossed the room to give him a check.

the anaphoric referent of 'he' remains somewhat ambiguous. But deictic verbs as dynamic signals of the deictic center can disambiguate the sentence. We can disambiguate (2c) in favor of John as 'he' by changing the verb as follows:

(2d) After John waved at Tom, he went across the room to give him a check.

In this example, John is in the deictic center and a shift in location out of the center would be signaled by using 'went'. Likewise, we can slant the interpretation of 'he' toward "Tom" by using the verb 'came':

(2e) After John waved at Tom, he came across the room to give him a check.

Movement of a character into the currently established deictic center (in this case, where John is) takes the verb 'came'.

We intend to specify in detail what deictic-center devices provide contextual cues allowing the comprehender to relate the information given in each successive sentence to the narrative as a whole. This is one task of the deictic center. That is, information conveyed by sentences is related to the overall gist of the narrative by construction and dynamic modification of successive deictic centers that identify and locate characters in narrative time and space.

2. SPECIFIC METHODOLOGIES.

2.1. COMPUTATIONAL MODELS OF DEIXIS.

This part of the project involves the design of a logically and psychologically adequate computer system (Cassie) for representing and reasoning about the spatial and temporal information and cognitive attitudes (beliefs, knowledge, and expectations) of intelligent agents. The belief representation component is the focus of a complementary, on-going research project by one of the PIs (Rapaport, NSF Grant #IST-8504713, "Logical Foundations for Belief Representation") and will be available for application to, and testing by, the present project. The initial stage of the temporal deixis component is nearly completed (Almeida, in progress; Almeida and Shapiro, 1983); during the first year of the present project, the time and belief representation systems (both of which are implemented in SNePS) will be merged. The spatial deixis project is just getting underway. These projects are described separately, below.

2.1.1. Belief-Representation and the WHO-Point. The system's data base will contain information about the world, the text, and such cognitive agents as the narrator and characters. It will also be able to contain information about the narrator's and characters' beliefs and be able to reason about them. E.g., in the film, *Desperately Seeking Susan*, two characters talk about Susan; unknown to them, but known to the audience, each is talking about a different person (only one of whom is really Susan), yet each believes that they are talking about the same person. In order for Cassie, say, to

understand such a situation, she must be able to represent who Susan really is (i.e., the narrator's Susan) as well as the beliefs of these characters about Susan. Such a data base constitutes the *beliefs of the system* about these agents and about their beliefs.

Since each of the agents is in fact such a system itself, each has beliefs about the beliefs of (some of) the others. Our system is able to represent (i.e., have beliefs about) beliefs about beliefs and to reason about these. Such beliefs are referred to as *nested* beliefs.

The system is also sensitive to the *intensionality of belief* and to the associated phenomenon of *referential opacity*. First, the intensionality of belief puts constraints on the system's inference mechanism. For instance, given the system's beliefs that an agent, *A*, believes some proposition *p* and that *p* is logically equivalent to another proposition *q*, the system should not automatically infer that *A* believes *q*, in the absence of further information. On the other hand, in ordinary circumstances, people often do draw such inferences. Insofar as Cassie is to be a model of a (human) cognitive agent, she would also need to be able to draw such inferences, yet be able to *correct* or *revise* her beliefs in the light of further information.

Second, an agent can have inconsistent beliefs about an object. For instance, *A* might believe both that the Evening Star is a planet and that the Morning Star is not a planet, even though the Morning Star *is* the Evening Star. This can happen as long as *A* does not believe that the Morning Star is the Evening Star. In this case, *A*'s "data base" contains *two* items, one for the Morning Star, one for the Evening Star. Such items are *intensional objects*, and the system is able to deal with them.

Third—and of special relevance to the concept of a deictic center—the system is sensitive to the *indexicality* of certain beliefs, in particular, to the phenomenon of *quasi-indexicality* (Castañeda, 1966, 1967). This feature is at the core of *self-referential* beliefs—i.e., beliefs about oneself—and their expression by others. Thus, the belief that *A* would express by "I am rich" must be reported by someone else thus: "*A* believes that *he** is rich"; it clearly should not be reported as "*A* believes that *I* am rich". The starred occurrence of 'he' is called a "quasi-indicator".

Quasi-indexicality is a feature that pervades all deictic phenomena (cf. Brecht, 1974). Suppose that Cassie believes that character *X* performs action *A* at the deictic center's here and now. Cassie's representation of the here- and now-points are *not* demonstratives representing Cassie's actual here- and now-point. Rather, they are *quasi-indexicals* used by Cassie to depict the narrative's here and now. Our belief-representation system was developed precisely in order to be able to handle quasi-indexical self-reference. The techniques used for this will be generalized to handle these other cases of quasi-indexical reference.

Fourth, the system is able to distinguish between *de dicto* and *de re* belief reports. The former expresses or communicates the actual propositional content of the agent's belief (cf. Castañeda, 1970: 167ff); the latter reports the belief in terms known to the speaker/hearer, but not necessarily to the agent.

Finally, Cassie must be able to expand and refine her beliefs. If the system is to be considered as a cognitive agent, and especially if it is to be used as a tool in understanding *human* belief-representation mechanisms, it ought to interpret ordinary statements about belief, expressed in (grammatical) natural language, the way humans do. Thus, the system must make reasonable or plausible interpretations of sentences in the narrative—based on such things as subject matter and prior beliefs—and to modify its initial representation, i.e., to revise its beliefs, as additional narrative is processed.

Current status. The present research is an extension of work begun by Maida and Shapiro (1982), the thrust of which is to employ a thoroughgoing intensionalism: The data base of an AI system capable of reasoning about the beliefs of itself and others must be such that all items represented are intensional, there is a 1-1 correspondence between nodes and represented concepts, and distinct items that are extensionally the same are linked by a "co-referentiality" mechanism. The current fragment of the system, implemented in SNePS and running on a VAX 11/750 in the SUNY Buffalo Department of Computer Science, was presented in Rapaport and Shapiro, 1984 and Rapaport, 1984. It can parse

English sentences expressing belief reports, build SNePS semantic network representations of them, and generate English responses to queries about its "knowledge" base. In particular, the system is capable of handling *de re*, *de dicto*, and self-referential belief reports expressed using quasi-indicators (see Figs. 1-3). The representation involves the construction of separate "belief spaces" for each agent (e.g., each character) whose beliefs are under consideration. An agent's belief space in the context of a reporter of the agent's beliefs (in this case, Cassie) is the set of propositions believed by the agent, together with the set of items about which the agent has beliefs, as represented by the reporter. This technique avoids the need to use or represent "possible worlds", and is thus a fully intensional approach.

Research aims. Thus, the belief system that we have been working on already provides much of the representational tools for investigating the deictic center:

- Our analysis of *de re/de dicto* beliefs has required an investigation of knowing who. This, in turn, is required for computing the deictic center.
- Our ability to represent nested beliefs will enable Cassie to represent the narrator's beliefs and the characters' beliefs—both of which are crucial for computing the deictic center as well as understanding the narrative.
- Our analysis of quasi-indexical self-reference points the way to a proper quasi-deictic representation of the information in the deictic center.

In the present project, we shall apply this system to the specific problem of comprehension of narrative text. Modifications will be made to the SNePS User Language to enable it to handle representations and inferences within the scope of belief spaces.

Procedures are being developed for *disambiguating* users' belief reports. Currently, the system treats all sentences of the form (3) '*A* believes that F*b*' as *de dicto* and all sentences of the form (4) '*A* believes of *b* that it is F' as *de re*. But ordinary users are not normally aware of the difference and, typically, express most of their beliefs using the formulation that we have chosen to be canonically *de dicto* in all cases. Thus, the system's parsing mechanism must be able to decide how to interpret the input on the basis of its current beliefs about the narrative.

It also needs to be able *to modify its representation* in the light of further input. The system is currently able to handle one class of such modifications: By the use of equivalence arcs (Maida and Shapiro, 1982: 304ff), distinct nodes representing intensionally distinct items can be "merged" when new information indicates that an agent treats them as extensionally equivalent (cf. Rapaport and Shapiro, 1984; Rapaport, 1984, Sect. VII).

One way of handling the disambiguation problem that is currently being investigated involves the use of *heuristics*. E.g., it seems plausible that a belief report of type (3), above, should be interpreted *de re*, rather than *de dicto*, if the system believes that *A knows who b* is. Thus, the parsing of (3) would involve inferencing, using the system's belief space, to find out whether it believes that *A* knows who *b* is. The result would then determine how to disambiguate (3).

"Knowing who" is of importance for computing the deictic center—i.e., for determining the current values of the WHO-, WHEN-, and WHERE-points. In particular, Cassie must be able to determine *who* the current focal character is—the character that her attention is drawn to by the narrator. In some cases, Cassie's beliefs about the WHERE- and WHEN-points will help determine this; in others, Cassie's beliefs about who the focal character is will help determine the WHERE- and WHEN-points. The focal character is the character who is "brought along" by shifts in the deictic center: if WHERE or WHEN change, so might WHO, and vice versa. Therefore, for Cassie to know who the focal character is requires knowledge of the rest of the deictic center, among other things.

Knowing who someone is, however, is a complex philosophical problem. According to the analysis of Boër and Lycan (1976), it requires having a *purpose*: That is, one cannot determine whether Cassie, say, knows who someone is *simpliciter*. Rather, we can only determine whether Cassie knows who someone is *for some purpose*. For instance, suppose we are at a party in honor of Marvin Minsky, and I ask you who Marvin Minsky is, for the purpose of introducing myself to him. If

you tell me that he is the father of AI, you have not answered my question. But, if I ask you who Marvin Minsky is, because I have been invited to the party but don't know why he is famous, then you will not have answered my question if you tell me that he is the man in the turtleneck sweater sitting in the corner.

Unfortunately, Boër and Lycan's analysis does not spell out the details of what a purpose is nor how it should be used in determining who someone is. Our project, however, provides a clear candidate for a purpose, namely, constructing the deictic center in order to comprehend the narrative. Cassie needs to be able to determine who the focal character is for the purpose of updating the deictic center (and not, say, for the purpose of providing a literary analysis of the narrative). The investigations of the linguists and psychologists in the research group will provide data for how this purpose will be used.

2.1.2. The Temporal Deixis Project. The temporal deixis part of our research is an investigation into the many factors that operate together within a narrative to indicate the temporal relations holding between the events and situations mentioned in the text. Among these factors are tense, the progressive/non-progressive distinction, time-adverbials, world-knowledge, and aspectual class. All of these factors interact with the WHO-point to determine the temporal structure of the narrative.

In this part of the project, we use an event-based, rather than a proposition-based, approach: i.e., intervals and points of time are associated with events represented as objects in the network rather than with the propositions that describe them. The temporal model itself consists of these intervals and points of time related to one another by such relations as BEFORE/AFTER, DURING/CONTAINS, etc. For example,

> John arrived at the house. The sun was setting. He rang the bell; a minute later, Mary opened the door.

The representation of this small piece of text is shown in Figure 4. The ARG-PRED-EVENT case frame asserts that the proposition consisting of the argument pointed to by the ARG-arc and the predicate pointed to by the PRED-arc describes the event pointed to by the EVENT-arc. Notice that the predicates are classified into various types. This information plays an important role in the temporal analysis of a text.

NOW is a reference point that indicates the present moment of the narrative; it is updated as the story progresses through time (Almeida and Shapiro, 1983). NOW is our current implementation of the WHEN-point. It is implemented as a variable whose current value is indicated in Figure 4 by a dotted arrow. Subscripts are used in the figure to show the successive values of NOW.

The BEFORE-AFTER-DURATION case frame is used to indicate that the period of time pointed to by the BEFORE-arc temporally precedes the period of time pointed to by the AFTER-arc by the length of time pointed to by the DURATION-arc. These durations are usually not known precisely. The value ε stands for a very short interval. Whenever an event occurs in the narrative line, it has the effect of moving NOW an interval of ε beyond it.

The DURING-CONTAINS case frame is used to indicate that the period of time pointed to by the DURING-arc is during (or contained in) the period of time pointed to by the CONTAINS-arc. Notice that the progressive sentence, "The sun was setting", created an event that contains the then-current NOW. If the system knows about such things as sunsets, then it should infer that the event of the sun's setting also contains John's arrival, his ringing of the bell, and probably also Mary's opening of the door.

2.1.3. The Spatial Deixis Project Designing a computer program to track the spatial deictic center (the WHERE-point) in a narrative is considerably more complicated than designing one to track the temporal deictic center (the WHEN-point), because space has more dimensions than time. By this, we are not just referring to the common notion that space is three-dimensional, while time is one-dimensional. In fact, our studies are convincing us (cf. Sect. 2.2) that space is treated linguistically as two independent domains, a one-dimensional vertical domain ('high', 'low', 'deep', 'shallow', 'tall',

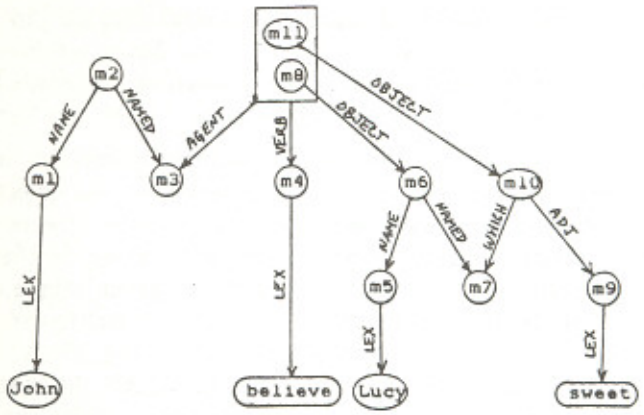


Figure 1. A SNePS network for the *de dicto* belief report
'John believes that Lucy is sweet'.

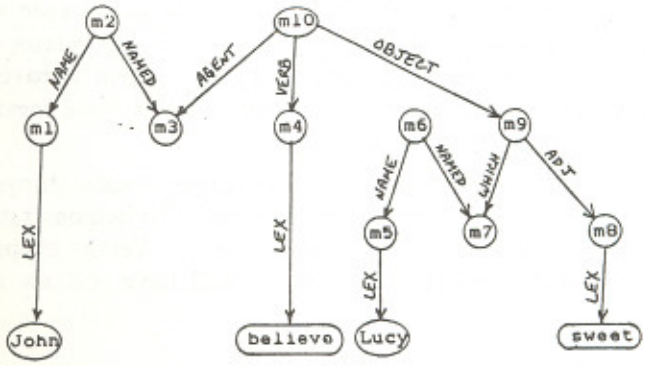


Figure 2. A SNePS network for the *de re* belief report
'John believes of Lucy that she is sweet'.

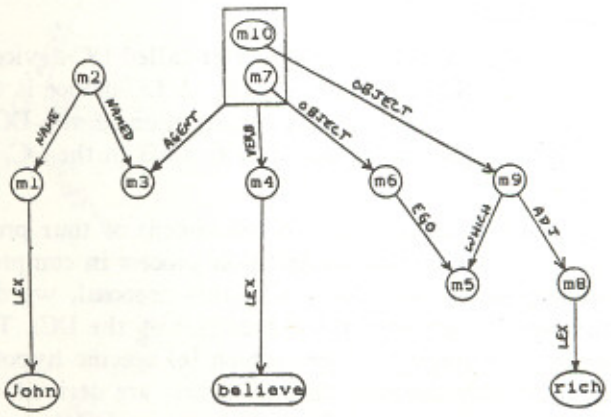


Figure 3. A SNePS network for 'John believes that he* is rich'.
(Node m5 is the system's representation of John's "self concept",
expressed by John as 'I' and by the system as 'he*').

'short', 'above', 'below', etc.), and a two dimensional horizontal domain ('in front of', 'behind', 'to the left of', 'to the right of', 'north', 'south', 'east', 'west', etc.), that never combine into a "diagonally vertical" direction. (One goes *up* a hill no matter how steep or shallow the grade.) Besides these directional terms, there are neutral extent or distance terms such as 'close', 'near', and 'far'.

Even these considerations do not exhaust the complexities of space over time. Time is treated as an objective dimension, independent of any observer or of any observed object, event, or action. Spatial directions, however, are relative both to the observer and to observed objects. For example, 'in front of the bush' means between the bush and the observer, while 'in front of the chair' means next to the chair at the side where people sit, and is independent of the observer. Some directions are fixed by the observed object regardless of its position in space. If you have a freckle three inches above your knee, it remains three inches *above* your knee, even when you are lying down. At other times, however, directions are changed by the background object or space in which the observed object is located. If Mary is seated in a theater and John is sitting in a row closer to where the performance occurs, then John is sitting in *front* of Mary, even if she is turned around talking to someone *behind* her.

The problem of deciding how to orient the spatial axes around an object so that spatial directions are defined has been called the "reference frame problem" (Zubin and Choi, 1984; Clark, 1973; Lyons, 1977; Talmy, 1975, 1978, 1983; Sondheimer, 1976, 1978a, 1978b; Sondheimer and Perry, 1975; McDermott, 1980; Pinxton et al., 1983). Before we can design a program to keep track of the movement of the WHERE-point in narratives, we must have a representation that relates various places (where the WHERE-point can be) by possible spatial directions, so that when a particular reference frame is imposed on these directions, the linguistic spatial direction terms have meaning. This representation design is the first task of the spatial deixis project.

The program will establish the reference frame in terms of such things as the WHO-point, characters and objects in the deictic center, and the background. To demonstrate understanding, the program needs to do more than simply parrot back the sentence. Yet its output should be less cumbersome than an elaborate verbal description. Instead, we will have it draw a picture of the expressed situation on a graphics monitor.

2.2. DEICTIC DEVICES IN NATURAL TEXT.

Grammatical devices that contribute to the stability and movement of the deictic center (DC) have been studied under various rubrics such as topicalization, focus, extraposition, foregrounding and backgrounding, presentatives, anaphora, tense, aspect, and spatial deixis. The study of each of these phenomena has dealt with specific isolated aspects of the structuring of narrative discourse. But there has never been a unified account of how cohesive devices are used to introduce, maintain, shift, and void the WHERE, WHEN, and WHO of the DC. Significant steps have been taken in this direction by text linguists such as Grimes (1975) and Longacre (1983), but these proposals lack the hypothesis-generating precision of our DC model.

We propose to study textual cohesive devices, hereafter called DC-devices, as they are used to signal both stability and change in the DC of narrative texts. A DC-device is thus a morphemic or syntactic structure of the text that affects the listener's construction of the DC by setting up candidate actors, places, and times for the DC, by signaling stability or shift in the DC, and by temporarily voiding some component of the DC.

The overall structure of the Linguistic Analysis component of tour project is depicted in Figure 5. Starting with (a) general properties of the construction process in comprehension and (b) the general concept of the DC discussed in the introduction to this proposal, we derive (c) a set of Deictic Center Principles that capture specific aspects of the behavior of the DC. These principles constitute very general hypotheses guiding the research, from which (e) specific hypotheses making predictions about the deployment of (d) particular cohesive devices in text are derived. The first set (e1) of such hypotheses to be tested concerns the individual effect of particular DC-devices; the second set (e2) concerns interaction effects that arise when co-occurring DC-devices either agree or conflict with each other. To the extent that tokens of particular DC-devices or combinations are difficult to find in text,

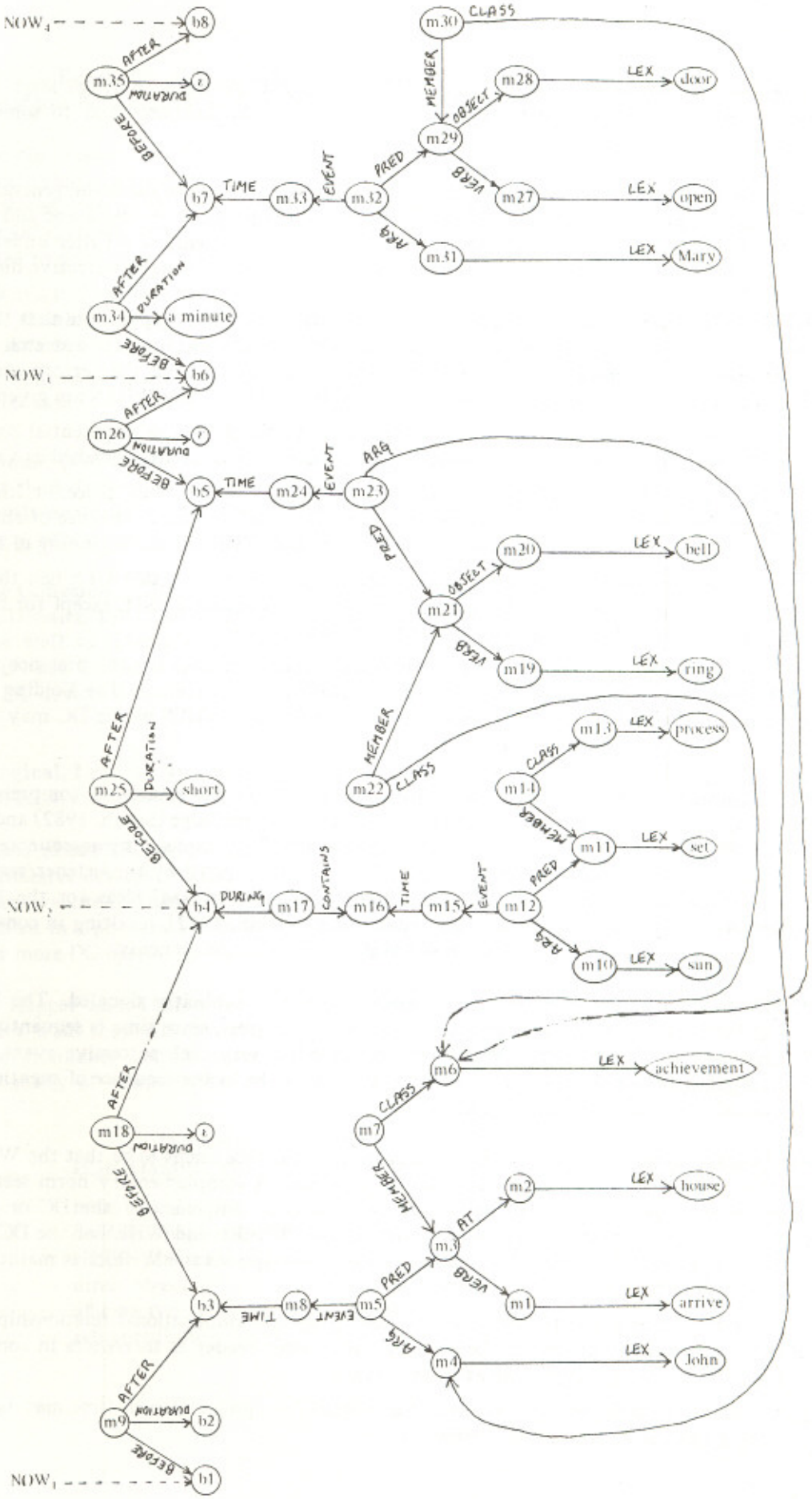


Figure 4. SNePS network for a short narrative.

(f) text-sorting programs will be used to locate and extract them from (g) large files of machine-readable narrative text, which to some extent are already available and to some extent will be developed in the project.

2.2.1. Deictic Center Principles. These are working hypotheses about the general operation of the DC in the comprehension process. A major concern of the project is to revise and add to them based on the results of specific hypothesis testing. Such revision will constitute a fuller understanding of how the DC functions, and hence a fuller understanding of the structuring of narrative discourse.

(P1) Deictic Operations. These are mental operations that we hypothesize that the listener/reader performs on the DC during the process of constructing an interpretation for a stretch of narrative text. We propose that much of the coherence of narrative text arises from the performance of these operations. Examples of each operation applied to the WHO, WHERE, and WHEN are given in Appendix 1.

(a) *Introducing* actors, places, and time intervals into the narrative as potential components (WHO, WHERE, and WHEN) of the DC. Introducing and Shifting may be accomplished as a single operation.

(b) *Shifting* the WHO, WHERE, or WHEN of the DC from one actor, place, or time to another. A new WHO is usually introduced before the DC shifts to it. A special instance of shifting is Initializing the DC, i.e., specifying the initial WHO, WHERE, and WHEN at the beginning of a narrative.

(c) *Maintaining* stability in the DC. Components remain stable either (i) when the listener expects this (cf. Inertia Principle) or (ii) when the listener might expect a shift, except for the presence of an Anti-Shifting device (cf. Scope Principle, (P5), below).

(d) *Voiding*: One or more DC components become indeterminate; i.e., the presence and identity of a WHO, WHEN, or WHERE is not relevant at that point in the narrative. The Voiding operation may be regarded as shifting to a null component; e.g., the WHO and WHEN of the DC may temporarily shift to null during a scene description.

(P2) Economy. The listener/reader constructs the DC in the process of comprehension, based not only on DC-devices in the text itself, but also on shared knowledge (Smith, 1982) and what Clark and Clark (1977) have called the "Reality" and "Cooperative" principles. In consequence of this construction process, much of what happens in the DC can be anticipated by the listener/reader, and need not be overtly encoded in a DC device. Put briefly, the text "evokes" ideas for the listener, and may remain silent when the listener can anticipate them (Slobin, 1982), resulting in considerable economy in the text. Principles (2) and (3) propose specific aspects of this economy.

(P3) Inertia. The DC remains stable unless a change is explicitly signaled. The WHO and WHEN stay the same unless they are signaled to change. In contrast, since time is sequential, the WHEN has dynamic inertia; i.e., a "stable" WHEN moves forward with each successive event in the narrative, unless a jump or stop is signaled. Events are inferred to be in the sequence of mention unless signaled to be out of sequence (Clark & Clark, 1977).

(P4) Deictic Synchronism. A norm of narrative discourse seems to be that the WHO, WHERE, and WHEN of the DC are maintained and shifted together. A complementary norm seems to be that this synchronism is periodically broken, either by voiding a component of the DC or by shifting them apart. In a text segment of character description, the WHERE and WHEN of the DC are voided while the WHO is maintained throughout, while in scene descriptions the WHERE is maintained, voiding the WHO and WHEN.

The principle of Deictic Synchronism leads to specific implicational relationships among DC components. These relationships can be used by the listener/reader as inferences in constructing the DC; i.e., they are functionally equivalent to DC-devices.

(a) Time sequencing entails a WHO and a WHERE; i.e., progression in time may be stopped by voiding either the WHO or the WHERE.

(b) A shift in WHERE entails either a shift in WHEN or in WHO (both can occur); i.e., if the WHERE shifts to a new place, time is updated or the WHO shifts to another actor.

(P5) Scope. Closely related to (P4). (a) Individual DC-devices have a specific scope, i.e. a "mental space" (Fauconnier, 1985), corresponding to to a chunk of text, within which the parameters they set are valid. Some scopes, such as the scope of initial adverbials, are broad, i.e. valid until they are cancelled by another DC-device signaling a shift. Other scopes, e.g., the scope of Anti-Shifting devices, are narrow, i.e., limited to one clause or phrase.

(b) Scope Conflict: Narrow scope supersedes broad scope. In the following example, the definite subject NP 'Juana' should shift the DC, but there is no shift, since this device occurs within the narrow scope of a complement clause (an Anti-Shifting device):

> Kino stood perfectly still. He could hear Juana whispering the old magic again, and he could hear the evil music of the enemy.

(P6) Extraposition. (a) DC-devices will be located at the beginning or end of clause/sentence units to the extent that these dislocations are permitted by the grammar of the particular language. (b) Initial DC-devices will establish the DC for the next sentences; final DC-devices will signal a pending shift in the DC (e.g., relative clauses).

(P7) Cumulative Cohesion. Cohesive devices in text tend to be redundant (Halliday & Hasan, 1976; de Beaugrande & Dressler, 1981; Zubin, 1977, 1980). In a narrative, there will be intervals of certainty about the DC, as well as intervals of uncertainty during which it is unclear whether the WHO, WHERE, or WHEN has shifted. Agreement of several DC-devices will clearly shift or maintain the DC. Absence of DC-devices or conflict among them will correspond to intervals of uncertainty in the text.

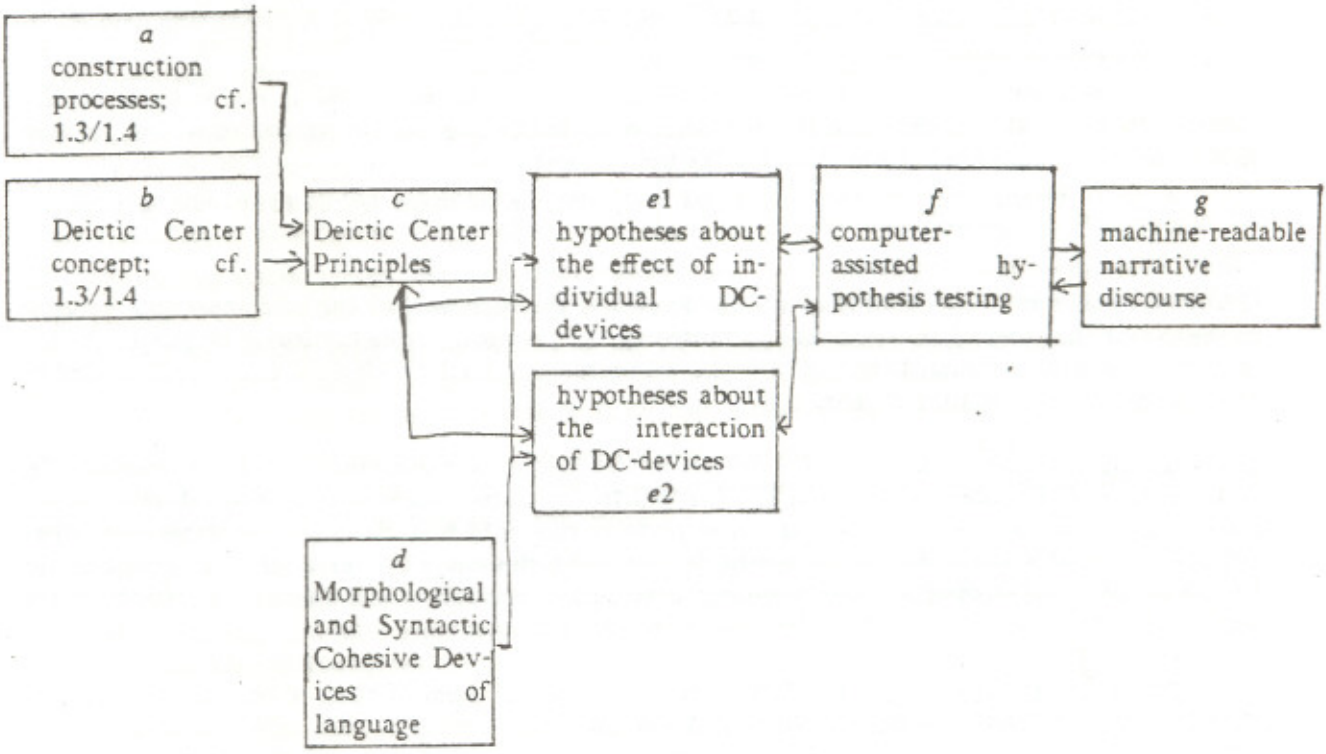
2.2.2. Morphological, Lexical, and Syntactic DC-devices. Some of those to be tested are given in the Sections 2.2.3.-2.2.4; an extensive list is in Appendix 1.

2.2.3. Hypotheses about DC-devices. The following is a summary of specific hypotheses about how individual cohesive devices introduce, maintain, shift, and void the WHO, WHERE, and WHEN of the DC. An extensive list of these hypotheses, together with illustrative examples from Steinbeck's *The Pearl*, is located in Appendix 1. These hypotheses take the form: Device D is significantly correlated with one or more DC-operations affecting the WHO, WHERE, or WHEN of the DC.

Transitivity. Hopper and Thompson (1980) describe a number of morphological and syntactic features that affect what they call the "transitivity" of the clause, and show how these features affect the discourse foregrounding and backgrounding of the information conveyed by the clause. We hypothesize that many of these devices, individually and conjointly, serve to either maintain or to void the DC:

Devices in English that contribute to:	
High Transitivity	Low Transitivity
main clause	dependent clause
definite, anaphoric object	indefinite object
simple past tense	progressive or perfect tense
direct object	no direct object
affirmative	negative
telic predicate	atelic predicate

Figure 5. Relation of Theory to Hypotheses, Methodology, and Database.
Arrows indicate relations among particular theoretical constructs and research activities. Reverse arrows indicate how principles, hypotheses and methodology will be revised in light of results.



Conjoined Clauses. Conjoined clauses signal that the DC remains stable within the conjunct (Fillmore, 1975). This reflects the frequent observation that the members of a conjunct are somehow conceptually bound closely together. Clause conjoining is often combined with other maintenance devices such as zero-anaphora.

Complement and Relative Clauses. Complement and relative clauses are Anti-Shifting devices. They permit reference to another actor, time, or place within their scope, while preventing the DC from shifting there. At the end of the clause, the scope of the device is cancelled, and the narrative automatically continues at the unshifted DC. Complement-taking predicates that are hypothesized to fulfill this function include perception predicates (*see, hear, feel,* etc.), cognition predicates (*know, understand, think,* etc.), speech predicates (*say, mean,* etc.) and causatives (*make, let, have,* etc.).

Initial Adverbial Clauses. Initial adverbial clauses shift the WHERE and WHEN. Brown and Yule (1983) suggest that initial adverbials may in general be a marker of "topic shift". In Fauconnier's (1985) terms, initial adverbials would mark a shift to a new "mental space" that the listener is constructing in the comprehension process, an idea implicit in Geis's (1985) study of initial and non-initial spatial and temporal adverbials. He finds that initial placement of a spatial adverbial sets up a spatial frame within which the event occurs, whereas non-initial placement does not. E.g., (a), below, places John in Chicago in the narrative context, while (b) does not:

(a) In Chicago John knew about some good Chinese restaurants.
(b) John knew about some good Chinese restaurants in Chicago.

We suggest that the DC is a type of mental space in Fauconnier's sense, which is crucial to the construction of narrative discourse. Specifically, we hypothesize that initial spatial and temporal adverbials will shift these aspects of the DC.

Additional hypotheses about the specific effect of devices on individual components of the DC are given in Appendix 1.

2.2.4. Hypotheses about Agreement and Conflict among DC-Devices. We hypothesize that when devices agree with each other, this increases the certainty of a Maintenance or Shift in the DC. When devices of like scope disagree, this will decrease the certainty of a Maintenance or Shift; i.e., the listener/reader will be in momentary uncertainty about the WHO, WHEN, or WHERE of the DC. Note that this is distinct from a Voided DC, in which case the listener/reader is certain that there is temporarily no WHO, WHEN, or WHERE. (See Appendix 2 for examples.) These hypotheses take the forms:

(a) Certainty about the identity of the WHO, WHERE, or WHEN of the DC during an interval in the narrative is proportional to the number of DC-devices that agree about the identity of this component of the DC.

(b) Uncertainty about the identity of the WHO, WHERE, or WHEN of the DC during an Interval in the narrative is proportional to the number of DC-devices of like scope that conflict concerning the identity of this component of the DC.

2.2.5. Method of Research. Steps (e-g) in Figure 5 involve the testing and revision of hypotheses concerning the effect of specific DC-devices, and their combinations, on the DC. In the linguistic portion of this project, these hypotheses will be tested with a text-based distributional methodology that has been pioneered by Zubin (1975, 1979), Reid (1977), Kirsner (1979), Li and Thompson (1979), Givon (1983), and others. Extensive samples of narrative text will be searched for instances of a particular cohesive device, or for the co-occurrence of particular cohesive devices. Contextual variables will then be used to test the hypothesized effect of the cohesive device. E.g., the presence of locative adverbials will be used as evidence that the WHERE of the DC has shifted.

Computer-Supported Methodology.

(1) Use of ZyIndex to sort text for infrequently occurring DC-devices and their combinations. ZyIndex Professional is a commercial software package produced by ZyLab Corporation, and used mainly by law offices for keyword content searches of large text databases. The following features make it ideal for the proposed research: (a) search up to 5000 datafiles of up to 400 book-pages of text each in one operation; (b) mark and save targeted DC-structures with context in a separate file during the search operation; (c) use of Boolean connectors OR, AND, and NOT; bracketing; and "wild card" characters in constructing search strings (for varying inflectional/derivational forms of a lexical item); (d) use of discontinuous variables in the search string (e.g. come + . . . + toward).

(2) Use of the Brown University Corpus of English as a database for initial testing of hypotheses. This corpus is presently available in machine-readable form in the SUNY Buffalo Department of Computer Science.

(3) Use of the Kurzweil Reading Machine, interfaced with an Apple IIe microcomputer, to produce machine-readable narrative text from published and from typewritten sources. A Kurzweil series 300 machine is currently available for such use in Lockwood Library at SUNY Buffalo. Pilot testing indicates that it can produce accurate machine-readable reproduction of printed text after editing with a dictionary program.

(4) Use of the Variable Rule Programs (Sankoff, 1976) to test for the statistical significance of the effect of individual DC-devices and their combinations. These programs are particularly suitable for post-hoc testing, since they allow for the revision of hypotheses through the elimination of non- significant variables.

2.3. HUMAN COMPREHENSION AND REPRESENTATION OF DEIXIS.

2.3.1. Specific Background and Specific Aims. This research aims to determine to what extent particular DC-devices (cf. Sect. 2.2) influence the normal reader of narrative. These devices include verb aspect, temporal and locative, preposed adverbials, and verbs, such as *come* and *go*, that have been classified as deictic in speech and presumably play a similar role in narrative. Three steps, using three different methodologies, will be taken to investigate the influence of deictic devices in reader's processing of narrative:

The first step is to establish the psychological reality of the particular linguistic devices that have been selected. As Slobin (1979) asserts, one of the goals of research is to find performance evidence for the existence of proposed structures. One way to test the validity of these deictic devices is to assess the accuracy of information a reader has about the deictic center at various points in a narrative, as a function of these linguistic devices.

Once the psychological reality of particular linguistic devices is established, the effect of these devices on the ongoing comprehension processes of the reader of narrative can be explored. Numerous studies have followed Haviland and Clark's (1974) lead in using sentence reading time to test hypotheses about sentence comprehension. Especially relevant is the recent work of Lorch, Lorch, and Mathews (1985) investigating on-line "macroprocessing". They found that reading times for topic sentences reflected the relationship of the sentence to the topic structure of the text. Similarly, sentence reading times should be sensitive to the deictic structure of narrative. The second step uses an on-line reading time task to assess the influence of deictic linguistic devices on the comprehension processes during "normal" reading of narrative.

After reading a narrative, readers have information about the story. The third step involves determining the representation of deictic information in memory following reading of a narrative. The technique used to explore that representation is to measure the facilitation or "priming" of sentence processing. Priming is taken as evidence that prime and target stimuli are connected in the memory representation. The degree of priming is assumed to reflect the closeness or degree of strength of this connection.

Recent research has extended the priming technique to explore representation in episodic memory. Ratcliff and McKoon (1978) found evidence for the propositional representation of sentence information in episodic memory by showing more priming of words that occurred within propositions than across propositions within sentences. Further, McKoon and Ratcliff have used priming to verify what the structural representation of propositions is based, in part, on overlap in arguments (1980a) and that the referent of an anaphor is connected in memory to other concepts that occurred within the same proposition as the anaphor (1980b). Post, Bruder, Greene and Voss (1982) used priming in a sentence recognition task to explore differences in the representations of text of experts versus novices.

Methods:

Step 1. Psychological validity of DC-devices: Sample experiment. In this experiment, specific hypotheses about the spatial WHERE-point in the narrative will be tested. In addition, some preliminary information about the WHEN- and the WHO-points in the narrative will be gathered.

Hypotheses. The hypotheses are: (1) Subjects will be less accurate or certain about the spatial locus of events or characters when *came* and *went* are interchanged in sentences. (2) Subjects will be less accurate or certain if preposed spatial adverbials present in the text are removed or moved to another position. (3) Since it is assumed that adverbials are not required to indicate the current deictic center when it remains the same, subjects will *not* be more accurate or certain if adverbials are introduced into the text.

Subjects. The subjects will be 120 student volunteers from introductory psychology classes who participate for course credit

Materials and Task. The experiment will use the first part of Steinbeck's *The Pearl.* The text was selected after careful linguistic analysis indicated the frequent occurrence of the spatial deictic indicators described above. The story will be divided into approximately thirty segments of varying length.

After each segment, several statements about the story will be presented. Subjects will be asked to judge the accuracy of these statements. A six-point scale will be used to assess certainty on the part of the subject about the truth of these test sentences. The response choices will range from definitely true to definitely false. The following manipulation of specific spatial DC-devices will be used to test the hypotheses described above: interchange of *came* and *went* in sentences, movement of spatial adverbials, and removal or addition of spatial adverbials. Thirty key sentences from the original text will be subjected to these modifications. The key sentences selected will conform to the assumptions about indicators of spatial deixis (e.g., that sentences with preposed adverbials occur at a change in deictic center). Different versions of the narrative will be used with different subjects in order to compare responses to the same questions under the various conditions described above. For example, with regard to adverbials, for each of these key sentences there will be one variation with a preposed adverbial, one variation with that adverbial in a non-initial position (i.e., postposed) and one with no adverbial. See Table 1 (in Appendix 2) for examples of key sentences within a segment of text and the questions that follow.

Planned Analysis of Results. Responses to statements on the six-point scale will be subjected to analyses of variance. Separate analyses will be performed on the deictic verbs and the adverbials. Comparisons will be made for accuracy and certainty between conditions when deictic information is provided in the appropriate way (as defined by the sentence variation provided in the original text) and when it is changed. Accuracy will be scored dichotomously (e.g., by giving credit for any of three responses within the true category for true sentences). The truth of a statement will be determined by consensus among judges reading the original version of the sentence. Certainty will be scored by scaling responses from 1 to 6 relative to the end of the scale that is accurate. E.g., "definitely true" would receive a 6 for true statements and a 1 for false statements.

Step 2. On-line comprehension of deictic information: Sample experiment. This experiment will look at the influence of specific linguistic devices (validated in Step 1 experiments) on the comprehension of sentences embedded in narrative.

Hypotheses. In this experiment, it is assumed that, since the deictic center changes in the story and must be computed either during reading the target sentence or soon after, appropriate and explicit indication of that change should facilitate comprehension. Reading time is used as an indicator of comprehension difficulty. The hypotheses are: (1) Reading time will be slower for the versions of target or subsequent sentences when *came* and *went* have been interchanged, compared to the original form. (2) Reading time for the target or subsequent sentence will be slower when a shift in deictic center occurs and the preposed adverbial is moved or removed from the original version. The effect of removal should be more evident in the sentence immediately following the target sentence. (3) Reading time will be slower with preposed adverbials when no change in deixis occurs (no adverbial or a postposed adverbial in the original form).

Subjects. Subjects will be paid volunteers from psychology classes.

Materials and Task. The different versions of the text as described in Step 1 will be used. The set of sentences will be broken into 7 sets of approximately equal length. In order to ensure careful reading, test statements about the story will be presented after each set. A practice narrative (including test statements) will be used prior to the presentation of the test text.

The task will be a sentence-by-sentence (self-paced) presentation task. Subjects will view one sentence at a time on a computer monitor screen and signal when they are ready for the next sentence by pressing the space bar. Sentence reading times are obtained by measuring the time between space bar presses.

Separate estimates of reading times for the 30 test sentences will be obtained outside the narrative context from a separate set of subjects in order to assess complexity differences among the various versions of test sentences. In this situation, names of characters will be changed, and sentences will be presented in a random order among filler sentences in order to prevent the detection of a story line.

Planned Analysis of Results. Correlations between sentence length (in words) and reading time for each subject will be used to reduce the contribution of sentence length to the variability of reading times. Preliminary data indicates that these correlations are substantial (most in the .80 to .90 range). A regression equation will be used to obtain a difference score (actual-predicted reading time) for each target and immediately following sentence for each subject. Separate analyses will be performed for the deictic verb and the adverbial conditions. Both target and subsequent sentences will be included in the analyses.

Although it is possible that sentence reading times will not be sensitive to subtle changes in the comprehension process (Just & Carpenter, 1980), preliminary results in a pilot study for Step 2 experiments suggest manipulation of preposed adverbials produces detectable effects many simultaneously occurring complex processes, not all increases in "deictic" processing may be evident in total sentence reading time. Where the sentence reading time appears insensitive to hypothesized DC-devices, a word-by-word reading time measure will be tried.

Step 3. Representation of deictic information: Sample experiment. The priming paradigm will be employed with two types of materials, constructed paragraphs and paragraphs selected from *The Pearl.* The intent is to determine whether clauses in the narrative that describe events within the same deictic center (i.e., shared WHERE and WHEN) prime each other more than those with differences in deictic center. Some clauses will share the same character referent (WHO) while some will not. Physical distance and overlap of words will be carefully controlled in assessing the influence of deictic overlap on priming.

Hypotheses. The hypotheses are: (1) Priming will be greater between statements that describe events with the same deictic center than those with different centers. (2) The degree of priming will reflect the number of intervening deictic shifts between events.

Subjects. Subjects will be 120 paid volunteers from psychology classes. All subjects will receive both sets of materials with order balanced.

Materials and Task. Thirty sets of about 10 sentences will be used for the constructed and natural materials. Each set will describe an episode involving several characters, times, and locations. See Table 2 in Appendix 2 for an example of constructed materials. There will be about 10 test sentences for each of the sets for both types of materials. Half to two-thirds of the test sentences will be "true". In the text, prime and target (primed) sentences will have 0, 1, or 2 intervening deictic shifts between them.

For the constructed materials, the order of presentation of the sentences will be varied to manipulate the relationship between prime and target sentences. Both the prime and target sentences will be the same across conditions. Other sentences between them will be changed to create deictic shifts. For the natural materials, prime sentences will vary across conditions in order to manipulate deictic distance. For half the prime-target sentence pairs a common character will be shared; for the other half, the character (WHO) differs.

The subjects will read the series of sentences, one at a time, and then receive the test sentences for that set, one at a time. Subjects will answer as quickly as possible whether the test sentence is true or not. All sentences will be presented, and all response times will be recorded by microcomputer.

Planned Analysis of Results. Analyses of variance will be performed on the reaction times to correctly selected "true" test sentences. Separate analyses will be performed on the constructed and "natural" materials. The design used is a 2 x 3 factorial with three levels of deictic distance and two (shared or not) levels related to the WHO in the prime and target sentences.

2.4. DEIXIS AND INDIVIDUAL DIFFERENCES.

This part of the project rests on the thesis that the spatial competencies needed to comprehend spatial deixis in narrative are related to the competencies needed for comprehending spatial relationships in general. We hypothesize that computing the deictic center in narrative requires knowledge of inherent spatial properties of objects, of spatial reference frames for objects, and of spatial tracking of moving objects. Our choice of the first two of these three areas of spatial competence derives from our own cross-linguistic studies of spatial terms, which show a lexical separability of spatial terms involving inherent spatial properties of objects from the orientation of those objects in a spatial reference frame (Zubin and Choi, 1984). The importance of the third area, tracking objects through space, is established by our conceptualized model of spatial deixis in narrative. We hypothesize that understanding narrative not only requires lexical knowledge of spatial terms, but also requires that readers and listeners create dynamic spatial representations by tracking and updating spatial events as they change across time and across perspective in the text. Thus, we implicate spatial tracking as a competency underlying a comprehender's ability to understand spatial deixis in narrative.

The literature on language and reading disorders indicates that there may be separable populations among the reading disabled: those who have visual-spatial problems and those who do not (Hatchette and Evans, 1983; Lyon and Watson, 1981; Mattis, French and Rapin, 1975; VandeVoort and Snef, 1973). Further, there are indications that spatial problems have more likelihood of occurring among the language and learning disabled than other clinical or normal populations (Johnston and Weismer, 1983; Savich, 1984).

Studies of the spatial abilities of language/learning disabled usually have taken a correlational approach, with little attempt being made to examine the way spatial information is represented in text, or how disabled readers and language learners with and without spatial disability comprehend that information. We propose to study whether comprehension of deixis in text involves spatial as well as verbal competencies and, if so, to what extent each of the three types of spatial competencies are needed.

Hypotheses. We predict that listeners who have selective difficulty in comprehending spatial deixis in a narrative perform poorly on nonverbal spatial tasks. Further, we hypothesize that listeners who

have problems with terms describing inherent spatial properties or terms marking spatial orientation have those same problems with inherent and spatial reference frame in non-verbal situations.

Subjects. Our subjects will be 40 college students whose performance on a standardized reading test will be at least one standard deviation below the mean for the general population, thus demonstrating some reading disability. The subjects will be tested for spatial and verbal knowledge (International Primary Factors Test Battery, 1973). Their scores on each subtest will be split into those above and those below the median performance. This two-way split will yield four subgroups.

Materials and Tasks. Subjects in each of the four groups will be administered three tasks involving verbal spatial reasoning (the nonverbal tasks) and three involving verbal spatial reasoning (the verbal tasks). The tasks under both the nonverbal and verbal conditions are designed to measure the ability to identify inherent spatial properties of objects, the ability to identify objects in different spatial reference frames, and the ability to track the main path of a moving object.

The nonverbal task measuring the ability to identify *inherent spatial properties* is a picture matching procedure, where subjects find which picture among a group of four matches a model. E.g., they will be shown a picture of a tree with a straight trunk and asked to select a matching picture from among: a crooked cane, a crooked pencil, a crooked fork, and a straight spoon. A second condition under the inherent spatial properties task also has the subjects identify the picture that has the inherent property, e.g., crookedness, but this time the objects containing the property will be rotated (the model will be upright, the matching item will be leaning). This control task will allow us to determine which subjects can identify the same inherent features regardless of the spatial frame of reference.

The second task, one measuring spatial reference frame regardless of inherent spatial properties, will have subjects match the object which is like the target in its spatial groundedness (e.g., tilted vs. upright). This *spatial reference frame task* will manipulate the spatial reference frame within an objective field, disregarding the viewer's perspective. So, a tilted object will be matched with another tilted object. A second condition for the spatial reference frame task is to manipulate the viewer's orientation of the object in the spatial field. E.g., multiple views of objects will be shown and the subject will be required to determine which of the views would be seen from a designated position (e.g., identification views of a mountain from the moving prow of a ship).

The third nonverbal spatial task will ask subjects to track the main course of a designated path. They will be shown a videotape of someone successfully traversing a maze that has several solution paths. The person on the videotape will make mistakes; however, the subject in the study will be asked to traverse the same solution path without making the mistakes.

Three verbal comprehension tasks related to the three visual tasks will be designed. For the corresponding inherent properties task, subjects will follow directions requiring them to identify pictured objects following a verbal description (e.g., the crooked ones). For the reference frame task, they will be told to carry out the directions using a narrator's orientations to a miniature scene (e.g., two dolls are presented facing one another with a tree in the middle, and the subject is of the tree).

The third verbal comprehension task will involve narrative. The subjects will be given a five-sentence narrative describing a character's movement through space and asked to re-enact the movement using a doll in a delineated space such as a doll house.

A fourth verbal comprehension task will serve as a control to determine whether the subjects are able to show non-spatial narrative comprehension. They will be asked to identify sentences that best capture the gist of a piece of narrative read to them. The gist sentences will not come from the narrative, and the narrative will contain a minimal amount of spatial description.

Planned Analysis of Results. A 2 x 2 x 2 factorial analysis will be done on each of the six spatial tasks. Two of the factors represent the four subject groups and the third factor represents the visual and verbal forms of each task. The performance of the four subject groups on the narrative comprehension tasks (one on spatial tracking and the other on gist understanding) will also be compared. In addition, an intercorrelation matrix will be obtained for the seven separate tasks.

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Figure 5. Relation of Theory to Hypotheses, Methodology, and Database.
Arrows indicate relations among particular theoretical constructs and research activities. Reverse arrows indicate how principles, hypotheses and methodology will be revised in light of results.

a
construction processes; cf. 1.3/1.4

b
Deictic Center concept; cf. 1.3/1.4

c
Deictic Center Principles

d
Morphological and Syntactic Cohesive Devices of language

*e*1
hypotheses about the effect of individual DC-devices

hypotheses about the interaction of DC-devices
*e*2

f
computer-assisted hypothesis testing

g
machine-readable narrative discourse

APPENDIX 1

DEVICES THAT AFFECT A SPECIFIC COMPONENT OF THE WHO-POINT OF THE DC.

3. THE WHO-POINT OF THE DEICTIC CENTER.

3.1. Devices that INTRODUCE a New Actor as a Potential WHO of the DC.

3.1.1. Presentative Structure.

(a) preposed adverbial phrase/clause + subject NP (usually indefinite).

> Down the rope that hung the baby's box from the roof support a scorpion moved slowly. His stinging tail was straight out behind him, but he could whip it up in a flash of time. (p. 6)

(b) there/it + be + NP

> His eyes flicked to a rustle beside him. It was Juana arising, almost soundlessly. On her hard bare feet she went to the hanging box where Coyotito slept. . . (pp. 3-4)

3.1.2. Noun Phrases with Extended Attributes or Relative Clauses.

> And the newcomers, particularly the beggars from the front of the church who were great experts in financial analysis, looked quickly at Juana's old blue skirt,. . . (p. 10)

3.1.3. Definite NPs in Direct/Indirect Object Position.

> And last he turned his head to Juana, his wife, who lay beside him on the mat,. . . (p. 3)

3.2. Devices that MAINTAIN a Character as the WHO of the DC.

3.2.1. Simple Maintenance (the Listener Expects Maintenance).

(a) Coordinate clause conjoining:

> As always when he came near to one of this race, Kino felt weak and afraid and angry at the same time. . . He could kill the doctor more easily than *he* could talk to him. (p. 11)

Note that the italicized subject pronoun refers to Kino, the WHO of the DC, even though the doctor is most recently mentioned.

(b) Subject chaining (Zubin, 1979), including pronominalization and zero-anaphora. Successive mention of a character as the subject of adjacent clauses.

> Kino's eyes opened, and he looked first at the lightening square which was the door and then he looked at the hanging box where Coyotito slept. At last he turned his head to Juana. . . (p. 3)

(c) Overall frequency of mention. Kino and Juana are the most frequently mentioned characters in the story. The DC shifts to them with fewer supporting features than an infrequently mentioned character, such as the beggars. For example, after an extensive passage of scene description in which the WHO and the WHEN are voided, a simple subject NP shifts the WHO from null to Kino, and thereby sets the dynamic WHEN back in motion:

> . . . But the pearls were accidents, and the finding of one was luck, a little pat on the back by God or the gods or both. KINO had two ropes, one tied to a heavy stone and one to a basket. He stripped off his shirt and trousers and laid his hat in the bottom of the canoe. (pp. 16-17)

3.2.2. Anti-Shifting Devices (the Listener Expects a Shift).

(a) Relative clauses:

> And every year Kino refinished his canoe with hard shell- like plaster by the secret method that

had also come to him from his father. (p.15).

(b) Indefinite subjects:

Kino. . . squatted down and gathered the blanket ends about his knees. He saw the specks of Gulf clouds flame high in the air. And a goat came near and sniffed at him and stared with its cold yellow eyes. Behind him Juana's fire leaped into flame. . . A late moth blustered in to find the fire. The dawn came quickly now. . . Kino looked down to cover his eyes from the glare. (p. 4)

(c) Complementation: In this example the definite subject NP Juana is a shifting device (cf. 6.3.2. ii), but the clause is a complement to the verb hear, and so the DC does not shift:

Kino stood perfectly still. He could hear Juana whispering the old magic again, and he could hear the evil music of the enemy.

(d) Switch reference markers in other languages (Haiman & Munro, 1983) often have an anti-shifting function in narrative.

3.3. Devices that SHIFT to Another Actor as the WHO of the DC.

3.3.1. Perception and Mental Predicates.

In this example the verb feel shifts the DC briefly to the scorpion, as shown by the deictic verb come in its scope:

Kino. . . could not move until the scorpion moved, and it felt for the source of death that was coming to it. Kino's hand went forward very slowly, very smoothly. (p.6)

3.3.2. Definite Noun Phrases (including Names) in Subject Position.

He (Kino) brought out a paper folded many times. Crease by crease he unfolded it, until at last there came to view eight small misshapen seed pearls, as ugly and gray as little ulcers, flattened and almost valueless. The servant took the paper and closed the gate again, but this time he was not gone long. He opened the gate just wide enough to pass the paper back.(p.13)

3.3.3. Shift in WHERE.

The gate closed a little, and the servant refused to speak in the old language. "A little moment," he said. "I go to inform myself," and he closed the gate and slid the bolt home. The glaring sun threw the bunched shadows of the people blackly on the white wall.

In his chamber the doctor sat up in his high bed. He had on his dressing gown of red watered silk that had come from Paris, a little tight over the chest now if it was buttoned.(p.11-12)

3.3.4. Devices that Temporarily VOID the WHO.

Chained Indefinite Reference.

The men. . . dug their paddles into the sea and raced toward Kino's canoe.

A town is a thing like a colonial animal. A town has a nervous system and a head and shoulders and feet. A town is a thing separate from all other towns, so that there are no two towns alike. And a town has a whole emotion. How news travels through a town is a mystery not easily to be solved. (p. 22-3).

4. THE WHERE-POINT OF THE DEICTIC CENTER.

4.1. Devices that INTRODUCE a Location as a Potential WHERE of the DC.

(a) go/take + non-initial goal adverbial:

> And rage surged Kino. He rolled up to his feet and followed her as silently as she had gone, and he could hear her quick footsteps going toward the shore.

(b) Preposed adverbials (simultaneously introduce and shift):

> Thus, in La Paz, it was known in the early morning through the whole town that Kino was going to sell his pearl that day.(p.39)

4.2. Devices that MAINTAIN a Location as the WHERE of the DC.

4.2.1. Simple Maintenance.

(a) Clause conjoining: see above.

(b) Spatial deictic adverbs here and there.

> And in the pearl he saw Juana with her beaten face crawling home through the night. "Our son must learn read," he said frantically. And there in the pearl Coyotito's face, thick and feverish from the medicine.(p.65-66)

(c) Deictic verbs come, go, bring, take: In this example maintenance of the WHERE is signaled by come, even though the WHO shifts.

> Kino squatted by the fire pit and rolled a hot corncake and dipped it in sauce and ate it .... When Kino had finished, Juana came back to the fire and ate her breakfast. (p. 5)

Often the goal of come and bring is left unspecified, since these convey movement toward the DC, which is already known to the listener/reader:

> Juana brought a little piece of consecrated candle and lighted it at the flame and set it upright on a fireplace stone. (p. 36-7)

4.2.2. Anti-Shifting Devices.

(a) Complement clauses. (Example 6.2.2. iv)

(b) Relative clauses.

(c) Perception verbs.

4.3. Devices that SHIFT to Another Location as the WHERE of the DC.

(a) Spatial deictic adverbs here and there. Note that these are also maintenance devices if they agree with a previous DC-device.

> Even in the distance he could see the two on foot moving slowly along bent low to the ground. Here one would pause and look at the earth while the other joined him. They were the trackers, they could follow the trail of the bighorn sheep in the stone mountains. They were as sensitive as hounds. Here, he and Juana might have stepped out of the wheel rut, and these. . . hunters could follow, could read a broken straw or a little tumbled pile of dust. (p.67)

(b) Preposed locative adverbials:

> [Kino] slipped his feet into his sandals and went outside to watch the dawn. Outside the door he squatted down and gathered the blanket ends about his knees. He saw the specks of Gulf clouds flame high in the air.(p.4)

(c) Verbs with directional valence (come, go, enter, leave, bring and take). In this example come successively shifts the narrative not only to a new WHERE but to a new WHO.

> The news came to the doctor where he sat with a woman whose illness was age. . . The doctor grew stern and judicious at the same time. . . The news came early to the beggars in front of the church, and it made them giggle a little with pleasure. . . (p.22-3)

In the following example go and come in combination signal a shift in the WHERE, which begins outside the hut:

> The world was awake now, and Kino arose and went into his brush house. As he came through the door Juana stood up from the glowing fire pit.

(d) Shift in WHO:

> The scorpion moved delicately down the rope toward the box. Under her breath Juana repeated the ancient magic to guard against such evil, and on top of that she muttered a Hail Mary between clenched teeth.(p6)

The place where Juana is becomes the WHERE of the deictic center.

5. THE WHEN-POINT OF THE DEICTIC CENTER.

5.1. Devices that INTRODUCE a Time Interval as a Potential WHEN.

(a) Initial adverbials (introduce and shift):

> In the afternoon, when the sun had gone over the mountains of the Peninsula to sink in the outward sea, Kino squatted in his house with Juana beside him.(p.24)

5.2. Devices that MAINTAIN the WHEN of the DC, i.e., which Maintain Its Dynamic Inertia (Keep Updating).

5.2.1. Simple Maintenance.

(a) Tense chaining (simple past, simple present, preterite followed by infinitives in Latin):

> And the newcomers, particularly the beggars from the front of the church who were great experts in financial analysis, looked . . . , saw the tears . . . appraised the green ribbon . . . , read the age of Kino's. . . and set them . . . . (p. 10)

(b) Accomplishment and achievement predicates (Vendler, 1967):

> Then from his bag he took a little bottle of white powder and a capsule of gelatine. He filled the capsule with the powder and closed it, and then around the first capsule he fitted a second capsule and closed it. (pp. 30-31)

(c) Clause conjoining. (See example 6.2.1. ii)

5.2.2. Anti-Shifting Devices.

These signal that an event is out of sequence, but that otherwise events are still sequential; i.e., beyond the scope of the Anti-Shifting device, sequencing returns to normal.

(a) Conjunction/adverbs: while, after, before, when, etc.

> And as always when he came near to one of his race Kino felt weak. (p.11)

(b) Past perfect, would + infinitive, conditional in conjoined sentences.

> In the pearl he saw Coyotito sitting at a little desk in a school, just as Kino had once seen it through an open door. (p.25).

5.3. Devices that SHIFT the WHEN of the DC.

(a) Preposed temporal adverbials:

> And then, in the first light, he heard the creak of a wagon wheeled cart go by, drawn by slouch-

ing oxen.(p.64)

5.4. Devices that VOID the Time Sequence of WHEN.

(a) Stative and activity verbs (Vendler, 1967):

> She, who was obedient and respectful and cheerful and patient, she could arch her back in child pain with hardly a cry. She could stand fatigue and hunger almost better than Kino himself. In the canoe she was like a strong man. (p.8-9)

(b) Habitual and iterative adverbs:

> For centuries men had dived down and torn the oysters from the beds and ripped them open, looking for the coated grains of sand.(p.16).

(c) Imperfective aspect (Reid, 1977; Hopper, 1982):

> Kino was not breathing, but his back arched a little and the muscles of his arms and legs stood with tension and a line of sweat formed on his upper lip.(p.68)

(d) Absence of a WHO: In this example the chained indefinite subjects void the WHO, which in turn voids the WHEN:

> The beach was yellow sand, but at the water's edge a rubble of shell and algae took its place. Fiddler crabs bubbled and sputtered in their holes in the sand, and in the shallows little lobsters popped in and out of their tiny homes in the rubble and sand. (p.14)

6. HYPOTHESES ABOUT THE EFFECT OF AGREEMENT AND CONFLICT AMONG DC-DEVICES.

We hypothesize that when devices agree with each other, this increases the certainty of a maintenance or Shift in the DC. When devices of like scope disagree, this will decrease the certainty of a maintenance or shift, i.e., the listener/reader will be in momentary uncertainty about the WHO, WHEN, or WHERE of the DC. Note that this is distinct from a Voided DC, in which case the listener/reader is certain that there is temporarily no WHO, WHEN, and/or WHERE.

6.1. Agreement.

The following passage illustrates the strong and certain DC resulting from multiple devices maintaining the DC.

> Juana. . . uncovered an ember from the ashes and shredded little pieces of cornhusk over it and blew a little flame into the cornhusks. . . And then Juana brought a little piece of consecrated candle and lighted it at the flame and set it upright on a fireplace stone. (p. 36-7)

The following passage illustrates how anti-shifting devices cooperate to prevent a DC shift:

> The four beggars in front of the church knew everything in the town. They were students of the expressions of young women as they went (1) in to confession, and they saw them as they came out (2) and read the nature of their sin (3). They knew (4) every (5) little scandal and (6) some very big crimes (7). They (8) slept (9) at their posts in the shadow of the church... (p. 10).

In this example WHO = beggars and WHERE = front of church. Four Anti-Shifting devices in boldface cooperate to prevent shift of the WHO to the women and the WHERE to the inside of the church: The obviating preposition of, the indefinite NP young women, the subordinating conjunction as, and the perception verb see with the beggars as subject. This maintenance of the WHO is supported by the deictic verb go signaling movement away from the WHERE of the DC, and come signaling return.

Note that this concerted maintenance of the beggars as the WHO throughout this passage allows the anaphoric pronoun they and zero-anaphora (marked with numbers in the passage) to switch back and forth in reference between the beggars and the women. Occurrences (2), (5) and (7) referring to the women are in the scope of the Anti-Shifting devices and of (cf. the Scope Principle, above). Occurrences (1), (3), (6), (8), and (9) referring to the beggars are not in the scope of such devices.

(Occurrence (4) is assigned to the women by a co-reference principle). Thus because of the stable DC the reader is able to keep track of switching reference, despite the use of potentially ambiguous pronouns and zero-anaphora.

6.2. Conflict.

In this example the WHO and WHERE start off together in the first sentence. In the second boldfaced sentence the initial adverbial signals a shift in the WHERE, but the anaphoric subject pronoun he signals maintenance of the WHO. This conflict leads to uncertainty about whether the WHERE has really shifted, or whether the WHO is going to shift. This uncertainty is resolved in the last sentence by the initial here and the change in subject pronoun: the WHERE and WHO have shifted to the location of the "two on foot".

> He crept into the cover of a thorny tree. . . and peeked out from under a fallen branch. Even in the distance he could see the two on foot moving slowly along, bent low to the ground. Here, one would pause and look at the earth, while the other joined him. (p.67)

The following passage reveals a similar conflict, resulting in momentary uncertainty about the DC:

> Juana went to the fire pit and uncovered a coal and fanned it alive. . . Now Kino got up and wrapped his blanket about his head and nose and shoulders. He slipped his feet into his sandals and went outside to watch the dawn. (p.4)

At this point the WHERE is inside the hut and Kino is the WHO. But since the WHO is leaving the WHERE it is highly probable that one will shift, and we are left in uncertainty, i.e. we don't know if we, the reader, are staying inside with Juana (shift of WHO) or going outside with Kino (shift of WHERE). This is resolved by the next sentence:

> Outside the door he squatted down and gathered the blanket ends about his knees.(p.4)

The anaphoric pronoun he referring to Kino signals maintenance of the WHO, while the initial spatial adverbial outside the door signals a shift of the WHERE, i.e. the reader is now certain that the WHO is maintained while the WHERE has shifted.

6.3. Stable Dissynchronism of the Deictic Center.

We have identified one nexus of DC-devices resulting in a separation of WHO and WHERE that is stable, i.e., that does not show the evidence of conflict of the examples above. This nexus seems to evoke a "Journey" schema (Lakoff and Johnson, 1980) in the listener/reader's mental model of the narrative. We hypothesize that the WHO is composed of the individual or group making the journey, and that the WHERE is their final goal as well as places they pass along the way. What creates the dynamic quality of the journey in the narrative, we hypothesize, is the fact that the WHERE keeps shifting out "ahead" of the WHO. The following passage illustrates this effect. Kino and Juana are going to the town doctor with their baby, accompanied by their neighbors and others in the town:

a The people in the door pushed against those behind to let [Juana] through.
b Kino *followed* her. They *went* out of the gate to the rutted path and the
c neighbors *followed* them. . . . They *came* to the place where the brush houses
d stopped and the city of stone and plaster began. . . . The procession *crossed*
e the blinding plaza and *passed* in front of the church. . . . the beggars from
f the front of the church . . . *went* along to see what kind of drama might
g develop. . . . they *followed* the procession, these endless searchers after
h perfect knowledge of their fellow men, to see what the fat lazy doctor
i would do about an indigent baby with a scorpion bite. The scurrying
j procession *came* at last to the big gate in the wall of the doctor's house.

One of the many devices of the text that set up the movement of the procession are the motion verbs *follow*, *pass*, and *cross* on lines b, c, d, e, and g of the text passage. According to our hypothesis, the verbs *come* (c, j) and *go* (b, f), in addition to expressing motion, express movement toward and away from the DC, respectively. If this hypothesis is correct, and if the WHO (procession) and the WHERE are synchronized, then *come* and *go* should express movement toward and away from the procession,

respectively. But the opposite is the case. To show this, we define a *locus* as a location noncoterminous with the WHO, with respect to which the WHO is moving. Both instances of *come* in the passage express movement toward a locus, not toward the WHO. *Go* in line (b) expresses movement away from a locus, and in (f), away from a locus and toward the WHO. In other words, the deictic verbs in this passage are orienting toward loci away from the WHO as if these were the WHERE of the DC. Thus, either our hypothesis about *come* and *go is wrong, or the WHO and the WHERE are indeed dissynchronous* in this passage.

We hypothesize that such dissynchronism of DC-devices maintaining the WHO and the WHERE will be systematically exploited in narrative to evoke a "Journey" schema.

APPENDIX 2

Table 1

Sample segments of text used in Experiment 1, with sample questions. The original version is presented, the variations are indicated in brackets.

In this first example, which is the beginning of the story, the location of Kino is not established.

> Kino awakened in the near dark. The stars still shone and the day had drawn only a pale wash of light in the lower sky to the east. The roosters had been crowing for some time, and the early pigs were already beginning their ceaseless turning of twigs and bits of wood to see whether anything to eat had been overlooked. Outside the brush house, a covey of little birds chittered and flurried with their wings in the tuna clump. [A covey . . . tuna clump outside the brush house. A covey . . . tuna clump.]

Statements:

> It is morning.
> Kino is outside.
> Kino is in bed.
> The little birds chittered before Kino awoke.

> The thing had become a neighborhood affair. They made a quick soft- footed procession into the center of the town . . . . And the yellow sun threw their black shadows ahead of them so that they walked on their own shadows. They came [went] to the place where the brush houses stopped and the city of stone and plaster began.

Statements:

> Kino and Juana have already arrived at the place where the stone and plaster houses are.
> It is mid-day.

Table 2

Sample of constructed materials for Experiment 3.

1. The equipment was ready.
2. At daybreak the fisherman went to the dock.
3. The fisherman got into his boat and went toward the cove.
*4. The fisherman returned to the dock to pick up his lunch.
*5. The motor shut off halfway across the lake.
*6. The fisherman adjusted his life jacket to find his fishing license.
**7. The cove was the best spot for fishing.
**8. The boat had a very old 10 horse power motor.
**9. A fishing license was required for anyone over the age of 16 years.
10A. The fisherman arrived at the cove in a few minutes.
10B. The blue heron flew out of the cove as the boat arrived.
11. The fisherman caught his quota of bass before noon.

Each subject will get 11 sentences. Sentence #3 is the prime and either sentence 10A or 10B is the target, depending on whether "who" is to be shared between the prime and target sentences. the following indicates which three sentences occur between the prime and target sentences during sentence presentation, according to condition.

Number of intervening shifts	Sentences
0	7,8,9
1	5,8,9
2	4,6,9
3	4,5,6

* Sentences that are hypothesized to shift the deictic center.
** Sentences that should not shift the deictic center.