The Structure of User-Adviser Dialogues: Is there Method in their Madness?

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ABSTRACT

Novice users engaged in task-oriented dialogues with an adviser to learn how to use an unfamiliar statistical package. The users'. task was analyzed and a task structure was derived. The task structure was used to segment the dialogue into subdialogues associated with the subtasks of the overall task. The representation of the dialogue structure into a hierarchy of subdialogues, partly corresponding to the task structure, was validated by three converging analyses. First, the distribution of non-pronominal noun phrases and the distribution of pronominal noun phrases exhibited a pattern consistent with the derived dialogue structure. Non-pronominal noun phrases occurred more frequently at the beginning of subdialogues than later, as can be expected since one of their functions is to indicate topic shifts. On the other hand, pronominal noun phrases occurred less frequently in the first sentence of the subdialogues than in the following sentences of the subdialogues, as can be expected since they are used to indicate topic continuity. Second, the distributions of the antecedents of pronominal noun phrases and of non-pronominal noun phrases showed a pattern consistent with the derived dialogue structure. Finally, distinctive clue words and phrases were found reliably at the boundaries of subdialogues with different functions.

INTRODUCTION

The goal of this paper is to find evidence for the notion of **dialogue structure** as it has been developed in computational linguistics (Grosz, 1977; Sidner and Grosz, 1985). The role of two hypothesized determinants of discourse structure will be examined: 1) the structure of the task that the user is trying to accomplish and the user's goals and plans arising from the task; 2) the strategies available to the user when the user is unable to achieve the task or parts of the task (i.e., meta-plans). The study of dialogue structures is important because computationally complex phenomena such as anaphora resolution have been theoretically linked to the task and dialogue structures.

FOCUSING AND ANAPHORA RESOLUTION

Dialogue Structure: A Key to Computing Focus

Given the computational expense of searching, of inferential processing, and of semantic consistency checking required to resolve anaphors, restricting the search a priori to a likely set of antecedents seems advantageous. The a priori restriction on the set of potential antecedents for anaphora resolution has been called **focusing** (Grosz, 1977; Guindon, 1985; Reichman, 1981; Sidner, 1983). Grosz defines a **focus space** as that subset of the participant's total knowledge that is in the focus of attention and that is relevant to process a discourse segment.

Task-oriented dialogues are dialogues between conversants whose goals are to accomplish some specific tasks by exchanging information through the dialogues. Task-oriented dialogues are believed to exhibit a structure corresponding to the structure of the task being performed. The entire dialogue is segmented into subordinated subdialogues in a manner parallel to the segmentation of the whole task into subordinated subtasks. Grosz (1977) assumes that the task hierarchy imposes a hierarchy on the subdialogue segments. As a subtask of the task is performed (and its corresponding subdialogue is expressed), the different objects and actions associated with this subtask come into **focus**. As this subtask is completed (and its corresponding subdialogue), its associated objects and actions leave focus. The task of which the completed subtask is a part then returns in focus. The segmentation of a dialogue into interrelated subdialogues is associated with shifts in focus occurring during the dialogue. Detailed task structures for each problem given in this study can be found in Guindon, Sladky, Brunner, and Conner (1986).

A cognitive model of anaphora resolution and focusing is provided in Guindon (1985) and Kintsch and van Dijk (1978). Human memory is divided into a short-term memory and a long-term memory. Short-term memory is divided into a cache and a buffer. The cache contains items from previous sentences and the buffer holds the incoming sentence. Short-term memory can only contain a small number of text items and its retrieval time is fast. Long-term memory can contain a very large number of text items but its retrieval time is slow. During the integration of a new sentence, the T most important and R most recent items in short-term memory are held over in the cache. Items in focus are the items in the cache and are more rapidly retrieved. Items not in focus are items in long-term memory and are more slowly retrieved. Because the cache contains important items that are not necessarily recent, pronouns can be used to refer to items that have been mentioned many sentences back. An empirical study demonstrates the cognitive basis for focusing, topic shifts, the use of pronominal noun phrases to refer to antecedents in focus, and the use of non-pronominal noun phrases to refer to antecedents not in focus.

Grosz and Sidner (1985) distinguishes three structures in a discourse structure: 1) the structure of the sequence of utterances, 2) the structure of the intentions conveyed, and 3) the attentional state. Distinguishing these three structures gives a better account of discourse phenomena such as boundary markers, anaphors, and interruptions. This paper will cover mainly the second structure and will attempt to find evidence linking the dialogue structure to the task structure. The main point is that the structure of the intentions conveyed in the discourse should mirror to some extent the task structure (but see the next section). The first structure of the dialogue, the structure of the sequence of utterances, will actually be examined with the pronominal and non-pronominal noun phrase distributions, the antecedent distribution, and the boundary marker analyses. We expect that these three analyses will support the derived dialogue structure, the intentional structure. The last structure, the attentional structure, is not discussed here but has been discussed in Guindon (1985).

The main point of "focusing" theories of anaphora resolution is that the discourse structure, based on the task structure, is a crucial determinant of which discourse entities are held in focus and are readily accessible for anaphora resolution. Subdialogues that are in focus are contexts that are used to restrict the search for antecedents of anaphors.

Task Structure Can Only Partially Determine Dialogue Structure

In any case, the task structure can only partially determine the goals and plans of the novice user and, indirectly, the dialogue structure. This is because the novice user does not have a good model of the task and is in the process of building one and because the adviser only has a partially correct model of what the novice user knows about the task. The verbal interaction between the user and the adviser is not just one of execution of plans and recognition of plans but rather one of situated actions and **detection and repair of imperfect understanding** (Suchman, 1985).

As a consequence, the dialogue structures from our data contained subdialogues that functioned as **clarification** (i.e., request of information) to correct imperfect understanding or as **acknowledgement** to verify understanding between the participants. The notion of meta-plans allows us to account for the presence of clarification and acknowledgement subdialogues (see Litman and Allen, 1984).

RESEARCH GOALS

There are many unanswered questions about the nature of dialogue structures, about the validity and usefulness of the concept of a dialogue structure, about the role of the task structure in determining dialogue structure, and in the contribution of the task structure to focusing and anaphora resolution. For example, the precise mechanisms to determine the initial focus and to update it on the basis of the dialogue structure are still unknown (Sidner, 1983).

The goal of this paper is to find evidence for the validity of the notion of discourse structure derived from the task structure by: 1) describing a technique to derive the structure of dialogues and 2) validating the derived dialogue structure by three independent converging analyses: a) the distribution of non-pronominal and pronominal noun phrases b) the distribution of antecedents of pronominal and non-pronominal anaphors, and c) the presence of subdialogue boundary markers.

If complete subdialogues get into and out of focus and if subdialogues are conceived as contexts restricting the set of antecedents to be searched and tested during anaphora resolution, identifying the appropriate unit of discourse corresponding to these subdialogues is crucial.

One phenomenon that should have correspondence to the dialogue structure is the distribution of non-pronominal and pronominal noun phrases. Non-pronominal noun phrases can be used to introduce new entities in the dialogue or to reinstate into focus a previous dialogue entity out of focus. In other words, non-pronominal noun phrases are used to indicate topic shifts. As a consequence, they should tend to occur more frequently at the beginning of the subdialogues than later in the subdialogues. On the other hand, pronominal noun phrases are used to refer to entities currently in focus. In other words, pronominal noun phrases are used to indicate topic continuity. As a consequence, they should tend to occur less frequently in the first sentence of a subdialogue but more frequently in subsequent sentences.

Empirical evidence for these claims are presented in Guindon (1985). She found that anaphora resolution time is faster for pronominal noun phrases whose antecedents are in focus than for those whose antecedents are not in focus. On the other hand, she found faster anaphora resolution time for non-pronominal noun phrases whose antecedents were not in focus than for those whose antecedents were in focus. In other words, the form of the anaphor signals whether the antecedent is in focus (as when the anaphor is pronominal) or not in focus (as when the anaphor is non-pronominal). Grosz, Joshi, and Weinstein (1983) have made similar claims about the role of non-pronominal definite noun phrases and pronominal definite noun phrases.

In linguistics, Clancey (cited in Fox, 1985) found that the use of definite non-pronominal noun phrases was associated with episode boundaries. Psychological evidence has shown the special status in memory for certain sentences in discourse found at the beginning of paragraphs. Sentences which belong to the macrostructure (i.e. gist) of the discourse have been shown to be recognized with more accuracy and faster than sentences belonging to the microstructure (Guindon and Kintsch, 1984). Macrostructure sentences are by definition more abstract and important than microstructure sentences. They express a summary of the or part of the discourse. The macrostructure sentences tend to be the first sentences in paragraphs and be composed of non-pronominal definite noun phrases (van Dijk and Kinstch, 1983).

Linde (1979) observed the distribution of *it* and *that* in descriptions of houses or apartments. She found that shifts in focus were associated with change in the room described. The pronoun *it* was used to describe objects **in focus** either associated with the room then described or to the entire apartment even when the apartment itself had not been mentioned for many sentences. The pronoun *that* was used either to refer to an object **outside the focus** or to an object in focus when the description of the object was in contrast with another description. Grosz (1977) observed a similar use of the pronoun *it* in her dialogues to the use of *it* in Linde's dialogues.

In summary, the most important sentences, often at the beginning of new paragraphs, tend to be composed of full definite noun phrases. These sentences often introduce a new discourse entity or reinstate a former one which was out of focus, creating a topic shift. Sentences which are "subordinated" to the most important sentence in the paragraph tend to be composed of pronouns and signal topic continuity.

Another clue to dialogue structures is the distribution of antecedents of anaphors. Given that pronominals are used to refer to important or recent concepts (Guindon, 1985), the distribution of antecedents of pronominal anaphors should cluster in the current subdialogue (i.e. recency or importance), its parent (i.e. importance and recency), and the root subdialogue (i.e. importance). On the other hand, because non-pronominal anaphors are more informative than pronominal anaphors they may refer to antecedents that are more widespread in the dialogue, that is, antecedents that are not as recent or as important.

Another obvious clue is the presence of reliable **boundary markers** for different subdialogue types. Some of these markers have been reported by Grosz (1977), Reichman (1981), and Polanyi and Scha (1983). The boundary markers found in our subdialogues should agree with those found in these previous analyses and extend them.

Derivation of a dialogue structure on the basis of the task structure

An important prerequisite in the interpretation of user-adviser dialogues is to analyze the task the users are trying to perform. A *task analysis* is a detailed description of the determinants of the user's behaviors arising from the task context. The first step in performing task analysis is to identify the *objects* involved in the task. In our case, these objects are vectors, matrices, rows, columns, variables, variable labels, etc. The second step is to identify all the *operators* in the task which when applied to one or more objects changes the state of the completion of the task. In our case, these operators are function calls (e.g. mean, variance, sort), subsetting values from vectors, listing of values, etc. Of course, not every operator applies to every object. A third step is to identify the *sequence of operators* which would produce a desired state (the goal - e.g. the problem solved) from an initial state. Such a task analysis can be performed at many levels of abstraction, from high-level conceptual operators to low-level physical operators. The desired level of abstraction depends upon the level of abstraction of the behaviors that one wants to account for. Usually, the more complex or cognitive the task modelled, the more abstract or coarse the operators selected. In such case, the operators will reflect the specifics of the task environment, such as, vectors, matrices, screen, keyboard. The finer the grain of analysis, the more the operators are associated with basic motor, perceptual, or cognitive mechanisms. Since the task we are trying to model is quite cognitive in nature - solving statistical problems with an unfamiliar statistical package - an appropriate level of analysis seems to be at the level of the so-called GOMS model (Card, Moran, and Newell, 1983). GOMS stands for: (1) a set of Goals; 2) a set of Operators; 3) a set of Methods for achieving the goals; 4) a set of Selection rules for choosing among competing methods for goals.

In the notation used in our examples, we have used a slightly different terminology and have used the term *action* instead of *operator* and use the term *plan* instead of *method*. We have also used the terms *prerequisites, constraints,* and *meta-plans* from artificial intelligence. The notion of meta-plans allowed us to account for the presence of clarification and acknowledgement subdialogues (see Litman and Allen, 1984) that could not be accounted directly by the task structure.

We will now describe how the task structure was used in deriving the dialogue structure. Goal or plan subordination arises from the plan decomposition into subplans or from unsatisfied prerequisites. In a task structure, plans are composed of other plans themselves, leading to a hierarchical structure. In other words, a subgoal to a goal can arise from a plan decomposition into subplans or from the prerequisite conditions which must hold true before applying the plan. Here are the coding decisions used in deriving the dialogue structure:

- If the user initiated a subdialogue consisting of the statement of a plan or of a goal, the subdialogue would be "inserted" in the task structure at the location of the plan described.

- If the user initiated a subdialogue consisting of the statement of a subplan within the decomposition of its parent plan, the subdialogue would be "inserted" in the appropriate daughter subplan of the parent plan in the task structure.

- If the user initiated a subdialogue consisting of a subplan arising from an unsatisfied prerequisite of a plan, then the subdialogue would be "inserted" as a daughter of the subdialogue associated with the plan.

Clarification subdialogues arise from the **restrictions on the meta-plans** that the participants can use when they cannot achieve one of their plans: In our study, they must ask help to the adviser aloud. The meta-plan, ASK-ADVISER-HELP, itself has prerequisites, one of them being that the linguistic communication be successful. This leads to the linguistic clarification subdialogues that occur when there are ambiguities in the message that need to be resolved by requesting disambiguating information from the adviser. Another consequence of the meta-plan ASK-ADVISER-HELP is the presence of **acknowledgement subdialogues** whereby participants ensure that the communication is successful by acknowledging that they have understood the message.

Let's continue describing the coding scheme:

- The clarification subdialogues are subordinated to the subdialogue mentioning the concept for which clarification is requested (e.g., goal, plan, term).

- The acknowledgement subdialogues are subordinated to the subdialogue mentioning the acknowledged concept.

- The linguistic clarification subdialogues are also subordinated to the subdialogue containing the utterance for which clarification is requested.

- Since we are not fully modeling the user's task, subdialogues regarding the participants' behaviors as a subject in a study were ignored.

• Since knowing the required statistical formula and knowing how to use the console were required to solve all the problems, these prerequisites were not always encoded explicitly in the task structure. Nevertheless, the clarification and acknowledgement subdialogues regarding statistics and the use of the console were subordinated to the subdialogue associated with the plan for which these clarifications were necessary to obtain.

DATA COLLECTION

Overview of Data Collection Method

Three novice users had basic knowledge of statistics. They had to use an **unfamiliar** statistical package to solve five simple descriptive statistics problems. There were two main restrictions imposed on the strategies employed to solve the problems: 1) the only source of information was the adviser; 2) all requests for information had to be said aloud. These restrictions were considered as restrictions on the meta-plans available to the participants when unable to solve the problems. The participant, the adviser sitting to his/her right, and the console were videotaped.

Coding of the Dialogues

Each subdialogue was segmented into subdialogues which appeared to be the execution of a plan to satisfy a goal of the user or the adviser on the basis of the task structure.

In addition to segmenting the dialogue into subdialogues, the relations between subdialogues were determined. One source of such relations is the decomposition of a total task into subtasks to be performed in some order. This decomposition is called the task structure (see Grosz, 1977) as described previously. Two important relations are **subordination** and **enablement**. Consider a dialogue occurring while performing a task, such as baking a cake, **composed** of three subtasks, (1) measure ingredients, (2) mix ingredients, (3) put the mixed ingredients in the oven. Subtasks 1, 2, and 3 are said to be **subordinated** to the task of baking a cake. Moreover, subtask 2 must **precede** subtask 3. Subtask 2 is said to **enable** subtask 3. The subdialogues that would be instrumental to the execution of these subtasks would stand in the same relations.

However, the decomposition of the task structure was not the only source of subordination and enablement relations between subdialogues. Clarification and acknowledgement subdialogues even though they did not correspond to a subtask in the task structure were subordinated to the subdialogue introducing the clarified and acknowledged concept respectively.

The coder then analyzed the distribution of non-pronominal noun phrases and pronominal noun phrases throughout the dialogue. The coder also noted words and phrases occurring at the boundaries of the subdialogues and mapped the distribution of the antecedents of pronominal and non-pronominal anaphors.

ANALYSIS OF THE DIALOGUES

ANALYSIS OF THE USERS' TASK

Three main types of subdialogues have been encountered associated with each aspect of the task described above :

1. **Plan-goal statement subdialogues** occur when the user describes a goal, or a plan, or the execution of actions composing the plan This type of subdialogue may be an adjunct to the goal or plan because expressing them verbally might not be essential for their satisfaction or realization (though expressing them verbally helps the adviser understand the user).

2. **Clarification subdialogues** occur when the user requests information from the adviser so that the user can satisfy a goal. In this study, these subdialogues arise from the constraints on the type of meta-plans available, ASK-ADVISER-HELP. There are two main types of clarification subdialogues: 1) those concerning the **determination of goals and plans** of the user (e.g., "What should I do next?", "How do I access a vector?"); 2) those concerning the **arguments (or objects) in goals and plans** (e.g., "What is a vector?"). In some cases, the clarification subdialogues arise from the prerequisite on the meta-plan, that is, assure mutual understanding. For example, the user will verify that he/she has identified the correct referent for an anaphor in the adviser's utterances.

3. **Acknowledgement subdialogues** occur when the user informs the adviser that he/she believes that he/she has understood an explanation. They arise from the prerequisite on the meta-plan, that is, assure mutual understanding.

A small subset of the graphical representation of a simplified subtask structure and of dialogue segmentation and structure is given in Figure 1 to show how the task structure partially influences the dialogue structure.
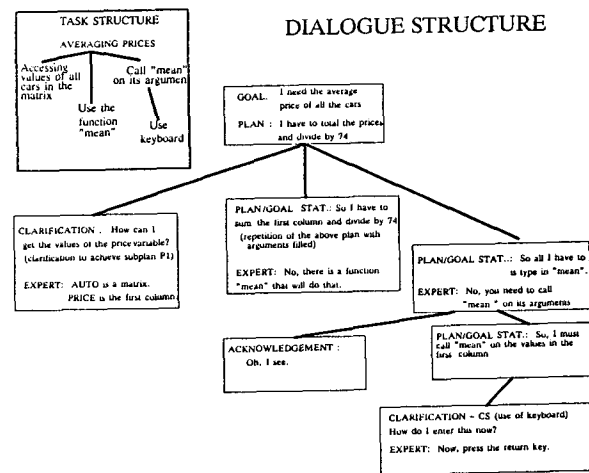

Figure 1: TASK AND DIALOGUE STRUCTURES

227

DISTRIBUTION OF NON-PRONOMINAL AND PRONOMINAL NOUN PHRASES

Non-pronominal noun phrases play a role in indicating and realizing topic shifts in a dialogue. Since new subdialogues are assumed to correspond to topic shifts, one can predict that non-pronominal noun phrases will tend to occur more frequently at the beginning of subdialogues than later in the subdialogues. On the other hand, pronominal noun phrases play a role in indicating and realizing topic continuity in a dialogue. Since new topics are introduced at the beginning of new subdialogues and developed in the following sentences, one can predict that pronominal noun phrases will tend to occur more frequently after the first sentence in the subdialogues. As can be seen in Table 1, there is a clear trend for the number of non-pronominal noun phrases to decrease as the subdialogue progresses, especially for the most frequent subdialogue lengths (i.e., 2 and 3 sentences), but less marked for the most infrequent subdialogue lengths (i.e., 4 and 5 sentences). Moreover, there is a clear increase in the number of pronominal noun phrases from the first sentence to the second sentence in the subdialogues, though again less reliable for the least frequent subdialgue lengths (i.e., 4 and 5 sentences). A complete statistical analysis of these data is presented in Guindon, Sladky, Brunner, and Conner (1986).

Table 1: DISTRIBUTION OF NOUN PHRASES

Sentence number	NON-PRONOMINAL NOUN PHRASES SUBDIALOGUE LENGTH IN SENTENCES				Sentence number	PRONOMINAL NOUN PHRASES SUBDIALOGUE LENGTH IN SENTENCES			
	2	3	4	5		2	3	4	5
S1	234	99	30	28	S1	13	2	5	0
S2	114	76	49	21	S2	24	15	4	5
S3		46	30	22	S3		9	11	2
S4			29	20	S4			6	4
S5				11	S5				8

The observed distributions of non-pronominal and pronominal noun phrases follow the predictions arising from previous work in linguistics and psychology. Because this analysis was performed independently of the dialogue segmentation and subordination, it is a converging analysis and it supports the derived dialogue structure on the basis of the task structure and the users' and adviser's plans and goals. This analysis supports the value of the concept of a dialogue structure and also support our proposed scheme to derive such dialogue structures.

DISTRIBUTION OF THE ANTECEDENTS OF ANAPHORS

The subdialogues were indexed as shown in Table 2. The current subdialogue, labelled N, is the location of the anaphor to be resolved. All subdialogues are indexed relative to the current subdialogue N. Thus, the node N-1 immediately dominates N, the node N-2 dominates N-1, and so on. The nodes subordinate to each of the nodes dominating N are indexed beginning with the left-most node and proceeding rightward. Thus, if N-1 is the first node dominating N, the left-most node subordinate to N-1 will be N-1/L1 and each sibling to the right will be N-1/L2, N-1/L3, etc.
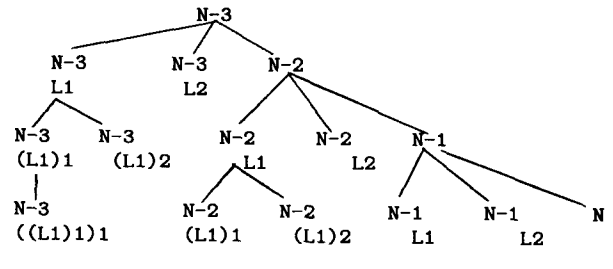

Table 2: INDEXING OF THE SUBDIALOGUES

Anaphoric - Pronominal Noun Phrases

Pronominal anaphors are used to refer to discourse entities that are in focus. Such entities should be either recent or of primary importance in the dialogue. Figure 2 represents graphically the distribution of the antecedents of pronominal noun phrases with a band, with highest frequencies shown with the widest bands. For sake of brevity, the exact frequencies are not reported here but can be found in Guindon, Sladky, Brunner, and Conner (1986).

Figure 2 shows that the majority of pronominal antecedents are located in the current subdialogue, with their frequency decreasing as distance from the anaphor increases. The current subdialogue contains recent antecedents. Then, they are most frequently found in the parent subdialogue which contains important and recent antecedents. Finally, a few pronominal anaphors (i.e. *it*) have their antecedent (i.e., *the statistical package*) found in the root subdialogue which contains important antecedents. Grosz (1977) also observed the use of *it* to refer to an important concept that had not been mentioned for many sentences. These data demonstrate the existence of constraints at the dialogue level on the distribution of the antecedents of
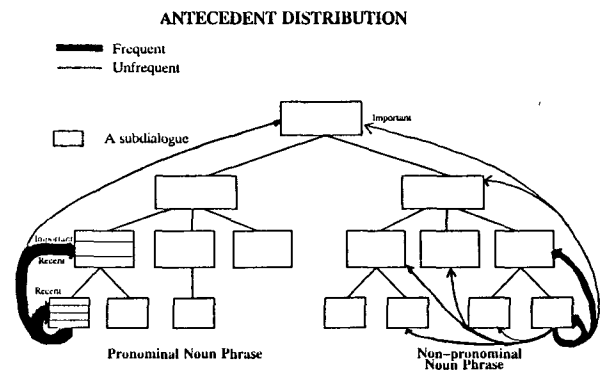

ANTECEDENT DISTRIBUTION

Figure 2: ANTECEDENT DISTRIBUTION

pronominal anaphors: most antecedents are located in the current subdialogue or in its immediate superordinate and a few antecedents co-specifying the main topic(s) of the dialogue are located at the root of the dialogue.

These data strongly suggest that recency plays a role within the current subdialogue, but also that another factor must be invoked to explain the high frequency of antecedents observed in N-1 and in the root subdialogue. This other factor is **topicality or importance** (Guindon, 1985; Kintsch and van Dijk, 1978).

A parent subdialogue describes information that is important to the information described in a subordinate subdialogue. Moreover, the antecedent *statistical package* was located at the "root" subdialogue of the dialogue structure. In other words, it was one of the most important concepts mentioned in the dialogue and because of its importance stayed in the user's and adviser's short-term memory during the complete dialogue and could be referred to by using a pronoun. The allocation of short-term memory during discourse comprehension corresponds to the concept of attentional state (Grosz and Sidner, 1985) and is described in more detail in Guindon (1985).

The task structure and the user's meta-plans correspond to the intentional structure described by Grosz and Sidner (1985). Note that the segmentation of the task into subtasks direct the segmentation of the dialogue into subdialogues and is also a determinant of focus shifts and the attentional state. The antecedent distribution for pronominal anaphors is consistent with the dialogue structure derived from the user's plans and goals and describe principled and psychologically valid constraints on the use of pronominal anaphors over an extended dialogue. As a consequence, the validity of the derived dialogue structure is increased.

Anaphoric - Non-pronominal Definite Noun Phrases

Selecting the proper antecedent for a non-pronominal definite noun phrase anaphor is less difficult than for pronominal anaphor since more semantic information is provided for matching the description of the antecedent. For this reason we would expect the distribution for antecedents of non-pronominal definite noun phrases to be far less constrained than the distribution for pronominal noun phrases. Figure 2 shows that this is the case. Definite noun phrase antecedents range over every dominant node N-1 through N-5 and over a few left-branching subordinate nodes. Nevertheless, there is a strong tendency for antecedents to be locally positioned in N and N-1. Their distribution is consistent with the derived dialogue structure on the basis of an analysis of the task and an analysis of the users' and adviser's plans and goals.

BOUNDARY MARKERS

The analysis of boundary markers revealed reliable indicators at the opening of subdialogues in adviser-user dialogues. This is shown in Table 3. The determined boundary markers were consistent with those found by Grosz (1977), Reichman (1981), and Polanyi and Scha (1983). The boundary markers can help identify three major types of subdialogues: 1) plan-goal statement; 2) clarification; 3) acknowledgement. Acknowledgement subdialogues occur very frequently at the end of clarification subdialogues, also acting as closing boundary markers for clarification subdialogues. A more detailed analysis of the boundary markers is given in Guindon, Sladky, Brunner, and Conner (1986).

A small subset of these markers for each type of discourse act is given in Table 3 (the symbol $<$ $>$ means optional, "or" is indicated as | ( ) ( ) |, and ACTION means an instance from a class of actions).

Subdialogue Types	Boundary Markers
[Plan-goal statement]	1. ...$<so>$... I | (want) (need) (have to) (am going to) (should) | ... 2. ...let's | (try) (do) | ... ACTION .... 3. ...I will ACTION....
Clarification	1. all types of interrogatives (e.g. How do I compute ..? What is a vector?) 2. negatives expressing lack of knowledge (e.g. ...I do not know...; ...I do not remember ...; ...I am not sure...) 3. declaratives expressing uncertainty (e.g. ...I assume that ...; ...it might be that ...)
Acknowledgement	1. discourse particles (e.g. OK, Allright; Good) 2. ...I |(see) (understand)|.... 3. repetition, restatement or elaboration of last adviser's utterance with clue words (e.g. In other words, ...; For instance ...)

Table 3: EXAMPLES OF BOUNDARY MARKERS

The boundary markers are part of the linguistic structure of dialogue, and so is the distribution of the non-pronominal and pronominal noun phrases. Both analyses are consistent with the derived dialogue structure on the basis of the task structure and the users' and adviser's plans and goals and they increase the validity of the derived dialogue structure. Both analyses also show that shifts in focus during discourse comprehension can be signalled in the surface form of the conversants' utterances. As a consequence, they can be capitalized upon by natural language interfaces.

CONCLUSION

Three independent converging analyses support the dialogue structure derived on the basis of the task structure and the users' and adviser's plans and goals. The distribution of the non-pronominal noun phrases shows that they occur more frequently at the beginning of subdialogues than later in the subdialogues, as should be expected if non-pronominal noun phrases introduce new entities in the dialogue or reinstate previous ones. The distribution of the pronominal noun phrases show that they occur less frequently in the first sentence than in the second sentence of the dialogue, as can be expected if they act as indicator of topic continuity. The distribution of pronominal antecedents shows that speakers are sensitive to the organization of a dialogue into a hierarchical structure composed of goal-oriented subdialogues. Antecedents of pronominal noun phrases tend to occur in the current subdialogue, in its parent, or in the root subdialogue. In particular, concepts mentioned in the current subdialogue, its parent, or in the root subdialogue tend to be in focus. In the case of non-pronominal definite noun phrase anaphors, while it is possible for antecedents to be much more widely spread across the dialogue, they also tend to be located in the current subdialogue or its parent. As a consequence, it would be possible to restrict and order the search for the antecedents of pronominal and non-pronominal definite noun phrases on the basis of the type of dialogue structure exemplified in this paper. The analysis of boundary markers reveals reliable and distinctive surface linguistic markers for different types of subdialogues.

The notion of a dialogue structure based on the task structure has been empirically supported. The notion of focusing and its relation to the segmentation of the dialogue into subdialogues has also been supported, especially by the antecedent distribution of the pronominal and non-pronominal noun phrases. The results of Guindon (1985) showing different anaphora resolution times for different types of anaphors with antecedent in or out of focus also support the "focusing" theories of anaphora resolution. This gives an impetus to include a model of the dialogue structure and a focusing mechanism in natural language interfaces. However, much further work has to be done to define precisely how the dialogue structure could be computed from the task structure and the meta-plans of the conversants and how precisely the anaphora resolution process would capitalize on this structure.

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