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ABSTRACT

Studies of natural dialogue indicate that people interact according to established patterns which are organized around the participants' goals. These patterns have been represented by a set of knowledge structures called "Dialogue-games" which are founded on conventional knowledge about communication and its uses to achieve goals. The "Parameters" of a Dialogue-game represent elements that vary across instances of a particular pattern, and the "Specifications" of these parameters represent the conditions which must be present for a particular Dialogue-game to be employed successfully. The "Components" are the expected sequence of intermediate states that occur during an instance of a particular conventional pattern. Representations of several Dialogue-games are presented, and a process model is discussed. (Author/WBC)

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Dialogue Games: Meta-communication Structures for Natural Language Interaction

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20. ABSTRACT

Our studies of naturally occurring human dialogue have led to the recognition of a new class of regularities which characterize important aspects of communication. People appear to interact regularly according to established patterns which span several turns in a dialogue and which recur frequently. These patterns appear to be organized around the goals which the dialogue serves for each participant. Many things which are said later in a dialogue can only be interpreted as pursuit of goals established earlier in the dialogue by goal-setting parts of these patterns.

These patterns have been represented by a set of knowledge structures called Dialogue-games, capturing shared conventional knowledge that people have about communication and how it can be used to achieve goals. A Dialogue-game has Parameters, which represent those elements that vary across instances of a particular pattern. The Parameters identify the particular dialogue participants and the content topic. The states of the world which must be in effect for a particular Dialogue-game to be employed successfully are represented by Specifications of these Parameters. Finally, the expected sequence of intermediate states that occur during instances of a particular conventional pattern are represented by the Components of the Dialogue-game.

This report describes a representation for several Dialogue-games, based on our analyses of different kinds of naturally occurring dialogue. A process model is described, showing Dialogue-game identification, pursuit, and termination as part of the comprehension of dialogue utterances. This Dialogue-game Model captures some of the important functional aspects of language, especially indirect uses to achieve implicit communication.

DIALOGUE-GAMES:

META-COMMUNICATION STRUCTURES FOR NATURAL LANGUAGE INTERACTION

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CONTENTS

ABSTRACT

Our studies of naturally occurring human dialogue have led to the recognition of a new class of regularities which characterize important aspects of communication. People appear to interact according to established patterns which span several turns in a dialogue and which recur frequently. These patterns appear to be organized around the goals which the dialogue serves for each participant. Many things which are said later in a dialogue can only be interpreted as pursuit of these goals, established earlier in the dialogue.

These patterns have been represented by a set of knowledge structures called ***Dialogue-games***, capturing shared conventional knowledge that people have about communication and how it can be used to achieve goals. A Dialogue-game has ***Parameters***, which represent those elements that vary across instances of a particular pattern - the particular dialogue participants and the content topic. The states of the world which must be in effect for a particular Dialogue-game to be employed successfully are represented by ***Specifications*** of these Parameters. Finally, the expected sequence of intermediate states that occur during instances of a particular conventional pattern are represented by the ***Components*** of the Dialogue-game.

Representations for several Dialogue-games are presented here, based on our analyses of different kinds of naturally occurring dialogue. A process model is discussed, showing Dialogue-game identification, pursuit, and termination as part of the comprehension of dialogue utterances. This Dialogue-game Model captures some of the important functional aspects of language, especially indirect uses to achieve implicit communication.

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1. INTRODUCTION

A pervasive aspect of natural language is the wealth of implicit communication accompanying even simple dialogues:

> Person 1: DO YOU HAVE A MATCH?
> Person 2: SORRY, I DON'T SMOKE.

This simple dialogue demonstrates that an immense amount of shared information is necessary for the communication to be effective. This example requires "world knowledge" of the following sort:

1) One is likely to possess matches if and only if one smokes.

2) The word "have" as used here is not simply ownership but also immediate access.

3) A match really is not required: anything that can perform the *function* of a match is satisfactory, such as a lighter, a lighted cigarette or any flame.

The example also requires knowledge of conventional reasons for certain behaviors:

If X is relatively inexpensive:

1) If I want you to give me X, I may ask you if you have X,

2) if you cannot provide X, you convey your apologies (even though there is no formal requirement for you to have X, or to give it to me even if you have it).

3) the reply probably terminates the interaction, since the initiating request has been denied.

It also relies on conventional knowledge of what response each can reasonably expect of the other:

If Z is relatively inexpensive:

If you know I want it, and if you have it, you may give it to me.

We have developed a model of dialogue comprehension, the Dialogue-games Model, that represents knowledge that people have about language and how it can be used to achieve their goals through interaction with other people. The model specifies the processes by which this knowledge is used to comprehend the utterances of another person. This processing infers what goals the other person could have for generating his utterance.

After looking at the current state of language comprehension research, we will present a detailed description of the Dialogue-games Model, covering both the representations for particular kinds of interactions, and the processes for using these knowledge structures in comprehension. Afterwards, we will discuss how this model addresses some of the important problems of language comprehension modeling.

2. PAST RESEARCH ON LANGUAGE COMPREHENSION

Most of the research into language comprehension has focused on the comprehension of single sentences or fragments of sentences. However some research has indicated the importance of the context created by surrounding sentences on the comprehension of an individual sentence. Much of this research has studied the comprehension of stories, starting with Bartlett (1932), who found that stories influenced the ability of subjects to recall the individual utterances within that story. In particular, he found that some sentences that did not make sense within the rest of the story were replaced in the recalls by other sentences that were similar in some ways, but differed so that they fit the story.

A similar result was found by Bransford and Johnson (1973), using "ambiguous stories". They generated stories, each of which could be interpreted in two widely different ways, and influenced the interpretation derived by subjects by giving each story one of two titles. For example, one story was titled either "Watching a peace march from the fortieth floor" or "A space trip to an inhabited planet". Most of the sentences in the story could be interpreted either way, but one sentence made sense only within one of these two interpretations. Subjects given one title were able to recall this sentence well, but those given the other title (with the incompatible interpretation) were not. Generally, these results indicate that knowledge spanning multiple sentences is involved in comprehending each individual sentence of a story. This multi-sentential knowledge is used to tie the comprehension of each sentence together, and any sentence which does not fit into this knowledge is not easily assimilated or remembered.

A specific model for the form of this multi-sentential knowledge is the "story schema", organized within a story grammar (Rumelhart, 1975). This model has been supported by the results of story recalls (Rumelhart, 1975; Thorndyke, 1977). Other similar kinds of theoretical constructs for organizing multiple sentences of stories have been proposed called: "frames" (Minsky, 1975; Charniak, 1975), "scripts" (Schank & Abelson, 1975), and "commonsense algorithms" (Rieger, 1975).

To account for the conduct and comprehension of dialogues, multi-sentential knowledge units have also been proposed by linguists and sociolinguists to explain certain kinds of regularities observed in naturally occurring dialogues. These regularities have been called "rules" by Labov & Fanshel (1974) and "sequences" by Sacks, Schegloff, & Jefferson (1974).

Once these multi-sentential knowledge units are evoked, they serve as a basis for comprehending the successive inputs. This is achieved by generating expectations and by providing a framework for integrating the comprehension of an utterance with that of its predecessors. Recently, we proposed (Levin & Moore, 1976) multi-sentential knowledge units that are specified primarily by the speaker's and hearer's goals. This differs from the other proposed multi-sentential units, some of which are specified only by co-occurrence properties, others by causal characteristics. These goal-oriented units, which we call Dialogue-games [1], specify the kinds of language interactions in which people engage, rather than the specific content of these interactions. People use language primarily to communicate with other people to achieve their own goals. The Dialogue-game multi-sentential structures were developed to represent this knowledge about language and how it can be used to achieve goals.

An important problem facing researchers in language comprehension is posed by sentences with which the speaker performs what philosophers of language have called "indirect speech acts" (Searle, 1969). The direct comprehension of these sentences fails to derive the main communicative effect. For example, declarative sentences can be used to seek information ("I need to know your social security number."); questions can be used to convey information ("Did you know that John and Harriet got married?") or to request an action ("Could you pass the salt?"). These kinds of utterances, which have been extensively analyzed by philosophers of language (Austin, 1962; Searle, 1969, 1975; Grice, 1975), are not handled satisfactorily by any of the current theories of the direct comprehension of language. However, these indirect language usages are widespread in naturally occurring language--even two year old children can comprehend indirect requests for action almost as well as direct requests (Shatz, 1975).

One theory proposed to account for these indirect uses of language is based on the concept of "conversational postulates" (Grice, 1975; Gordon & Lakoff, 1971). If the direct comprehension of an utterance is implausible, then the indirect meaning is derived using these postulates. Clark & Lucy (1975) formalized and tested this model, and found support for a three stage model (deriving the literal meaning, check its plausibility, and if implausible, deriving the "intended" meaning" from conversational rules).

In general, this approach to indirect speech acts is inference-based, depending on the application of conversational rules to infer the indirect meaning from the direct meaning and the context. A different approach has been proposed by Labov & Fanshel (1974) and by Levin & Moore (1976). Multi-sentential knowledge, organizing a segment of language interaction, can form the basis for deriving the indirect effect of utterance within the segment. For example, a multi-sentential structure for an information-seeking interaction can supply the appropriate context for interpreting the subsequent utterances to seek and then supply information. The inference-based approach requires one set of conversational rules for information requests, a different set of rules for answers to these requests, and a way to tie these two rule sets together. The Dialogue-game model postulates that there is but one knowledge structure for this kind of interaction, and leads to a model of three sets of cooperating processes for: (1) recognizing when this kind of interaction is proposed, (2) using this knowledge to comprehend utterances within its scope, and (3) identifying when the interaction is to be terminated.

---

[1] The term "Dialogue-game" was adopted by analogy from Wittgenstein's term "language game" (Wittgenstein, 1958). However, Dialogue-games represent knowledge people have about language as used to pursue goals, rather than Wittgenstein's more comprehensive notion. Although there are also similarities with other "games," the properties of Dialogue-games are only those described here. For example, they are not necessarily competitive, consciously pursued, or zero-sum.

3. THE DIALOGUE-GAME MODEL

This section describes our Dialogue-games model at its current state of development. In particular, we attempt to answer the following questions:

1. What is the knowledge we are representing within the definition of a particular Dialogue-game?

2. How is this knowledge used to model the receptive acts of dialogue participants?

3. What sort of machinery does it take to support this model?

3.1 An Overview of Dialogue-games

In our studies of naturally occurring dialogues, we have concentrated upon those regularities relating to the ***function*** of the dialogue for the participants, as distinct from its ***topic.***

We have examined a number of dialogues between a Link-user of a computer system (L) and the Operator of the computer (O). The following types of systematic interaction have been identified.

1. ***Helping***: L wants to solve a problem, and interacts with O in an attempt to arrive at a solution.

2. ***Action-seeking***: L wants some action performed and interacts with O to get him to perform it.

3. ***Information-seeking***: L wants to know some specific information, and interacts with O in order to learn it.

4. ***Information-probing***: L wants to know whether O knows some particular information, and interacts with him to find out.

5. ***Instructing***: L wants O to know some information, and interacts with him to impart the information.

6. ***Griping***: L is unhappy about some state of affairs, and interacts with O to convey that unhappiness.

This classification is certainly not a complete classification of all systematic types of interaction in the Link-user/Computer Operator dialogues. Rather, it is an initial attempt to delineate the nature of these stereotypical interactions. One point that is evident from this description is the importance of the goals of the participants in determining the type of interaction. In all of these interactions, one participant wants something, and initiates the dialogue in an attempt to achieve that goal. Furthermore, it appears to be the case that the other person cooperates with the dialogue only if he holds goals which will be served by such cooperation. The Dialogue-games model has been built to account for these and similar regularities and implicit elements of dialogue, and contains the following generalizations about language comprehension:

1. Part of the comprehension of any utterance is to associate particular functions with it, that is, to impute to the speaker that he is using the utterance as a means to accomplish one or more particular, identified goals which he holds.

2. The speaker ordinarily holds multiple goals, and these are related in highly constrained ways.

3. The goals held by the two participants of a dialogue are not independent but rather are closely related in ways which strongly and systematically constrain co-occurrence of goals.

4. These related sets of participants' goals underlie a significant amount of dialogue behavior and the knowledge of these recurrent goal patterns is essential for language comprehension.

5. People use their knowledge of goal structures in dialogue to effect implicit communication of various kinds, including the performance of indirect speech acts and the implicit communication of assumptions about each other.

Concerning particular communication structures, we also hold that

6. Changes of "topic" in dialogue are directly dependent upon changes in the participants' goal structures, and are accomplished as side effects of goal structure changes

7. Indirect communication, including indirect questions and requests, arises out of the part of language comprehension which associates functions with utterances.

3.2 Dialogue Sources

We are interested in representing regularities of naturally occurring dialogues. This goal separates us from other approaches for studying language comprehension, and requires different research methods.

Much of the recent work in language comprehension has worked on the comprehension of stories. This is especially true of those studies dealing with the comprehension of multiple sentences (Bartlett, 1932; Bransford & Johnson, 1973; Rumelhart, 1975; Thorndyke, 1977). The general approach used by these studies is to collect recalls of the original story, and to analyze these recalls for deletions, modifications, and intrusions. Stories have been used because they are well structured, especially in comparison to naturally occurring oral language. Sentences are usually grammatical in written stories, and some of the topic structuring is explicitly marked by paragraphing.

However, there are a number of problems with using stories for our studies. Our work investigates the role that a speaker's motivations play in structuring what he says. These motivations are particularly obscure for the "speaker" of a story - it is difficult to determine what the goals of Shakespeare were in writing Macbeth, for example. Another problem with using stories is that the writer generally reworks his "utterances" a number of times before they are communicated to his audience. A good writer tailors his sentences to serve multiple purposes--this makes for good literature, but also for a difficult subject for the study of language comprehension.

Thirdly, a number of recent studies have shown that speakers modify their speech to fit their hearers. There is a special language that mothers use when talking with infants, called "motherese" (Newport, 1976). Not only do adults modify their speech based on their knowledge of the person they are talking to, but even four-year-old children use different language when talking with two-year-olds than when talking with adults (Shatz & Gelman, 1973). Since the prime function of language is to communicate, this shouldn't be surprising. However, these results do indicate that, even at an early age, people have sophisticated knowledge about language and how it can be used, based on one's goals and one's knowledge of the other. It is more difficult to investigate these issues studying stories, because the nature of the hearer of a story is a diffuse audience of readers, rather than just one specific other.

Since we are interested in the importance of a speaker's goals on language use, and how these goals interact with the speaker's knowledge of his hearer, we have decided to study dialogues rather than stories. There are several approaches one can take to studying the comprehension of dialogue. For example, one can collect dialogues conducted within an artificial environment. This is the approach taken by Chapanis (1975), for example, who gave his subjects tasks to perform, and collected dialogues conducted over different kinds of communication channels. The problem with this kind of dialogue for our purposes again stems from the central importance of speaker goals in our studies. One of the general problems with an experimental situation is that subjects are asked to adopt artificial goals. Normally this isn't an important problem, but it does become critical in cases where the nature of the subject's goal is a central point of interest. In a situation where a person is asked to adopt a certain goal solely because he is a subject in a scientific experiment, there are problems with insuring that he has in fact adopted that goal in the same way as a person who has that goal naturally. The literature on experimenter effects (e.g., Rosenthal, 1974) shows the difficulty with precisely controlling the motivations of subjects. For this reason, we have decided to study naturally occurring dialogues.

In our previous work, we have analyzed a wide variety of dialogues, including transcripts of the Apollo 13 lunar mission, radio talk shows, and teaching interactions. However, the data we have relied upon most heavily are interactions between the users of the TENEX computer system and the system's operators. The TENEX system contains a mechanism (called the "LINK") through which two users of the system can directly communicate by typing on their terminals. Once a "LINK" is established, that which either participant types appears on both computer terminals. We have focussed our research on these LINK sources, because they are:

Natural. These dialogues are spontaneous, not part of an experiment. They are initiated by the participants for their own reasons.

Unbiased. These dialogues are completely unaffected by the goals of our research, since most of them were conducted before the research started.

Without non-verbal cues. The participants of these dialogues interacted only through typing on their respective computer terminals, and saw only what was typed by the other. Thus, no nonverbal cues were available (though the conversations were clearly successful).

Self-transcribed. The difficulty of transcribing voice interactions are avoided (capturing tone and stress patterns and problems in legibility), since these LINK transcripts are typed by the participants themselves in the course of conducting the dialogue.

We have a collection of over 1000 transcripts available to us. We have examined approximately 60 in some detail, and have found that they are sufficiently varied and complex to be of interest. Their goal-pursuit methods and structures appear to be of the same nature as those of the voice dialogue and face-to-face interactions we have examined.

3.3 What's in a Game?

A Dialogue-game consists of three parts: a set of ***Parameters***, the collection of ***Specifications*** that apply to these Parameters throughout the conduct of the game, and a partially ordered set of ***Components*** characterizing the dynamic aspects of the game.

For the balance of this section, we will elaborate on these three parts and exemplify these with an example of the Helping-game.

Bidding and Acceptance are entry operations which people use to enter Dialogue-games. Bidding accomplishes:

1. Identifying the game
2. Indicating the bidder's interest in pursuing the game
3. Identifying the Parameter configuration intended.

It is performed many different ways, often very briefly. It is typically the source of a great deal of implicit communication, since a brief bid can communicate all of the starting predicates of a game.

Acceptance is one of the typical responses to a Bid, and only acceptance leads to pursuit of the game. Acceptance accomplishes:

1. Recognition that a bid has been made
2. Satisfactory recognition of the particular game and Parameter values bid
3. Agreement to pursue the game

4. Assumption of the acceptor's role in the game.

Acceptance is often implicit, especially in relatively informal dialogue. It can be indicated by agreement or approval, or by beginning to pursue the game (i.e. . attempts to satisfy the goals). Alternatives to acceptance include rejection, negotiation and ignoring.

Bidding and acceptance appear to be part of game entry and termination for the Dialogue-games of ordinary adult dialogue. In the case of termination, there are three other alternatives: interruption and spontaneous termination, either by goal satisfaction or unconditional goal failure.

Parameters

Dialogue-games are intended to capture a certain collection of information, common across many dialogues. However, the particular individuals involved, and the subject of the dialogue may vary freely over dialogues described by the same Dialogue-game. To represent this, each Dialogue-game has a set of Parameters that take on specific values for each particular dialogues.

The dialogue types we have represented so far as Dialogue-games have required only three Parameters: the two participants involved (called "Roles"), and the subject of the dialogue (called "Topic").

Parameter Specifications

One of the major aspects distinguishing various types of dialogues is the set of goals held by the participants. Another such aspect is the individual knowledge states of the participants. We have found that for each type of dialogue, there is a corresponding set of descriptions which must hold for the goal and knowledge states of the participants, vis-a-vis each other and the subject. Within the formalism of the Dialogue-game, these are called the Parameter Specifications, and are represented by a collection of predicates on the Parameters.

We claim that these Specifications are known to the participants of the dialogue, and the requirement that they be satisfied during the conduct of a game is used by the participants to signal what game(s) they wish to conduct, recognize what game is being bid, decide how to respond to a bid, conduct the game once the bid is accepted and terminate the game when appropriate. These Specifications also provide the means with which to explain the implicit, but clearly successful, communication which accompanies any natural dialogue.

Examples and discussions of these Specifications will accompany the example of the Helping-game, below.

Components

The Parameter Specifications represent those aspects of a dialogue type that remain constant throughout the course of a dialogue of that type. We have also found that certain aspects change in systematic ways; these are represented in Dialogue-games as Components. In the Dialogue-games we have developed so far, the Components have been represented as a set of participants' subgoals, partially ordered in time.

Once a game has been, in effect, bid and accepted, the two participants each pursue the subgoals specified for their role in the Components of this game. These subgoals are mutually complementary -- each set facilitating the other. Furthermore, by the time the termination stage has been reached (subject to a few constraints) pursuit of the Component-specified subgoals will have assured satisfaction of the higher, initial goals of the participants, in service of which the game was initiated in the first place.

3.4 An Example Dialogue-game: HELPING

In this section, we will introduce our representational formalism by discussing in detail a representation of the helping interaction, in which one person helps another accomplish some task. First we will present the Helping Dialogue-game as it would be entered into our semantic network implementation, and then we will describe in detail both this DG and the underlying representational format. In the following discussion, the formal statements made to the system are underlined, and the messages printed by the computer system are *italicized.*

```
DEFINEDG ( HELPING )

The Parameters are:
>HELPEE HELPER TASK

The Parameter Specifications are:
>HELPEE ISA PERSON
>HELPEE WANTS (HELPEE PERFORM TASK)
>((HELPEE ABLE (HELPEE PERFORM TASK)) NOT)
>HELPEE PERMITTED (HELPEE PERFORM TASK)
>HELPER ISA PERSON
>HELPER WILLING (HELPER ENABLE (HELPEE PERFORM TASK))
>HELPER ABLE (HELPER ENABLE (HELPEE PERFORM TASK))
> )

The Components are:
>DS1: (HELPEE WANT (HELPER KNOW (HELPEE PERCEIVE ACTION/EXPECTED-1 PAST)))
>DS2: (HELPEE WANT (HELPER KNOW ((HELPEE PERCEIVE ACTION/EXPECTED-2 PAST) NOT)))
>TS: (((HELPER WANT (HELPEE KNOW ACTION/NEW)) AND
  ((HELPEE PERFORM ACTION/NEW) CAUSE ACTION/EXPECTED-2))
>((DS1 AND DS2) THEN TS)
> )
```

These statements are taken in by the DEFINEDG function and stored in a semantic network. This network consists of a set of nodes, interconnected by relations. Each of the Parameters are stored as nodes, each with a relation connecting them to the node for HELP, as shown graphically here:

```
HELPING
  |
  |--Parameter-->HELPEE
  |
  |--Parameter-->HELPER
  |
  |--Parameter-->TASK
```

HELPING Parameter Specifications

The Parameter Specifications are a set of predications on the Parameters. In our input formalism, the second element of an input clause is the name of the predicate for that clause, and all the other elements are arguments of that predicate. Thus, the clause ***(HELPEE PERFORM TASK)*** is stored as a particular instance of the predicate PERFORM, with HELPEE and TASK as arguments:

```
A0004
  |
  |--pred-->PERFORM
  |
  |--agent-->HELPEE
  |
  |--object-->TASK
```

An element of a clause may simply be a name of a node, or it may be an entire predicate itself. Some predicates take propositional arguments. For example, the clause ***HELPEE WANT (HELPEE PERFORM TASK)*** causes the following structure to be stored:

```
A0005
  |
  |--pred-->WANT
  |
  |--agent-->HELPEE
  |
  |--prop-->A0004
```

The Parameter Specification predicates create an interrelated structure with the Parameters nodes as central elements. This structure represents conventional knowledge about the participants and the topic of a helping interaction. The goal of the person seeking help is expressed by the WANT clause. Other clauses specify the participants' abilities (or inabilities) with respect to the task, and other properties of the participants. As we shall see later, this knowledge about the Parameters is used in several ways - to select a particular DG (shorthand for "Dialogue-game"), to initiate a DG, to generate expectations, and to terminate a DG. The set of Parameter Specifications represents the state of the world that has to hold throughout the course of a particular kind of interaction.

HELPING Components

Components represent those aspects of a kind of interaction which systematically change during the course of the interaction. Each Component clause creates a predicate structure that is tied to the DG node with a "Component" relation. The Components are often ordered in time, as is the case in the HELPING DG.

In the DEFINEDG function, names ending with a ":" are interpreted as the explicit name of the following predicate structure. So part of the structure created by the Component clauses of the HELPING DG is:

```
HELPING
   |
   |--Component-->DS1
   |
   |--Component-->DS2
   |
   |--Component-->TS
```

The Components of a DG specify a set of subgoals that if achieved, usually lead to the achievement of the higher level goals of the participants given in the Parameter Specifications. In the HELP DG, there are three Components, two of which are pursued together before the third is pursued. This captures the two stage nature of the helping interactions that we have studied - an initial "diagnosis" stage focusing on identifying what the problem is, and a "treatment" stage during which the helper provided the required assistance. We found this two stage nature in all the helping dialogues in which the request for help was not immediately rejected.

The two Components of the first stage specify a "context-violation" pattern we have found in our analysis of helping interactions. In this pattern, the help seeking participant lays out a completely normal set of actions taken and results observed, and then describes some violation of expectation that occurred. (Either some expected result which didn't occur, or some unexpected result which did occur.)

In an analysis of fourteen helping dialogues, we found a simple Context->Violation sequence in five cases, the Context->Violation->More Context sequence in three cases, and a compound Context->Violation->More context->Another violation sequence in two cases. In one case, the use described a context setting only, after which the operator asked him what his problem was. This "failure" to follow the Context-Violation pattern in fact is evidence for the pattern, since the Helper in this case guided the course of the dialogue back to the pattern. (There were, however, two cases that deviated from the Context-Violation pattern in a more serious manner - both described a desired end state, rather than a puzzling violation of expectation.)

Overview of Dialogue-game Processing

For an overview of how this representation of regularities of the helping interaction is involved in the comprehension of a dialogue, let us quickly run through a hand simulation of how it is used in comprehending a particular helping dialogue:

LINK FROM [L], TTY 47[2]

L
1.1 Are you there? Go ahead.

O
2.1 Yep, what's up?

L
3.1 Know anything about the TELNET SUBSYS? Go ahead.

O
4.1 Try me.

L
5.1 I just connected to [computer site name 1] via TELNET,
5.2 and tried the DIVERT.OUTPUT.STREAM.TO.FILE command.
5.3 Strange things happened. Esp., my TELNET typescript is "busy". Go ahead.

O
6.1 TELNET.TYPESCRIPT will always be busy until you do a RESET,
6.2 but when you do that, be careful not to EXP, since that is a temporary
6.3 file. Go ahead.

L
7.1 I see...it's not enough for me just to do a DISCONNECT? Go ahead.

O
8.1 Correct, is that the only problem?

L
9.1 No. Does the DIVERT.OUTPUT.TO.FILE work? Must the file exist
9.2 before I divert to it? Will the output also come to my TTY? Go ahead.

[eight more turns occur in this interaction]

After this dialogue is opened in turns 1 and 2, the question in turn 3 is interpreted by the Dialogue-game Model as a bid to engage in the Helping DG, since it can be seen as an

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2 TECHNICAL TERMS USED IN THE DIALOGUE

TELNET: A program for communicating with remote computers.
SUBSYS: a system program
TYPESCRIPT: A file containing a record of a user's interactions with a program
"BUSY": part of an error message when one tries to read a file that is open
RESET: a command that clears the system, closing any open files
EXP: a command, which deletes temporary files
DISCONNECT: a command that terminates one's connection to a remote computer
DIVERT.OUTPUT.STREAM.TO.FILE: a command which diverts the output stream of the program to a file
TTY: A computer terminal

attempt to establish the Operator as fitting the HELPER role in relation to the TASK of using the TELNET SUBSYS. Once this DG bid is accepted (turn 4), the Linker pursues in turn 5 the goals specified in the first two Components of the DG, first setting up a context in 5.1 and 5.2, then describing in 5.3 a violation of his expectations. Once these Component goals are achieved, the Operator pursues in turn 6 the goal specified in the third Component of the DG. Finally the Operator bids a termination to the overall Helping DG in turn 7, which in this dialogue is rejects by L, since he seeks additional help pursued in the remainder of the dialogue not shown here.

Although this has been a very sketchy view of how the Helping Dialogue-game is involved in comprehension, we will present a more detailed view later. However, even at this level of detail, there are several points of interest.

First, notice that there is an interaction involved, turns 3 and 4, just to get the Helping DG going. These two turns constitute themselves a simplier Dialogue-game, called Info-Seeking:

DEFINEDG (INFO-SEEK)

The Parameters are:
>SEEKER SOURCE INFO

The Parameter Specifications are:
>S1:((SEEKER KNOW INFO) NOT)
>S2:(SOURCE KNOW INFO)
>S3:(SEEKER WANTS S31:(SEEKER KNOW INFO))
>)

The Components are:
>((SEEKER WANTS (SOURCE KNOW S3))
THEN
(SOURCE WANTS S31))
>)

In this case, one Dialogue-game (INFO-SEEK DG) is being used to initiate another Dialogue-game (HELPING DG). This represents a phenomena described by sociologists as "pre-sequences" (Schegloff, 1968; Terasaki, 1976).

The importance of the Parameter Specifications of is brought out by comparing the Info-seek DG with a different kind of interaction we call Info-probe. In this interaction, a person requests information of another person that the first person already knows.

DEFINEDG (INFO-PROBE)

The Parameters are:
>PROBER PROBEE INFO

The Parameter Specifications are:
>S1:(PROBER KNOWS INFO)
>S2:(PROBER WANTS S21:(PROBER KNOW ((PROBEE KNOWS INFO) WHETHER)))

>S3:(PROBEE WANTS S21)
> }

The Components are:
>C1:(PROBER WANTS (PROBEE KNOW S2))
>C2:(PROBEE WANTS S21)
>C1 THEN C2
> }

Both of these DGs can be initiated by a simple question, and in that case must be distinguished from each other on the basis of their Parameter Specifications. We can tell whether a question is a "probe" question or a real question only if we know or can infer that the asker already knows the information being asked about. The comprehension of such a question within the Dialogue-game Model uses the Parameter Specifications to determine which of these Dialogue-games to evoke.

Each Dialogue-game can be seen as a problem solving operator, selected to accomplish some given high level goal (represented in the Parameter Specifications), and then specifying (through its Components) a set of subgoals to pursue. Given that human problem solving is often top-down and depth-first in its pursuit of goals (Newell & Simon, 1972), we would expect to see nested Dialogue-games. And since the topic content is a Parameter of Dialogue-games, we would expect to see topics to be nested. This topic structure occurs in most of the dialogues we have analyzed for topic (Mann, Carlisle, Moore, & Levin, 1977), and has been found by others analyzing dialogues (Deutsch, 1974).

However, the Dialogue-game Model by no means *requires* strict nesting. The Processors involved run concurrently and semi-autonomously, so that multiple peer goals can be pursued if they don't conflict. And in fact, in some dialogues that we have analyzed, strict nesting is violated, with the dialogue participants switching among several independent topics. For example, in one section of the Apollo-13 Air-to-ground voice transcript, the Lunar Module Pilot discusses with the Capsule Communicator on the ground his meal, while discussions of the availability of water and an ongoing report of an instrument's reading were suspended, being resumed afterwards without reintroduction. The topic of "water availability" started before the discussion of the instrument's reading, and also stopped before it stopped, thus giving a non-nesting topic structure.

3.5 Dialogue-games in Non-task-oriented Dialogues

So far, most of the naturally occurring dialogues we have studied have been task oriented, with the participants consciously involved in solving some problem. Are the Dialogue-game structures, with the associated goal oriented view of language, restricted to this special use of language?

Terasaki (1976) has analyzed a body of non-task-oriented dialogues, within the sociolinguistic viewpoint (cf. Sacks, Schegloff, & Jefferson, 1974). Focusing on the ways in which people announce news to other people, Terasaki found regularities very similar to those represented by the Dialogue-games Model. Although phrased in different terms, much of the structure she found can be represented as an Announcing Dialogue-game:

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DEFINEDG (ANNOUNCING)

The Parameters are:
>DELIVERER RECIPIENT NEWS

The Parameter Specifications are:
>DELIVERER KNOWS NEWS
>(RECIPIENT KNOWS NEWS) NOT)
>RECIPIENT WANTS (RECIPIENT KNOWS NEWS)
>S4:(DELIVERER WANTS S41:(DELIVERER KNOWS (RECIPIENT ASSESSMENT-OF NEWS)))
>)

The Components are:
>((DELIVERER WANTS (RECIPIENT KNOWS NEWS))
            THEN
 (RECIPIENT WANTS S41))
>)
```

Thus, Announcements are distinguished here from the simple delivery of news because of the second "assessment" Component. A simple example of this kind of announcement is given by Terasaki (1976):

1 D: Guess what=I haven't had a ***drink*** for eight days now.
2 R: Fan-tas-tic!"

The first turn delivers the report of the news, and the second consists of R's assessment of it.

Terasaki also found extensive uses of pre-announcement sequences, similar to the "pre" sequences mentioned previously. A small example of such a "pre" occurs in the example above: "Guess what". Many "pre" sequences are more extensive, often spanning several turns. But most of the example given in her analysis can be seen as Dialogue-games used to initiate the Announcement DG.

None of the instances of announcements given in the appendix of Terasaki's paper deal with task-oriented interaction, in which the participants are consciously involved in solving some problem. Yet she has found regularities in these interactions that fit directly into the Dialogue-games Model. This is evidence that Dialogue-games are characteristic of language use in general, rather than artifacts of specialized task-oriented interaction.

3.6 Dialogue-game Processing

In this section we describe the five stages of dialogue assimilation and detail the involvement of Dialogue-games with each stage: 1) nomination, 2) recognition, 3) instantiation, 4) conduct, and 5) termination.

Processing Environment

Our description of the model should be viewed as representing the changing cognitive state of one of the participants, throughout the course of the dialogue. The Dialogue Modelling System consists of a long-term memory (LTM), a workspace (WS), and a set of Processors that modify the contents of WS, contingent upon the contents of LTM and WS. LTM contains a representation of the knowledge that the particular dialogue participant being modelled brings to the dialogue before it starts. This includes knowledge about the world, relevant objects, processes, concepts, the cognitive state of his partner in dialogue, rules of inference and evidence, as well as linguistic knowledge: words and their semantic representation, case frames for verbs and predicates and, of course, the multi-turn language structures, the Dialogue-games.

WS is the volatile short-term memory of the model, containing all the partial and temporary results of processing. The contents of WS at any moment represent the model's state of comprehension and focus at that point. The Processors are autonomous specialists, operating independently and in parallel, to modify the entities in WS (called "activations"). These Processors are also influenced by the contents of WS, as well as by the knowledge in LTM. Thus, WS is the place in which these concurrently operating Processors interact with each other. This anarchistic control structure resembles that the HEARSAY system (Erman, Fennell, Lesser, & Reddy, 1973).

Nomination

When dialogue participants propose a new type of interaction, they do not consistently use any single word or phrase to name the desired type of interaction. Thus we cannot determine which Dialogue-game(s) represent the dialogue type, through a simple invocation by name (or any other pre-known collection of words or phrases). Instead the dialogue type is communicated by attempts to establish various entities as the values of the Parameters of the desired Dialogue-game. Thus, an utterance which is comprehended as associating an entity (a person or a concept) with a Parameter of a Dialogue-game suggests that Dialogue-game as a possibility for initiation.

The Dialogue-game Model has two ways in which these nominations of new Dialogue-games occur. One of the Processors of the model is a "spreading activation" (Collins & Loftus, 1975) system called Proteus (Levin, 1975). Proteus generates new activations in WS on the basis of relations in LTM from concepts that are already in WS. Proteus brings into focus concepts related to those already active. A collection of concepts in WS may lead to focusing on some aspect of a particular Dialogue-game, in this sense "nominating" it as a possible new Dialogue-game.

MATCH and DEDUCE are two of the model's Processors which operate in conjunction to generate new activations from existing ones, by means of finding and applying rule-like transformations. They operate through partial match and plausible inference techniques, and if they activate Parameters, then the Dialogue-game that contains those Parameters becomes nominated as a candidate Dialogue-game. Match and Deduce operate together as a kind of production systems (cf. Newell, 1973).

For example, from the input utterance:

"L: I tried to send a message to P at S and it didn't go."

the following two sequences of associations and inferences would result:

(1a) L tried to X.
(2a) L wanted to X.
(3a) L want to X.
(4a) HELPEE wants to do TASK.

(1b) It didn't go.
(2b) What L tried to do didn't work.
(3b) X didn't work.
(4b) L can't X.
(5b) L didn't know how to X.
(6b) HELPEE doesn't know how to do TASK.

(Where: L = HELPEE and X = do TASK = send a message to P at S.)

At this point, (4a) and (6b), since they are both Parameter Specifications for the Helping-game, cause the model to focus on this Dialogue-game, in effect nominating it as an organizing structure for the dialogue being initiated.

Recognition

The Processors described so far are reasonably unselective and may activate a number of possible Dialogue-games, some of which may be mutually incompatible or otherwise inappropriate. There is a Processor called the Dialogue-game Processor, which investigates each of the nominated Dialogue-games, verifying inferences based of the Parameter Specifications, and eliminating those Dialogue-games for which one or more Specifications are contradicted.

A second mechanism (part of Proteus) identifies those activations which are incompatible and sets about accumulating evidence in support of a decision to accept one and delete the rest from the WS.

For example, suppose the utterance:

How do I get RUNOFF to work?

leads to the nomination of two games:

Helping-game (person asking question wants to know answer)
and
Info-probe-game (person asking question wants to know if other knows answer)

These two Dialogue-games have a lot in common but differ in one crucial aspect: In the Helping-game, the questioner does not know the answer to the question, while in the Info-probe-game he does. These two predicates are represented in the Parameter Specifications of the two Dialogue-games, and upon the nomination of these Dialogue-games, are discovered to be contradictory. Proteus represents this discovery with a structure which has the effect of eliminating from WS the conflicting Dialogue-game for which there is the least supporting evidence. Such support might be, for example, either the knowledge that the speaker is the hearer's teacher or that he is a novice programmer (which would lend support for the choice of the Info-probe-game or Helping-game, respectively).

Through these processes, the number of candidate Dialogue-games is reduced until those remaining are compatible with each other and the knowledge currently in WS.

Instantiation

Once a proposed Dialogue-game has successfully survived the filtering processes described above, it is then instantiated by the Dialogue-game Processor. Those Parameter Specifications not previously known (represented in the WS) are established in the WS as new inferred knowledge about the Parameters. It is through these instantiation processes that a large part of the implicit communication between participants of the dialogue is modelled.

To illustrate this, suppose that the following are represented in WS (i.e., known):

SPEAKER does not know how to do a TASK.
SPEAKER wants to know how to do that TASK.
SPEAKER wants to do the TASK.

This would, presumably, be adequate to nominate the Helping-game. In the process of instantiating this Dialogue-game, the following predicates, derived from the Parameter Specifications, would be added to WS:

SPEAKER believes HEARER knows how to do TASK.
SPEAKER believes HEARER is able to tell him how to do TASK.
SPEAKER believes HEARER is willing to tell him how to do TASK.
SPEAKER wants HEARER to tell him how to do TASK.
SPEAKER expects HEARER to tell him how to do TASK.

The model predicts that these predicates are implicitly communicated by an utterance which succeeds in instantiating the Helping-game. This would correspond to a dialogue in which "I can't get this thing to work" is taken to be a request for help (which on the surface it is not.

Conduct

Once a Dialogue-game is instantiated, the Dialogue-games Processor is guided by its Components in comprehending the rest of the dialogue. For the speaker, these goals guide what he is next to say; for the hearer, these provide expectations for the functions to be served by the speaker's next utterances.

As we will see in more detail later, these "tactical" goals are central to our theory of language: an utterance is not deemed to be comprehended until some direct consequence of it is seen as serving a goal imputed to the speaker. Furthermore, although the goals of the Components are active only within the conduct of a particular game, they are so constituted that their pursuit satisfies the goals described in the Parameter Specifications which were held by the participants prior to the evocation of the Dialogue-game.

In the case of the Helping-game, the goals in the "diagnostic" phase are that the HELPEE describe a sequence of related, unexceptional events leading up to a failure of his expectations. These model the state of the HELPER as he assimilates this initial part of the dialogue, both in that he knows how the HELPEE is attempting to describe his problem, and also that the HELPER knows when this phase is past, and the time has come (the "treatment" phase) for him to provide the help which has been implicitly requested.

Termination

The processes described above model the identification and pursuit of Dialogue-games. How, then, are they terminated? As we said previously, the Parameter Specifications represent those aspects of dialogues that are constant over that particular type of dialogue. The Dialogue-games model pushes this a step further in representing that the dialogue type continues *only as long as* the Parameter Specifications are perceived to hold by both participants. Whenever any predicate in the Specification ceases to hold, then the model predicts the impending termination of this Dialogue-game.

For example, if the HELPEE no longer wants to perform the TASK (either by accomplishing it or by abandoning that goal), then the Helping Dialogue-game terminates. If the HELPER becomes unwilling to give help, or discovers that he is unable, then the Helping-game also terminates.

4. DIALOGUE-GAMES AND COMPREHENSION ISSUES

Now that we've introduced the Dialogue-game Model, with representations for several Dialogue-games and a description of the Processors for using them in comprehension, let us consider again some of the issues addressed by this model.

What are the functions served by of these multi-sentential structures? In some ways, adding levels of structure just seems to complicate the comprehension process. However, the Dialogue-game structures, add a number of important characteristics to a comprehension models. Given that a Dialogue-game has been identified, the number of utterances that have to be generated to successfully communicate is reduced - thus Dialogue-games allow more abbreviated communication. Conversely, a fewer number of utterances have to be comprehended to understand sufficiently what is being communicated, thus gives the comprehension model the ability to function when given "noisy" input, like most naturally occurring dialogue. In general, multi-sentential structures like Dialogue-games allow the comprehension processes to generate expectation of what will occur, which can be used by lower level comprehension processes to resolve ambiguities, for example. They provide a basis for focusing lower level comprehension processes. Some of the earlier comprehension models had a problem with the unlimited, undirected inferences that the model could make. For example, the inference part of the MARGIE system (Rieger, 1975) was faced with this problem.

The Dialogue-game structures provide a basis for directing inferences in a particular direction. As a part of the larger theoretical view of language as a problem solving mechanism (Moore, Levin, & Mann, 1977), Dialogue-games provide the knowledge to focus the comprehension process in the direction of determining what goals the speaker is pursuing by saying each utterance.

A Goal-Oriented View of Language

The usual approaches to language comprehension treat the problem as one of decoding the words of utterances, building some abstract representation that encompasses the surface words. Even the most advanced language comprehension systems build a representation of what has been called the "propositional" content of the utterances processed. Recently, philosophers of language (Austin, 1962; Searle, 1969; Grice, 1975) have focussed on the functional aspects of language. People use language not merely to convey information, but also to make promises, to give orders, to do things beyond the scope of the propositional content of what they say.

Our approach to language builds upon this functional view. When attempting to understand people's behavior, it has been fruitful to view them as goal pursuing organisms. This approach dominates the studies of human problem solving (Newell & Simon, 1972). We have extended this view to the study of human language behavior. In this view, people use language as a way of pursuing goals that they currently hold. When a person generates an utterance directed at a particular other, the choice of what to say (and who to say it to) is primarily determined by how likely the utterance is to further goals of the speaker if directed toward the particular other person.

Our research has so far studied comprehension, not generation, so we haven't dealt with the issues of selecting utterances that are most likely to achieve some given set of goals. But this same view of language is also valuable for studying comprehension. If language is used by people to achieve goals, then the identification of the speaker's goals motivating his utterances becomes a central focus for comprehension.

In fact, inherent in the Dialogue-game Model is a Meta-goal of comprehension: *To comprehend an utterance is to find some previously known goal of the speaker which this utterance can be seen as furthering.* This Comprehension Meta-goal is used in the Model in two different ways to handle the problem that language comprehension systems have with the explosion of possible inferences. Given a powerful inference mechanism and a large database, a language comprehension system can make an unbounded set of inferences about a given utterance. For example, the MARGIE system (Schank, Goldman, Rieger, & Riesbeck, 1974) ran into this problem, since its inference making Component (Rieger, 1975) had the capability of making a large number of inferences without having a good basis for stopping.

The first way in which the new goal-oriented view of language helps solve this problem is that it suggests a "Stopping Rule" for Comprehension: : *Continue processing an utterance until the system infers that the utterance serves a goal that is known to be held by the speaker.*[3] In some cases, this Stopping Rule will be satisfied relatively soon, so only a minimal amount of processing will have to be spent in comprehending the given utterance. In other cases, if a goal for the utterance is not immediately obvious, then processing will continue until one is found, serving as some more indirect use of language.

The Meta-goal of comprehension also helps limit the explosion of inferences by providing a focus to comprehension processing, favoring inferences which look for possible goals over other inferences. This focusing of effort is implicit in the Dialogue-games Model, since the Dialogue-games themselves serve to concentrate processing on goal-oriented aspects. Knowledge of participant goals is a central part of the Dialogue-games, and the processing flows through these goals, activating other goals in turn. These multi-utterance knowledge structures serve as a systematic basis for generating likely goals and subgoals for the speaker. Given the context of an interconnected set of goals (many of which were generated by Dialogue-games), then it is much easier to find a goal that a given utterance can be inferred as serving.

Indirect Uses of Language

As has been pointed out by the philosophers of language (Austin, 1962; Searle, 1969, 1975), not only do people do things with words, but they also indirectly do things with words. People make requests with declarative statements, give orders with interrogative statements, make promises with assertions, etc. For example, in one of our Link dialogues, the following interaction occurs:

L: Do you know the system clock is an hour fast?
O: Thanks. I didn't reset it.

Although phrased as a question, the Linker's utterance is functioning instead as an announcement to the Operator. If the Operator were to comprehend only the direct usage of the Linker's statement, the Linker would be surprised and either upset, or perhaps

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[3] This "Stopping Rule" for comprehension was originated by William C. Mann, and further developed in our discussions with him.

amused ("O: Could you hum a few bars?"). Similarly, in another Link dialogue:

L: We would like to unarchive tapes 1120 and 1121. ...

O: OK but you'll have to give me those names again. ...

the declarative statement is interpreted as a request for action by the Operator, rather than simply as a direct assertion by the Linker of his likes or dislikes.

Currently, the best model of how these indirect uses of language function is Speech Act Theory (Searle, 1969; Grice, 1975). Within this theory, utterances are seen as having both a propositional Component and a speech act Component. The propositional part encompasses the reference and predication aspects that theories of language have concentrated on in the past. The speech act Component of an utterance specifies how the utterance is being *used* by the speaker - to declare, to inquire, to promise, to order, to suggest, etc. Speech acts have felicity conditions, which must hold for the act to be performed sincerely. The indirect uses of language described previously are called "indirect speech acts" (Searle, 1975).

The Dialogue-game Model deals with these indirect uses of language in several ways. The most common case is the use of one Dialogue-game interaction in order to initiate another DG. The example given at the very beginning "Do you have a match?" is a case of this "initiation indirect speech". These indirect uses have the function of establishing the Parameters of the second DG.

Examples of indirect requests for information are:

Assertions of the speaker's own lack of knowledge
Questions about the other person's knowledge
Assertions about the speaker's own desires for the information
Questions about the other person's willingness to supply the information

Any utterance which will serve to establish the Parameters of the Info-seek DG can serve an an indirect request.

A second indirect use of language is that intended to terminate an ongoing Dialogue-game. A Dialogue-game can continue only as long as its Parameter Specifications are known to hold. So any utterance which is intended to establish that some Parameter Specification of an ongoing DG no longer holds will have the indirect function of terminating that Dialogue-game. So a statement in a Link dialogue:

L: Thank you for solving my problem. ...

not only serves as a thanks giving statement, but also as a bid for termination of the ongoing Helping DG, since it makes it clear to the Operator that the Linker has become *able* to do the Task. These "termination indirect speech" utterances are often used to break off an interaction - for instance, the traditional "Its getting late and we really must go" serves not only as an assertion of fact and obligation, but also indirectly as a bid for terminating a visit.

A third, and somewhat less obvious, indirect use of language encompasses by the Dialogue-game Model is the set of "pursuit indirect speech" utterances. THese are utterance which fulfill one Component goal of an on-going Dialogue-game, thus generating an expectation that the next Component will be pursued. For example, in the Helping DG, an utterance which accomplishes the first stage of diagnosing the problem will generate the expectation that the Helper communicate to the Helpee a solution for the problem. Thus, the utterance will serve indirectly as a request for the needed information.

Dialogue-games and Speech Acts

There are a number of similarities between Dialogue-games and Speech Acts as they are currently conceived. They both specify ways of interpreting individual utterances, depending both on the words of the utterance and on the context in which the utterance occurs. They both depend on knowledge of the dialogue participants, especially in relation to the content topic of the interaction.

However, Speech Acts are unilateral actions, while Dialogue-games are bi-lateral. A Dialogue-game by definition involves an interaction between two people, and encompasses multiple utterances and turns of a dialogue. Speech acts generally refer to a single utterance. Much of the complexity of existing Speech Act theory, with its proliferation of types of Speech Acts, can be simplified by reconceptualizing Speech Acts as very simple and few in number, operating within the framework of multi-utterance structures like Dialogue-games. This modified view of Speech Act theory is described by Heringer (1977).

5. SUMMARY

We have presented here a model for Dialogue-games, structures spanning multiple utterance, capturing common knowledge about language and how it is used to achieve goals. A number of representations for particular types of interaction have been described, based on our analyses of naturally occurring dialogues. These structures, along with the set of processes presented here for using them in comprehension, have proven valuable for dealing with some previously puzzling problems in studies of human language use, particularly, ways in which language can be used indirectly. This Dialogue-games Model illustrates the utility of a goal-oriented view of language, a promising new approach to the study of language.

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