Progress Report 3 on the BBN Group

of the Center for the Study of Reading

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Principal Investigator: Bertram Bruce
Report Editor: Brenda J. Starr

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1. Introduction

In August of 1976 the National Institute of Education established the Center for the Study of Reading as "a major national resource for producing and applying knowledge about reading." The contract for the Center was awarded to the University of Illinois at Urbana/Champaign with a subcontract to Bolt Beranek and Newman Inc. (BBN). Richard C. Anderson and William S. Hall are Co-Directors of the Center itself; Bertram Bruce is Principal Investigator for the BBN group. This report summarizes BBN's research activities for the Center since April 1979.

Purpose

Research in reading has traditionally focused on the process of decoding written symbols. As a result, much has been learned about visual feature detection and the recognition of letters and words. But reading is obviously more than just word recognition. Because of fundamental differences between oral and written language experiences, the addition of decoding skills to those required for ordinary oral communication is not sufficient to support proficient reading. If we are to understand the difficulties that some people have with reading (and writing), we must look at the entire process of written communication, including, but not limiting ourselves to, studies of decoding.

In particular, we need to consider issues such as the social organization of written communication, the relationships among different modes of communication, the cognitive demands of different linguistic structures and text contents, the effects of cultural differences between reader and writer or between student and teacher, and the relation between purpose and cognitive processing. The contribution of these and similar factors can never be fully analyzed, but recent work in artificial intelligence, linguistics, cognitive psychology, social psychology, and developmental psychology suggests some new approaches. This recent work has been loosely clustered under the name "cognitive science".

Using the techniques of cognitive science we are attempting to gain a better understanding of the processes of written language comprehension. We are also working on translating that

understanding into knowledge that will make a difference in the home or classroom. The next section highlights some of our research results.

Highlights

Our research has produced results that run the spectrum from advances in theories of language or meaning to tangible devices that have been used in schools. The most exciting results are those which broaden our understanding of reading comprehension in a way that leads directly to guidelines, techniques, curricula, or devices for education. In this section we highlight a few such results. For details in any of these areas the reader should turn to Section 3 (Current Research Activities) or to publications (see Sections 6 and 7).

- Our analysis of the cognitive demands of different modes of communication has led to a taxonomy of "language experiences". This in turn is suggesting new ways to introduce children to reading that will help them to understand the purpose of reading and to acquire necessary skills without being overwhelmed by the task demands (Sections 3.1, 3.2, 3.7, 3.12, 3.16).
- Our work on text characteristics and our experimental and theoretical work on language comprehension are producing a definition of "conceptual readability", which can provide better criteria for selecting texts for children or diagnosing comprehension problems. In addition, it will give us a better understanding of what is lost and what is gained when we design texts to teach specific sub-skills (Sections 3.3, 3.4, 3.9, 3.11).
- Our work on the relation of reader's beliefs to author's beliefs suggests better ways of selecting and designing texts for specific reader populations. Furthermore, it implicates new dimensions along which the cultural bias of texts and tasks ought to be evaluated. In addition, it suggests new ways of working with children who are having difficulty in comprehending what they read (Sections 3.4, 3.5, 3.6, 3.8).
- Through our text analysis work, we have identified ways in which the packaging of textual information affect its coherence. From this work, we have defined issues to consider in adapting texts for special reading needs (e.g., beginning readers, second language groups, hearing-impaired readers). This has led, for example, to work with WGBH-TV on guidelines for writing captions for television for hearing-impaired viewers (Sections 3.3, 3.6, 3.9, 3.11, 3.12).
- Through the combination of text analysis, conversational analysis and experimental work, we have identified a number of distinct differences in the syntactic structures typically used in written and informal oral language. We have also identified aspects of syntactic knowledge that vary systematically with age or amount of schooling. This work is helping us to identify reading comprehension difficulties that may be specifically related to syntactic properties of formal text, to identify aspects of syntactic structure that should be explicitly taught to beginning readers, and to develop metrics for syntactic dimensions of readability (Sections 3.1, 3.2, 3.9, 3.11).
- Through our study of the relationship of writing to reading, we have identified ways in which both activities are often distorted by the way they are typically presented to children. We have designed an educational activity called the *Story Maker* which addresses this problem. It is being made available to teachers in both a pegboard and a computer version via articles in teacher publications, workshops and conferences (Section 3.16).

- Through our work on metacognition, we have identified strategies that good readers use to guide and monitor their comprehension processes. This has led to the design of new curriculum units to aid poor readers in developing similar strategies (Sections 3.10, 3.13).
- Our research on plans and speech acts at a highly theoretical level has been coupled with analyses of children's reading problems (often in one-to-one tutoring situations) to guide the development of educational activities and games on small personal computers. We hope that our efforts will ensure that the new media of personal computers will incorporate what is now being learned about communication and reading (Sections 3.1, 3.3, 3.7).
- Our study of the knowledge and skills needed for reading comprehension has led us to question the view that equates reading comprehension skills with decoding skills plus oral language skills. This work has led to critical evaluations of standardized tests and a richer perspective on cross-cultural differences in reading performance (Sections 3.1, 3.5, 3.8).
- Our research on decoding and word recognition skills in the context of reading comprehension has led to new perspectives on the relationship between "disability" and normal difficulty in reading. This research has suggested better ways to identify and remediate problem readers (Section 3.14).
- The work we have done on "interactive" models of reading has led to a better understanding of the relationship of bottom-up and top-down aspects of reading. A product of this understanding has been the development of a diagnostic test. Because the results of the test are defined with respect to proficiency with basic skills, rather than ad hoc curriculum goals or the performance of some normative group, they are, in effect, prescriptive of the remedial work from which each individual child might profit most (Sections 3.14, 3.15).

2. Project Organization

General Organization

The Center for the Study of Reading is a joint project between the University of Illinois at Urbana-Champaign and Bolt Beranek and Newman Inc. (BBN), with the larger portion of the effort at the University of Illinois. In some cases, research at BBN is somewhat independent of the work at the University of Illinois; in many cases there is closer collaboration than that usually found within a university department. In general, goals of the project, research activities and dissemination efforts have been closely coordinated.

At BBN, Bertram Bruce is the Principal Investigator. He also serves as an Associate Director for the Center as a whole, helping in particular to coordinate work of the two groups. Brenda Starr is the Project Coordinator at BBN and has primary responsibility for report editing, computer use, liaison with the University of Illinois, and liaison with schools.

Inter-site Collaboration

Close collaboration between BBN and the University of Illinois has been a marked success for the Center for the Study of Reading. Areas such as analysis of communication in different modalities, cultural variation and minority issues, readability, analysis of stories, and metacognition have most benefited from the interactive efforts. In general, the collaboration has occurred by the usual means of telephone, mail and occasional meetings either at one of the two sites or at conferences. However, we have employed a number of special mechanisms to further the interactions, such as a computer message system for transmitting messages and papers in progress.

We have also had several workshops or small conferences at both BBN and the University of Illinois. Finally, during the past year Mark Seidenberg of the University of Illinois has spent considerable time working at BBN, while Phil Cohen of BBN has spent a large part of his time at the University of Illinois. These inter-site working arrangements have greatly furthered collaboration between BBN and the University of Illinois.

Relation to Other Projects at BBN

There is some concordance between the objectives of the Center for the Study of Reading and other projects at BBN. To the extent that such concordance exists it can work to the advantage of both projects. Many of the Center's personnel are partially supported by other projects, and the Center benefits from close coordination between their work for the Center and their work for related projects. In particular, some of the work described in the report was also funded through the National Institute of Child Health and Human Development (Section 3.14), and the Office of Naval Research (Sections 3.13 and 3.15).

Personnel

The research interests of the primary investigators at the BBN part of the Center for the Study of Reading are summarized here:

- Marilyn Jager Adams is studying developmental aspects of reading comprehension, with special emphasis on children's awareness, and use of various ways in which the meaning of written text is clued by structural devices.
- Bertram Bruce is Principal Investigator for the BBN part of the Center for the Study of Reading. He is working on problems of comprehension in oral and written language from the perspective of computational models. Much of his work is focused on the role of goals and beliefs in the understanding of stories and dialogues.
- Philip R. Cohen is concerned with the pragmatic problems a child must solve in comprehending text. In exploring differences between oral, written, and "intermediate" modes of communication, he has been attempting to apply theoretical work on speech acts and plans to natural dialogues.
- Allan Collins is developing reading and writing activities for children that can be implemented on small computers for use in the home or school. He is also analyzing people's strategies in reading and writing.
- Dedre Gentner is conducting research in cognitive processes including representation of meaning and natural language understanding. Specific topics she addresses are acquisition of meaning; representation of meaning; processes of comprehension; processes in writing; metaphoric processing and development of metaphor; and the uses of analogical models in learning.
- Andee Rubin is interested in determining the impact of the differences between oral and written language on the process of learning to read and in developing classroom activities which help bridge the gap.
- Ed Smith is conducting research in cognitive processes including perceptual, memory, and comprehension processes in reading, and is currently applying schema-theoretical notions to an analysis of reading.
- Brenda Starr is Project Coordinator for the BBN part of the Center for the Study of Reading. She has participated in research on problems of testing, decoding and word recognition.

- Kathleen Starr has been involved in analyzing and comparing texts used to teach reading in schools and children's books produced for the commercial market.
- Cindy Steinberg is interested in the formulation of a model for the rhetorical structure of narrative and its application to problems in reading comprehension and to the design of textual materials for children.
- Others at BBN who have contributed to the work of the project in the past year include: Scott Fertig, John Frederiksen, Joan Hirschkorn, A. W. F. Huggins, Cindy Hunt, Aleida Inglis, Phil Kohn, Kathy Larkin, Daryle Lewis, Adam Malamy, Denis Newman, Raymond S. Nickerson, Martin Ringle, Mark Seidenberg, and Roger Wallach.

Methodology

Research on reading comprehension requires new methodologies and wise use of existing approaches. It is unlikely that any single approach will be successful, particularly one tied to a single discipline. For example, a computer program that could read stories and answer difficult questions about them might be an achievement in the field of artificial intelligence, but would not necessarily answer any fundamental questions about reading. On the other hand, the analysis that enables one to implement a coherent and robust theory on a computer can be invaluable for giving structure to ideas. Among the approaches we are using to study reading are the following:

- Formal experiments: We are conducting experiments on reading comprehension and language understanding, using as subjects both children and adults.
- Conversation analysis: We are studying children's conversations as a means of assessing their ability to produce and comprehend spoken language. Conversational skills are being compared with written language skills.
- Text Analysis: We are examining texts used in schools now and in the past as well as texts encountered outside of school. We hope to arrive at a better understanding of what makes texts difficult, interesting, or conducive to the development of reading skills.
- Computer representation: We are using representation conventions and techniques from artificial intelligence in building theories about the processes of reading.
- Protocol analysis: We are gathering and studying protocols of both children and adults as they reason about things they read. Analyses of these protocols often generate hypotheses about underlying reading problems.
- Consulting teachers: We are drawing on the experience of elementary and junior high school teachers and specialists in remedial reading and learning disabilities.
- Tutoring: We are applying our ideas about reading in public and private schools and tutoring programs. Members of the Center have tutored children in all grades from K through 8, individually and in small groups.[1]

Computers and Reading Research

One of the questions frequently asked about the BBN part of the Center for the Study of Reading is whether our work is primarily concerned with computer modeling of reading comprehension or other computer work. The question is a natural one, given BBN's work in

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[1] We are indebted to the following organizations for allowing us to attempt the leap from theory to practice: Cambridge School Volunteers; Abraham Lincoln School (Cambridge School System); Fitzgerald School (Cambridge School System); Cambridge Friends' School.

Artificial Intelligence and its extensive computer facilities. The answer is that most of our work could be done, perhaps less effectively, without computers. On the other hand, computers have played important and diverse roles in our research. In this section we enumerate a few of them.

- *Educational games and activities.* We have viewed the computer as an educational medium that may someday rival the textbook or chalkboard. Using research results, we are developing educational games and activities for computers from the Apple to the DEC PDP-20. This effort is discussed in Sections 3.7 and 3.16.
- *Effects of technology.* The influence of computers on education both inside and outside of schools warrants a study in itself. Part of our work has involved critical studies of the properties and effects of computers. For example, one of the modalities included in our studies of communication in different modalities (see Section 3.1) is written communication over linked computer terminals. We are also looking critically at the impact of computers on education.
- *Computer models.* One of our important uses of computers has been as a vehicle for models of aspects of the reading comprehension process. We have developed models that either have been or could easily be implemented on a computer for aspects of language use such as the generation of speech acts (Cohen & Perrault, 1979), syllable identification (Adams, in press), derivation of antecedents and referents for discourse anaphora (Webber, 1978), semantic integration (Gentner, 1978), and story understanding (Bruce & Newman, 1978; Bruce, in press-a). Development of these models has forced us to be more explicit about theoretical assumptions and has helped to illuminate the strengths and limitations of specific theories (see Sections 3.1, 3.3, 3.9).
- *The computer as metaphor.* In a number of cases, theories that we have developed have not been brought to the level of specificity necessary for a computer implementation, but have still been influenced by the computer metaphor. Notions implicit in computer modeling, such as explicit representation of knowledge and the need for well-defined procedures or algorithms have furthered the development of theories, even where there was no plan to implement a computer model. Examples of this can be seen in our work on writing (Bruce, Collins, Rubin, & Gentner, in press; Collins & Gentner, in press) and on inference (Collins, Brown, & Larkin, in press).
- *Research assistance.* We have also made extensive use of the computer in some more traditional ways, especially as an aid to experimentation. Computers have been used for data gathering, data analysis and data presentation (e.g., plotting programs).
- *Document preparation.* The computer has also been a major aid in document preparation, simplifying such tasks as editing, formatting, and spelling correction.
- *Bibliography.* We are building and maintaining a computer-based bibliography which currently has about two thousand entries. The bibliography permits extraction on the basis of search keys attached to each entry.
- *Readability program.* We have written and are using a program which applies readability formulas to texts (see Section 3.11). Currently the program embodies the Fog, the Dale-Chall, and the Spache formulas, but it is relatively easy to add any new formula as long as it is based on factors such as sentence length, syllable counts, or presence of words on special word lists.
- *Dissemination.* We have also computerized our mailing list for document dissemination. The list includes both practitioners and researchers in related fields. Use of the computer

expedites mailing and up-dating routines, and has enabled us to "tag" entries for areas of interest.

- *Message system*. Finally, we have made extensive use of computer message systems, principally the BBN-HERMES system. This has facilitated interactions between researchers at BBN and those at the University of Illinois, among BBN people, and between BBN researchers and outside groups, e.g., the WGBH-TV Caption Center (see Section 3.12).

3. Current Research Activities

The Center for the Study of Reading at BBN is currently focusing on a variety of areas including dependencies of discourse structure on modality, developmental studies of oral conversation in relation to written text, story structure, rhetorical structure and the author-reader relationship, background knowledge, comparative analysis of stories for children, educational games and activities, cultural variation and reading comprehension, comprehension of sentence meaning, metacognition, readability, TV captioning for the deaf, teaching strategies, word recognition, interactions between bottom-up and top-down aspects of reading, and writing and its relationship to reading. Each of the following sections briefly describes our past and present work in a particular area, demonstrates its role in reading comprehension, discusses future work needed in the area and considers how the research might affect classroom practice.

3. 1 Dependencies of Discourse Structure on Modality

Traditionally, researchers have regarded reading comprehension as a process of decoding text to a "speech equivalent" representation followed by a process of oral language comprehension. While the simplistic nature of this "equation" is now commonly recognized, little research has addressed just how communication differs across modalities. This study is directed at uncovering structural and pragmatic differences among language experiences. Our position is that language is always situated. It is produced by an author or speaker with various communicative, educational, or entertainment purposes, with the expectation that it will be interpreted by a listener or reader who tries to understand that set of purposes. In short, authentic text is as much an instance of the social action of communicating (Bruce, in press-c) as is face-to-face conversation. The purpose of our work is to investigate differences in the way in which the communicative contract is achieved in the two modalities.

Children approach the task of learning to read with varying degrees of knowledge about the pragmatics and functions of text. Children who have been exposed to different types and uses of text at home, may come prepared with a fair appreciation of what reading is all about. Others may find text, and especially basal readers, to be alien territory.

We suspect that, for many young readers, the communicative functions of text are not perceived. Rather, for them the reading of text amounts to a decoding game. This should not be surprising inasmuch as a major goal for the author of a basal reader is precisely that of developing students' decoding skills. On the other hand, it must be appreciated that language-as-a-decoding-exercise will not only be foreign with respect to many children's previous communication experiences but, further, is orthogonal to the communication experiences for which it is meant to prepare them.

True comprehension of history books, recipes, editorials, math problems or stories depends critically on the reader's sensitivity to the content and rhetorical purpose of the author's statements. The work we have undertaken is a first step toward discovering ways of helping the young reader to

acquire the knowledge and strategies that must underlie such sensitivity. Specifically, we are trying to identify the dependencies of discourse structure on modality.

Our study builds upon Rubin's (in press) analysis of language experiences. Rubin has classified language experiences in terms of their characteristic values on several dimensions such as interaction, spatial or temporal setting, and concreteness or mutual familiarity of referents. Face-to-face conversations are seen to lie at one extreme within this "communication space." They are, by definition, interactive; the speaker and listener share a single spatio-temporal setting; and the topics are typically concrete and familiar to both parties. Formal text is, in contrast, seen to lie at the opposite extreme. The author and the reader of formal text are typically unknown to one another; they may be greatly removed from each other in space and time; excepting occasional pictures, the referents of the discourse will rarely be concrete; and, of course, there is no real possibility for interaction.

The importance of Rubin's analysis for the present study is that for each of the values along each of the dimensions she has specified, there correspond constraints on the content and structure of the discourse. For example, in the absence of a common spatial and temporal setting, the author must compensate by carefully describing the relevant world and creating a consistent deictic system within it; the reader must compensate by constructing that world from the text and adopting, at least temporarily, the referential stance that the author has set up. Similarly, without freedom of interaction, the author must develop alternate devices for checking and reinforcing the reader's comprehension; the reader in turn must learn to recognize such "checkpoints" and develop strategies for assessing and correcting her or his understanding of the text whenever something seems awry.

To summarize, our position is that the comprehension of formal text differs from that of informal, face-to-face conversation in both the cognitive operations and the linguistic knowledge it requires. Before school, the majority of a child's language experiences are conversational; in school, a child's success depends critically on the ability to cope with written text. The goal of our study is to investigate systematically the ways in which communicative acts are transformed or adjusted to accommodate the requirements of the modality in which they occur. The rationale is that, once specified, such transformations can be examined for the purpose of identifying their troublesome components so that we can then determine what might most helpfully be taught and how.

Design. To generate an appropriate data-base for our analyses, we are video-taping the interactions of pairs of adult subjects as they assemble a toy water pump.[2] Each pair of subjects includes a "novice" and an "expert". The novice is unfamiliar with the water pump but is responsible for putting it together; the expert is thoroughly familiar with the water pump and is responsible for providing all necessary instructions to the novice.

Each pair is assigned to one of five communication modalities. The two modalities of primary interest are face-to-face interaction and the writing and reading of formal text. These two modalities are most disparate in terms of Rubin's (in press) analysis; they occur most frequently in the real world; and, it is specifically the differences between them that we suspect cause much difficulty for young students.

In addition, we have included two "intermediate" modalities: communication via telephone and teletype. We refer to these modalities as "intermediate" because, as with face-to-face

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[2] This experimental setting is modeled after Chapanis, et al. (1977) and that of the SRI task-oriented dialogue setting in which an expert directs an apprentice in assembling an air compressor (Nilsson, 1975).

communication, the two parties enjoy a common temporal frame and can interact, checking each other's models of the situation as it evolves. In contrast, as with formal text, the two parties are removed in space. Consequently, they cannot watch each other's gestures or responses, and a far greater portion of the communication must be couched in language per se. Further, as with formal text, a significant part of what must be established through communication is a common system of reference so that progress can be "blindly" discussed. In short, one reason for including the telephone and teletype modalities is that they allow us to look inside the communication space -- to see how the participants adapt to the characteristics of particular dimensions of the space.

The second reason for including the telephone and teletype modalities is that they represent, in terms of Rubin's (in press) analysis, virtually identical communication situations except that one involves talking and listening and the other, writing and reading. By comparing performance across the two, we should therefore gain insight to the constraints specifically associated with the oral/written dimension.

Finally, for the fifth modality that we are examining, the experts are to record their instructions on audio-tape. The novices may rewind or stop the tape, but will have only the tape to rely on. Thus, except for the fact that this communicative situation is oral, it is equivalent to those involving formal written text. The primary reason for its inclusion is to allow us to evaluate the extent to which the language and structure of the experts' instructions acknowledge this similarity -- that is, the extent to which they reflect characteristics more typical of written than spoken discourse.

A critical aspect of our design is that all subjects are engaged in the same task: assembling the water pump. Thus, although there will, of course, be subject-specific variations in the discourse, its basic content and structure are fixed. This greatly facilitates our capacity to perceive systematic differences in the discourse that may be attributable to modality.

There are also several advantages to the pump assembly task itself. First, it naturally dissolves into a set of relatively immutable steps or subgoals that are explicitly "opened" and "closed" (Deutsch, 1974; Grosz, 1977). Thus, by engaging all pairs of subjects in this task, we ensure commonality not only of the overall discourse but also of its separable episodes.

Other advantages derive from the fact that the pump is not a generally familiar object. Most novices have little idea of what it is ultimately to look like before they begin. Further, its pieces or parts are such that cursory inspection does not yield obvious hypotheses as to how they should be fit together. Inasmuch as the novice must rely on information available from the expert, the task implicitly depends on communication and requires the sort of meaning resolution in which we are most interested.

Use of the pump also allows us to track the progress of the communication between our subjects. We can evaluate the experts' references and descriptions because we know what their referents must be. We can interpret the experts' various speech acts to the extent that we know what their intentions must be. Furthermore, in assembling the pump, the novices provide us with concrete evidence of what they have understood.

Cross-modal comparisons of pragmatic structure. A major aspect of our experiment is the comparative analysis of discourse. However, our survey of the discourse/conversational analysis literature indicates the field is in disarray. There are no agreed upon methodologies, tools, goals, or formalisms (cf. Cicourel, 1980; Streeck, 1980). Even the possibility of theorizing about conversation is doubted by some writers. In contrast, by imposing some experimental controls on the topic of conversation, by restricting the experimental task to instructions, by employing methods for eliciting authors' descriptions of their intentions as well as readers' use of cues to infer those intentions, and by employing precise formal and computational models of speech act production and

comprehension, we expect to develop a sound methodology and set of tools for studying task-oriented discourse. Clearly, such tools would find application to other problem areas central to reading research -- for instance, the analysis of classroom interaction.

Our theoretical research has been directed at the integration of speech act theory into formalisms for problem-solving (e.g., Fikes, Nilsson, & Hart, 1972; Sacerdoti, 1977). The essence of our approach is that the processes involved in the production and comprehension of speech acts are essentially the same as those involved in non-linguistic planning and plan recognition processes. To support this claim, we have developed formal and computer models of the planning and recognition of speech acts -- primarily requesting, informing and questioning (Allen, 1979; Allen & Perrault, in press; Brachman, Bobrow, Cohen, Klovstad, Webber, & Woods, 1980; Bruce, 1975; Cohen, 1978; Cohen & Perrault, 1979; Perrault & Allen forthcoming). A major accomplishment of this research has been the identification and computational modeling of planning and plan recognition inferences underlying the use of a class of indirect speech acts in task-oriented dialogue.

Currently, our theoretical efforts are showing that speech act identification per se may not be necessary for engaging in dialogue (Cohen & Levesque, 1980). Instead, speech acts can be defined in terms of shared plans -- plans based on the shared beliefs of the participants. Conversants respond to one another based on their perception of the other's intentions rather than their perception of which speech acts were performed. Thus, while plan (intent) recognition is crucial to comprehend discourse (and thus to our models of "comprehenders") speech act identification becomes a process of after-the-fact summarization.

Our experiment provides a suitable domain to test this plan-based theory of conversation. Because the pump assembly task imposes the same goals and subgoals on all subjects, regardless of modality, the deep structure of the discourse -- that is, its structure at the level of plans -- must also be essentially invariant across modalities. To take fullest advantage of the task constancy, we have developed a formal model of the pump assembly situation. By incorporating that model into our process models of speech act understanding as plan recognition, we can track subjects' progress through the task and predict how utterances will be interpreted. To test our theory, we shall attempt to verify these predictions by identifying phenomena that would supply evidence of a hearer's interpretation of the intentions behind a speaker's utterance. We have already isolated one such phenomenon: the presuppositions of hearers' subsequent actions and utterances (Cohen, 1980) can indicate their interpretations of speakers' intent.

Finally, the interpretation of referring expressions will be a major concern for our analyses. We hope to take advantage of the research on reference and focus in task-oriented dialogue (Deutsch, 1974, Grosz, 1977; 1978; Robinson, Appelt, Grosz, Hendrix, & Robinson, 1980; Sidner, 1979). Consonant with our plan-based theory, we shall attempt to model focussing and referring as intentional actions that can be planned and recognized with the same process model.

We are looking initially at two aspects of the dialogues across modes:

- In the spirit of speech act theory, we shall investigate the synchronization of actions (speech or physical) and especially indices of when the novice is to perform an action. Thus we are concerned with "generalized turn taking" as it occurs in each modality.
- We shall explore how the expert and the novice communicate about the successful completion of subgoals. Such communication is required by the nature of the task and thus must be described in any analysis of the resulting discourses. For example, communication of successful completion might occur by visual inspection in face-to-face modes, by uttering "Done" in telephone/teletype modes, and by including "checkpoints" in audiotape and written modes.

We expect to see patterns within modes and diversity across modes. Thus our task will be to employ formal and computational tools to explain those patterns. If such explanations can be developed, we can point to their dependencies on modality.

In using the phraseology, "generalized turn-taking" and "successful completion", we do not mean to suggest that these communication activities are only relevant to task-oriented situations such as that of assembling the pump. On the contrary, we believe that these two classes of communication are critical to virtually every type of discourse. For example, "turn-taking" occurs in expository text when the author "requests" that the reader construct or retrieve related information. The skilled reader also observes "turn-taking rules" in selecting points at which to interrupt reading or to begin again, once having been interrupted. Communication about successful completion is also critical in expository text. Authors frequently insert such "checkpoints" when they are ready to move from one phase of an explanation or description to the next. The efficient reader must learn to recognize such checkpoints and to respond appropriately by reviewing or consolidating the relevant information. In the pump assembly situation, these two classes of communicative activities should be relatively transparent. Our ultimate goal is to compare the linguistic cues by which they are signalled in our concrete task with those that occur more generally in formal text.

Cross-modal comparisons of linguistic structure. A major difference between face-to-face linguistic situations and formal text is that, in the case of the former, the listener generally has many more clues, aside from the words themselves, from which to construct or corroborate interpretations. In face-to-face conversation, the listener shares a single frame of time and space with the speaker; this allows for much of the speaker's meaning to be inferred from or at least reinforced by, the extra-linguistic context. The speaker can also convey meaning through gestures, facial expressions, and the tone and stress patterns of her or his voice. At the same time, the speaker signals the phrasal and clausal structure of the message through prosodics. Finally, the situation is interactive, and this quality is significant in at least two ways. First, it means that both parties have the opportunity to shape the discourse -- to bring it into terms or domains of their own choosing. Second, it allows for the speaker and the listener to continuously monitor each other's interpretations of the discourse. The speaker will often know when the listener misunderstands and will then try to clarify the message; or, alternatively, the listener can ask questions of the speaker.

The telephone mode differs from face-to-face situations primarily in that the speaker and listener are removed in space. This means that they cannot use gestures, eye movements, or facial expressions to support their communication. Further, the expert cannot directly monitor the novice's comprehension by watching her or his progress in assembling the pump. Instead the expert must solicit or await relevant information from the novice.

Importantly, much of the communication that takes place via telephones can be paralinguistic rather than linguistic, per se. The tone and stress patterns of the two parties' voices will carry much of the information: what is important, what is parenthetical, what is unclear, etc. Through timing and stress patterns, the expert has considerable freedom to direct the priorities and temporal course of the novice's activities as well. And, of course, the telephone supports such paralinguistic forms of communication as grunts, ahas, murmurs, and inordinately long or strangely located silences.

In a narrow sense, the teletype affords the same opportunity for interaction as does the telephone. At least the two parties share a single frame of time and can interrupt each other if they like. However, the teletype mode differs from the telephone mode in several ways that can be expected to affect the nature of the exchange.

First, paralinguistic communication is greatly limited in the teletype mode. Subtleties of tone and stress are precluded by the modality, and whatever information might be captured in the timing

is confused by production and transmission factors. Thus, in the teletype mode, communication depends even more on the content and structure of the language. Because of this, many dimensions of the message that might be conveyed through prosodics over the telephone -- illocutionary intent, topic versus comment, emphasis, parenthetical remarks, corrections, and elaborations -- must be explicitly identified through its content or structure. Thus, in terms of linguistics per se, statements over the teletype are likely to be more carefully planned and more complete than they might be over the telephone.

There are two other aspects of the teletype mode that are also expected to alter the nature of the exchange. First, message production is more work with the teletype than the telephone, and second, the record of each message is permanent. Communicative efficiency can be metered in terms of either comprehension or production. Because of differences in the difficulty of producing messages and in their permanency, we suspect that, relatively speaking, in the telephone mode priority will be given to easing comprehension whereas in the teletype mode it will be given to easing production. For example, over the telephone an expert might venture something like:

> See the blue thing? The thing that looks sort of like a miniature saddle? See the little hole on the top? Okay, now see the little peg on the red thing--that little sort of post on the side? What you want to do is to attach the blue thing to the red thing. Snap the hole over the peg so the blue thing's sort of wrapped around the red thing.

Over the teletype, such an instruction might be reduced to:

> Fit the blue, saddle-shaped piece around the red piece. Snap the hole securely over peg.

The instruction has been transformed in several ways: the information is structured very differently; it is more tightly packaged; it is complete but stingily so, including little more than the necessary and sufficient. As a consequence, it places much greater demands on the linguistic, observational and deductive capacities of its recipient.

The differences between the formal text and audiotape modes are expected to be similar to those between the teletype and telephone modes. This is again because the major distinction between the two modes is that one is vocal and the other, written. Thus, as between the telephone and teletype modes, the major difference in the communicative constraints of the formal text and audiotape derive from the role of prosodics, the production effort, and the temporal permanence of the message.

However, the formal text and audiotape modes, as a pair, differ from all of the previously described modes in that the expert and the novice are removed from one another in time as well as space. Thus, there is no opportunity for interaction. There is no opportunity for the novice to ask for clarification, and there is no opportunity for the expert to discern when she or he needs it. The expert's instructions must therefore be meticulously clear. Ideally, in this situation, the expert should provide not just that information that is necessary and sufficient, but should also provide enough redundant information to allow the novice to check any interpretations on her or his own. In addition, we suspect that in both of these situations, where the expert is so removed from the novice, there is a premium on sound organization -- on constructing the instructions so that the novice will feel they make sense.

In short, we hypothesize that, as we step across the modalities from face-to-face conversation to formal text, the requirements of both the producer and the recipient of a message will systematically shift. The producer of a message must be much more thorough and precise in the textual than in the conversational situation. Given the lack of extra-linguistic support and the impossibility of directly monitoring the progress or interpretations of the reader, the writer must explicitly describe many details that would be left unstated in a face-to-face interaction. In addition,

the writer must carefully structure descriptions so as to communicate the interrelations among details and their importance to the overall goal of the discourse. Without recourse to prosodics, the primary mechanisms for so doing are syntactic and rhetorical structures. Further, as the number of explicitly introduced concepts increases, so too must the difficulty of keeping them straight. Thus, the writer must be meticulous in the use of deictic and anaphoric devices. Indeed, the full meaning of formal text can generally be expected to pivot on linguistic devices that do not even occur in typical conversation. All of this requires, in turn, that the reader approach the text with a degree of linguistic sophistication and self-discipline that is rarely needed in oral language situations.

The goal of the analyses to be undertaken in this part of the effort is that of specifying the ways in which language tends to change across modalities. Among the dimensions that we plan to examine are: the development of referential terms; the proportion of relevant information that is explicitly stated; the propositional depth of sentences; characteristic syntactic structures; marking of topic versus comment; and the correspondence between the order in which the linguistic information is provided and the order in which it must actually be used by the novice to construct the pump.

We have frequently asserted that there are significant structural differences between the language of conversation and formal text. The goal of these analyses is, in short, to begin to empirically justify and refine these claims. We can then begin to specify the kinds of linguistic knowledge and processes which are likely to cause difficulties for young or poor readers -- the kinds of knowledge and processes which deserve explicit instruction.

Other potential domains of application of this work include writing instruction, the development of structural metrics of readability, and guidelines for coherent captioning, as for deaf or non-English speaking students.

Progress. As of this date, we have formally modeled the pump and experimental situation; we have run the experiment in all modalities; we are generating transcripts; we are developing a scheme for coding the video tapes; we are coding utterances and actions for intentions and presuppositions; and we are revising our formalisms to deal more adequately with our current view of speech acts as post hoc summaries of plans.

3. 2 Developmental Studies of Oral Conversation in Relation to Written Text

In order to discover characteristic differences between structural aspects of spontaneous speech and formal, written English, we are analyzing a corpus of informal conversations among first graders, third graders, fifth graders, and adults included in Carterette and Jones (1974). Such differences can be viewed as instances of either the productive tendencies of the speakers or the linguistic experiences of the listeners. When interpreted with respect to speakers, the most interesting differences are those which systematically diminish with age. To the extent that such differences reveal developmental trends in linguistic competence they should help us to identify aspects of text structure that are especially problematic for young readers. When concern is turned to the listener, the focus is on structural devices that are rarely used, or rarely used correctly, in oral language. To the extent that both the need to understand and the opportunity to learn the significance of these devices arise only with written language, they are expected to create difficulties for young readers in general. Examples of the dimensions along which we are analyzing the corpus include: syntactic structure of sentences; use of verb tenses and other devices for signalling relative time of events; adequacy and marking of given versus new information; and the ideational structure of the individual contributions to the conversation as a whole.

Study of the corpus has already made evident that the use of many constructions develops only gradually across the elementary school years. In the interim, children use conventions which

effectively simplify the structure of the language. A major task before us is to develop systems of data reduction and analysis to evaluate and document the nature and pervasiveness of the differences we have observed.

A question that must be raised with respect to any differences found through these analyses is whether they reflect differences in linguistic competence as opposed to performance, and if so, how they are likely to express themselves in reading situations. Our analyses of children's speech are therefore to be complemented with experimental assessments of children's comprehension. As an example, the younger children in the sample rarely include new information or modification in the subject phrases of their sentences; rather, new information is relegated to the predicate. In written text, by contrast, modification and new information (especially new background information) occur in subject clauses quite often. In view of this, we plan to assess experimentally how the presence of new information and modification in the subject clause affects the readability of sentences for younger children. As a second example, we have observed that, as compared with the adults, the younger children in the corpus use a preponderance of present tense verbs. Through examination of the corpus alone, we cannot determine the extent to which this bias is due to performance variables versus either insufficient syntactic competence with the verb tenses or insufficient cognitive flexibility for managing references to relative time; however, we should be able to evaluate these alternatives experimentally.

In other projects, we have used William S. Hall's corpus of spontaneous speech (see Hall & Tirre, 1979) which includes conversations of young children from different racial and social class groups. This corpus involves children of black and white middle and lower class families in various communicative situations. Application of the plans analysis described in Section 3.3 to these conversations revealed unexpected complexities of plans and intentions in the speech of even very young children.

We are also comparing the vocabularies exhibited by the groups represented in the corpus with the word lists used in readability formulas. These lists are compiled from standard beginning reading texts and from studies in which elementary school age children are asked the meaning of common words. Importantly, they are also used in the composition of classroom texts. They inevitably reflect the backgrounds of the publishers, the researchers, and the children tested. In our study, we hope to determine whether or not the formulas encode racial and class bias.

We believe that these analyses of children's spontaneous speech together with the experiments on their comprehension have great potential for yielding useful guides for the design of texts for beginning or less skilled as well as minority group readers, the evaluation of the linguistic appropriateness of existing texts, and the identification of structural aspects of written language that warrant explicit instruction.

3.3 Story Structure

Telling a story may be the most powerful way to communicate an idea. An artful recounting of events not only reveals much about the people involved, but also triggers generalizations that reach far beyond the story itself. It is not surprising then that numerous theories have arisen to explain the structure of stories and how people understand them. Much of our research has been concerned with the processes of story comprehension, in particular, with the use of structured knowledge in building an interpretation of a story.

Story grammars. One of the most popular approaches to analysis of narrative structure in current psychological research literature involves story grammars. Story grammars formalize observations such as that the setting of a story is usually in the beginning, that episodes within the story themselves have internal structure, and so on. This work is exemplified by (among many

others) Propp (1958) in his analysis of Russian folk tales, and more recently by the work of Rumelhart (1975), Mandler and Johnson (1977), Sutton-Smith, Botvin, and Mahoney (1976), Stein and Glenn (1979), and Thorndyke (1977). Glossing over, for the moment, important differences in structural analyses of this sort, we can say that they do capture important regularities in story structure. For example, they can be used to describe differences in the folk tales of different cultures or to describe developmental levels of story understanding.

Plans. What a story grammar approach fails to capture is the fact that episodic structure is typically produced by interactions among characters attempting to achieve goals. Any purely syntactic approach, which ignores the effect of characters in the story as active agents, will necessarily be incomplete in its account of the story's structure. Specifically, it will miss the underlying connections among what are viewed as syntactic units of the story.

We have thus been led to a second approach to the analysis of story structure, one which analyzes characters' goals and plans. Since we can never know what is in a character's mind, we must infer plans on the basis of the character's actions, statements, and whatever insight the author allows us into his or her mind. Research on plans in stories (e.g., Wilensky, 1978; Schank & Abelson, 1977; Bruce, 1975) has moved towards elaboration of the knowledge about plans and goals that a character could be presumed to have in a given situation. This study may lead to a partial explanation for the types of structures that emerge from a story grammar. Thus, part of understanding a story may amount to constructing a detailed representation of the protagonist's goals and plans -- e.g., "because the protagonist needed money for an operation, he devised a plan to borrow it from his long-lost uncle, which led him to have a subgoal of locating his uncle, which in turn led him to the plan of calling his cousin, etc."

To evaluate this hypothesis experimentally, we are presenting our subjects stories that delete mention of certain goals and plans, and seeing if subjects' reading times increase at just those points where the missing goals and plans have to be inferred. We expect that the time needed to construct a correct interpretation will increase with the number of distinct goals and plans that subjects have to infer, unless this number is too great (say, about four or five missing goal-plan units) in which case subjects will very likely misinterpret the story.

Another aspect of our research focuses on the memorial consequences of constructing goal-plan structures during comprehension. The basic idea is that memory for a story-statement mentioning a goal will increase as more of the story is devoted to the attainment of this goal. That is, if the reader must continually utilize a particular goal in understanding various story events, the proposition expressing that goal will have undergone extensive processing and will consequently be in a relatively accessible state at the time of recall. Our preliminary results provide support for this prediction.

Interacting (social) plans. An analysis of characters' plans and goals is useful but, as an account of stories, is incomplete unless it incorporates an analysis of the social situation in which these plans arise. We cannot assume that a character acts out of the context of other characters' actions. Their actions may help, hinder, or even be the target of the first character. A character must plan and act with the understanding that the other characters are also purposeful creatures whose plans will likely interact with his or her own. Recognition of the interdependencies among plans leads us as analyzers of story structure to posit notions such as social episode to represent the interactions among plans, e.g., cooperation and conflict.

But we must go still further. No one has direct access to the true plan of another; one can only hypothesize on the basis of the other's actions. In order to plan, each character must form a model of the plans of the other characters. We must have a way to represent characters' beliefs about each others' plans and to show how their beliefs affect their plans.

Finally, any character can realize that other characters are not only active planners, but also active interpreters of the interactive situation. He or she can then perform actions to influence or discover the beliefs of others. What a character believes that another believes can be crucial to the structure of a story. Since beliefs can be about beliefs, we can have nested or recursive propositions such as A believes that B believes that A believes P (see Cohen, 1978). This makes possible things such as virtual plans, e.g., a plan that P intends for Q to believe that P has, but that P does not intend to carry out.

The facts that plans of characters in stories are interdependent, that actions are based on beliefs, and that beliefs are recursive lead to our third approach. The analysis of interacting or social plans (as in Bruce & Newman, 1978) becomes necessary for the study of story structure.

In the course of our analysis, we have identified a set of entities (acts, intentions, beliefs, states, etc.) and relations among these entities that we believe are necessary and sufficient for the representation of interacting plans. From these basic elements, we have begun to build a set of configurations which represent generalizations from specific interactions among plans. We are now working on the representation of more complex notions, such as deception, using these configurations of basic elements. This type of analysis will enable us to specify the underlying structure of social events such as "conflict" and "intention" in a way that allows direct assessment of the similarities and relative complexities of the social structures across texts.

3.4 Rhetorical Structure and the Author-Reader Relationship

We often think of reading as a solitary activity in which the reader more or less successfully draws information from a text. The information may be in the form of an argument intended to convince the reader of some proposition, in the form of a narrative intended to enlighten, in the form of a description intended to entertain or instruct, or in any of various other forms with corresponding assumed intentions. In any case, we often assume the text contains information and the task for the reader is to glean as much as possible from that information, all of which was supposedly put in the text by the author.

But an important dimension of reading is often overlooked when one takes this information/in - information/out view. To put it simply: a text is written by someone; it is read by someone; and when the text is read, meaning can be created. What we call the "structure of a text" is not some characteristic that blossoms forth from a particular string of sentences. In fact, it is not a property of sentences of texts at all, but rather, an attribute conferred on the text by a reader on the basis of the "meaning of the text", which, in turn, is created by the reader in the process of reading. Holland (1975) and Postman and Weingartner (1969) show what a rich and powerful activity this meaning-making can be. Texts are written by authors who expect meaning-making on the part of readers and read by readers who do the meaning-making. These considerations have led to the development of a model of the author-reader relationship (Bruce, in press-b; Steinberg & Bruce, 1980). Briefly stated, the model defines levels of social interaction implied by the acts of reading and writing.

The first level derives from the fact that the act of reading itself occurs in a social context. A person reads alone or in a group, or is read to by another. The real reader may or may not know the real author personally. The actual time and place of writing interact with the actual time and place of reading. As observers we can thus describe the act of reading as an interaction among characters such as the reader, the author, the editor, the reviewer, the bookseller, the decoder (applied to one who reads aloud for others), the teacher, the librarian, or the tester, wherein a single person may play two or more roles at once. The resulting interaction, like a story, has its beginning, middle, and end. Like a story it can be described in terms of the interaction among the plans and beliefs of its participants.

A second level that is constructed in the event of reading concerns the social context that is implied by written communication. That is, any text, by virtue of its permanence, has a level one implied author and a level one implied reader, whose characteristics may match more or less to those of the real author and the real reader (see Booth, 1961; Chatman, 1978). For example, a person might write a letter so that it appeared to be written by someone else. Even in the case of a genuine and sincere letter, though, we cannot say that the implied author is the real author. Conventions of the language and constraints of the written medium cause the words of the text to differ from what the real author could say. Suppose, for example, that the letter began "I was just thinking about you...". For the implied author this phrase means, perhaps, that immediately prior to implied time of writing the implied author was "thinking about [the implied reader]". The action the real author was "just" doing prior to the actual time of writing might have been to search for stationery and a pen. This discrepancy merely illustrates that the real and the implied authors live on different time scales. In fact, they also live in different places and different social worlds. In the case of a letter such discrepancies usually pass unnoticed; in the case of formal writing they lay the basis for irony and other rhetorical devices. In any case, the implied social interaction between the implied author and the implied reader is its own story within the story of the interaction between the real author and the real reader.

The meaning constructed on the basis of the text by the implied reader can be a simple accounting of events or set of facts, but often it includes the message: "someone else is saying this". A character may describe her or his adventures to another character; the implied author may come across a forgotten text; or the implied author may effectively introduce another implied author through irony. The new speaker is called a "narrator" if the implied communication is spoken; otherwise, she or he is what we might call an "implied implied author". These new characters speak, not to the real or implied reader but to yet another character, the "narratee" (cf. Prince, 1971) or the "implied implied reader", respectively. For simplicity, regardless of the medium of communication, we refer to the speaker at level two as the level two implied author and the listener as the level two implied reader. Thus we have a third level of social interaction created as a result of the communication at the second level. The interactions among the new characters occur in their own place, time, and social setting; they determine the third story for a single text.

The story told at level two can be about characters who have the need to communicate. These characters will then resort to the same device, namely, story making, that is used by the real author, the level one implied author, and the level two implied author above them. Their stories demand readers, and can, again, be about people and their social interactions. Thus the level creating activity is self-renewing. The level three story can give birth to a level four story, which can contain a level five story, and so on.

The process of embedding levels is indefinitely extensible, and more commonly invoked than one might suspect. As described in detail in Bruce (1980, in press-b), for example, the familiar story "Rip Van Winkle" includes five distinct levels of communication. The first of these is the discourse between Washington Irving (the real author) and the real reader. The story that Rip Van Winkle narrates to Diedrich Knickerbocker is embedded three levels within the real author-real reader dialogue, and the stories that characters in Rip Van Winkle's story tell one another are embedded yet another level below Rip's story. There are explicit signals for the creation of some of these subsequent levels, while others are induced by a variety of apparently unrelated rhetorical and narrative devices.

We have developed a formalism for describing these rhetorical relationships. We have identified six basic rhetorical forms, each defining a possible relationship that exists between the author and the reader. An embedded level is one of the side effects of the use of one of eight devices, e.g., introduction of a narrator who is not engaged in the action of the story she or he tells,

or immersion of the reader in the story. We have also described various point of view types, and the relation of point of view toinside view, where inside view is the portrayal of a character's thoughts and feelings, from surface observation to deep insight into his or her perceptions.

The formalism is being applied in analyses of a wide range of texts. We hope to identify through these analyses characteristics of texts which affect interest, comprehension, and memorability. Many of the rhetorical features are culture-specific (cf. Taylor & Ortony, 1980; Smitherman, 1977); thus our analyses may shed light on interest and comprehension problems that are likely to arise when a reader's cultural background is different from that which the author presumed. Most importantly, perhaps, this framework may help us to understand reading as a true communication activity and not just as the process of translating visual symbols into spoken ones.

3.5 Background Knowledge

A fundamental constraint on acquiring information through language, as opposed to direct experience, is that linguistically presented information can be understood only as it can be assimilated or represented in terms of information that is already known. A corollary observation is that speakers or writers do not and, in fact, cannot directly communicate their intended meanings through language. At best, they can provide clues that allow their audience to construct approximations to that meaning from their own prior knowledge (see Adams & Bruce, in press).

From this perspective, it is clear that the foremost determinant of text comprehensibility must be the goodness of the match between the interpretive resources that are presumed and possessed by its readers. One aspect of our research has been to identify characteristics of texts and of readers that affect the goodness of the match. We have been examining such dimensions as: the conceptual knowledge that is necessary for understanding the intensional and extensional meaning an author hopes to evoke with a particular word or words; knowledge about social conventions and values that is necessary for inferring the underlying argument or event structure of a text; familiarity with stereotypes introduced for capsulized character development; knowledge about genre characteristics; and knowledge about general text structure.

As an example, the reader's appreciation of a story depends critically on recognizing social relations among the characters. The creation and release of tensions among the beliefs, plans, and goals of the characters are major techniques an author uses to produce such rhetorical effects as conflict, suspense, surprise, and happy endings. The catch is that these aspects of the story structure are typically not fully or explicitly described by the text. To be sure, the text will provide clues with respect to the beliefs, plans, and goals of its characters, but their elaboration and their relationship to the event structure and message of the story as a whole must be left largely to the inferential processes of the reader.

Our analysis of interacting plans (see Section 3.3) demonstrates that even apparently simple stories may recount actions that derive from complex, interacting plans. The apparent simplicity of many stories vanishes when one begins to consider such things as the effect an action or event is intended to have on the plans and actions of another character. Connections of this kind between social actions and beliefs are difficult to explain without explicit representation of the interactions among plans.

Interacting plans also occur at the author-reader level. An author writes with some particular communicative purpose or goal: to inform, to instruct, to persuade, or to entertain. In addition, he or she writes with a particular audience in mind. The text is thus jointly determined by the purpose of the discourse and the author's beliefs about the prior knowledge and interests of the projected readers. Whether or not any given reader ultimately understands the passage in the way intended by the author will depend in part on whether that reader does in fact possess the prior knowledge and

interests presumed by the author, whether the author's goals are correctly perceived, and how those goals mesh with the reader's. In view of this, we have begun to extend our analyses to account for rhetorical features (see Section 3.4).

One line of research is concerned with the ways in which the social underpinnings of stories are communicated. We are trying to delineate the kinds of clues to social schemata that authors frequently resort to in stories. Examples include stereotyped characters (e.g., princesses, wicked witches, foxes, owls), sudden or unexpected reversals of a situation, inconsistencies with real world knowledge, etc. We plan to evaluate experimentally the effectiveness of such devices in evoking the intended inferences among readers of different cultural backgrounds.

We are collecting protocols of children reading simple stories and answering questions about the actions of characters. This work has supported one of our main hypotheses: a critical belief (Bruce, in press-a) about characteristics of people, about forms of social interaction, or about the social force of utterances can dramatically alter one's understanding of a passage. We need to be aware of these effects when teaching reading or testing for comprehension.

Differences among readers in their critical beliefs may arise from differing literary experiences or from general cultural differences. For example, we found that when children read the story, "The Fox and the Rooster", that their experience with fables about foxes affected the way they interpreted the story. In particular, the adult or conventional interpretation of the story pivots on the critical beliefs that foxes in fables are greedy, devious, and like to eat roosters. In no way can these beliefs be considered general knowledge, and yet, unless they are part of the reader's knowledge, the story will, from the conventional point of view, almost certainly be misunderstood. This corroborates some more general findings about cross-cultural differences in text comprehension (Bartlett, 1932; Steffensen, Jogdeo, & Anderson, 1978; Kintsch & Greene, 1978). We plan to investigate further the prevalence of this critical belief phenomenon and its effects on readers whose cultural backgrounds may reasonably be expected to differ from those of the author of a children's text.

3.6 Comparative Analysis of Stories for Children

Traditional surveys of children's literature have examined features such as text structure and topic, but have failed to take into account rhetorical elements such as author-reader distance, commentary, point of view, and insight into characters' minds. Similarly, they have glossed over aspects of character to character interaction, such as responses to interpersonal conflict. These "higher level features" of stories may be what make stories interesting to read. They are also principal contributors to story complexity, and hence, to difficulty for beginning readers.

We are currently analyzing stories for children in terms of the higher level features. At the level of author-reader interaction we have looked at rhetorical forms, point of view, and inside view of characters. At the character-to-character level we have examined types of conflict, the response of characters to conflict, and the resolution of conflict. Conflict is a situation in which a character or characters are unable to achieve one or more of their desired goals. The conflict can be interpersonal, internal, or environmental. Verbalizations, thoughts, or actions that occur subsequent to and are related to the conflict, are defined as belonging to the character's a response mode. The final element in the structure of story conflict is resolution, the working out of the conflict or an end to the original conflict (Steinberg & Bruce, 1980).

Story survey. The formalizations of rhetorical structure and conflict which we have developed provide a useful framework in which to study children's stories. In order to apply notions made explicit by our analysis we have devised a coding form intended for use with children's texts. The form is composed of questions on conflict type, response and resolution modes, rhetorical form,

point of view, and inside view. In addition, it includes a single metric of conflict complexity we have devised which takes into account such factors as: the number of conflicts per story, the number of different types of conflict, the number of participants involved in story conflicts, the intensity of each conflict, the length of time story conflicts remain in focus, the number of response modes utilized, etc.

We had three main purposes in conducting an initial story survey: (1) to determine the prevalence and distribution of the story features illuminated by our analysis in a sample of children's texts, (2) to examine the relationship between traditional measures of story complexity, the most well known of these being readability formulas, and our own conflict complexity measure in the sample of texts chosen, and (3) to explore relationships that might exist between preference ratings of the stories and the coding of story features such as conflict type, response modes, and inside view. We selected a sample of 32 children's texts composed of 16 upper primary level and 16 lower primary level stories distributed evenly among four groups: popular trade books, random trade books, widely read basal stories, and stories from other educational texts. We then computed the Fog and Spache readability formulas on each of the stories in the sample. Five adult raters were asked to read the 32 stories in the sample and then rank them in order of preference. During a separate session, the five raters coded the stories using the form discussed above.

We found there to be 100% agreement among raters that 29 out of the 32 stories exhibited conflict. All three of the stories in which evidence of conflict was unclear were lower level primary texts. Although these numbers are small, this finding, if corroborated in a larger study, suggests that the traditional emphasis placed on vocabulary and sentence length in beginning readers, may be too narrow. Perhaps we are unnecessarily neglecting those features of text that lend structure, cohesiveness, excitement, and diversity to stories.

We calculated the distribution of conflict types for the four story groups in our sample. Interpersonal conflict was found to be more prevalent in all groups except the popular basal category, where environmental conflicts outnumbered the other two types. This trend was even more pronounced when we examined the lower level stories separately. In particular, in the lower level popular basal category, environmental conflicts outnumbered interpersonal conflicts by six to one and there were no internal conflicts. This somewhat unusual distribution of conflict types in basal stories cannot optimally prepare children for understanding conflict forms encountered in reading other texts and may even lead to difficulties.

Examination of inside view reported for the 32 stories in our sample reveals an increase in the incidence of high inside view in the upper level stories. This was even more pronounced for the basal stories in the sample: all of the upper level basal stories displayed high inside views of characters; none of the lower level basal stories provided similar inside views. This abrupt shift in a key story feature such as inside view is an important finding to investigate further, for it points to a possible explanation for some of the difficulty children encounter in the transition from lower to upper primary level reading.

A second aim of our study was to determine if a relationship existed between the readability scores on our sample which purport to measure story complexity and our own conflict complexity measure. Neither of the correlation coefficients we calculated achieved conventional levels of statistical significance. The low correlations suggest that traditional readability measures are insensitive to important facets of what makes a story complex (see Bruce & Newman, 1978).

A third aim of our study was to look at the relationship between higher level features of stories and readers' preferences. We found a statistically significant correlation between the amount of inside view and reader preference. The results are significant even when calculated separately for upper level or lower level texts. This result is for adult ratings of inside view and preference.

Nevertheless, it suggests inside view as a rhetorical device may be of general importance for creating and maintaining reader interest.

Implications. Our model of author-reader interactions and conflict is one step towards a richer language for discussing stories and for enhancing children's understanding of stories. Its most important contribution may lie in furthering the dialogue between teachers and students regarding the literature which they read. This new language also permits us to examine some other issues more effectively.

- Defining the readability of texts. The problems children encounter in comprehension may lie in the complexity of the rhetorical structure or the conflicts portrayed in the story (Bruce, in press-b).
- Reader involvement. If conflict in real life situations has the power to arouse and engage human interest and generate excitement, mystery, curiosity, suspense, and surprise, it is important to study what types and features of conflict in stories could generate the same excitement for a reader.
- Better criteria for text design and selection. By applying our model we hope to be able to articulate criteria which will improve the quality and balance of stories in children's texts.
- Defining effects of cultural differences. Children's difficulties in understanding texts might be due to mismatched expectations arising from cultural differences. Smitherman (1977) has argued that in Black folk tales, to take one example, characters frequently respond to conflict by engaging in clever deception. Also, the Black folk tales have a high incidence of commentary by the author and other distinctive rhetorical structures. Further study of stories from different cultures and subcultures may reveal other distinct patterns. This might indicate the need to diversify the diet of stories given to children.

Our studies of children's stories are highlighting features which may account for reader involvement with characters and the author, for reader enjoyment, and for difficulty in comprehension. These features have traditionally been viewed as being in the domain of literary analysis rather than that of reading research, though they have direct implications for reading. We believe it is useful to continue this exploration, and plan to expand our survey of children's texts. We are also currently planning experiments to investigate children's reactions to the textual features we have defined.

3.7 Educational Games and Activities

New ways to teach reading. One way in which school language experiences are different from children's linguistic interactions with their families and peers is their lack of clear function. When a child learns to talk, it is clear why she or he needs to do so; for many children, this is not true for reading. One kind of language activity which maintains some degree of functionality -- and increases interest and motivation -- is a game. We have begun and intend to continue developing games in which reading is an integral component. Treasure hunts, for example, are a great favorite with children and have the inherent advantage that more practice in reading, i.e., getting the next clue, can be deployed as the reward for doing well. Story-writing games (in which, for example, each person writes a line of the story after seeing only the preceding line) are fun and provide a way to discuss story structure with children.

We have implemented some of these reading games and activities on both a small desk-top computer which would be suitable for classroom use, and in pencil and paper format. (See, for example, the description of the *Story Maker*).

The activities involve different skills required for reading: vocabulary, syntax, understanding complex plans, forming hypotheses, etc. We have been trying the games out with both individual children and groups of children. In trying out these games with children, we will address questions such as: What role can a computer play in teaching reading in a classroom? Which games are received better using a computer? When is the kind of immediate, individual interaction that computers can provide most useful? What kinds of interactive capacities could be most effectively implemented? What differences are there between computer and paper-and-pencil versions of the same games? How well do competitive games work? Is it possible to create motivating cooperative games, rather than competitive games? What kinds of learning experiences are better supported by individual versus group activity?

Personal computers. The advent of the personal computer has brought with it a potential for major changes in formal education. An impact will also be felt in the home, where the computer may soon become a standard appliance -- one which plays as important a role in a child's education as does the school.

We believe that the beneficial impact of personal computers on education will come not from traditional computer-assisted instruction approaches nor from the simple transfer of information from a book to the computer. The real potential of the personal computer lies instead in its ability to encourage learning by doing, and to provide entertaining and motivating contexts in which the learning activities will spontaneously occur. Using the personal computer, it is possible to create an environment for learning in which the student interacts with a dedicated, supportive, and knowledgeable tutor. The usefulness of interactive environments that facilitate learning by doing has already been amply demonstrated (Stevens & Collins, 1977; Bates, Brown, & Collins, 1979; Brown & Goldstein, 1977).

We have developed a number of educational games and activities for use on a personal computer. One of these, the *Story Maker*, is described elsewhere in this report. Another is the Adventure game, described below. These games share a number of features:

- They present learning in a meaningful context, so that there is a purpose for reading or problem solving.
- They are adaptive, that is, they can be molded to fit individual needs and abilities.
- They emphasize the practice of higher level skills, e.g., understanding of story structure.
- They are non-threatening to children and are, in fact, self-motivating.
- They exploit the graphics, music, and speech capabilities of current and currently envisioned personal computers.
- They support the role of the computer as a coach, which guides the student, rather than simply judging.
- They are intended to have user models.

User models and coaches. The last two points deserve some discussion: We believe that any library of games, activities, and languages on home computers should have a user model (Rich, 1979), which starts with stereotypical information about user preferences and which individuates its model as the user interacts with the system. The function of the model is to suggest activities that would be fun and challenging to the user and to give the user the most useful kinds of help or hints. An example of such coaching tactics appears in the Adventure dialogue shown below.

As in Rich's Grundy program, a user model should have information about what kinds of activities are suitable for children of different ages. It should also have knowledge about what games

are likely to be challenging or interesting given that a child enjoyed a particular game and did well at it, or didn't enjoy it, but still did well, etc. The recommendations should use any salient characteristics in giving advice: whether the child likes to take advice, whether the child likes language activities or math activities, whether the child needs practice in some skill, whether the child likes or needs highly structured activities vs. loosely structured activities, etc. The user model should collect information by asking children if they liked each game, by recording how well they do, by seeing if they take advice, etc.

As well as directing a student to appropriate activities, the user model should be integrated with any coaches that are built into specific games. Much of the information used by a coach should be transient (i.e., not preserved and accumulated between user sessions), but for some purposes a long-term memory can be very useful for coaching. For example, a long-term user model might store information as to how much and what kind of coaching the student is most responsive to, what kinds of bugs were manifested in previous attempts at this or related activities, and what level of achievement was demonstrated.

Adventure. Adventure is one example of the educational activities we are developing. In Adventure, the player moves from room to room in a cave looking for a treasure and then tries to escape with it. As the player enters each room, the computer prints a description of its contents and its spatial relationship to tunnels connecting it to other rooms. The user must read the passage and decide whether to stay in the room and do things there (for instance, ask the wizard or slay the dragon) or to move through one of the many tunnels to some other room to find the treasure.

This game is an example of "reading for a purpose". We have seen in tutorial sessions that even the most reluctant and self-conscious readers rise to the challenge of the game and play for a longer period of time than they would sit with a book. Adventure also provides non-threatening help -- children often realize that they have miscomprehended, as a result of an unexpected consequence, and are eager to know what went wrong. The following dialogue illustrates the kinds of hints that could be offered by the computer in an Adventure game, if it had in it a user model and strategies for coaching.

Example: * * Finding the Tootsie Roll * *

This dialogue illustrates the student pursuing the goal -- a three-ton Tootsie Roll. To get the Tootsie Roll, the player must get to a circular room which has 50 doors leading off of it and look behind the correct door. Since opening all 50 doors is too tedious, the player must find out which door hides the goal by asking someone. Notice that when the player wants to get some information, (s)he just types ASK and the computer prompts for whom to ask and the information to ask for; this latter must always be in the form of a WHERE question.

P: Ask

C: Who?

S: Computer

(The computer is the "I" of the system and is always available to answer questions.)

C: What?

P: Where is the tootsie roll?

C: 1. I don't know. 2. Ask the dragon.

(While the computer is always available for questioning, it doesn't always have the answers. It knows, however, that the dragon has some relevant information. At this point, in fact, it implies that the dragon knows the location of the tootsie roll.)

P: Ask

C: Who?

P: Dragon

C: 1. The dragon isn't here now.

(Characters must be present (in the same room as the user) in order to be spoken to. This response does not make that rule explicit -- it just applies it in the current situation. We can tell if the player has understood this more general rule by seeing if (s)he uses the ASK command appropriately later in the game. In this example, the student understands that first (s)he must find the dragon and, after doing so, proceeds to ask the dragon for information. We pick up the dialogue again at this point.)

P: Ask

C: Who?

P: Dragon

C: What?

P: Where is the tootsie roll?

C: 2. The dragon says, "I don't know, but the fairy princess does."

(The dragon responds using a fairly complicated structure for his sentence. Understanding it requires knowing rules for quoted conversations, interpretation of deictic pronouns (The "I" here is not the computer) and the elliptical verb phrases ("does" means "knows where the Tootsie Roll is".) This entire exchange also probes the player's ability to keep track of different characters' "belief spaces" -- that is, "who knows what?" What is actually happening here is a complex exchange of information -- although the computer implied earlier that the dragon knew where the Tootsie Roll was, he actually only knows that the fairy princess has some relevant information.)

P: Help 2

C: 3. Ask the fairy princess.

(The user doesn't understand this complicated sentence, so the computer rephrases it more simply. Actually, it does even more than this, as it has now told the student what a next appropriate action would be.)

P: Ask

C: Who?

P: Computer

C: What?

P: Where is the fairy princess?

(The player has become pretty savvy -- (s)he clearly understands the convention that questions can only be addressed to characters who are present, so (s)he needs to find the fairy princess before asking the crucial question. Realizing (s)he doesn't know where the fairy princess is, (s)he decides to get that information from the computer. Pretty clever. The computer can also be

clever enough to record that the player has learned this rule as part of an individual profile of his/her performance.)

C: 4. You met her before and she is still there.

P: Help 4

C: 5. You were in a room with the fairy princess before and she is still in the same room.

(The computer's simplification of the previous statement differs along several dimensions: vocabulary, pronominal reference ("her" and "she" refer to the fairy princess).)

The game continues from here with the student eventually arriving in the room where the fairy princess is and finding out from her which door hides the Tootsie Roll, then trekking back to the circular room, opening the appropriate door and grabbing the enormous chocolate Tootsie Roll. When the player reaches the goal, something exciting should happen on the terminal, such as displaying a picture of the candy, playing a tune, or generating a fireworks display.

3.8 Cultural Variation and Reading Comprehension

The way in which we perceive and interpret our world depends most of all on the worlds we have experienced in the past. Our minds can be described as the organized memories of whatever we have experienced, either directly or indirectly, of whatever we know, either consciously or tacitly. Understanding, can be described as the process of retrieving or constructing interrelations among subsets of our knowledge that coherently model the phenomena under consideration.

If this view is correct, then cross-cultural differences are to be expected. Our knowledge must vary at several different levels with the culture in which we live. At the most basic level, the phenomenal world may differ markedly across cultures, and even where it overlaps, the full or contextually elaborated meanings of particular objects or events may nonetheless differ significantly. To this extent, our direct knowledge of the world, both simple and complex, will be culture specific. (See Whorf, 1956, for a forcefully presented, though perhaps untestable, version of this issue.) Our cultural environment also influences the kinds of knowledge we are likely to gain through vicarious experiences. Culture shapes not only the topics but the social functions of the oral language around us. Further, it determines the nature and availability of other sources of vicarious experience, such as books, newspapers, and television programs.

Attitudes toward schooling. Thus, our cultural environments are strong determiners of the kinds of experiences to which we are haphazardly exposed. In addition, however, there are social differences between cultures which must affect our cognitive development in a more systematic way. Specifically, cultures differ in the *uses* they make of knowledge. This impacts not only the kinds of thinking a culture fosters, but also the attitudes it fosters toward education. In a technologically sophisticated society, thinking and learning are prize commodities. They are highly valued both socially and in the marketplace and, like other prize commodities, are sought in their own right. That is, the technological society carries an atmosphere that is not only conducive to thinking and learning but, further, to thinking and learning about thinking and learning.

Western educational systems are both the products and promoters of this cultural syndrome. They are our institutionalized best effort to provide for our children within the system -- to pass on our culturally endorsed fortunes, as it were. We have designed our formal educational system to expand and elaborate on those skills and values which our children have, in any case, been reared to accept and pursue. By opening the educational system to children with different backgrounds, we offer to them the opportunity to move into and up in our social structure. The problem is that to the extent children lack the knowledge and values that the system presumes, it must be extremely difficult to assimilate those which it offers.

Explanations for cross-cultural differences in performance. The difficulties faced by children with different cultural backgrounds have been made poignantly clear through cross-cultural studies of cognition and education. Explanations for cross-cultural performance differences typically fall into one of two categories: (1) the child is "disadvantaged" or "deprived", and (2) the child's culture differs from that of the teacher, text, test, or task.

In the first category accounts of failure on school-type tasks focus on factors such as the following:

- Nutritional deprivation or malnutrition
- Environmental stress, e.g., from living in a noisy, crowded, and dangerous inner-city (Hess, 1970)
- Lack of access to museums, art galleries, libraries, or books at home (Grogan, Hewett, Nauta, Stein, & Rubin, 1976)
- Family stress (Hess, 1970)
- Lack of successful role models (Katz, 1964)
- Poor formal education, e.g., classrooms where preventing violence and keeping order becomes the primary occupation of teachers
- Failure of parents to be supportive of abstract intellectual tasks, lack of pre-reading activities at home (Hess, 1970)
- Physical and mental illness (Hess, 1970)
- Poorly developed receptive or expressive competence in the dominant language for instruction (Bernstein, 1971; Kagan, 1968)

The list, unfortunately, goes on and on. These factors, any one of which could plausibly be viewed as a cause of poor school performance, are typically associated with low socio-economic status and, in most cases in the USA, with membership in various minority groups, most notably Black or Hispanic.

The second category of explanations emphasizes difference, not deprivation:

- Mis-match between the language or dialect of the teacher and the student (see Hall & Tirre, 1979; Mitchell-Kernan, 1972; Labov, 1972; Gumperz & Cook-Gumperz, 1980; Gumperz, Jupp, & Roberts, 1979; Ervin-Tripp & Mitchell-Kernan, 1977; Smitherman, 1977; Hall, 1978)
- Cultural bias in curricula, tests, and textbooks (Nairn, 1980; Bruce & Rubin, 1980; Bruce, Rubin, & Starr, 1980; Smitherman, 1977; Hoffman, 1962; Padilla, 1979; Hillyard, 1979).
- Different conceptions of the purpose of reading, of tests, of answering questions in class, and so on (see Cole, Hood, & McDermott, 1979; Gay & Cole, 1967).
- Differences in background knowledge (see Adams & Bruce, in press; LeVine, 1970)
- Differences in values, even where the basic knowledge is shared (Cloward & Jones, 1963; Hess, 1970; Freire, 1970)
- Different beliefs about authority (of the teacher, of an author, of an experimenter) (Hoffman, 1960)
- Different social relationships (Goffman, 1969; Bruce, in press-c)

Again, the list could be extended indefinitely, since ultimately nearly every aspect of culture could be expected to influence performance in school, which is itself a cultural institution.

There is some validity to each of these accounts of culturally associated difficulties with school-type tasks. But, each account carries a danger. If we focus on deprivation, we may tend to localize the problem (at least as the school has control over it) in the student. That is, we view the child as a "damaged" product of the environment outside of school, a product for whom the school can only hope to do its best but not to expect true success (see Bereiter & Engelmann, 1966). Such a view is reminiscent of Moynihan's (1964) report "The Negro Family" which laid the blame for black family distress on the slavery of 100 years ago. The problem with this view is that it tends to circumscribe a critical examination of the school itself, its language, curriculum, teachers, tests, and so on. Since society at large can be blamed, the school doesn't need to be changed and the child can be conveniently tracked into low expectation classes and, ultimately, low status, low paying jobs, or no job at all.

Furthermore, the deprivation account risks being ethnocentric: A child who knows, let's say, Haitian art and music, who speaks both English and Haitian Creole French is culturally enriched, not deprived. The fact that schools may not recognize and build on the culture a child knows points to a weakness of the school and a parochialness in the dominant sub-culture.

The second account, that the schools just fail to match what the child needs or can use, holds its own dangers. If we minimize the real damage that may befall students, then we may impose unreasonable expectations on them that can lead to repeated failure and lower self-esteem. Tutors, bilingual programs, enrichment programs, and screening for hearing and visual difficulties are examples of useful programs that might be lost if we did not recognize real deprivations. Also, a focus on differences might lead one to propose segregated curricula that could keep some children from ever succeeding in the mainstream cultural, academic, and vocational worlds. The latter concern has become very real in the effort to implement bilingual education programs in the United States.

The issue is, in fact, a bit more complex, for there are interactions between the difference and the deprivation accounts. It is too often the case that difference <u>is</u> a disadvantage in itself. That is, the mere fact that one speaks a different dialect, looks different or has different ideas too often leads to discrimination and hence, inadequate educational and employment opportunities. Low expectations, misunderstanding in both directions, mismatch with written material, and so on, ultimately lead to inferior education (Rist, 1970; Covington, 1975). Also, discrimination against minority group members in school and work leads to culturally different attitudes about the value of schooling (Zigler & Butterfield, 1968), and of self (Asher & Allen, 1969; Clark & Clark, 1939). "Study hard so you can get a good job!" becomes a hollow phrase for someone who believes that job opportunities depend largely on factors other than just success in school (Bowles & Gintis, 1976). Separating the effects of the two categories of factors is not easy, for they pervade not only school activities but society at large.

Studies of cultural differences and their effects. Because of factors such as those discussed above, it is not surprising that cross-cultural issues pervade much of our research. In particular, they have arisen in areas such as developmental studies of oral conversation in relation to written text (Section 3.2), story structure (Section 3.3), rhetorical structure and the author-reader relationship (Section 3.4), background knowledge (Section 3.5), comparative analysis of stories for children (Section 3.6), comprehension of sentence meaning (Section 3.7), and readability (Section 3.11). In the remainder of this section, we present three examples of work that bear directly on cross-cultural problems in education.

Analysis of standardized reading comprehension tests. Standardized tests of reading comprehension have been criticized on many grounds. It has been said that they are too insensitive to detect differential effects of educational programs and that the information they provide lacks diagnostic value. Charges that the tests are biased against minority children are made with great frequency. Even the claim that reading tests measure reading ability has been challenged, and perhaps for good reason. We believe that many of these concerns are related to a common cause. Responses to standardized reading test questions depend heavily on the individual's prior knowledge. This strong dependency decreases the sensitivity of the tests to differences in reading programs, decreases their diagnostic value, increases differences between cultural groups, and, more generally, confounds the measurement of reading skills with the measurement of background knowledge. There is considerable evidence of this confounding. For example, studies have shown that many reading comprehension questions can be answered at much better than the chance level without reading the passage. That is, prior knowledge alone is often sufficient to answer the question.

To make matters worse, standard item analysis procedures probably lead to an increased dependence on items that actually measure cultural differences. Item analyses identify items that consistently discriminate among individuals, whatever the nature of the underlying differences that give the items discriminative power. If much of the variance in reading comprehension tests is attributable to differences in background knowledge, attitudes towards testing and the like, then a possible unintended consequence of the usual item analysis procedures is that they lead to a preference for precisely those items on which there are large differences in performance between minority and majority group children. This is a concealed form of bias, since the item analysis procedures are apparently impartial. The selection of items that give the minority child a poorer chance may seem to be justified on the basis of objective data (See for example, Jensen's, 1980, discussion of predictive validity, pp 367-463 and Gould's, 1980, review of Jensen's book).

The idea that differences in prior knowledge can be factored out, or at least minimized, has considerable appeal. But it is hardly a new idea. Test publishers have long been concerned about balancing test content and in recent years have engaged in a variety of special efforts to avoid bias against minority examinees. Nevertheless, a strong confounding between reading skill components and prior knowledge components continues to exist in most standardized tests of reading comprehension.

We sketch here an example of the kind of content analysis we have done. The passage and items are taken from the ETS Cooperative English Test on Reading Comprehension (1960):

As to clever people's hating each other, I think a little extra talent does sometimes make people jealous. They become irritated by perpetual attempts and failures, and it hurts their tempers and dispositions. Unpretending mediocrity is good, and genius is glorious; but a weak flavor of genius in an essentially common person is detestable. It spoils the grand neutrality of a common-place character, as the rinsings of an unwashed wineglass spoil a draught of fair water. No wonder the poor fellow who belongs to this class of slightly favored mediocrities is puzzled and vexed by the strange sight of a dozen men of high capacity working and playing together in harmony.

25. The writer suggests that persons of exceptionally great ability

A. tend to like and appreciate one another.

B. dislike the company of ordinary men.

C. are likely to be jealous of one another.

D. are essentially common except for their genius.

Although the writers of the test consider A to be the correct answer some of our subjects chose (and justified) C as their answer to this question. People who select C interpret the first sentence of the passage to mean that clever people are jealous of one another (the same interpretation those who choose A make), but then equate "clever people" with "geniuses". Although there are other indications in the passage that the author does not consider clever people to be geniuses, this evidence does not change their opinion, so they assert that "persons of exceptionally great ability are likely to be jealous of one another". In our sample, those who chose C also considered themselves members of the lowest of the three groups of people identified by the author (ordinary people, slightly gifted people, and geniuses); one is tempted to conclude that they were therefore less conscious of the intended differences between geniuses and clever people. A child who has been taught for years that he is "disadvantaged" or a "low achiever" is more likely to see himself as an example of "unpretending mediocrity" -- and choose the wrong answer to the question. In addition, the entire passage reeks of elitism -- the glorification of intellect above all and the pity afforded the "poor fellow" who can't quite make it to the top.

Reader preference. Anyone who has read books with children knows that every child finds some books fascinating and others boring. How interesting a child finds a book obviously affects how much he or she understands the story and how much he or she enjoys reading it. Unfortunately, if a child's early reading experiences are dominated by boring or irrelevant material, he or she is likely to view reading as a tiresome task. Thus, it is important for teachers and parents, who play a large role in selecting reading material for young readers, to have accurate perceptions of the kinds of books particular children will be most likely to enjoy.

Research in this area has focused on the development of instruments for measuring reading interests (e.g., Dulin, 1974) on measuring the effect of interest on comprehension (e.g., Asher, 1978), and on comparing reading patterns and preferences of different cultural groups (e.g., Zimet & Camp, 1977). This last area is of particular interest to us, as it is clear that a child's culture will fundamentally influence his or her preference in reading material. While studies such as Zimet's move in the right direction, little has been done to investigate the accuracy of teachers' perceptions of their students' preferences, especially in cross-cultural situations. In conjunction with our work on rhetorical structures, inside view, and readers' preferences (see Section 3.4), we plan to carry out a series of experiments designed to investigate the following questions:

- Are teachers good predictors of children's reading preferences in general?
- Is there an overall difference between inner-city and suburban teachers as predictors?
- Are elementary school teachers more successful at predicting the books children find most popular in the community in which they teach (i.e., where they share cultural and socio-economic background) than in an "alien" community?
- Within a group of inner-city teachers, are Black teachers better predictors of their students' preferences than white teachers?

We plan to assess children's preferences in several culturally and racially different communities by at least two methods. One source of information will be the relative frequency with which certain children's books have been borrowed from the community library. Another will be interview sessions in which children are asked to rate a set of books. We will then ask teachers from those communities to predict the order of books on each list. We will also interview the participating teachers to determine what criteria they used in ordering the lists. Results of this study should provide useful information for parents accompanying their children to libraries, teachers assembling classroom libraries, and administrators planning pre- or in-service language arts

workshops. In addition, they will of course be used to select text and evaluate the results of our comparative analyses of children's literature (Section 3.6).

Discourse level differences in language and communicative style. Prior research on minority dialects such as Black English Vernacular (BEV) has emphasized hypotheses about differences on the phonological or syntactic levels. Work on these hypotheses, however, has failed to produce the expected results, and reading programs which focus only on the phonological and syntactic distinctions between BEV and standard English have not been notably successful. Our emphasis on language experience, (see Sections 3.1 and 3.2), however, leads us to look in other directions for differences between the linguistic expectations of minority children and white children. The use of intonation, the role of extra-linguistic communication and the structure of conversation differ significantly between BEV and Standard English. For example, Smitherman (1977) describes much of black conversation as following a "call-response" pattern derived from minister-congregation interactions. To a child who has grown up with this form of communication, the conversations in regular primers may seem strange. We intend to investigate further this kind of "linguistic mismatch", rather than mismatches at the levels of phonology and syntax.

We have begun this investigation by looking at a number of texts which are written in BEV, are directed specifically to Black students or relate Black folk tales. Some of these texts are in Bridge, a remedial series written especially for Black adolescents reading at elementary school levels. This series provides parallel stories written in three different dialects: Black dialect, transitional dialect and standard English. By comparing the three versions of the story on several levels, including story structure, discourse structure, and plot, we hope to identify culturally bound differences so that we can investigate how they facilitate or complicate reading comprehension for different groups of students.

3.9 Comprehension of Sentence Meaning

The framework for this research is a model of active comprehension of sentence meaning by overlapping context-sensitive processes of:

- determining the conceptual referents of nouns and noun phrases;
- deriving semantic relations that follow from the verb or other predicates;
- adjusting those relations to fit with the conceptual referents of the nouns and noun phrases;
- combining relations across sentences in a manner dictated in part by the current text structure; and
- monitoring all of these component processes to insure that comprehension is progressing (Section 3.10).

Thus the process of reading for meaning requires not only knowledge of the relevant vocabulary, but also knowledge of the rules by which word meanings are combined into sentence meanings and paragraph meanings are combined into a meaning for the text as a whole, as well as metaknowledge about the process of comprehension (Section 3.10).

Nature of concepts. To understand how people use words to determine conceptual referents, we need to know something about the nature of concepts. There is currently a good deal of consensus that most concepts contain a prototype component, that is, a relatively concrete description that is closer to some members of the concept than others. And when readers come across a word designating a concept, the first component of the concept that seems to become available to them is the prototype; this makes the prototype component highly influential in rapid

reading. We are currently studying different proposals about the nature of prototypes, for example, whether a prototype is best thought of as a hypothetical average, or as some specific instance of the concept that is learned during a critical period. There may be developmental differences here: for children, a prototype may often be a specific instance, while for adults it may often be an average or some other measure of central tendency.

Another issue about concepts that is of concern to reading involves the optimal level at which to describe a particular referent. To illustrate, if a text has to mention a particular apple, should the text use the term fruit, or apple, or something more specific like MacIntosh apple? Though this choice can be affected by context (e.g., useMacIntosh apple if there is a need to distinguish the referent of interest from other kinds of apples), it turns out that one particular level of conceptual description works best in most cases. This level is called the basic level of concepts, and it corresponds to apple in the above example. The basic level has been shown to be the first one acquired by children, thereby suggesting the importance of using basic-level terms in beginning readers. We are currently working on the question of what determines whether an object concept will be basic-level or not, as well as on the related issue of whether or not there are basic-level concepts for actions and events of the sort found for object terms.

Semantic integration. Focusing on the role of the verb as the chief provider of relational information, we are studying the development of skills for comprehending the semantic relationships conveyed by a piece of text. Proficient readers attempting to recall prose make characteristic "integration errors" indicating that they have combined semantic relationships that were originally conveyed by separate words into one complex relational word (e.g., they may combine giving and owing into paying). This kind of fusion is an indication of deep understanding; therefore, it is important to distinguish integration errors from other errors in children's recall of prose.

We have investigated some of the parameters that control semantic integration among proficient readers. Two important parameters are the distance between the two pieces of information and the order in which the information is presented. Good readers are more likely to make semantic integration errors if the two separate items are close together in the passage. When a separation is one sentence or less, semantic integration errors are significantly more likely than when the two words are separated by a paragraph. This is another indication that such errors are one result of combining information at the conceptual level, rather than mere forgetting. The second structural parameter is order of information. Semantic integration errors are more likely if the general statement (e.g., give: the information that there is a transfer of possession) precedes the specific information (e.g., owe: the information that the transfer is obligatory). It seems that the integration of information proceeds best when the general framework is set up early and then followed by more specific details.

We plan to extend this research to chart the development of semantic integration strategies, comparing children with adults on the kinds of relationships that are combined into units, the distance across which the child will integrate information, and so on.

Semantic cohesion. A related line of research is the investigation of the way in which text is held together by relational terms. We have found that for good readers, memory for the objects mentioned in a sentence is better if the verb in the sentence is a highly connective verb. For example, sell is a more connective verb than give, since it sets up more transactions between the participants in the event. Similarly, the verb scrub is more connective than the verb clean, since it tells what actions took place between the actor and the object, as well as what change-of-state (dirty to clean) occurred in the object. For good readers the nouns in a sentence are more strongly associated in cued recall tests if the sentence contains sell or scrub then if it contains give or clean.

Adjustment of meaning. We are also investigating the strategies that good readers use for interpreting odd sentences. When adult readers paraphrase sentences with unusual combinations of subjects and verbs -- e.g., "The lizard worshipped" vs. "The lizard grew" -- they show characteristic strategies for adjusting the strained sentences. Verb meanings are altered more than noun meanings in these adjustments; and more generally predicate meanings change more than topic meanings. We plan to investigate the development of these strategies, using a detailed model of the process by which predicate meanings are adjusted.

Development of metaphor/analogy. Metaphors and analogies are often used in explaining new topics. Thus, it is important to understand what kind of interpretations of metaphor and analogy will be made by a child at a given level of development. Children's poor performance on some analogy tasks indicates that there may be important developmental changes in the interpretation of figurative language. In initial research with adults, we found that metaphorical processing involves preserving a set of semantic relationships across different conceptual domains. Recently we have extended this research to compare children and adults in their interpretations of simple metaphorical comparisons. We find developmental trends towards increasing use of relational information in the interpretations, and decreasing use of adjectival or attributional information. A five-year old typically will interpret "A camera is like a tape recorder" to mean, for example, "Cameras and tape recorders are both black and shiny.", focusing on the object attributes of cameras and tape recorders. Adults instead ignore the specific qualities of the objects, focusing on the common set of relationships between the domain of cameras and the domain of tape recorders: for example "They both are used to capture an event in some kind of medium that so that it can be reexperienced later." Further, adults judge metaphors as more apt the more relationships they can find on which to base their interpretations. Children, on the other hand, show no correlation between aptness and relationality.

Further research will investigate whether these differences are caused by differences in children's interpretation strategies for metaphorical comparisons or by children's lack of sufficient knowledge of the relations themselves. We are also investigating the development of the rules for analogical mapping given different uses of metaphor/analogy (e.g., for literary comparison vs. scientific modeling).

High-level connectors. Another important area of semantic relationships is the reader's understanding of such connective phrases as on the contrary, in contrast, however, nevertheless, in the same vein. These connectors can be considered high-level predicates that convey relationships among relatively large blocks of text. These high-level connectors perform a crucial function in orienting the reader to the plan structure of the text. Yet they are seldom taught explicitly in the schools and they are often improperly used in writing by high school and even college students. We plan to explore the effects of teaching these connectors and their functions in text.

3.10 Metacognition

Good reading seems to require the reader to monitor the progress of all the comprehension processes described above. Thus one needs to check that one has found conceptual referents for all words encountered, that one has been able to use the verb to integrate all the concepts expressed in a sentence, that one has been able to combine propositions from related sentences into a coherent whole, and so on. This kind of checking, or monitoring, really involves two components: (1) monitoring for possible problems, and (2) applying corrective procedures whenever a problem arises. There is already some evidence that proficiency on these two components are major factors that distinguish good readers from poor ones.

We are attempting to provide a relatively complete taxonomy of the kinds of problems that readers must monitor for, as well as the corrective procedures that should be applied whenever a

particular kind of problem is encountered. In addition to specifying these corrective procedures, we are also trying to characterize what conditions favor each procedure; for example, given that the monitoring process has detected a failure to understand a word, the corrective procedure of "suspending judgment" should be used if the text has repeatedly introduced new terms and then subsequently defined them.

The outcome of our conceptual work, then, will include three components:

- a list of possible comprehension problems for which to monitor;
- a list of corrective procedures for each comprehension problem; and
- a specification of the conditions that favor each corrective procedure for each problem.

We think that these are valuable things to teach readers, and we are planning research to evaluate the possible benefits of an instruction program that includes our three components.

3.11 Readability

Traditional readability. To be able to measure the readability of a text with a simple formula is an enticing prospect, as there are many tasks for which a simple measure of text difficulty would be enormously useful. These include: designing (writing, selecting and adapting) texts appropriate to the level of a child in school, choosing among trade books for children, choosing passages for tests, evaluating difficulties in reading, making writing clear for adults, designing materials for special populations, and writing and evaluating materials to be used in research. In our work on readability formulas, we have studied specific examples of the common uses of readability formulas, and identified problems that come up in using the formulas in these ways.

Our analyses, further described in Bruce, Rubin, and Starr (1980) and in Bruce and Rubin (1980) have illustrated various ways in which readability formulas give faulty predictions, or even lead to the writing of passages which are harder to read. In many cases, one can point to an assumption about the use of the formulas which has been violated. Our list of assumptions has arisen from examination of cases where the formulas have failed, but similar lists have been put forth by designers of the formulas themselves. For example, explanatory material put out by the publishers of the Raygor Readability Estimator states quite accurately some of the limitations of readability formulas:

> Reader interest level, reader experience, or any other personal or ethnic variables are not measured by this or any other estimators of readability. Readability estimators do not measure style or syntax.

Making materials less difficult by shortening sentences and substituting shorter or more common words for longer and more difficult sentences and words may not, in fact, reduce the difficulty level indicated when the formula is applied to the new material. The new material may appear easier and show a lower grade level with the estimate but the concept level may still be high. Readability estimates use variables that predict but do not necessarily control the difficulty of the material. Estimates work best on discursive or narrative prose. Applying estimates to poetry, test items, or other types of non-prose material may produce inaccurate results.

These cautions seem clear enough, and examples that we have analyzed give strong evidence that the cautions should be observed. Nevertheless, it appears that nearly all of the common uses of readability formulas violate the basic assumptions on their applicability. The problem is that the assumptions restrict readability formula use to trivial cases of little import for educational or social policy. Our analyses have indicated that readability formulas should be used only where the following criteria are met: (1) material may be freely read, (2) text is honestly written, (3) higher-level text structures are irrelevant, (4) purpose in reading is irrelevant, (5) statistical averages are

meaningful in individual cases, (6) the readers in whom you are interested are the same as the readers on whom the readability formula was validated. Rigorous adherence to these assumptions effectively prevents use of readability formulas for TV captioning, adaptation, selection of texts for readers of different cultural backgrounds, designing special texts for children, selection of test passages, choosing trade books, or designing remedial readers. Thus, there seem to be no areas in which the assumptions about the readability formulas are satisfied and the formulas improve on intuitive estimates of the readability of the text.

Conceptual readability. Our view is that there are many higher-level characteristics of texts which substantially affect their readability and in particular determine how difficult they will be for children to comprehend. Rather than focusing on syllables, words, or the length of individual sentences, our approach is to examine, in addition, the syntactic and larger structural and conceptual levels of text -- how information is packaged, how arguments are presented, what place examples play in an exposition, what inferences must be made by the reader, how characters' plans are developed. We have called this perspective "conceptual readability", in order to emphasize its focus on the content of reading material and the structure in which it is communicated. perspective "conceptual readability".

We are developing new methods of analyzing text with the idea of conceptual readability in mind. Examples of our work in this area follow:

- Understanding an apparently simple story may involve complex inferences about characters' beliefs and plans. We are examining children's texts used in and outside of school to determine the skills and knowledge needed to comprehend the plans and social interactions of characters. (Bruce, in press-c; Bruce, in press-a; Steinberg & Bruce, 1980)
- The difficulty of a particular text depends on the syntactic relationships both within and between sentences. These relationships can facilitate or hinder comprehension of the underlying meaning of text. (Gentner, 1979; Huggins & Adams, in press)
- The complexity of concepts found in a text can be examined in light of rhetorical elements such as author-reader distance, commentary, point of view, and insight into characters' minds. We have developed a formal model for these rhetorical elements and applied it to basal readers, children's trade books, and traditional children's literature classics. (Steinberg and Bruce, 1980; see Section 3.6)

Real readability. Even the definition of conceptual readability fails to take into account many of the real factors that affect the readability of a text. In thinking about the kinds of questions a reader might ask her- or himself in determining whether a particular text is difficult to read, we find questions such as the following relevant:

- How do I feel? Am I tired? Hungry? Do my eyes hurt? Am I distracted or preoccupied?
- How interested am I in this topic or this story?
- What do I already know about the subject? Do I have enough background knowledge?
- How similar is the writer's language to mine?
- How plausible to me are the writer's presuppositions? What do I have to take for granted in order to understand this text? Which of my own beliefs must I temporarily lay aside?
- Why am I reading this? Do I want a clear model of all the facts presented in the article or is a general understanding sufficient? Is my purpose merely escape?
- How long do I have to read this? How does this limitation affect my reading goals?

- What do I want to do with the information I get?

This mere beginning of a list reflects the personal, interactive nature of reading. Each question examines the relationship of the text and the reader; none relates to the text in isolation. In this view of reading, it is bizarre to think of a text as having a degree of readability in and of itself, apart from considerations of the reader. Thus, we are now looking at factors such as the background knowledge of the reader relative to the knowledge presumed by the writer, the purpose of the reader relative to the purpose of the writer, and the purpose of the person who is presenting the text to the reader (Adams & Bruce, in press). These factors cannot be captured in a simple formula, but ignoring them in trying to assess readability may do more harm than good.

3.12 TV captioning for the deaf

We have discovered that our research on text structure and the comprehension process has applications beyond the domain of books and classrooms. As the role of printed text in the communications field expands, research on reading comprehension becomes more relevant to production of broadcast text. In particular, the process of captioning programs for the hearing-impaired, children, and second language learners raises many of the same issues which we have pursued in our work on texts. We have done preliminary studies in collaboration with the Caption Center at WGBH-TV investigating captioning practices and their effect on the comprehensibility of captioned programs.

In the past, information communicated on television has been almost totally inaccessible to the deaf and hearing-impaired. The recent introduction of closed captioning systems insures that the amount of captioned programming will greatly increase in the near future. While the technology exists, however, the answers to a multitude of important questions do not. Should captions be verbatim transcriptions of the audio portion of a television show? If not, what principles should guide the editing process? Do these principles differ significantly from one genre of program to another? How should vocabulary be controlled? What considerations are relevant to deciding where to insert line or page breaks into captions?

In fact, captions are usually syntactically and lexically simplified versions of the soundtrack of a program. Because the target population is often assumed to have low-level reading abilities and because of constraints on the temporal and spatial dimensions of the printed display, verbatim captions are generally considered inappropriate. Yet, aside from some written guidelines, captioning for adult viewers is currently done primarily on a case by case, intuitive basis. Little is known about the properties of captioned texts that contribute to their comprehensibility or about the consequences of current practices. In the simplification process, cues to text structure, connectives, and transitional material are frequently deleted. This may result in a text that is syntactically simple, but difficult to comprehend because the reader must generate deleted information and integrate different portions of text in the absence of explicit cues to its structure.

In our preliminary work with WGBH, we have examined several audio scripts and the corresponding captions to try to identify crucial areas where captioning decisions can greatly affect comprehensibility. The following example, in which the audio portion of a news broadcast is compared to the captions that actually appeared on the screen, exemplifies some of the major areas we have investigated.

> Original -- (Reporter:) The energy proposal almost went down the drain today here in the House of Representatives. The battle was over lumping the natural-gas bill with less controversial energy bills. Some senators wanted to split off natural-gas,hoping then to kill it. (Senator:) "I could go on all day reciting the prestigious national organizations that are in all-

> out opposition to this legislation. And yet, we're being told as a proud legislative body that we should swallow this whole indigestible mass with one single up-or-down vote."
>
> Captioned version -- (Reporter:) The energy program almost ended today in the House of Representatives. The argument was about linking the natural-gas bill to less controversial energy bills. (Senator:) "I could continue listing the honored national organizations that completely oppose this legislation. But we are being told that we should accept this whole legislation by voting on it once."

The captioned text differs from the original in several ways. It has been shortened by about a third through deletion; individual sentences are shorter and syntactically less complex. Simple lexical items have been substituted for more difficult ones (e.g., "honored" instead of "prestigious"). Idiomatic expressions have been replaced by non-idiomatic ones (e.g., "ended" replaces the idiom "down the drain").

These alterations, which are typical, affect both the ease with which individual sentences can be decoded, and the coherence of the story. Some alterations change the meaning of the text; this is especially true in cases of idiom replacement. For example, saying that "the energy program almost went down the drain" does not mean "the energy program almost ended." The latter implies that an existing energy program was about to end, which is untrue; the former correctly suggests that the bill which would have created the energy program was almost defeated. Similarly, idiomatic phrases in the quotation have been replaced with neutral phrases that fail to convey the speaker's attitude and manner.

Information that may be critical to understanding the story has been deleted entirely. By eliminating the sentence about splitting off natural-gas in order to kill it, the explanation for the senator's argument has been lost. The phrase "by voting on it once" in the final sentence of the captioned text is not a rephrase of this missing information. Furthermore, it is ambiguous.

The result of these alterations is a text that may fail to convey the story accurately, despite the fact that individual sentences are indeed simpler than the originals.

The reader is left with a series of sentences that may be difficult to integrate into a meaningful interpretation; thus, readability may not have been enhanced. Research is needed to determine which factors contribute to the comprehensibility of captions and to assess how well current captioning practices fit the language-processing abilities of the target audience.

Our analyses so far have revealed five areas for further research: display conventions, cues to sentence structure, global structure cues, lexical choice, and genres. Future work will involve a more systematic investigation of these factors in a group of scripts and experimental investigation of the effects of captioning strategies on subjects' comprehension of captioned programs.

3.13 Teaching Strategies

We have attempted to build formal process theories of the goals and strategies of human tutors. These theories are based on analysis of the strategies of the best teachers for whom we could obtain films or transcripts.

The teachers we have analyzed have diverse teaching goals and strategies. Nevertheless, we can abstract out common elements in their teaching, as well as reasons for the differences. All of the teachers use some version of the case inquiry, or discovery, method of teaching (Anderson & Faust; 1974; Sigel & Saunders, 1979). They do not simply teach facts, but rather basic principles or basic problem solving strategies for approaching different kinds of problems. For example, one teacher we analyzed is particularly effective in teaching his students how to attack problems. His students end up using many of the same techniques he uses to approach novel problems. Such an outcome

indicates that it is possible to teach problem solving strategies and that these techniques are sufficient to do so.

The theory of interactive teaching that we are constructing is cast in a framework similar to that used by Newell and Simon (1972) to describe human problem solving. It contains three parts:

1. The goals and subgoals of effective teachers.
2. The strategies used to realize different goals and subgoals.
3. The control structure for selecting and pursuing different goals and subgoals.

Teachers typically pursue several goals simultaneously. Each goal has associated with it a set of strategies for selecting cases, asking questions, and giving comments. These are represented in our theory as condition-action pairs (Collins, 1977). In pursuing goals simultaneously, teachers maintain an agenda (Collins, et al., 1975; Stevens & Collins, 1977) which allows them to allocate their time among the various goals efficiently. The theory therefore encompasses goals, strategies, and control structure.

We see two kinds of uses for a formal theory of interactive teaching. Currently there is much active research in developing intelligent computer assisted instruction (ICAI) systems (e.g., Sleeman & Brown, 1979; Goldstein & Brown, 1979). To the degree we can develop precise theories of effective teaching strategies these can be embedded in ICAI systems. Equally important are the implications for teacher education. We think we can make explicit the kinds of goals our best teachers pursue, and the specific strategies they use for dealing with different kinds of situations. In summary, we think it is possible to make the accumulated tacit knowledge of our best teachers explicit enough both for future teachers to learn and for ICAI systems to use.

3.14 Word Recognition

Although much of our research has focused on the effects of higher-order variables on comprehension, we have not ignored the role of word recognition. After all, the ability to recognize written words is the sine qua non of reading. It is this ability that the beginner is most obviously lacking. And there is increasing evidence that word recognition difficulties are often at the core of many ostensibly higher-order reading problems.

In particular, there is evidence that difficulties at the word recognition level may block the normal flow of information or divert attention from the task of understanding. Thus, in the interest of improving children's reading comprehension, a major goal for researchers is that of identifying the knowledge and processes that underlie the relatively automatic word recognition abilities of skilled readers.

Toward this goal, we have developed a model of word recognition that seems to account for the performance of skilled readers quite well (Adams, 1979a). The model is based on laboratory data. Among the experimental phenomena it captures are: the word superiority effect, the word frequency effect, the difference in the perceptibility of pseudowords and nonwords, and the dependency of correct order of report on orthographic structure. Within the model it is assumed that single letters are the basic units of perception. However, perception is mediated through associated networks of letter and word recognition units in memory. Through top-down and bottom-up activity within these networks, the various word recognition phenomena cited above are seen, not as mediated by active processes such as sophisticated guessing, but as the automatic products of the system. Moreover, the structure of the system is compatible with schema-theoretic representations of higher-order knowledge. Indeed, Adams and Collins (1979) have described how it might readily be extended upward to syntactic and semantic levels of processing so as to capture automatic aspects of comprehension.

According to the model, good readers draw on four more or less separate skills in the course of word recognition:

- Letter recognition
- Extraction of order information
- Sensitivity to the sequential redundancy of English orthography
- Sensitivity to whole words.

To discover which of these abilities tend to be especially problematic, we conducted a subsequent study with good and poor high school readers (Adams, 1979b). The data from this study indicated that, as a group, the poor readers were just as sensitive as the good readers to familiar (high frequency), four letter words. However, the poor readers did not exhibit the same facility as the good readers either in recognizing the individual letters of nonwords or in encoding their order. In addition, among good readers the accuracy of identifying and ordering the letters of nonwords was strongly affected by their expectations of whether the string would be regular; among poor readers it was not.

The implication is that for poor readers, the coherence of the reading task will depend critically on their recognizing the words as wholes. Word recognition should cause no problems as long as the words to be recognized are very familiar. However, poor readers will be handicapped whenever they encounter less familiar words. When the memory representation for the whole word is not immediately available, they have relatively little to fall back on. They will have to do more work to recognize the letters and to encode their order than a good reader would. And, because of their lack of sensitivity to orthographic regularity, the information they do extract will not be met with the same automatic support and amplification as it would for a good reader. From this perspective, it is understandable that poor readers might have less capacity and even patience left over for the task of comprehending what they have read.

The finding that a major difference between the good and poor readers was in the influence of orthographic regularity on their letter-order errors is provocative. Letter reversals and transpositions are frequently observed among very poor readers but have traditionally been interpreted as evidence of neurological dysfunction or so-called "primary dyslexia." The present data suggest that these behaviors may reflect nothing more than inadequate knowledge of sequential redundancy. This suggestion is reinforced by Estes' work on the perception of item order in visual arrays (Estes, 1975, 1977; Estes, Allmeyer, & Reder, 1976).

A second direction of research we have taken from our model of word recognition is towards puzzling out the functional significance of the orthographic structure of English. In particular, we have hypothesized that the major value of the sequential redundancy of English, and especially of the redundancy contributed by the vowels, derives from the cues it provides to readers with respect to the syllabic structure of words. This extension of the model is described in Adams (in press). If the hypothesis is correct, it justifies one more argument as to why phonics, or at least some such method for instilling sound knowledge of orthographic structure, should be taught to beginning readers. In addition, it suggests several types of decoding "bugs" that are likely to be displayed by young or poor decoders and that can be experimentally assessed.

Beyond work that has grown from our model of word recognition, we have been developing a diagnostic test of decoding skills for children in the second through fifth grades. This effort was initiated under a contract from the National Institute of Child Health and Human Development, but has proceeded in close collaboration with the Center for the Study of Reading.

The purpose of the test is to identify children whose mastery of particular skills is not commensurate with their overall level of reading proficiency. That is, the test is concerned, not with the rate, but with the balance of component skill acquisition. It may be unavoidable that some children learn to read more quickly than others. Yet we may assume that, except for extreme cases, any child who is acquiring the proper composite of skills in their proper relationships is on the way to becoming a good reader. If, on the other hand, a child is experiencing special difficulty with some subset of the requisite skills, overall progress will be impeded, and the reading complex, as it is eventually established, may be disadvantageously unbalanced. As an analogy, consider the piano student with a weak left hand. He may learn to compensate more or less through various gyrations of his wrist and arm; he may learn to avoid materials which tax the hand too much. But he will probably never realize the proficiency he could have attained if his difficulty had been diagnosed and remediated.

The dimensions of the reading complex that the test is designed to assess are:

- Letter recognition
- Application of regular spelling-to-sound correspondences in translating unfamiliar orthographic strings into phonetic representations
- Ability to read isolated words of varying orthographic complexity
- Flexibility in applying alternate spelling-to-sound rules
- Access of familiar words from sounded-out approximations
- Depth of sight vocabulary
- Knowledge of orthographic regularity and permissible orthographic sequences
- Unitized perception of frequent words
- Use of semantic and syntactic context to supplement orthographic cues in word recognition
- Interference of syntactic processing by effortful word recognition
- Word-calling versus on-going processing of syntactic and semantic constraints while reading

The procedure followed in developing the test consisted of: identification of skills believed to be integral to word recognition proficiency and its relationship to reading comprehension; design of tasks that would yield measures of those skills; validation of the tasks by ascertaining that performance varies with stimulus parameters and reading proficiency in the expected ways; iterative testing and revision for the purpose of simultaneously maximizing both the efficiency and the discriminative power of the tasks; and generation of skill profiles for individual children. In the course of the NICHD contract, various versions of the test were administered to over 300 children. At this point we have begun follow-on work within the Center for the Study of Reading.

3.15 Interactions between bottom-up and top-down aspects of reading

This research represents the further development of a componential theory of reading. The theory proposes that reading is an interactive process in which a number of component processes operate simultaneously and communicate with one another through their operation on a common memory store. The purpose of the research is first to extend the analysis of reading components to include discourse processing and, second, to test the validity of the interactive model we have developed through a series of training studies.

The skill components currently under investigation in the discourse processing domain are inferential processing, and the use of context in lexical access. The experiment on inferential processing is designed to measure the effects of text characteristics on text-based inference. The reader's text model at any moment may or may not contain propositions other than those explicitly stated in the text. If a proposition that is inferable is later explicitly realized in the text, it will be redundant for a reader who has made the inference, but not redundant for one who has not. It was expected that reading time should distinguish readers who make advanced inferences from those who integrate propositions concurrently with the presentation of new text. We have also explored how text characteristics influence inference-making processes. Text characteristics manipulated included topicality of the subject of the inference, intensification of pre-requisite states or relations, explicit statement of additional premises, and presence of a conjunctive phrase pointing out the inferential relationship among propositions.

Subjects were presented with text, one sentence at a time, displayed on the monitor of a microcomputer. Our main interest was in the time to read the target sentence as it occurred in different text environments. Results showed no evidence for advanced inferencing among any group of readers. Effects of text manipulations on time for processing the sentence containing the inference were striking, and supported a theory in which propositions co-residing in working memory are automatically integrated, while those residing in long-term memory are integrated upon presentation of a retrieval cue such as in conjunctive phrases. Poorer readers took longer to integrate propositions from prior sentences than did more skilled readers. However, there were no fundamental differences between good and poor readers in overall method for processing propositions, or in utilizing the antecedent textual information that is available to them.

Our investigation of the effects of context upon lexical access grew out of previous studies that found a significant relation between individual differences in reading ability and context utilization. The experiment is designed to investigate the effect of lexical ambiguity on reaction time in making semantic appropriateness judgments. Specifically, we are interested in whether individual meanings of lexically ambiguous words can be separately primed and accessed, and if such priming effects show the same good/poor reader differences observed repeatedly in other context utilization experiments.

The current training studies are being implemented on a Sorcerer microcomputer, for which several gaming formats are being designed to test the trainability of individual components of reading, and to allow a test of the spread of training effects to other components that are thought to interact with components related to decoding efficiency and the utilization of context.

3.16 Writing and its Relationship to Reading

The connections between reading and writing are varied and complex. Writing involves reading one's own work. Writing is also a vehicle for discovering and discussing structural properties of texts. Furthermore, skilled reading involves an awareness of the author and the writing process. Therefore, we have included an exploration of the development of writing skills as part of our work on reading. This research views writing both as a communicative act and as a decomposable process whose product must fulfill an overall communicative function. Each of these perspectives has implications for teaching as well as for research.

Writing as a communicative act. Viewing writing as a communicative act forces us to focus on the active role of the reader and leads us to emphasize the role of audience in choosing tasks for beginning writers. We have identified four principles that form tacit objectives in any communicative act (Bruce, Collins, Rubin & Gentner, 1978). In writing, these objectives are realized by different structures and devices at different levels of a text. There are sometimes other objectives, such as making a text legally unambiguous, but these four appear to have the greatest generality.

- *Comprehensibility.* An important objective in writing is to make the text as easy as possible for the reader to understand. What the writer must do is to give the reader enough clues to construct the correct model of the text. Some strategies that increase comprehensibility are the following; using examples to illustrate general principles, filling in intervening steps in arguments, and using short, simple sentences.
- *Enticingness.* If a reader gets bored and puts aside a text before finishing it, its comprehensibility is irrelevant. Therefore, it is important to use various devices to hold the reader's attention. In conjunction with this, it is sometimes wisest to include the most important information in the beginning, in case the reader stops reading for some reason. There are a variety of devices designed to accomplish this objective: pyramid text form, the use of suspense or humor, and entrapping the reader emotionally with the characters.
- *Persuasiveness.* Commonly in expository texts, the goal is not only to explain some set of ideas, but also to convince the reader the ideas are true (Martin & Ohmann, 1963). There are a number of devices used to make texts more persuasive: the argument form used in some texts, admission by the writer of any problems or limitations, the detailed description of methods used, and the invocation of authoritative opinion.
- *Memorability.* An important principle, particularly for expository writing, is to structure the writing so that the reader can hold the essential parts of the text in memory. This quality, which we call memorability, goes beyond ease of understanding. A text can be easy to understand, but not very memorable; magazine articles, for example, are often highly readable but nearly impossible to remember after a few days.

Writing as a process. Viewing writing as a process enables us to specify a group of subprocesses and their relationship to one another. At the highest level, the writing process can be separated into producing ideas and producing text for those ideas (Collins & Gentner, 1979). The major categories of producing ideas and producing text can be further separated into component subprocesses. Teaching people to separate the various task components allows them to learn how to use the most effective generation strategies for each subprocess, how to edit with respect to each subprocess, and how to ignore other constraints while working on a subprocess (Flower & Hayes, in press). People who write a lot develop many of these techniques, but they are not usually taught explicitly and must be learned in a painful trial-and-error fashion.

It is important to separate idea production from text production. The processes involved in producing text, whether they operate on the word level, the sentence level, the paragraph level, or the text level, must produce a linear sequence which satisfies certain grammatical rules. In contrast, the result of the process of idea production is a set of ideas with many internal connections, only a few of which may fit the linear model desirable for text. Although the set of ideas generated is subject to rules of logical consistency, plausibility, and relevance, these rules are traditionally less codified than the rules for text production, and the number of allowable relationships between ideas is greater than the number of allowable relationships between elements of text.

At least two different subprocesses are involved in idea production: capturing ideas and manipulating ideas. These subprocesses are generally interleaved in most people's writing, but in some situations it is possible to separate them and to apply systematic generation and editing strategies for each process. This kind of separation is most important for the beginning writer.

The process of text production follows that of idea production; the goal here is to impose text structures on the ideas within structural constraints operating on different levels of the text, e.g., the text level, the paragraph level, the sentence level, and the word level. Devices for producing effective texts and editing operators exist for each level of the text.

Separating the various steps in producing text helps the writer in two ways: It simultaneously eases the number of constraints that must be satisfied at one time and it increases the likelihood of satisfying any particular constraint.

- One useful step-by-step procedure is as follows:
- Create a detailed outline of the text structure.
- Apply text-level editing operators.
- Create a semi-text with all the ideas included in paragraphs, but not in finished sentences.
- Apply paragraph-level editing operators.
- Create finished sentence-level text.
- Apply sentence-level editing operators.

This step-by-step approach helps the writer because much of the necessary editing can be done before producing finished text. It also allows the writer to concentrate on generation and editing with respect to one aspect of the text at a time. But it is important that the writer think of the outline or semi-text as modifiable; too often outlines are treated as rigid entities.

Analyzing documents. Having specified both the general goals of writing as a communicative act and the characteristics of a process designed to meet these goals, we can analyze how well specific documents meet these goals and what operators could be applied to improve them. We have studied in depth airline safety instruction cards (Collins, Rubin, Gentner, & Haviland, 1978), emphasizing the importance of memorability and comprehensibility in this document and pointing out problems with excerpts such as:

> There is also a door in the rear of a passenger cabin. REAR CABIN EXIT (STAIR). (If usable, will be opened by a crew member).

Our analysis was also concerned with determining how effective graphic illustrations are in communicating different ideas. For example, we observed that pictures were less effective than words in communicating the advice "When using the emergency slide, jump onto it rather than sitting on it" because the distinction between jumping and sitting was difficult to illustrate.

We performed a similar analysis on patient package inserts for oral contraceptives, noting in this case the particular importance of comprehensibility given the difficult technical nature of the material and the wide audience for which it is intended. Aside from considerations of vocabulary and sentential complexity, one possible modification suggested was to organize potential side-effects of the pill listed in the document anatomically, superimposing them on a schematic of the body in order to enhance both comprehensibility and memorability.

Prototype writing activities. Based on our description of writing as a decomposable process, we have begun to develop teaching activities which address individual subprocesses of writing and afford students practice in a less complicated task which can later be integrated with other related subprocesses. One such group of skills are those related to paragraph organization. The concept of a paragraph as a segment of text expressing a "main idea" is fundamental to a writer's ability to develop cohesive text. Nevertheless, this concept is abstract and difficult to communicate, and children often achieve no more than a superficial understanding of it. Explicit knowledge about the rhetorical devices an author may use to interrelate and organize the information in text should enable students to become better writers (and readers).

We have developed a prototype activity which attempts to teach these paragraph organization skills to students (Nickerson, et al., 1980). Students are given a list of sentences which

can be organized into several paragraphs which make up a brief passage. After all students have read through the sentences, the class as a whole proceeds to group and order the sentences into paragraphs, starting by piecing together pairs of sentences, then moving on to larger structures. When the passage is in its original form, the teacher and class discuss the unifying theme of each paragraph and the role each sentence plays in supporting the theme. Follow-up activities require students to piece together paragraphs and identify the underlying themes on their own.

Story Maker. The *Story Maker* is an educational device which grew out of our concern for teaching reading comprehension and our growing realization that both reading and writing are best taught when they are regarded as inseparable -- as the two necessary components of written communication. As we explored the devices we will describe here, it became clear that it is possible to design methods which serve to re-unite reading and writing in the classroom, where they have been to a large extent artificially separated. Children using the *Story Maker* are actually creating stories which are clearly meant to be read and discussed by classmates -- and are therefore practicing writing -- but they are simultaneously reading stories which someone else has written and therefore having to contend with unfamiliar words, events, and plot structures.

In considering the general characteristics of educational tasks to teach reading and writing, we have identified a set of specific educational goals which can guide the design of effective school tasks. *Story Maker* activities serve to fulfill these goals:

1. Providing an active language experience which allows children to construct stories easily.
2. Demonstrating to children the consequences of choosing different ways for a story to proceed.
3. Avoiding the pitfall of overemphasis on low-level characteristics of text such as spelling and handwriting.
4. Providing a real audience for children's compositions.
5. Creating a natural context for comparing and discussing stories with different high-level characteristics.
6. Providing a social and cognitive context in which it is natural for children to work together on language activities.
7. Providing a motivating, non-threatening, success-oriented context for language activities.

The devices we have developed attempt to address all of the above goals. Although there are a large number of language activities which derive from these tools (Rubin, 1980), we will focus on only two of the basic ones here and explain how they relate to the general points we have listed. Both of these have been implemented on an Apple II computer and in non-computer versions.

The most basic device we will describe is called a *Story Maker*. It is essentially a tool which allows children to create stories by choosing options from a set of already-written story segments. After making a series of choices, a child has a completed story which he or she can read, copy, illustrate and show to parents and friends. These choices are structured as a tree - that is, initial choices a child makes constrain choices he or she can make later in the process.

The beginning of a story tree in Figure 1 illustrates the basic structure of a *Story Maker* activity. The tree is made up of a group of stories about a Haunted House; each story segment is contained in a box. Each story begins with "Lace opened the front door and..." and one possible story a child might construct within this story tree would start out

Lace opened the front door and slipped into what looked like a bowl of spaghetti.
Frankenstein was cooking it for his dinner.

In the most elementary process of constructing a story from the tree, a child is actively involved in a reading and writing experience which quickly yields a complete story; thus this activity fulfills goal #1, that of providing an active experience.

We have implemented the *Story Maker* so that a child cannot see a given set of alternatives until the time has come to choose from them. Thus, a child is sometimes surprised at the consequences of his or her choice. A child choosing from the first three choices in this tree, for example, would have no idea what story segments followed along any of the branches. The technique thus addresses the second general goals of demonstrating the interrelatedness of story segments.

The *Story Maker* prevents both children and teachers from focusing attention on syntax, spelling or the like by guaranteeing that each and every story a child produces will be acceptable along these dimensions. Thus, the third goal is realized. Because it requires simultaneous concentration on fewer levels of the text, a child's task using the *Story Maker* is simpler than the job of writing a story from scratch.

To illustrate a way of fulfilling the other four goals in our list, we will introduce an extension of the *Story Maker* idea -- a device called the *Story Maker* Maker. After children have had some experience with the basic *Story Maker*, they can construct their own *Story Maker*s, deciding on the individual story parts and, perhaps, even the tree structure. Children working in groups can write story segments on index cards and then place them on hooks on a pegboard; branches can be indicated by pieces of yarn connecting the hooks. Multiple branches allow different children to see their own ideas of how the story should proceed included in the final product.

When the *Story Maker* is completed, another group of children can use it in the activities we have described above. This interaction achieves our fourth goal of providing a real audience for children's compositions. The Haunted House story tree partially shown in Figure 1, in fact, was written by Michelle, a third-grader, with the help of an adult tutor.

When the children in Michelle's class used the Haunted House *Story Maker* to produce their own stories, the activity provided a means of addressing the fifth goal -- the creation of a context for comparing stories with different high-level characteristics. Because the stories were all constructed from the same story tree, they were similar enough to invite comparison. Because each reflected an individual child's choices, they were different enough to force a contrast.

Goal #6, that of collaboration on a particular story, is facilitated by the actual physical layout of the *Story Maker* and *Story Maker* Maker. The size of the pegboard *Story Maker* Maker we have built (4 feet by 7 feet) almost necessitates participation by more than one child at a time. Thus a group writing experience develops in which children trade off as main author or designer.

Finally, *Story Maker* activities appear in our experience so far to be highly motivating, satisfying goal #7. Because every story produced using a *Story Maker* is correct in terms of spelling and syntax, a child is guaranteed at least partial success in this language activity. Children have shown marked persistence in working with the *Story Maker*. Our early successes have encouraged us to continue developing this classroom tool and to test our hypothesis that activities that concentrate on the educational issues raised by our seven goals have the potential to positively affect classroom language experiences.

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Dissemination

Teacher-oriented Work

Several of our activities have been oriented to the needs and interests of the classroom teacher. Among these are the following:

- Many of us are engaged in tutoring in the Cambridge private schools (the Lincoln and Fitzgerald public schools and the Cambridge Friends' School). We are doing this to observe classroom situations, to test ideas about reading strategies and kinds of difficulty of texts, and to discover potential "bugs" in the comprehension process.
- We have given presentations based on our research that emphasize the impact on education to groups such as the National Council of Teachers of English, the Massachusetts Right to Read workshop, the National Reading Conference, International Reading Association, and the American Educational Research Association.

- We have communicated with teachers at conferences such as the Lesley College Children's Literature Weekend, the Northeast Regional Conference for the Social Studies, a teacher training workshop sponsored by Educational Development Center and the Lesley College Conference on Computers in Education.
- We are preparing reports for IRA publications and such journals as Principal, The Reading Teacher, Journal of Reading, and Language Arts. These reports deal with topics such as difficulties of assessing comprehension, the complexity of stories, and different reading strategies.
- We have had as consultants elementary and junior high school teachers and specialists in remedial reading and learning disabilities.

Book

A selection of our research will appear in a book entitled Theoretical Issues in Reading Comprehension, R.J. Spiro, B.C. Bruce & W.F. Brewer (Eds.) The book will be published by Erlbaum, Inc. and is expected to appear in 1980.