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ABSTRACT

The problem of the panel on semantics, concepts, and culture, sponsored by the National Institute of Education Conference on Studies in Reading, was to determine how lexical, semantic, conceptual, and cultural factors contribute to reading comprehension. The contents of the document include the following: "Word Recognition Skills," which explores the extent to which reading comprehension depends on the readers' knowledge and recognition of the words they are reading, and which presents two projects, one concerned with a psychological investigation of the organization of lexical memory and its relevance for word recognition, the other with the simulation of lexical memory and retrieval in text-processing systems; "Sentence Comprehension Skills," which has as its goal exploration of the extent to which reading comprehension depends on the reader's mastery of conceptual relationships within a sentence; "Text Comprehension Skills," the goal of which is identification of those skills that are important for text comprehension, as distinguished from word or sentence comprehension, and the determination of how those skills can be taught; and "Priorities and Recommendations," which discusses assigning priorities. (WR)

Semantics, Concepts, and Culture

No. 1

CONFERENCE ON STUDIES ON READING

"It was unlawful, as well as unsafe, to teach a slave to read.
'It will forever unfit him to be a slave. He will at once become unmanageable and of no value to his master.'
These words sank deep into my heart. From that moment, I understood the pathway from slavery to freedom. Though conscious of the difficulty of learning without a teacher, I set out with high hope and fixed purpose, at whatever cost of trouble, to learn how to read."

Frederick Douglas

NATIONAL INSTITUTE OF EDUCATION

Washington, D.C.
June, 1975

U.S. Department of Health, Education and Welfare

NIE CONFERENCE ON STUDIES IN READING

PANEL 1

SEMANTICS, CONCEPTS, AND CULTURE

## PROBLEM STATEMENT

How do lexical, semantic, conceptual, and cultural factors contribute to reading comprehension?

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PANEL 1

SEMANTICS, CONCEPTS, AND CULTURE

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## PREFACE

The National Institute of Education (NIE) came into being during 1972. Its authorizing legislation requires the NIE to:

- Help solve or alleviate the problems of, and achieve the objectives of, American Education.
- Advance the practice of education as an art, science, and profession.
- Strengthen the scientific and technological foundations of education.
- Build an effective education research and development system.

In order to aid in meeting these general objectives, the National Council on Education Research (NIE's policymaking body) approved the creation of five priority areas in December, 1973. One of the priority areas was the Essential Skills Program.* The purpose of that program was:

> To investigate through research and development, ways to aid all children to obtain skills essential for functioning adequately in school and society.

The initial focus of the Essential Skills Program was in the area of reading. During 1974, the Essential Skills Program carried out an intensive effort designed to formulate plans for funding research and development activities in reading. A variety of meetings were held with groups of teachers, school administrators, and scientists to designate directions for the program. The most ambitious of the meetings was held in Washington, D.C., in August, 1974, and directly involved over 175 individuals -- 50 as Conference participants and 125 as consultants to the Conference. This report is the product of one of the 10 panels of the August Conference.

The impetus for the Conference stemmed from a number of concerns about the state of Federal funding of research and development in education. Four concerns stood out in particular for reading.

1. Research in the field of reading was fragmented and noncumulative.

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*During the past few months, the Essential Skills Program has been renamed the Learning Division of the Basic Skills Group. Both the Basic Skills Group and the Learning Division continue to follow the guidelines set out by the National Council in December, 1973 (above).

2. The Federal Government was not making constructive use of the state of knowledge in the field in their decisions to fund new research and development.

3. There was a lack of positive and firm coordination between the Federal Government and the professional research and practicioner organizations around the country.

4. A large number of scientists in a variety of disciplines carry out research with relevance to reading. We considered it important to attract these scientists to work in the applied areas of educational research.

The Conference itself was a step in meeting these concerns. During the past year, the NIE has been developing plans for funding research and development in reading for the next two years. Suggestions from the Conference have played an important role in this process. But planning is an ongoing process and we hope by publishing and widely disseminating the reports from the Conference to stimulate discussion of the reports, of research and development in the field of reading, and, indirectly, of the plans of the Institute.

To some extent the format for the Conference was influenced by three other similar efforts of the Federal Government. In the area of health research, the conferences leading to the National Cancer Plan and the National Heart and Lung Institute Plan served as partial models. Within NIE, the Teaching Division had held a major planning effort in the area of teaching research during the early summer of 1974. The intent in each of these efforts was to develop a coherent set of documents that would be responsive to the needs of the American public and to knowledge in the field.

We felt it necessary to structure the Conference in two important ways. First, after extensive consultation with scientists and practicioners in the field we arrived at the conclusion that major efforts in the past had often ignored or down-played the critical importance of the stage of reading called "reading comprehension." Although we realized the impossibility of actually separating out "reading comprehension" from the earlier stages of learning to read -- which requires the learner to be able to translate written letters and words into speech -- our advice suggested that the comprehension or "reading for meaning" stage required far more attention than it had received in the past. Consequently, seven of the ten panels focused on problems in this area. Second, to direct the focus of the panels to planning future research we requested the panelists to organize their ideas into general approaches within the problem area, within the approaches to suggest programs for research, and, finally, when possible to specify particular research or development projects.

The seven panels addressing problems in comprehension spanned a wide range of concerns. The first three panels focused on basic research issues. Their panel reports are titled: Semantics, Concepts, and Culture, The Structure and Use of Language, and Attention and Motivation. The fourth panel was asked to consider the problem of Modeling the Reading Process. The fifth panel directed its attention to the issue of measuring how well people read and its report is titled Assessment of Reading Comprehension. The sixth and seventh reports directed themselves respectively at the practical problems of the Application of Existing Reading Comprehension Research and Reading Comprehension and the High School Graduate. The final three panels directed their attention to three pressing concerns in early reading: Learning and Motivation in Early Reading; Reading Strategies for Different Cultural and Linguistic Groups; and Essential Skills and Skill Hierarchies in Reading.

Although the reports have undergone some revision and editing since the Conference, the major part of the work was done in concentrated sessions in the space of a few days. The resulting documents are not polished or exhaustive. They are meant to be working documents to stimulate debate, suggestions, and comments. Such comments or requests for other reports should be directed to:

Director, Learning Division
National Institute of Education
Washington, D.C. 20208

The work of organizing the Conference was carried out by members of the Essential Skills staff at the NIE -- each of the panels had an NIE staff person as a permanent liaison. Special acknowledgements are due to Susan Duffy and Donald Fisher for their assistance in preparing the reports for publication and to Arthur Young & Company for coordination and arrangements before, during, and after the Conference. Finally, the work of NIE cannot proceed without the kind of skill, involvement, and hard work given by the panel chairpeople, panelists, and consultants for this Conference. The ideas and emphases in the reports are the products of their cumulative expertise.

Marshall S. Smith
Conference Chairperson

## LIST OF PANEL REPORTS AND CHAIRPERSONS

1. Semantics, Concepts, and Culture, Dr. George Miller, Rockefeller University

2. The Structure and Use of Language, Dr. Thomas Trabasso, Princeton University

3. Attention and Motivation, Dr. Sheldon White, Harvard University

4. Modeling the Reading Process, Dr. Richard Venezky, Wisconsin University

5. Assessment of Reading Comprehension, Dr. Ernst Rothkopf, Bell Laboratories

6. Application of Existing Reading Comprehension Research, Dr. Lauren Resnick, University of Pittsburgh

7. Reading Comprehension and the High School Graduate, Dr. Mina Shaugnessy, City University of New York

8. Learning and Motivation in Early Reading, Dr. Richard Hodges, University of Chicago

9. Reading Strategies for Different Cultural and Linguistic Groups, Dr. Manuel Ramirez, University of California, Santa Cruz

10. Essential Skills and Skill Hierarchies in Reading, Dr. Irene Athey, University of Rochester

PANEL 1

SEMANTICS, CONCEPTS, AND CULTURE

## INTRODUCTION

Preparation of instructional materials appropriate to the age, knowledge, and cultural background of persons learning to read and understand written texts is necessarily based on assumptions about the lexical, conceptual, semantic, and syntactic skills of learners. The validity of those assumptions will determine, in large measure, the effectiveness of the materials. It is important, therefore, to subject those assumptions to scientific test. In that direction lies progress toward better instructional materials, curriculums, and teaching methods--if, indeed, progress can be made.

The panel's concern was to formulate those steps that might be taken in order to provide a better scientific base for technological applications designed to improve the teaching of reading comprehension. Improving our fundamental knowledge about comprehension is not the sole responsibility of the National Institute of Education, of course, and some of the programs described are written as much to our colleagues and to the general public as to the Agency that sponsored the panel's work. We believe that the general outline sketched here reflects what will have to be done in the years ahead if psychology and linguistics are to contribute to better reading comprehension skills; much of it will probably be done one way or another as part of the organic growth of these disciplines. It will be done sooner and with more obvious relevance to educational problems, however, if the NIE provides support.

As educators have long been aware, a program of instruction in reading comprehension, like any other instructional program, stems from three basic theories: one that describes the structure of the content, another that describes the capabilities of the learner, and a third that describes how society's values may be applied to this instructional program. In the case of reading comprehension, all three of these basic theories have been weak. The research described here should help to strengthen the first two theories by indicating more clearly the structure of the skills to be taught and the abilities that learners can bring to instructional situations. At this point, a theory of social values must be brought to bear in order to determine which of the learnable skills involved in reading comprehension are desirable to learn. When this theory is employed to select the skills to be taught, the result is the curriculum content for reading comprehension. Still other theories--instructional theory and evaluation theory--will thereupon turn the skills and attitudes in the curriculum into an instructional program. The panel's mandate did not extend into these subsequent decisions, but we were well aware that the advancement of society toward broader and deeper literacy will not follow automatically from the successful strengthening of the first two theories in isolation from the third.

In order to deal with these problems, the panel had available reports from field consultants who attempted to summarize the current state of

knowledge on various issues and to suggest how important pockets of ignorance might best be eliminated. The members of the panel represented a wide range of disciplines--social anthropology, developmental psychology, education, artificial intelligence, and psycholinguistics--and were able to supplement their own knowledge with that of other panelists dealing with other aspects of reading comprehension at the same conference.

The initial meeting of the panel resulted in discarding the outline prepared in advance of the conference, and replacing it with the three approaches that serve to organize the body of this report: word recognition skills, sentence comprehension skills, and text comprehension skills. Within each approach, an effort was made to focus research on one of four areas or problems: models of adult performance, descriptions of the development of this competence in children, information needed to facilitate the development of reading comprehension, and the implications of subcultural variations. Each program was then further divided into specific projects. In conclusion, the 12 programs were evaluated, priorities assigned, and all reported to advise the NIE.

The general outline of the report was imposed on the panel by the organizers, presumably for the purpose of facilitating selection of particular projects or programs of special importance to American education and to the mission of the Essential Skills Program of the NIE. As any careful reader will discover, however, the outline format has the effect of separating things that will have to go together later, and of producing occasional redundancy when essentially the same kind of theory construction or research is called for at more than one level of skill. The panel is aware, for example, that effective modeling of the reading process should not (probably cannot) be undertaken independently at the word, sentence, and text levels of comprehension. The panel regrets the awkwardness resulting from this method of preestablished, uniform, content-free outlining, and trusts that readers will be able to discern an underlying coherence, in spite of the obstacles.

## PROBLEM AREA DESCRIPTION

### Problem Area Statement

The problem for Panel 1 was [illegible]mine how lexical, semantic, conceptual, and cultural factors [illegible] to reading comprehension.

Individuals may fail to understand what they read for any one of several reasons. Most failures in the early years of school have to be attributed to failures to learn how to decode printed language into its spoken counterpart. However, as children grow older and enter high school, nearly all learn to decode accurately. Yet, a large number of reading failures persist. Many of the later failures can be attributed to students not mastering skills involved in comprehending. But others seem to be due to the fact that, although students have achieved accuracy in decoding, they have not achieved proficiency in that process. That is to say, they have the skills required for decoding, but the skills have not become sufficiently automatic to be carried on outside the focus of conscious attention. Thus, the decoding process is so halting and laborious for them that it interferes with their ability to apply whatever comprehension skills they may have acquired. Clearly, we cannot design effective instruction in either decoding or comprehension skills until we understand the nature and extent of this interference effect. Beyond knowing that the interference exists, we know little else about it.

We recommend, therefore, that research be supported to determine what proportion of the failures to comprehend prose is attributable to inability to decode print accurately, to decode print proficiently, and to apply comprehension skills, and how these proportions change with the amount and kind of reading instruction given. We also need research to explore the nature of the relation between decoding proficiency and the ability to comprehend text.

We believe that a sizable proportion of comprehension failures will be found even in readers who are proficient decoders, and that even if decoding skills could be taught more effectively than at present, many children would still be functionally illiterate in high school. The discussion that follows is based on this assumption. That is to say, we have excluded from consideration here the problems of students who presumably need further drill in decoding printed words.

We also exclude from our discussion here that small percentage of children who are truly dyslexics. "Truly dyslexic" implies severe and specific retardation in learning to decode text to the level of identified lexical items. How specific the retardation is open to question. At the minimum, these children have adequate intellectual abilities, are not severely abnormal emotionally, have normal visual and auditory acuity, and have had ample educational opportunities to learn to read. The best available evidence is that the deficits these children have are not specific in

the sense of being completely limited to reading disabilities. However, in at least a sizable proportion of the cases, the deficits are highly specific, reflecting isolated syndromes. That is, there are clearly identifiable subgroups among dyslexic children. Reading is impaired for different reasons among these different subgroups, because each syndrome affects different components of the reading process. The exact characterization of the subgroups is a very live current issue and research goal. Further work must be done on the isolation of these syndromes and the identification of what aspects of reading acquisition are being interfered with. The development of appropriate educational therapies must follow such diagnoses.

These truly dyslexic children are explicitly distinguished from those who are "minimally brain damaged" and show general developmental lags in all motor, linguistic, and perceptual functioning. These latter groups will also be retarded in reading, as they are retarded in everything. Any child, retarded in learning to decode text (whether due to a general developmental lag or to a specific dyslexic syndrome which has been overcome), will, of course, have problems developing the higher order comprehension skills concerning us here. At the very least, these skills will not be as automatic for these children as for their normal age mates.

The problem area of Panel 1 is limited, therefore, to a consideration of comprehension problems that cannot be attributed to decoding difficulties, whether those difficulties arise from lack of practice or from functional disorders of other types.

Although the severity of comprehension difficulties attributable to causes other than low decoding proficiency has not been carefully investigated, teachers are quite confident in their claims that readers with such problems exist. Indeed, these students make up the majority of the "poor readers" in the higher grades and college. The importance of comprehension skills beyond decoding has long been recognized by educators, and various attempts have been made to provide materials and instruction designed to inculcate such skills. In spite of these attempts, the problem has not been solved.

We assume that current attempts to teach comprehension skills have not been as successful as hoped because they were not based on a valid description of what was to be taught. At the present time, however, an active surge of research and theory construction has begun in the fields of psychology and artificial intelligence. This research is directly concerned with the structure and processes of any system able to understand and produce language. The "state-of-the-art" in these fields is developing rapidly and we will not attempt to summarize it here. The different approaches to be recommended below are in various stages of development. The current status of each stage will be characterized, where relevant, in each approach.

Problem Area Potential

Work in this area will augment the scientific base underlying educational technology and improve current practice in imparting better comprehension skills to children. Because linguistic communication plays such an important role in formal education, and because comprehension is such a critical process to learning, the potential value of a deeper understanding of the psychological processes involved seems obvious.

Division of the Problem Area

The problem area has been divided into three parts: word recognition skills; sentence comprehension skills; and text comprehension skills. This division corresponds to the size of the units with which readers must deal. Different processes are involved in comprehension at each level, and different kinds of research are needed at each level.

The division should not be interpreted to mean that there are three different kinds of reading--reading words, reading sentences, and reading texts. For the skilled reader, these are merely three aspects of an organic whole. For the poor reader, however, the units represent alternate sources of difficulty ordered in complexity. If word recognition is deficient, it will affect both sentence and text comprehension; if word recognition is proficient, but the student has difficulty constructing an interpretation for sentences, text comprehension will be affected. If word recognition and sentence comprehension are both proficient, a student may still have difficulty in relating the sentences of a text or in distinguishing what is important from what is subordinate or supporting information. All three types of difficulty have been reported; but, at the present time, we are unable to say which source of difficulty is the most common, or which deserves the more intensive investigation.

APPROACH 1.1

WORD RECOGNITION SKILLS

Approach Statement

This approach explores the extent to which reading comprehension depends on readers' knowledge and recognition of the words they are reading.

Approach Potential

Theories of the organization of lexical memory and the processes of retrieval of word meanings from memory are currently under active investigation by psychologists. The potential relevance of this research to education--to reading comprehension, to instruction intended to build vocabulary--needs to be explored and evaluated.

Approach Rationale

The ability to assign meaning to a word one sees must be clearly distinguished from the ability to pronounce it correctly from its written form. Pronouncing it correctly depends on what we call "decoding skills"; comprehending its meaning depends on what we call "word recognition skills." There is obviously more involved in comprehending a word than in merely recognizing it, but "word recognition" has some currency in the educational community; so we will use it instead of "word comprehension." This use may extend "word recognition" beyond its usual interpretation.

People who have learned to decode written English will often be able to pronounce nonsense syllables, giving them a sound consistent with the phoneme-grapheme correspondences they have mastered. Because this is possible, one cannot tell from the fact that a passage can be read aloud whether readers understand the words they are reading or are simply pronouncing the words as nonsense syllables. That is to say, not only must readers be able to move from printed words to spoken words, but they must also be able to recognize the words pronounced and to understand what they mean in that context.

In language with reasonably regular spelling--Spanish for example--it is possible to read rather fluently, even when one does not know the meanings of the words one pronounces. We can assume, however, that beginning readers will seldom find themselves in this situation. They will have a basic stock of familiar words in their language before they come to the reading instruction, and the instructional materials with which they will be asked to deal will have been carefully written to insure that the words used are common and familiar to most children. We can assume, in short, that the number of words the child must treat as nonsense syllables will be relatively small. How large it can be without frustrating the reader's

attempts to understand raises problems for research, e.g., how does reading comprehension vary as a function of the ratio of unfamiliar to familiar words? We assume that the ratio should be small; we also assume it cannot, and probably should not, be zero.

Children learn words first by hearing them used; there is no reason to think this ability is lost when they encounter the printed word. If the unfamiliar words do not constitute too large a fraction of the text they are reading, children can probably guess their meanings on the basis of what would be reasonable to say in the given context. If guessing leads to confusion, they can use a dictionary--although little is known about the best form of wordbook for children's use. If they must use dictionaries too often, however, it will be difficult for them to remember the thread of the text. Still, reading is one way people learn new words, and it would be interesting to know--and possibly important for the authors of beginning reading texts to know--what conditions lead to learning something new, and what conditions lead to frustration. Moreover, children with different cultural backgrounds can be expected to have different vocabularies, so it is difficult to see how any single text could optimize the familiar to unfamiliar ratio for everyone.

The problem is further complicated by the fact that "knowing" a word is a relative matter. Readers may know something about the word--its syntactic category, perhaps, and the general semantic domain to which it belongs--without really being master of the precise meaning. Most words have several senses; readers may be familiar with some and not with others, perhaps not with the sense appropriate to the text. It is not difficult to imagine confusion and misunderstanding resulting from readers themselves not being aware that they don't know the author's meaning.

These remarks should illustrate that we need merely scratch the surface to find questions of pedagogical importance that we are unable to answer. The basic difficulty is that we do not know how lexical competence contributes to reading comprehension. On the assumption that reading skills will be acquired more quickly if students understand the words they are reading, efforts have been made to determine what words children know and what words they should know, and to prepare basal readers that rely on the former and introduce the latter. That is to say, efforts are made to avoid lexical difficulties for the beginning reader, but little is known about the consequences of such difficulties for the child's learning or motivation.

It seems plausible that children who must divide their attention between a search for the meanings of unfamiliar words and an attempt to understand the text's message will comprehend less of what they are reading --will have less attention free for dealing with the message--than children who know all of the words. As far as we know, however, this plausible hypothesis has never been convincingly demonstrated by educational research. And the kinds of confusions that can result from lexical incompetence have never been diagnosed and classified for the purpose of different educational treatments.

The organization of lexical knowledge and the processes whereby this knowledge is exploited in understanding discourse are current areas of research. The theories underlying this research come from linguistic and logical theories of the lexical component of language, and from ethnological and psychological theories of meaning and memory. These theories need to be generalized in order to include the learning process, and they need to be realized in terms of information-processing systems whose components can be studied experimentally and explored by computer simulation.

Division of the Approach

A variety of models for the memory structures and retrieval processes involved in word recognition have been proposed, many in the form of, or inspired by, computer simulations of text-processing systems. If these models can be extended and taken as descriptions of the skills children are expected to acquire, students of child language can use the models to investigate how semantic development proceeds and what factors facilitate or inhibit that development. Given a characterization of the development of word recognition skills, educational development of age-appropriate and culture-appropriate materials should be facilitated. These considerations lead to a division of this approach into the following four programs.

Program 1.1.1: Word Recognition as Information Processing.

Program Statement

The aim of this program is to formulate information-processing models of reading comprehension that adequately account for the development and effects of word recognition skills on reading comprehension.

Two components are essential to such a system. It must have a memory in which is represented the information about the meanings of the words and their syntactic possibilities, and it must have a processor that retrieves information from lexical memory and organizes it into executable programs. Although word recognition focuses attention on that part of the system that retrieves stored linguistic and conceptual information about words, retrieval is not an end in itself; the retrieval processes must, therefore, be embedded in a larger system designed to use the retrieved information in some way. The operations of the larger system dictate the nature of the retrieval process, and the retrieval process dictates the nature of the memory structure it exploits. The goals here are, first, to use text-processing systems as an environment in which to explore that component of the total system which corresponds to word recognition, and, second, to use understanding of that component as a source of hypotheses about memory organization and retrieval in people learning to read.

Program Potential

Psychologists and students of artificial intelligence are currently developing many different systems for processing natural language texts.

These systems have provided the stimulus for better studies of text-processing by humans and have set the stage for advances in our understanding of what linguistic comprehension is in general, and what reading comprehension is in particular. The breadth and depth of research now feasible is unprecedented, but we cannot foresee its implications for education clearly until further progress is made and until the results are evaluated and adapted to the needs of educational research and development.

Program Research Considerations

Although there must be a theoretical distinction between the memory component and the retrieval processes in any text-processing system, research on word recognition by readers has been unable to separate them experimentally. Attempts to dissect the structure of semantic memory must involve tasks that require people to retrieve information from that memory, so both components are necessarily involved. If it were possible to introspect on the processes, the two might be separable in that way, but, in fact, the processes of word recognition are so automatic and involuntary in anyone who knows a language well that introspection is of no avail.

People are able, however, to make judgments of similarity of meaning between words, and these judgments can be used to formulate hypotheses about the organization of semantic memory. Linguists have speculated on the basis of such felt similarities that lexical memory must be organized into semantic fields. Additionally, ethnological research on color terms, kin terms, lay taxonomies and the like, has generated the hypothesis that much of lexical memory is organized into hierarchical systems of contrasting sets of terms. This hierarchical hypothesis has been explored by psychologists using a variety of tasks involving word retrieval, where the dependent variable has been reaction time and/or accuracy of response. Although psychological studies have confirmed certain aspects of the hypothesis, difficulties (e.g., problems arising from the nonequivalence of all instances of a given contrastive set) have indicated a need for more complex theories of the retrieval process. Such relations as part-to-whole or hyponym-to-superordinate must be represented somehow in semantic memory, but the details of that organization and the processes whereby it is exploited in word recognition are still under active investigation and dispute. Research into the organization of semantic fields should continue, and alternate hypotheses should be actualized in computer simulations wherever possible in order to permit analysis of different aspects of word recognition that are difficult to separate experimentally or introspectively.

As a companion project to investigations focused on semantic fields, research could also begin with some of the basic concepts that people talk and write about. The two approaches differ. For example, a basic concept like class inclusion is found to hold between nouns in very different semantic fields; causal relations are expressed by verbs in very different semantic fields, and so on. Some of the most basic concepts represented lexically are quantity, space, time, cause, and personal relations.

Quantitative relationships can be expressed linguistically by number words and arithmetic operations, by logical quantifiers, by comparatives, by verbs of quantity, and, perhaps, in other ways. If the underlying concepts could be defined and age-appropriate tasks devised to elicit language expressing the concepts, it might be possible to determine whether a child has mastered both the basic concepts and the language in which they are expressed. This general program could be pursued for spatial relations (place names, locative prepositions, directional adverbs, size terms, deictic and intrinsic systems of spatial identification, etc.), for temporal relations (time terms, temporal locatives and adverbials, tense and auxiliary verbs, aspect, temporal connectives, dates, etc.), for causal relations (why-questions, periphrastic causatives, causative verbs, etc.) and for personal relations (personal pronouns, kin terms, proper names, performative verbs, interpersonal verbs, trait names, etc.). The goal would be to catalog some of the basic ideas that people must have by virtue of the fact that they speak English, and to regard those ideas as shaping the internal structure of the semantic fields in any information-processing model of word recognition.

Because the purpose of a text-processing model would presumably be to translate input language into programs for the mental or behavioral operations of the system, it seems natural to explore the hypothesis that lexical "entries" are themselves subroutines compiled into programs by the system. The operation to be performed will vary enormously from one use to another; thus, it may be more practical to assume that, not routines, but information from which routines can be constructed, is stored in semantic memory. Then the relationships between words that have been discussed in terms of conceptual relations or semantic fields might be represented as shared information between lexical entries. There is a great variety of ways such a system might be actualized in computer simulations, and considerable experience with different alternatives will be required before we have a clear idea of what a word retrieval device should be and do.

Division of the Program

This program is divided into two projects, one dealing with psychological investigations of the organization of lexical memory and its relevance for word recognition, the other with the simulation of lexical memory and retrieval in text-processing systems. This division should not be interpreted to mean that these two projects should be pursued independently. Indeed, the most rapid progress will result from the combination of psychological and artificial intelligence methods in a single research project. A comprehensive listing of projects might provide a variety of such collaborative enterprises embedded in different text-processing systems. The panel is unable to identify those systems currently under development that would be most suitable and receptive to such research, however, so the following is a characterization of two types of methodology that should be brought to bear on the problem of word recognition, rather than being performed as two distinct projects. (If funding were available,

we would recommend one to three projects, combining these methods of investigation.)

### Project 1.1.1.1: Organization of Lexical Memory.

#### Project Statement

The aim of this project is to conduct psychological and linguistic studies of the semantic and conceptual relationships underlying the organization of lexical memory.

#### Project Potential

Rapid progress is presently being made along a number of related lines by highly skilled investigators, and their results should be directly relevant to our understanding of word recognition skills and their acquisition.

#### Project Research Considerations

As noted above, this research can be profitably combined with simulation of proposed theories of lexical organization. The lexical knowledge a person acquires is vast, and it is frequently difficult to foresee consequences of theoretical assumptions without realizing them in a simulation. The principal thrust of this project, however, is to make more of the workers in this field aware of the educational implications and applications of their ideas, and so make available to the National Institute of Education the services and advice of the leading experts in word recognition skills.

### Project 1.1.1.2: Simulation of Lexical Memory.

#### Project Statement

The goal of this project is to simulate alternate theories of the organization of lexical memory by incorporating them into a more general text-processing system.

#### Project Potential

See Project 1.1.1.1.

#### Project Research Consideration

The theories to be simulated should be based as closely as possible on results obtained by psychological and linguistic methods of studying lexical organization. In most cases, of course, the theory based on psycholinguistic research will be realizable in a variety of implementations, and decisions of critical importance to the operation of a text-processing system may be left unspecified by psycholinguistic results. A particular

challenge to the simulation designer would be to devise a text-processing system that can provide a suitable context for testing a variety of retrieval and memory organization hypotheses, and that will be capable of modification and growth as a consequence of its own operations.

Program 1.1.2: Vocabulary Growth, Semantic and Conceptual Development.

Program Statement

The aim of this program is to develop a theory of vocabulary growth and semantic development in children.

We need a comprehensive theory of vocabulary growth and semantic development in children. Partially, this theory will concern the lexicon itself: what words does a child know, how are these words organized, and how are they accessed?

A new word is encountered (either in speech or in reading): What is the process by which children represent the word as a word and begin to assign it a meaning? Children must map that word onto their conceptual structure. A comprehensive theory of semantic development must provide an account of this process and specify what kinds of partial meanings are assigned to the word. These processes may change with the context in which the new word is encountered, i.e., speech or reading. If a child's conceptual memory is reorganized during development, this reorganization may in turn affect the learning of the meanings of new words.

Program Potential

This research is essential if we are to apply results of psycholinguistic and artificial intelligence studies of lexical memory (most of which are oriented toward adults) to the problems of reading comprehension in children.

Program Research Considerations

The basic research required in the development of a comprehensive theory of vocabulary growth and semantic development in children must integrate two sources of ideas and methods. First, we must work from models of lexical organization and semantic memory in adults. We cannot have a theory of the development of something unless we know what the something is. We await, therefore, the fruits of Program 1.2.1 in its attempts to discover the psychological relevance of various current theories of meaning. Second, we must work from what is known about conceptual development, especially where conceptual immaturity can be expected to limit the nature of the semantic representations of the words children know. At present we do not even know how children develop a concept of "words," or how they learn to identify these units in the ongoing stream of speech; yet this concept is basic to understanding the spacing of words in written texts and instructional

programs. We generally presuppose that children understand discussions of "words," and the difference between them and "letters" or "sentences." How these concepts develop would seem a critically important question for research.

There has been much research on vocabulary growth and on what words children should be expected to know at each grade level. This research is subject to a variety of important criticisms. For example, children from different social backgrounds may acquire very different vocabularies, although children from middle class homes where the language of standard dictionaries is spoken are generally taken as the norm. We do not know to what extent children unfamiliar with the "school vocabulary" are actually deficient or backward in lexical development, or to what extent they have been learning a different lexicon. Or, again, children's interests in different words differ; can there be any fixed list that all children must know, whether the words coincide with their own interests or not? Or again, speaking, listening, writing, and reading vocabularies are different; which vocabulary has been measured, which should be, and how do relationships among these different measures vary with age, reading ability, or absolute vocabulary size?

With respect to the organization of the lexicon, root words and their inflected forms--go, goes, going, went, gone--are different words; is this a matter of learning one word or five? If five, when does the child recognize a relationship among these forms, and how is this relationship represented? Similarly, how is the relationship among such words as critic, critique, criticize, critical, and criticism represented? When does a child learn productive rules for generating related lexical items from root forms? We must have answers to these questions if we are to understand how children deal with unfamiliar words while they are reading. If their lexicon is reorganized during development, we would expect different strategies for handling new words to follow upon this reorganization.

What it means to "know" a word has never been clearly defined. Does it mean the ability to select one definition from four alternates? Or to provide a definition independently, or to use it correctly in sentences? To be able to distinguish it from nonsense words? It is clearly possible to know only part of the meaning of a word.

Division of the Program

The program has been divided into two groups of projects. The first concerns the lexicon itself--how can we accurately assess the size of children's vocabulary, and predict which words they will know? The second group is concerned with the meanings children assign to a word. Although three different projects have been described, they are obviously closely related and progress in one depends on progress in the other two.

Project 1.1.2.1: Estimates of Vocabulary Size.

Project Statement

The aim of this project is to develop new methods of estimating vocabulary size that will not be biased by ethnic and occupational variations in children's backgrounds.

Project Potential

An estimate of vocabulary size in itself is of no particular interest. It becomes important only if we can demonstrate consequences of absolute level of vocabulary for growth. Perhaps reorganization of the lexicon depends upon its reaching a certain size. Perhaps changing rates of acquisition of words is a function of absolute size of vocabulary. We cannot look for such relationships without an accurate estimate of overall vocabulary size.

Vocabulary size is also an important component of IQ tests. If it can be shown that some children with low IQ's do not have a small lexicon, but, rather, a different one, then this would have important social consequences.

Project Research Considerations

Any method of vocabulary estimation that samples from a standard dictionary is ruled out for the present purposes. There is one well-motivated measure which does not have this property--the type-token ratios from samples of free speech. Basically, the idea is to elicit speech on any topic of interest to the child (perhaps one could tape-record samples of children's speech when they are talking to each other). The larger the child's vocabulary, the less repetition of any individual word there will be. Thus, the larger the ratio of types (the first usage of any particular word) to tokens (individual words), the larger the vocabulary is estimated to be.

We must compare the sensitivity of this measure to standard measures of vocabulary size on middle class populations (where bias is not a problem). If it is a good measure, there will still be methodological problems in applying it to other populations. They are mainly sampling problems. How is the free speech to be elicited? The actual type-token value will certainly depend on the domain of discourse and the role of the experimenter in eliciting speech. In spite of the problems, this method is a promising one for estimating vocabulary size and should be explored.

Project 1.1.2.2: Vocabulary Content.

Project Statement

The goal of this project is to develop methods for predicting what words are in any given child's vocabulary.

Project Potential

For the purpose of designing texts with a known familiar to unfamiliar ratio of vocabulary items, we must be able to predict for any given children whether they will know any given word. We will need a comprehensive model which assigns a probability that a word will be known as a function of differences among words and differences among children. This is a huge project. We need to discover the important parameters which differentiate both children and words.

Project Research Considerations

The development of such a model requires collaboration among mathematical psychologists, psycholinguists, and developmental psychologists. This project can be attacked on many fronts which are now well within the realm of practicality.

For reference purposes, careful and definitive studies of the vocabularies children hear and use are essential. For many practical purposes, however, more rapid methods of estimating vocabulary content for individual children would be extremely useful. One practical problem, for example, is how to sample quickly from a huge range of domains of vocabulary items. Traditional methods requiring children to give definitions or to choose among definitions are too time-consuming. Two shortcuts should be explored. First, can children distinguish between words and nonwords? That is, do they know that "ank" is not a word? If so, in a relatively short period of time, a long list of words and nonwords could be presented for children to judge and a rough estimate of their vocabularies obtained. An empirical issue: what determines which words in any domain are learned first? If this is known, then principled choices can be made of which words from any lexical domain should be sampled to assess a child's range of vocabulary.

Project 1.1.2.3: Acquisition of Word Meanings.

Project Statement

The goal of this project is to develop a model of the process by which a new word is assigned a meaning.

Project Potential

Work already performed provides a firm basis for this project. Models of the structure of the lexicon, detailed analyses of the structure of semantic domains, and developmental hypotheses abound.

Project Research Considerations

Obviously, there are many ways a new word can be assigned a meaning. If somebody uses a word we do not know, we can ask what it means, or look it up in the dictionary. However, the meanings of most new words are learned from the context (both speech and reading) in which the words are used. It is this process for which we seek a model.

This research must begin with theories of the representation of word meanings in the adult lexicon. Within those theories, hypotheses can be formulated about what kinds of partial representations are constructed enroute to knowing the full meaning of a word. One simple hypothesis is that the first representations are part of the full representation, and the process simply involves adding more of the same. (That is, if one conceives of lexical representation as lists of semantic features, then, at first, only a few of the features are present and additional features are added as the child has more experience with the word. Or, if lexical entries are subroutines, more subroutines are added to the representation of the word.) Alternately, it is possible that the form of representation of a word changes drastically during the course of acquisition of that word's meaning. For instance, it is possible that early representations of a new word are more episodic than later ones. Finally, developmental changes in semantic memory (Project 1.1.2.4) should affect the kinds of partial readings a new word has.

We should extend the developmental work already done on particular semantic domains. It is extremely important to separate failures due to incomplete representations of the meanings of words from failures due to the particular demands of the task. To this end, several different tasks must be used on the same word domain in order to look for consistent, incomplete representations in the patterns of judgments across all the tasks.

We need to develop new techniques to study the course of acquisition of words (perhaps "words" invented for the purpose of these studies) as a function of age, of semantic organization, of how the word is introduced, etc. In these studies, we can compare the processes of learning new words from reading and learning new words from speech.

A theoretical issue of some importance underlying this research is the question of whether children must have a well-developed conceptual structure for some domain before they have a "place" for the meaning of a new word, or whether the occurrence of an unfamiliar word stimulates conceptual development by creating a need for a structure in which to place

it. Commonsense suggests that new words and new concepts are learned in both ways, so the practical question is whether there are preferred ways for learning (and teaching) new words and concepts in specific domains. One might expect words for relatively concrete things and actions to be learned subsequent to the sensorimotor development of a schema for such things and actions, but more abstract words may serve to direct children's attention to concepts that they would not otherwise have apprehended.

### Project 1.1.2.4: Development of Semantic Memory.

#### Project Statement

The goal of this project is to assess how the structure of semantic memory changes with age. We need to formulate developmental hypotheses about overall changes in semantic memory and also about changes restricted to various subparts of the lexicon. What relationships among concepts are represented at various stages of development? Are there developmental changes in the kinds of, or choices of, properties that are parts of the representation of concepts, or does development consist entirely of adding more information and representing more relationships among concepts?

#### Project Potential

This research is being actively pursued by a number of highly competent students of child language. Its relevance to sequencing instruction was described earlier.

#### Project Research Considerations

In addition to the comprehension and production techniques currently used in studies of semantic development, the experimental paradigms developed to distinguish among various models of semantic memory in adults should be adapted for children. These include timed-inference tasks, measures of category and item dominance, prototypicality, multidimensional scaling of similarity judgments, etc. Of course, some modifications of techniques will be necessary, depending on the age of the children.

### Project 1.1.2.5: Relationship to Conceptual Development.

#### Project Statement

The goal of this project is to assess how conceptual development limits the representations of the meanings of words. As mentioned in Program 1.1.1, certain basic concepts (e.g., spatial relations, temporal relations, causal relationships, personal relationships) are represented in many different domains of the lexicon. It is possible that some of these basic concepts emerge after language acquisition has begun, and change further during development. If so, semantic development will necessarily reflect these changes.

Project Potential

This is extremely important basic research and should increase our understanding of conceptual as well as semantic development.

Project Research Considerations

This project requires identification of the underlying concepts and the invention of age-appropriate tasks to elicit language expressing them. In many cases, it will also be possible to devise nonlinguistic tasks for determining the presence or absence of these concepts. It will then be possible to relate basic conceptual development and the acquisition of the various linguistic structures expressing these concepts.

Program 1.1.3: Optimizing Vocabulary for Comprehension.

Program Statement

The goal of this program is to determine the contribution of lexical and semantic knowledge to text comprehension. How can the vocabulary of reading materials be manipulated to facilitate reading comprehension?

Program Potential

Deeper theoretical and empirical understanding of the role of lexical information in language comprehension would generally be of great value to psychologists and linguists. The potential for important educational applications based on that understanding depends on the effectiveness of present techniques for dealing with the problem; for the majority of children (middle class speakers of Standard English), present techniques are probably not far from optimal. If failures of word recognition are an important source of comprehension difficulties in children from subcultural groups, however, knowing how to optimize the choice of words in beginning readers would make a proportionately important contribution to the education of those children.

Program Research Considerations

The research envisioned here should be based on results obtained from Programs 1.1.1 and 1.1.2. That is to say, given a model of word recognition in adults and some account of how children acquire that skill, the next step is to apply the information to problems of reading comprehension.

Division of the Program

The following projects are selected to provide basic information that would be required for educational applications; they are not intended to provide such applications. Other projects would be needed to apply this information to the development of appropriate teaching materials.

Project 1.1.3.1: Frequency of Word Usages.

Project Statement

The goal of this project is to determine the frequencies with which words are used in each of their senses in various topics of discourse and in various educational materials.

Project Potential

Studies of word frequency have had far-reaching effects on the teaching and the scientific study of language skills. The frequency a word is used indexes people's familiarity with it and accounts for a modest but important share of the difficulty they may have in perceiving, recognizing, learning, and comprehending it.

Project Research Considerations

Word frequency counts have a major limitation. A single word may be used to express several different concepts; each of those semantic usages may occur with very different frequencies in the language; and those differences may have a large effect on the difficulty of comprehending the word. Thus, knowing only the frequency of a word, rather than the frequency of each semantic use of the word, provides us with less than a desirable and attainable amount of control over its difficulty. Lorge attempted to remedy the problem by counting the semantic usages of words. But, because he was forced to rely entirely on manual methods, he had to restrict his study to only 500 selected words. So, his results have not been very useful. Now that we have computers and a better understanding of language processes and text-processing techniques, it may be feasible to obtain quite satisfactory counts automatically. The scientific and practical benefits of such a study would be considerable. This information would enable us to determine when a particular word meaning should be taught, or even if it should be taught at all.

Some approaches to this project could be prohibitively expensive, and others could be reasonably economical. Although it appears likely that an economical approach could be developed, it is less than certain. Thus, a phased approach should be employed, calling first for feasibility studies, and then deciding whether to proceed and which approach to employ.

Project 1.1.3.2: Recognizability of Word Usages.

Project Statement

The goal of this project is to determine what aspects of the concepts a word expresses influence the likelihood and ease of its comprehension.

Project Potential

This project has both scientific and practical utility. On the one hand, it will provide us with useful information for discovering the nature of the process by which people comprehend the meaning of a word. And, on the other hand, it will provide us with information directly and indirectly applicable for predicting and manipulating the comprehensibility of prose.

Project Research Considerations

The research must start, of course, by determining the influence of the frequency of a word's meaning and the frequency of the word. But those variables themselves must be explained, for frequency itself depends on other characteristics of the word and its meanings, and on cultural factors. Thus, this series of studies should also examine the effects of still more fundamental aspects of a word's meaning. These ought to include characteristics such as the number of different meanings with which a word is used, the generality-specificity of the particular meaning, the semantical-grammatical categories in which the word's meaning may be used, and the "sensibility" of both the referent and the distinguishing attributes of the word's meaning.

Project 1.1.3.3: Word Recognition in Context.

Project Statement

The goal of this project is to determine what aspects of the context in which a word occurs affect the likelihood and ease of recognizing a word's meaning.

Project Potential

This project will provide information about the dynamics of the word recognition process. And, like the preceding one, it will be useful both in obtaining a basic understanding of the process and in controlling the comprehensibility of prose.

Project Research Considerations

These studies should examine the effects of the nature and amount of a word's surrounding context. They should employ variables such as the associative frequency of the word with the words in the adjacent text.

Program 1.1.4: Cultural Differences in Word Recognition.

Program Statement

The goal of this program is to determine whether proficiency in word recognition is related to subcultural differences.

Program Potential

Failure to understand what is read can result from failure of word recognition. Because children from subcultural groups may encounter many unfamiliar words in the Standard English of the schools, it is important to determine whether failure of word recognition is a major cause of their reading difficulties.

Program Research Considerations

Although we can see many of the effects produced by the differences in the cultures of society's various subgroups, we have only the thinnest support for our conjectures about how peoples' culture influences the comprehension skills that they acquire. It seems highly probable, though, from what evidence we do have, that a considerable portion of that influence shows up in the form of peculiarities in words and concepts that children acquire within their cultural subgroup and in the way language is employed. The projects that follow are intended to ferret out those differences associated with the various cultural subgroups in our society, to arrive at a basic understanding of how cultural factors might affect peoples' comprehension of Standard English and their subsequent achievement in school subjects.

Division of the Program

This program has been divided into four projects. The first concerns cultural differences in size and content of vocabulary. The second concerns subtle subcultural variations in the meanings of words. The third project is of considerably greater scope. It calls for a systematic investigation of the role that Socio-Economic Status (SES) and subcultural differences play in basic cognitive development. The fourth project recommends study of the effects of bilingualism on vocabulary growth.

Project 1.1.4.1: Cultural Variation in Vocabulary.

Project Statement

The goal of this project is to conduct a series of studies to estimate the size and content of the vocabularies possessed by children in major cultural subgroups.

Project Potential

At present it is unclear whether differences in comprehension abilities of subgroups arise because some are linguistically affluent, or whether the differences arise for some other reason. These studies on cultural variation can be used directly to help formulate the answer. Moreover, we have now arrived at fairly good agreement on how these studies ought to be conducted, and have had enough experience with them to reorganize that concern

with the interplay between culture and performance often brings to the fore theoretical questions of basic significance for understanding developmental processes in all populations.

Project Research Considerations

The language deprivation theory of cultural differences in comprehension skills arose from observations that cultural subgroups perform differently on the standard vocabulary tests now in use. It is now generally agreed that these results are highly suspect, because the words in these tests were drawn from dictionaries, word frequency counts, and other samples of Standard English. Thus, they were heavily biased in favor of those groups whose language peculiarity was that they spoke Standard English. The studies in this project should be carefully designed to avoid all such sources of bias in arriving at their estimates of vocabulary size and content. (Projects 1.1.2.1 and 1.1.2.2.)

Project 1.1.4.2: Differences in Word Meanings among Cultural Subgroups.

Project Statement

The aim of this project is to conduct a series of studies to determine if words have different connotative and denotative meanings among subgroups.

Project Potential

This project can test a major alternative explanation of cultural differences in reading comprehension ability. That is, nearly all written language employs Standard English words and the Standard English meaning of those words. Now, suppose that those materials are being read by people who attach somewhat different meanings to those words. They will surely arrive at an understanding of those materials different from the one the author intended, and that would be judged incorrect by a person who spoke Standard English. This theory is lent much credibility by the common observations that cognates between major languages often refer to related but different concepts, and that even from one topic of discourse to another or from one geographic region to another within the same language community, the same phenomenon will occur. These studies should result in the evaluation of this theory.

Research Considerations

See projects 1.1.2.3, 1.1.2.4, and 1.1.2.5.

Project 1.1.4.3: Replication Studies.

Project Statement

The goal of this project is to determine how the development of comprehension skills differs among cultural subgroups.

Project Potential

It seems virtually certain that children in different cultural subgroups acquire many of the comprehension processes at different ages. It is essential to have exact information on this matter for both basic theoretical and applied reasons. Its usefulness in theory building is to permit us to determine exactly how cultural factors interact with and shape cognitive development. Its practical usefulness is to provide information essential for designing and adapting instruction to meet the needs of students from each major cultural subgroup.

Project Research Considerations

If we were concerned only with scientific theory, it would be possible to conduct these studies with parsimony, using small samples and investigating the properties of just certain skills. However, because the same data must be gathered in order to solve problems in the design of instruction, parsimony may often be on the side of designing studies with care taken to represent the populations of the major cultural subgroups. Where an exhaustive replication on all cultural groups is impossible or impractical, carefully designed pilot studies may indicate which full replications would be most informative.

A "project" format for this recommendation is somewhat inappropriate, because we are really addressing a policy question rather than a research project. This is not a call to replicate every study that has ever been done on middle class children in order to determine whether the results are affected by variation in race, culture, socioeconomic status, etc. It is a recommendation that future studies supported by the NIE be designed to provide information as to whether these variables must be taken into account in instructional applications of the results of those studies.

Ideally, the study of cultural variations in cognition would be recognized as a valuable approach to basic theoretical issues in the psychology of cognition--the exploitation of opportunities provided by "natural experiments," as it were. Practically, this approach has been too little followed. In advocating it as an essential step in developing literacy skills of many groups inadequately served by existing programs, we would not wish to suggest, even indirectly, that such studies deal with some separate subset of research questions unrelated to the central task of increasing our scientific knowledge about the cognitive processes involved in reading and reading comprehension. The policy advocated here should produce results of importance both to educational technology and to scientific psychology.

Project 1.1.4.4: Bilingual Vocabularies.

Project Statement

The goal of this project is to determine the effects of bilingualism on vocabulary growth.

Project Potential

Many cultural subgroups are bilingual and have limited English vocabularies. We need much better information about this situation and its consequences for programs of reading instruction.

Project Research Considerations

It is self-evident that estimates of vocabulary size for bilingual individuals based entirely on English vocabulary will underestimate their lexical resources, and may lead to false and discouraging estimates of their level of semantic development. Repeating the test in the second language and adding the two scores together will not do, of course, since there will be duplicate entries. We need further research to determine what a meaningful measure of development would be in such cases, and how it might be obtained.

The design of reading programs for bilinguals would be facilitated, of course, if all members of any particular subculture had the same mixture of vocabulary from the two languages. It is important to determine whether the particular words bilinguals know in each language are idiosyncratic to them, or whether a similar division obtains for a group sizable enough to justify the development of special teaching materials. An important research task might be the development of indexes of vocabulary overlap of commonality over a representative sample of semantic and conceptual domains. Without such indexes, we are unable to determine whether norms of word usage or word familiarity are truly normative for various population subgroups.

APPROACH 1.2

SENTENCE COMPREHENSION SKILLS

Approach Statement

The goal of this approach is to explore the extent to which reading comprehension depends on the reader's mastery of conceptual relationships within the sentence.

Approach Potential

Recent advances in the linguistic theory of syntax have stimulated considerable interest in the process of sentence comprehension, but research has concentrated on either adults or preschool children. Similar studies of sentence comprehension are needed on children of elementary school age. Experience gained during the past decade should make it possible to avoid some of the more unfortunate mistakes for which the earlier work has been criticized.

Approach Rationale

Simple clauses and sentences, predicating properties or relationships of one or more nominal constructions, are the building blocks of discourse. Children who are unable to understand these blocks, or who are unable to identify the simple constituent clauses in compound and complex sentences, will be unable to comprehend texts in which the sentences or clauses occur. Although most children acquire the basic grammatical rules of their native language by the time they are 4 years old, there is reason to believe that grammatical learning continues for many more years. Thus, grammatical constructions that appear simple to adults may be difficult for children. To the extent that children must devote conscious attention to grammatical complexities, they will be diverted from the central task of comprehending the message. At the present time, however, only fragmentary information is available about those constructions difficult for school children, and that should be avoided in those textual materials not directly intended to teach such constructions.

Much psycholinguistic research on sentence perception, memory, and comprehension has been based on the assumption that there is a stage in the process that corresponds to parsing the sentence. Once the phrase structure of the particular sentence is extracted, the next step in understanding is to infer its deep structure--the simple sentences it contains and their relationships to each other. Given the deep structure, the final step is to consult the lexicon for interpretations of the words it contains and to construct a semantic reading for the sentence on the basis of those words arranged in that particular deep structure. The linguistic theories on which this approach relied have themselves evolved as a

consequence of progress in linguistic theory. In retrospect, therefore, it is hardly surprising that efforts to characterize the psychological processes of sentence comprehension in terms of the earlier linguistic theories were unsuccessful. Fodor, Bever, and Garrett (The Psychology of Language, New York: McGraw-Hill, 1974) have reviewed this work and have concluded that the comprehension process cannot use grammatical information in the same form in which a grammar represents it. As an alternative, they propose various heuristic strategies that might be used to identify clause boundaries, to identify the major verb in the sentence, and so on. The assumption is still made, however, that the result of these heuristic devices is to compute the same underlying grammatical structure that the grammar would compute.

From work on sentence processing by computer, however, alternate approaches have emerged. For example, grammatical structures might be regarded as abstractions from (rather than components of) what is basically an attempt to assign a semantic reading to the sentence (Davies and Isard, "Utterances as programs," D. Michie (Ed.), Machine Intelligence 7; Edinburgh University Press, 1972). In computer terminology, the phrase structure of a sentence might correspond, at least roughly, to the "trace" of the comprehender's operations in achieving the semantic reading; the basic operation would be analogous to compiling the program that the sentence expresses, at which point the sentence is "understood" and a decision is required as to whether the program should be executed. Such possibilities put sentence comprehension in a somewhat different light, and suggest obvious relationships between the sentence compiler and the lexical component. In both cases, the operation of the system is automatic and involuntary. Individuals may decide not to act on the basis of a simple sentence they hear in their own language, but they cannot decide not to understand it. How a sentence will be compiled will depend on the context in which it occurs--on the state of the system when the sentence is received, on the higher order goals the system is attempting to attain, on the particular situation at the particular time the sentence is used. Thus, the computer approach does not assume a single, correct semantic reading for every sentence, but permits a variety of interpretations for the same sentence depending on external considerations. This fact opens the theory to suprasentential relations of the sort that occur in discourse, and so offers important opportunities for theoretical integration. The exploration of these possibilities, and the evaluation of their relevance to the problems of sentence comprehension in reading, is an important approach to the problem.

Division of the Approach

The division of the approach into programs parallels that of Approach 1.1.

Program 1.2.1: Models for Processing Syntactic and Semantic Structures of Sentences.

Program Statement

A model of exactly how meaning or semantic readings are abstracted from surface print or speech is the goal of this program.

Program Potential

Work in this area is progressing in three different directions: Computer simulations, psycholinguistic models, and philosophical theories. Further integration of this work should be supported.

Program Research Considerations

Just as models of lexical organization must be developed in the light of psychological evidence concerning the lexicon, so must simulations of sentence processing be developed in the light of psycholinguistic determination of the role of syntactic and semantic variables in speech perception. Especially important is psychological evidence about online processing. For example, there are now several methods for determining relative information-processing load during reading or listening to a sentence. This work suggests that the surface structure clause (and perhaps also the deep structure clause) is an important unit of perception. Therefore, a processing model of speech perception must account for how people identify such units, how relationships among the words in the clause are established, and how relationships among clauses are established. The relative roles of syntactic, semantic, and contextual variables in this process must be discovered. Theoretical work is needed on the relationships among syntactic and semantic representations of sentences and conceptual memory in a model of realtime processing.

Division of the Program

The first project does not involve empirical research. Rather, we need an overview, with special attention to the psychological relevance of current philosophical and linguistic theories of meaning. The second project is to harvest the fruits of the first.

Project 1.2.1.1: Semantic Theories.

Project Statement

The goal of this project is to evaluate the psychological relevance of current philosophical and linguistic theories of meaning.

Project Potential

Many philosophers and linguists believe that psychologists do not understand what a theory of meaning is a theory of: many psychologists believe that philosophers and linguists are analyzing their own linguistic fantasies. Some clarification of the conceptual foundations of work on meaning and comprehension seems indicated.

Project Research Considerations

There seem to be three kinds of theories of meaning that philosophers are working on. The first flows out of philosophical theories of association, and holds that the meaning of any object, event, sign, or symbol consists of the associations to it that people have built up through their prior experience. Although this approach has been abandoned by most contemporary philosophers and linguists, it is still the kind of theory many psychologists have in mind when they talk about meaning. This view is compatible with the idea that words in isolation have meaning; the other two theories focus on the meaning of sentences or propositions.

A second approach can be seen in the work of the "ordinary language" philosophers following Wittgenstein. Roughly speaking, it is a theory about what speakers are properly understood to be intending to do when they produce an utterance of a sentence that is grammatical in their language, and about how listeners construe the communicative intentions of the speakers on the basis of the linguistic forms the speakers produce. Inasmuch as the object is to show how the linguistic forms people exchange are related to intentions, beliefs, etc., this approach is explicitly psychological, yet is little-known among psychologists.

The third philosophical approach arises from theories of such formal languages as logic, mathematics, etc. Typically, logicians have been interested in languages that provide appropriate vehicles for formalizing such ideas as the validity of inferences. As applied to natural languages, to understand a sentence is to know what its truth conditions are. The hope would be that, from the truth conditions of simple sentences, one could project to the truth conditions of all grammatical compounds of those sentences (and so "understand" them, too). At present, this is possible only for formal languages, but the formal program is taken as the model for semantic theories of natural languages as well.

Although there is currently much controversy between these two latter views, it would seem that the goal of psychological model building should be to integrate them, to attempt to construct models of natural-language communicative exchanges. There is some indication that work in artificial intelligence, which is generally oriented toward achieving certain well-defined objectives, will promote this integration in some kind of "procedural semantics" by clarifying what it is we expect such a theory to do. Whatever the eventual synthesis would be, however, it seems clear that

a collaborative enterprise is involved. The minimal personnel required would include psychologists, linguists, logician-philosophers, and artificial intelligence workers. It would entail considerable mutual education, and that, in turn, would require getting the various parties to pay more attention to each other than they generally have in the past.

What is proposed here, therefore, is not a program of empirical research, but the creation of a mechanism whereby funds would be available to support collaboration among the various parties. Initially, a series of conferences bringing together the more broadminded representatives of the different disciplines might be charged to scout the ground and draw up a proposal for more extended collaboration. Then, the Center for Advanced Study in the Behavioral Sciences might be a willing and appropriate host to small groups desiring to spend a year together. If clarification of basic issues emerged, summer training institutes or other such mechanisms, in addition to the normal publication routes, could be used to spread the word. Progress at this level is slow, but not enormously expensive, and any serious study of what kinds of models could be models of the human mind would have enormous long term implications for psychology and education.

### Project 1.2.1.2: Research Applications of Semantic Theories.

#### Project Statement

The goal of this project is to develop research and simulation applications of linguistic and philosophical theories of meaning.

#### Project Potential

See Project 1.2.1.1.

#### Project Research Considerations

Some of the current philosophical and linguistic theories of meaning make no claims to psychological relevance at all. For others, possible roles in processing models of communicative exchanges can be imagined. Project 1.2.1.1 will raise empirical questions. The present project should develop methods for answering them. We will need new techniques for establishing the psychological reality of various concepts and distinctions, and for testing aspects of the models. Obviously, there will be a need for many specific projects. We suggest that the NIE should fund a few such projects in the interest of exploring the implications of semantic theories for a psychological model of comprehension.

Program 1.2.2: Syntactic Development.

Program Statement

The aim of this program is to characterize syntactic development in children who are beyond the preschool years.

Program Potential

Without information about syntactic development, we cannot discover the effects of syntactic variables on readability of texts. Higher order comprehension skills are very likely to require efficient and automatic processes for identifying and analyzing surface and deep clauses, as well as for assigning relationships among them. We cannot foster these skills instructionally until we understand their normal course of development. To this end, we are now in a position to integrate research on preschool syntactic development and adult psycholinguistics.

Program Research Considerations

We must systematically extend the work that has shown that syntactic development is not complete by age 4. The first goal of this research would be a catalog of constructions that are difficult for elementary school children. The real goal, of course, would be a statement in terms of psycholinguistic theory of why some constructions are developmentally more complex than others. For this, we must do more than merely catalog constructions that cannot be understood. The psychological methods that provide evidence for models of online processing of speech in adults must be adapted for children. We must try to simulate syntactic processing at different ages.

Division of the Program

The program has been divided into two projects. The first concerns the discovery of syntactic constructions that cannot be understood by some elementary school children. The second concerns developmental changes in online processing of complex sentences.

Project 1.2.2.1: Development of Syntactic Competence.

Project Statement

We must discover which syntactic constructions cannot be understood by elementary school children.

Project Potential

The potential of this project is excellent. The methodology for this research has been worked out. We know that there are some constructions

that pose difficulty after age 4, but we have little idea of the extent to which syntactic development is not complete by that age. The difficult constructions often involve complex relationships among constituent clauses.

Project Research Considerations

This research should be a collaboration of linguists and developmental psychologists. Linguists must provide candidate constructions and candidate determiners of developmental complexity. Developmental psychologists must then show that the constructions can or cannot be correctly interpreted by children. Because children cannot be directly interrogated about grammatical acceptability, competence must be assessed by a wide variety of tasks requiring correct interpretations of the structure in question. These tasks would include comprehension tasks (e.g., acting out sentences or choosing which picture depicts the proposition expressed in some sentence), memory tasks, imitation, and others. These studies are typically done on sentences taken out of context, in which case, the syntactic relationships under question must be explicitly processed for the sentence to be understood. An important question, therefore, is the extent to which these same constructions pose difficulty when they are embedded in text.

### Project.1.2.2.2: A Developmental Model of Syntactic Processing.

Project Statement

The processing of syntactic relationships may change in fundamental ways during childhood. Age-appropriate simulations and models of the processing should be generated.

Project Potential

There has been little attention to the development of how syntactic variables affect comprehension, as opposed to the development of which syntactic relationships are understood. Therefore, the adaptation--for children--of the methods for studying online processing of sentences by adults should have a high payoff.

Project Research Considerations

Developmental studies of the processing of complex sentences in realtime must begin by adapting adult psycholinguistic techniques for children. For example, phoneme monitoring tasks, reaction times to clicks, and detection of clicks during the processing of ongoing speech provide measures of relative information-processing load during comprehension. Probed recall tasks can assess how the syntactic structure of a sentence influences the deployment of limited short term memory. Techniques exploiting ambiguity could also be adapted for children. The research would bear on such questions as: Are clauses perceptual units in the same

ways for children as they are for adults? Do children have efficient strategies for identifying clauses in ongoing speech? Are clauses identified in the same ways by children of different ages (i.e., in terms of surface-structure markers, word order strategies, knowledge of lexical subcategorizations of verbs, etc.)?

Program 1.2.3: Comprehension of Sentence Meaning.

Program Statement

The goal of this program is to explore the extent to which we can manipulate the ease of acquisition and recall of the meaning of a sentence.

Program Poten

It is important to obtain information that can be used to facilitate the preparation of texts that children can understand, and to guide the development of better instructional techniques.

Program Research Considerations

The general idea is to treat sentence comprehension as a problem-solving task, with the eventual goal of discovering which problems are hard and which are easy for a beginning reader. A sentence can be regarded as a symbolic device that readers can use to calculate concepts new to them. The words in the sentence represent some fairly general concepts that they already know; the syntactic structure of the sentence specifies the order and manner in which they must combine these known concepts; and the result of these combinatorial processes is some new concept. The questions to be addressed under this heading are: what are the nature of these combinational processes, and how can we adjust prose and the instruction of students to influence the ease and accuracy with which they can employ these processes in reading comprehension?

Division of the Program

The following projects are all closely related. The program begins by attempting to gain an understanding of the logical nature of the combinatorial processes and how they correspond to and might be signaled by the structural features of written language. It then proceeds to determine the psychological reality and to analyze the psychological nature of these processes. This analysis should provide at least a general description of a central component of the comprehension processes, of how people store the information they get from sentences, of what they may still need to learn. This information should enable us to better facilitate the comprehension and recall of the meanings of sentences being read.

Project 1.2.3.1: Processing Sentences.

Project Statement

The goal of this project is to analyze and describe the logical and semantic operations people must perform in order to generate meaningful strings of words.

Project Potential

In order to prepare reading materials appropriate to different levels of comprehension skills, we need to know whether certain grammatical constructions or semantic combinations should be avoided because they entail logical or conceptual processes readers are unable to perform or, if able, do not recognize as required by the text.

Project Research Considerations

In order to comprehend language, we need to determine the relationships among words, relationships that resemble those things linguists describe as grammatical structures. Then this information is employed to determine the order in which the words should be combined. For example, one of these combinatorial processes could be said to be akin to identifying the intersection of two sets. For example, in the phrase "blue book" we identify its meaning as being the subset of books that are blue. A different process is required by the phrase "very tall" multiplied by an amount representing the meaning of "very." Exactly what psychological operations of this sort are required in order to understand English does not seem to have been investigated systematically. Until we have conducted such investigations, we will not understand even at the purely logical level what it is that people are supposed to be learning to do when they learn to comprehend language.

It should be noted that what is being called for here is a conceptual analysis of the processes involved in understanding sentences out of context. The end product of these studies should be an enumeration of each of the different meaning-combining processes involved in comprehension, a description of each process, and an enumeration of what linguistic structures require each process.

Project 1.2.3.2: Difficulties in Processing Sentences.

Project Statement

The goal of this project is to determine the abilities of children of various ages to perform the various meaning-combining processes in linguistic and nonlinguistic tasks.

Project Potential

Children's failure to comprehend some segment of text correctly may be attributed to a failure to have acquired the skill necessary to "parse" the structure of sentences correctly, to a failure to have learned how to perform the logical processes necessary to combine the meaning of the constituents they are dealing with, or to a failure to have learned where in a structure they should apply this process. In order to design instruction, we must know if and when the meaning-combining processes in a linguistic situation require prior competency in applying these processes in nonlinguistic problems.

Project Research Considerations

The tests of children's ability to perform a combinatorial process should provide plausible evidence of whether a child can perform that process in simple nonlinguistic situations. Evidence of whether children can perform that process in simple nonlinguistic situations can be obtained both by naturalistic observations and by observing transfer effects in experiments on children.

Project 1.2.3.3: Sentence Focus.

Project Statement

The goal of this project is to determine how the "focus" phenomenon in sentence structures influences the meaning of the sentence.

Project Potential

This series of studies could clarify the function of the focus phenomenon in sentence structures and, perhaps, shed some light on the storage and retrieval of the semantic information communicated by a sentence. The results could be used both in the preparation of texts (writers could signal their intended emphasis in ways young readers would understand) and in the design of instruction (students could be taught the significance of such signals).

Project Research Considerations

The term "focus" has been used to refer to the effect obtained by switching the subject and predicate nouns when an active sentence is passivized or by the reordering of the direct and indirect objects of a verb. It is popularly supposed that these structural alterations leave the meanings of sentences unchanged and that they serve merely to focus readers' attention more on the first noun phrases to occur. For example, consider such sentence alterations as John rode the bike versus The bike was ridden by John. Although the truth conditions of these two sentences

are the same, they clearly emphasize different things. In most contexts, the first sentence would focus attention on John, and would leave a somewhat modified version of the initial concept of John; the second sentence would refer to some bike and leave a somewhat modified version of that concept. Although a full analysis of the techniques used to signal coordination or subordination of emphasis would have to consider whole texts, many of these signals operate at the sentence level.

### Program 1.2.4: Cultural Differences in Sentence Comprehension.

#### Program Statement

The goal of this program is to determine the educational consequences of syntactic differences between the language used in school and children's own speech.

#### Program Potential

Claims that grammatical differences handicap poor children in understanding sentences in school need better evaluation.

#### Program Research Considerations

Active participation by members of affected groups should be encouraged.

#### Division of the Program

Current understanding of the differences provide groundwork for two studies.

### Project 1.2.4.1: Syntactic Differences.

#### Project Statement

The goal of this project is to determine the extent of dialect divergence in the syntactic properties of sentences used by speakers of nonstandard English dialects.

#### Project Potential

In light of research over the past decade which has demonstrated differentiation in English dialects, which affects the surface representations of sentences, we need to give careful consideration to the possibility of semantic correlates of these differences.

Project Research Considerations

We need to investigate the effect of loss of certain grammatical features such as past tense morphemes and possessive suffixes in the spoken language on the neglect of the semantic information they carry in the printed word. Where semantic redundancy is eliminated by dialectal differences in grammar, we need to investigate the effect on comprehension of introductory redundancy in the form of greater lexical elaboration.

Project 1.2.4.2: Differences in Usage.

Project Statement

The goal of this project is to determine whether dialect differentiation such as that represented in Black English (B.E.) favors the use of some types of syntactic construction and the neglect of others.

Project Potential

Although there are excellent descriptions of B.E. phonology and grammars, much less is known about the uses of these syntactic properties of B.E. It is important to investigate the relative frequency of certain syntactic constructions and sentences of different degrees of syntactic complexity in use in speech communication where nonstandard English dialects are spoken.

Project Research Considerations

Infrequent exposure to certain sentence types can undoubtedly play a role in comprehension when the sentences are encountered in the printed word, where many of the disambiguating devices of spoken language are necessarily absent. We need to know more about the relative ease with which nonstandard dialect speakers comprehend sentences with syntactic properties infrequently occurring in their spoken language.

APPROACH 1.3

TEXT COMPREHENSION SKILLS

Approach Statement

The goal of this approach is to identify those skills that are important for text comprehension, as distinguished from word or sentence comprehension, and to determine how these skills can be taught.

Approach Potential

An understanding of what readers do when they comprehend text is critically important to design instruction that strengthens comprehension skills.

Approach Rationale

We intend to focus on those factors which are unique, or especially important, to text comprehension and which are not treated in discussion of word, concept, or sentence comprehension. Thus, while word comprehension skills are clearly essential to text comprehension, they will not be discussed here.

Work on text comprehension is not yet far-advanced. There are major gaps in our understanding of the anatomy of the text comprehension process, and in our knowledge of the skills that make comprehension possible. The task will be to draw on imperfect empirical knowledge and on hints contained in a few simulation studies to arrive at reasonable guesses as to what this process is and what these skills may be.

The following model, while very incomplete, appears consistent with available data and ideas, and provides a framework in which to place our guesses about comprehension skills. The model starts with raw text as input and ends with information coded in a format acceptable to some special processor as output. For example, if the text is a problem statement, then the comprehension process must generate an output that is acceptable as input for some problem-solving process.

We assume that the raw text is processed by a parser and that anaphoric reference is handled by another processor. Neither of these processors will be discussed here. The model then has three general steps.

First, we need to identify important elements of the text. The output of the above processes is passed to an attention program that makes preliminary judgments about what is important in the text. These judgments include identifying major themes, judging which elements of the text are relevant to the major themes, etc. It seems essential that the

attention process be responsive to context. Thus, in a history text, the attention process might tag dates as important and interpersonal relationships as not, but do the opposite in a novel.

Second, we need to construct internal representations of the important information in the text. Once the important aspects of the text have been identified, a representation that incorporates these aspects must be constructed. The construction of representations seems to involve many subprocesses:

(a) Retrieval of information from long term memory. To understand a story about a vicious dog, for example, it is essential to know that dogs bite and that they are more than a centimeter high, even if the story does not mention these facts. Presumably, construction of internal representation depends heavily on retrieval of this kind of knowledge from long term memory. This, in turn, clearly depends on the existence of a large store of well-indexed information in long term memory.

(b) Elaborating and abstracting. In forming representations, people display at different times quite contrary tendencies. In some cases, they elaborate on the information in the text by adding details of appearance, spatial and temporal settings, etc. It is possible that this elaboration enhances retention. In other cases, the subject may strip the representation to its bare essentials. It is not uncommon in problem-solving situations to observe a subject construct an elaborate representation of the problem situation and then, late in the solution process, generate a new, more abstract representation with all unessential detail removed.

(c) Integrating the representation. This includes drawing inferences implied by the representation (in the sense of Bransford and Franks) and detecting and correcting inconsistencies between two parts of a representation or between the representation and new text elements. For example, at one point in a text, readers may interpret the words "perform for x" to mean "perform for the benefit of x," while at another point they may interpret that same phrase to mean "perform instead of x." Later in the comprehension process, they should correct this inconsistency and successfully resolve the ambiguity.

(d) Naming. The assignment of unique names to the elements of the representation appears to be an important part of the comprehension process. This fact becomes more evident in situations that interfere with the naming process. For example, if we hear a narrative about a family upstairs and a family downstairs, we have little trouble comprehending as long as the families do not move. However, if the family upstairs moves downstairs from the family downstairs, we may find that comprehension is aided by calling them Family A and Family B. Simple naming, of course, is trivial; the real skill here is to recognize when, and what, to name.

Third, we need to match the representation to an appropriate special processor. We view comprehension process as being complete when the

representation has been constructed and mapped onto the appropriate special processor. (By "appropriate processor" we do not necessarily mean a processor that will solve the problem.) This step, of course, requires both that a large and well-indexed set of special processors be available, and that the mapping onto the appropriate processor be accomplished. This last requirement is by no means trivial, as experience in problem-solving shows. Often, superficial changes in the form of a problem will make its solution either much more difficult or in some cases impossible. For example, in one situation a subject who was working on an isomorph of the Tower-of-Hanoi problem constructed a representation that resembled the Tower of Hanoi except that it was upside down. This simple difference in orientation prevented the subject from recognizing that he already knew how to solve the problem. In some cases, the mapping is facilitated by the use of multiple representations. The puzzle literature is full of situations in which comprehension is very difficult indeed until one hits on the right representation, at which point the problem becomes trivial.

Divisions of the Approach

The division into programs parallels the division of Approaches 1.1 and 1.2.

Program 1.3.1: Process Models of Text Comprehension.

Program Statement

The aim of this program is to develop models for the text comprehension process and for subprocesses of the total process.

Program Potential

Work has proceeded on question-answering and natural-language understanding systems for a number of years now. This work has met with considerable success, particularly with respect to the solution of parsing problems. With this work as background and with several new developments in text comprehending systems, it seems likely that models of text comprehension can now be developed more rapidly.

Program Research Considerations

In this program we should emphasize computer simulation studies which can be closely checked against observation of human performance. Artificial intelligence studies, while potentially of great value, seem less likely than simulation studies to generate ideas useful in practical reading contexts. Similarly, mathematical models or other less formal models seem less appropriate than simulation models for handling complex processes such as text comprehension.

Divisions of the Program

The program is divided into a global project and a number of specific projects. The specific projects were chosen because they seem to be highly isolatable and "doable" parts of the total process. The global project was included because we believe that if all the parts were built separately, there would still be much to learn by putting them together in a total text comprehension system.

Project 1.3.1.1: Simulation of the Text Comprehension Process.

Project Statement

The goal of this project is to conduct psychological studies of text comprehension and construct computer simulation models of the observed behavior.

Project Potential

See Program 1.3.1

Project Research Considerations

Because of the complexity of the text comprehension process, there are many parameters which seem likely to influence human behavior in this task, e.g., the organization of the text, the relation of the text to information in long term memory, special training procedures, etc. Generating sufficient data to exercise a simulation model should not be difficult.

Project 1.3.1.2: Models of Relevance Judgments.

Project Statement

The goal of this project is to conduct psychological studies of relevance judgments in text comprehension and to develop models of the judgmental process.

Project Potential

Although relevance judgments constitute only a small part of the text comprehension process, they are likely to play a critical role in determining the efficiency of the total process. This area of investigation is quite narrowly defined, and it may be relatively easy to progress with it.

Project Research Considerations

A number of heuristics suggest themselves as possible candidates for use by readers in identifying relevant elements in a text. For example, the reader might judge relevant: (1) those elements most frequently mentioned; (2) those elements most frequently connected by logical or grammatical relationships to other elements in the passage; (3) those elements entering into important logical relationships, such as set relationships or negotiation; or (4) all of the above.

It might be interesting to focus this research on the identification of the heuristics which subjects in fact use.

Project 1.3.1.3: Models of Isomorph Recognition.

Project Statement

The goal of this project is to conduct psychological studies of the conditions under which humans can identify the isomorphism of two text structures (e.g., two narratives, two problems) and construct models of the identification process.

Project Potential

It seems likely that human use of information from long term memory in text comprehension is severely limited by failure to recognize the isomorphism of complex structures. Success of this project could contribute much to our understanding of memory-use limitations.

Project Research Considerations

One possible line of research in this area is the exploration of the role superficial features play in hiding the identity of isomorphs of problems or narratives. The Tower-of-Hanoi problem can be coded in a great many forms that differ superficially, e.g., as a problem in which a set of people exchange tasks on the basis of their route or as a problem in which tribes exchange villages depending on their birthplaces, etc. Some of these codings are much easier to recognize as the original Tower-of-Hanoi problem than others. Finding those factors that interfere most with isomorph identification may shed light on the identification process.

P-ogram 1.3.2: Procedures for Facilitating Comprehension.

Program Statement

The aim of this program is to develop procedures for facilitating comprehension of text, and test the procedures with human subjects.

Program Potential

While there is relatively little work in this area, and what there is, is scattered, the practical importance of advances in this area is great.

Program Research Considerations

The lack of theoretical integration, which has characterized this area in the past, suggests that work on this program should be coordinated with work on Program 1.3.1 in order to give it theoretical focus.

Divisions of Program

Six strategies for approaching this problem appear promising.

Project 1.3.2.1: The Role of the Readers' Knowledge Base.

Project Statement

The goal of this project is to (1) explore the relationship between the size and nature of readers' knowledge base and their ability to comprehend (a) general text passages (passages for which nearly all readers have the relevant information), (b) text passages on topics that are especially familiar to readers, and (c) text passages on topics with which readers are not familiar; and (2) to explore the effect on text comprehension of increasing the subjects' knowledge base (a) over the shortrun in specific subject matters and (b) by an intensive and long term push in a broad range of topics.

Project Potential

Semantic memory is currently an active research area; thus, this project should be able to profit by borrowing from the rich pool of theoretical ideas which has recently become available.

Project 1.3.2.2: Questioning Skills.

Project Statement

The goal of this project is to determine ways to provide subjects with skills for detecting gaps in their own knowledge bases and for increasing these knowledge bases over an extended period of time.

Project Potential

If successful, this project could be of great practical value, for the same reason that all self-instructional material is valuable--it could

provide knowledge at low cost. Similarly, it would have the disadvantages of self-instructional material in that it would depend on individual interest and effort in the target population.

Project Research Considerations

Skills that subjects would need to acquire include: (1) skills for detecting gaps in the knowledge base. These might include the use of systematic checking procedures such as checklists of standard knowledge and the use of "failure to understand" as a cue to self-questioning; and (2) skills for retrieving information from information sources, e.g., teachers and librarians.

To succeed, it seems likely that this project would need to make a long term change in the fine grain of subject behaviors. This suggests that it would involve intensive training--perhaps for short periods of time, repeated at intervals.

### Project 1.3.2.3: Knowledge Integration.

Project Statement

The goal of this project is to develop procedures for improving readers' ability to integrate knowledge acquired from a passage of connected text.

Project Potential

Because it has been reported that poor readers are deficient in the ability to integrate information, this project may be concerned with a skill of central importance to reading comprehension.

Project Research Considerations

Bransford and Franks' procedures may provide a valuable technique for conducting research in this area. Detection of inconsistencies in the text might provide another useful dependent measure. Techniques developed in connection with Project 1.3.2.4. might suggest useful training techniques.

### Project 1.3.2.4: Elaboration Skills.

Project Statement

The goal of this project is to develop training procedures to increase subjects' ability to elaborate on relevant text elements, and conduct psychological tests to determine if such elaborations increase memory for, or comprehension of, the text.

Project Potential

It may be that when one says that individuals are taking an "active attitude toward a text," what is meant is that they are employing elaboration skills. If so, training in such skills may aid text comprehension.

Project 1.3.2.5: Using Pictures as Aids.

Project Statement

The goal of this project is to determine under what circumstances pictures aid text comprehension, and under what circumstances they hinder text comprehension.

Project Potential

A great deal of effort and expense goes into illustrating school texts and other educational materials; but there is some evidence that illustrations can actually hinder comprehension of the text. This project is, thus, of considerable importance.

Project Research Considerations

The research on the effects of pictures on learning to read and on comprehension of text has been reviewed by Samuels (Review of Educational Research, 1970, 40, No. 3, 397-407). He concludes that "There was almost unanimous agreement that pictures, when used as adjuncts to the printed text, do not facilitate comprehension." This evaluation comes as a surprise to most educators and publishers when they first encounter it. It is widely assumed that interesting pictures help children infer meanings of unfamiliar words and interpret difficult constructions in the text, motivate them to read, and instill positive attitudes toward reading. Those unwilling to abandon their intuitive beliefs find the research results difficult to accept.

An important word to note in Samuels' conclusion is "adjuncts." An adjunct picture is redundant--it repeats in visual form information that is given by the text in linguistic form. An adjunct picture may divert children's attention from the text. At best, they acquire the information without having to puzzle over the text; at worst, they pay attention to irrelevant aspects of the picture and, so, acquire the wrong information.

It is not necessary, however, for a picture to be a mere adjunct to the text. Bransford and Johnson (Journal of Verbal Learning and Verbal Behavior, 1972, 11, 717-726) have studied comprehension of passages that presuppose information given in a picture--pictures are used as advance organizers. For such texts, comprehension and recall are poor if the picture has not been seen in advance; readers feel they have come in at the middle of something. References are made to things, relationships, or

situations which they do not recognize; and they are unable to guess about them intelligently. Thus, it is possible for pictures to play an important role in total communication if the pictures provide a representation necessary for p[illegible]essing textual information. In most basal readers, however, pictures are not used in this manner. Whether they should be, or whether they should be eliminated entirely from instructional materials designed to teach reading, cannot be answered without further research.

### Project 1.3.2.6: Identifying Relevant Information In Text.

#### Project Statement

The aim of this project is to develop procedures for improving readers' [illegible]ility to identify relevant information in text, and to conduct psychological tests to measure the effectiveness of the procedures. The goal is to promote educational applications of work performed under Project 1.3.1.2.

#### Project Potential

It has been observed in some text comprehension tasks that half of the text material is irrelevant to the completion of the task. The ability to make accurate judgments of relevance, then, may be very important in insuring efficiency in processing text information.

#### Project Research Considerations

Good dependent measures for this project might include (1) direct relevance judgments, (2) identification of major themes, (3) construction of an outline for the text, and many others.

### Program 1.3.3: Development of Text Comprehending Skills.

#### Program Statement

The goal of this program is to conduct psychological studies of developmental changes in text comprehending skills.

#### Program Potential

Study of the development of text comprehending skills is important, both for clarification of theoretical issues and for practical applications. Developmental observations should help in understanding how the integrated package of skills which underlies adult competence in text comprehension was put together, and, hence, should provide insights into its functioning. Such observations should also be directly applicable in the classroom to help define teaching goals and to determine performance expectations. If children at a given developmental stage cannot make relevance judgments,

for example, then it is unreasonable to expect them to outline paragraphs well or to write sensible book reports.

Although developmental norms have been established for vocabulary and grammatical skills and for text comprehension as a whole, there is a lack of such norms for the component skills which make up text comprehension. Research would help to fill this important gap.

Program Research Considerations

A theoretical orientation for research in this area could be obtained by integrating this research with other work in Approach 1.3, and/or by employing a Piagetian framework. Within the latter framework, the developing abilities for basic metalinguistic and metaconceptual judgments seem particularly relevant.

For some comprehension skills, it may be important to extend the range of developmental stages studied below the age of reading by exploring the child's developing comprehension of spoken passages.

Division of the Program

The division of this program reflects the rationale outlined above for Approach 1.3.

Project 1.3.3.1: Development of Relevance Judgments.

Project Statement

The goal of this project is to conduct psychological studies of the development of children's ability to make judgments about the relevance of text elements.

Project Potential

Relating the temporal course of development of this skill to the course of development of comprehension as a whole can help to define the role of this skill in the total process.

Project Research Considerations

Experiments in this area need to be designed so that the preliminary relevance judgments readers make prior to full comprehension are studied, rather than judgments of relevance made after the text is comprehended. Thus, it may be important to present the text one sentence at a time, and to obtain relevance judgments of each sentence before the next is given.

Project 1.3.3.2: Development of Text Integration.

Project Statement

The goal of this project is to conduct developmental studies of children's ability to draw appropriate inferences relating the elements of a text.

Project Potential

This project parallels that of Project 1.3.3.1.

Project Research Considerations

Potentially valuable dependent measures include discrimination of new and old text elements (in the manner of Bransford and Franks)and detection of inconsistencies in the text. Independent measures might include the number of text elements required to make an inference, and the distance separating them in the text.

Project 1.3.3.3: Development of Retrieval Processes.

Project Statement

The aim of this project is to conduct psychological studies of developmental changes in the processes by which information is retrieved from long term memory.

Project Potential

This project parallels that of Project 1.3.3.1.

Project Research Considerations

Of particular interest for understanding reading comprehension would be evidence concerning developmental changes (1) in the probability that a cue will lead to retrieval, and (2) in the nature of effective retrieval cues.

Project 1.3.3.4: Basic Metalinguistic and Metaconceptual Skills.

Project Statement

The goal of this project is to relate developmental changes in text comprehending skills (Projects 1.3.3.1, 1.3.3.2, and 1.3.3.3) to basic cognitive development, especially in the realm of metalinguistic and metaconceptual abilities.

Project Potential

Learning to decode text requires basic metalinguistic skills. Children must be able to segment speech into words and phonemes if they are to learn the conventions of writing. Recent work has shown that most children under 5 lack these metalinguistic skills, that many poor readers in the early elementary grades lack these skills, that these skills can be taught, and that teaching them improves reading at the decoding level. Analogously, higher level text comprehending skills require that children be able to make their thoughts the objects of their thinking. It is plausible that this is a general ability which develops during the elementary school years, and that lags in developing higher order comprehension skills follow directly from lags in this ability.

Project Research Considerations

There are several paradigms, scattered in the developmental literature, which potentially relate to the ability to think about one's own thinking. Piaget's stage of concrete operations can be seen in this light. In determining children's developmental stages, Piaget emphasizes children's justifications for their judgments. The apparently different concepts of life which Piaget finds characteristic of children under 12 may reflect the requirement of consciously defining "life," rather than a truly different conceptual structure. That is, once children have committed themselves in a Piagetian interview to the definition "life = movement," they say that clouds are alive, the sun is alive, etc., even though in ordinary circumstances they might not make that confusion. Similarly, the lack of clustering in free recall tasks is often taken as evidence that children do not "have" some abstract conceptual distinction. It is equally likely that children simply fail to recruit a distinction they make in other contexts as a strategy for this task. That is, adults characteristically adopt strategies for dealing as efficiently as possible with any task they are set; children do not have comparable flexibility. This difference may reflect an inability to represent and manipulate the demands of the task. If there are basic developmental changes in these abilities during the elementary school years, they would underlie the higher order comprehension skills we have isolated. If this can be demonstrated, effort should be put into direct attempts to foster these basic cognitive skills.

Program 1.3.4: Cultural Differnces in Text Comprehension.

Program Statement

The goal of this program is to determine whether there are subcultural differences in the development of text comprehending skills.

Program Potential

Research in this area is extremely important, for the percentage of children failing to attain full literacy is especially great among some cultural subpopulations. Programs 1.1.4 and 1.2.4 seek reasons for this difference at the level of processing individual words and sentences; in this program, we look directly at the text comprehending skills we isolated in Approach 1.3. The work of Michael Cole and his associates suggests that a large proportion of the variance among subpopulations might be found at this level. They have found that apparent differences in knowledge are often differences in deployment of knowledge, especially as it relates to strategies for particular tasks.

Program Research Considerations

This work must follow the work in Program 1.3.3. We cannot look for subcultural differences in the development of text comprehending skills without some idea of the general course of development of these skills. Therefore, we cannot guess at present which, if any, of the text comprehension abilities we have isolated will be most sensitive to such differences.

Various lines of cross-cultural research are currently converging on the idea that cultural differences in cognitive tasks are attributable to factors that call particular operations into play and regulate their role in the performance of a task. It is important, therefore, to study not only cultural differences in the acquisition of cognitive skills, but also cultural differences in the way those skills are employed in particular situations.

Division of the Program

The program has been divided into three projects. The first concerns basic metalinguistic and metaconceptual skills and the second the particular text comprehension skills we have isolated. The third is more basic, and even more ambitious. We seek relevant descriptions of communication practices among different cultural subgroups which might account for any subcultural differences found in the first two projects.

Project 1.3.4.1: Subcultural Differences in Metalinguistic and Metaconceptual Skills.

Project Statement

The goal of this project is to determine if cultural variations exist in the nature of, and in the rate of attainment of, various metalinguistic and metaconceptual strategies and abilities.

Project Potential

Just as there is evidence for the development of abilities to "think about thinking" in the elementary school ages (Project 1.3.3.4), there is also evidence for cultural differences in this development. This situation might be expected if cultural subgroups differ in the degree to which they play metalinguistic games with their children, or if they differ in more basic aspects of the use of language (Project 1.3.4.3).

Project Research Considerations

The tasks devised to obtain an overall picture of the development of metaconceptual skills (Project 1.3.3.4) should be given to children with varying subcultural backgrounds. The aim of this research is to discover if there are differences in the development of abilities for constructing strategies appropriate to some particular cognitive task, for rationalizing one's thinking, etc. More important, if there are such differences, there should be work on discovering what kinds of experience foster the metalinguistic or metaconceptual attitude.

### Project 1.3.4.2: Subcultural Differences in Text Comprehending Skills.

Project Statement

The goal of this project is to determine the extent to which differences among subgroups in their attainment of full literacy depend upon differences in text comprehension skills.

Project Potential

Although it seems likely that many of the differences in ultimate reading skills depend on text comprehension skills, this dependence cannot be tested until work under Programs 1.3.1, 1.3.2, and 1.3.3 has a firm beginning.

Project Research Considerations

See Project Potential.

### Project 1.3.4.3: Communicative Resources of Cultural Subgroups.

Project Statement

The goal of this project is to conduct a series of anthropological-sociological studies to determine if cultural subgroups differ in their communication resources and communication practices.

Project Potential

Differences in the size of vocabularies and meanings of words seem unlikely to explain fully the differences observed in comprehension abilities of cultural subgroups. Even if differences in vocabulary sizes do occur, they will require further explanation. This explanation is very likely to point to factors in the socialization milieu which promote strategies for conveying semantic information other than the rules of lexical selection and syntactic concatination. It appears that, in bilingual and bidialectal speech communities, code switching can convey information of considerable social and expressive (and perhaps even referential) importance. It would seem important to understand better the relationship between the type of linguistic responses available in different speech communities and such factors as vocabulary size, development, and elaboration. The availability of alternate communication strategies may be relevant to understanding the sources of differences in vocabulary development among children who belong to different social groups.

Project Research Considerations

The object of this research is to obtain a better understanding of the impingement of social and cultural factors on the way language functions in the social life of a speech community and of the relationship between this functioning and the kind of linguistic skills acquired by developing children in the community. Basic ethnographic information on the functions of language among social groups can yield insight into the kind of communication settings which may be useful in promoting the development of new language skills.

In particular, subcultural differences in the role assigned to reading should be studied. Students whose culture teaches them the pragmatic and economic value of reading may approach the learning task quite differently from students who believe that reading is an activity useful for learning something new about the world. Two readers differing in this way might also differ considerably in the level of information processing they would bring to the task of reading a text dealing with unfamiliar subjects. The information extracted from a text is highly sensitive to the task demands placed on the reader, yet we know little about the task demands that beginning readers place on themselves or the factors, situational or cultural, that lead them to such interpretations of their task. Students' conceptions of what reading is all about probably differ in different social strata; we need to know whether their conceptions significantly affect how they go about the activity of reading. The problem may not be that students do not know how to perform the various cognitive processes

involved in reading comprehension, but that they simply do not recognize that those processes are relevant to the task they think they have been given.

We have argued that reading a text can be regarded as a problem-solving task. It is a well-established fact that the difficulty of a problem varies according to context, even when the logical structure of the problem is the same. This variation should be studied in cultural terms. Subcultures differ in their knowledge of and interest in different domains of knowledge. It should be possible to estimate the importance of the content domain for reading by varying the content of text according to these cultural variations in knowledge while keeping the texts equivalent in terms of syntactic, logical, and rhetorical structure. Such processes as elaboration or representation may be spontaneously practiced in one domain but not in another--in relation to social life, say, as opposed to physical phenomena. In that case, the problem would become one of determining how operations well-developed for one domain may be generalized to other domains.

## PRIORITIES AND RECOMMENDATIONS

### General Discussion

The organizing idea behind this report was an attempt to characterize different strata of language skills at which reading comprehension can be frustrated: (1) decoding; (2) word recognition; (3) sentence interpretation; and (4) textual analysis. In proficient readers, information processing at levels (1), (2), and possibly (3) should occur automatically, so their conscious efforts can be directed totally to level (4). Poor readers, on the other hand, may be deficient at any level, with the most noticeable and disruptive deficiencies being ordered first. (We do not assume, however, that this order dictates a corresponding order of acquisition of skills, or that success at a higher level does not interact with performance of lower level skills.)

Incompetent, inaccurate, or slow decoding, attributable either to pathological causes or to lack of practice, can cause serious difficulties for all processing at higher levels. It is possible that some failures to learn to comprehend text easily result from insufficient automaticity of decoding. How frequently this occurs is not known, although it would seem to be important information for allocating priorities. The panel, however, accepted the popular consensus that the majority of poor readers in the upper grades are both accurate and proficient decoders; their problems arise from other, more complex sources.

The panel concentrated, therefore, on difficulties in word recognition, sentence interpretation, and textual analysis. Attention was further limited to the scientific aspects of these processes, and to the basic information required for intelligent educational applications and development; how these applications should be realized was little explored. Even with these limitations, however, the plan of the report is quite ambitious, so that in the short time available to prepare it the panel could not go as deeply into many questions as the questions deserved.

For each of the three levels considered, the division into programs followed the same plan. First, we called for a better theory of adult competence at that level. Second, we asked how that competence develops in children. Third, we wanted studies based on this knowledge of children's developing linguistic skills that would enable educators to facilitate reading comprehension, or to ameliorate difficulties at each level. And, finally, we pointed to subcultural variations whose effects at each level are poorly understood, but which seem to provide valuable opportunities for testing and extending theories of cognitive competence and their developmental course.

Priorities could be assigned to the various programs that resulted from this scheme either (1) in terms of the seriousness of the difficulties

at each level or (2) in terms of the scientific or intellectual merits of the programs. For the former rating, it would be important to know how frequently each type of difficulty occurs in different populations of students. Lacking such studies, the panel was forced to rely on the impressions and intuitions of its members, which are of doubtful validity. For the latter rating, judgment is easily prejudiced by one's personal interests and intellectual history. Weighing objectively the host of relevant factors--expense, time required, probability of success, dependence on outcomes of related research, utility of the results, relevance to existing or developing psychological or linguistic theories, number of established facts to which new facts can be related, difficulty of execution, general level of interest among workers in the field, excellence of personnel willing and able to do the work, and so on--would have been difficult, even if we were able to make valid judgments of each program or each factor in isolation.

Criteria and Priorities

All panelists determined their own criteria, but there was some consensus (1) that a survey of poor readers would probably reveal more students deficient in text comprehension than in lower level skills, so Approach 1.3 was of greater social importance; and (2) that practical applications are not feasible lacking valid theories to apply, so that the more basic studies deserve priority at the present time. Together, the panel selected Program 1.3.1 as of highest priority based on these criteria.

The general picture that emerges from the panelist's rating is that priority should go to modeling the comprehension process (at all three levels), then to collecting information on the development of those processes in children (at all three levels), and finally to application of this information to practical educational problems. This ordering presumably reflects an opinion that this is the sensible order in which to work toward fruitful applications, not a judgment that applied research and development is of secondary or tertiary importance. In particular, it is not a judgment that the reading problems of children from various American subcultures are uninteresting or unimportant. Rather, it follows from the panel's interpretation of the task it was assigned, namely, to propose approaches to establishing a knowledge base on which more successful teaching of reading comprehension skills might be based.