DOCUMENT RESUME

ED 140 226 CS 003 395

AUTHOR Paris, Scott G.; Brooks, Penelope
TITLE Cognitive Factors in Children's Listening and Reading Comprehension: Assessment and Facilitation. Final Report.
INSTITUTION George Peabody Coll. for Teachers, Nashville, Tenn.; Purdue Univ., Lafayette, Ind.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
BUREAU NO ER-3-2334
PUB DATE 1 Feb 77
GRANT NE-G-00-3-0089
NOTE 76p.

EDRS PRICE MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS Child Development; *Cognitive Processes; Context Clues; Elementary Education; *Listening Comprehension; *Reading Comprehension; *Reading Research; Recall (Psychological); Retention; Thought Processes; *Visual Learning

ABSTRACT

This report describes a series of studies of how children learn to operate on incoming information as it is transmitted by language or pictorial representations. Specifically, the studies examined (1) the relationship between what is known and the structure of incoming information and (2) the active operations children use in the process of comprehension. Among the results was the finding that children can and do act on incoming information in ways similar to adults. The studies also indicated that common, familiar relationships are comprehended faster than uncommon or unfamiliar relationships; that comprehension is aided if the reader acts on the information in the test; and that readers benefit from being given a topic which further information will elaborate. The studies leading to these conclusions are described in detail in the report. (AA)

FINAL REPORT

PROJECT NO. 3-2334
GRANT NO. NE-G-00-3-0089

COGNITIVE FACTORS IN CHILDREN'S LISTENING AND READING COMPREHENSION: ASSESSMENT AND FACILITATION

SCOTT G. PARIS
PURDUE UNIVERSITY
LAFAYETTE, INDIANA

PENELOPE BROOKS
GEORGE PEABODY COLLEGE
NASHVILLE, TENNESSEE

February 1, 1977

The research reported herein was performed pursuant to a grant with the National Institute of Education, U. S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgement in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official National Institute of Education position or policy.

U. S. DEPARTMENT OF

HEALTH, EDUCATION AND WELFARE

NATIONAL INSTITUTE OF EDUCATION

OFFICE OF RESEARCH GRANTS

TABLE OF CONTENTS

PREFACE

We wish to thank the National Institute on Education for its support of this work. It was a productive project; the artilces and papers stimulated by the project are listed on pages 66 and 67 of this report. It is not a bad investiment/ yield ratio. The principal investigators have also benefitted considerably from our intellectual involvement in the problems stimulated in this project.

Dr. Paris' career has developed and turned toward constructive approaches to cognitive and metamemory. Dr. Brooks' interests have turned towards children's acquisition of operative information. Both of these directions have, in part, been inspired by the thinking, agonizing, arguing--ASSIMILATIVE and ACCOMMODATIVE processes which resulted from our involvement in these projects. For that, most of all, we thank you.

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

While most educators have an intuitive grasp of the concept of comprehension and most people know whether they comprehend something, cognitive psychology is just beginning to "understand what it means to comprehend" (from "A sketch of a cognitive approach to comprehension," Bransford & McCarrell, 1975). Research in cognitive psychology has focused on two aspects of comprehension: (a) the role of context in determining what is comprehended, and (b) the operations that the comprehender performs on incoming information to help comprehension. The most recent developments have been based on the characterization of the reader or listener or viewer as constructing meaning from available information. This construction process is a product of his previous knowledge and assumes a "motivated" organism, i.e., one that seeks meaning (Bartlett, 1932).

The concept of comprehension from cognitive psychology is similar in many ways to Piaget's principles of assimilation and accommodation. Assimilation describes the organism's selection of information in the environment that can be related to what he already knows. Accommodation refers to the altered state of the organism as a function of having assimilated something relatively new. While these principles are short on explanatory power, they do provide a descriptive framework for embedding the developmental accounts of comprehension. Indeed, they place the control of comprehension squarely in the domain of environmental engineering. Comprehension can be promoted or retarded by various manipulations of the structure and content of the material which is being considered. Bransford and Johnson (1972), for example, demonstrated that adult's comprehension and memory for paragraphs improves greatly if context (pictures) is provided. Other researchers have found enhanced comprehension by presenting a theme or title before a prose passage (Ausubel, 1968; Dooling & Lachman, 1971). Often subjects provide their own context or structure to enhance recall, as has been found in the numerous studies on elaboration in paired-associate learning, e.g., Milgram, 1967; and Rohwer, 1970). In this case, the role of the environment is that of "telling" subjects a strategy that will help them comprehend the material, and thus, remember it better. In the last analysis, however, the type of context subjects can generate or use is only as good as their prior knowledge and their ability to use that knowledge in the situation. "...the acts of perceiving and remembering are...activities determined by the quality of the cognitive operations applied to that experience by a subject" (Paris, 1975). As Bartlett (1932) stated, "To speak as if what is accepted and given a place in mental life is always simply a question of what fits into already formed apperception systems is to miss the obvious point that the process of fitting is an active process, depending directly upon the preformed tendencies and bias which the subject brings to the task" (p. 85). The mapping of new information to pre-existing knowledge is not the entire task of comprehension.

We come then to an interactional conception of comprehension--an interaction between what the comprehender already knows, the structure of incoming information, and the ways the comprehender has of interfacing the two, of operating on one or the other so that a quasi-match is obtained. Paris and Lindauer (1977) summarized this interrelation in the statement, "Constructive processes are determined jointly by the context of experience, the cognitive abilities, and the socio-historical milieu of the subject." Our goal in the series of studies conducted under the auspices of Grant NIE-G-00-3-0089 was to examine this interaction in more detail.

Statement of the Problem

If comprehension (assimilation-accommodation) is to be considered the basic principle of intellectual adaptation, then its promotion becomes the primary purpose of education. How can comprehension be facilitated? One of the prerequisites for understanding this question is the question of how knowledge develops and how children learn to operate on incoming information as it is transmitted by language or pictorial representations. We considered two aspects of these processes:

1. The relationship between what is known and the structure of incoming information.

2. The active operations subjects use in the process of comprehension.

In every case we wanted to describe, classify, and explain some of the operations which are necessary conditions for comprehension and to trace their development in children.

The first three studies were concerned with the relationship between what children know and the content or semantic structure of incoming information. The closer the relationship between what is known and incoming information, the easier it should be to understand that information. The remainder of the studies looked at ways in which comprehenders operate on information in attempting to make it contact what they already know. For purposes of this report, knowledge is viewed as being organized into schemata, a concept used by Bartlett, Piaget, and many others. It refers to organized, dynamic units of knowledge. The nature of the organization may vary depending on the person's age, past experience, and on the nature of the reality that is being represented by schemata. When information is being understood it is, according to this model, incorporated into pre-existing schemata. While some transformations of the information may occur, the process of complete comprehension requires a merger of the two so that they are relatively indistinguishable. This merger allows one to "go beyond the information given," i.e., to make inferences. Inferential comprehension permits fuller understanding, ready assimilation, and multiple cues for retrieval. We wanted to investigate the developmental course of inferential comprehension in children in order to determine how children's memories benefit from elaborative comprehension skills such as inferring new semantic relationships.

CHAPTER 1

NATURE OF OLD-NEW RELATIONSHIP

One way to investigate the relationship between what children already know and incoming information is to regulate what children already know. In general, this approach has been represented by experiments on benefits obtained by using advanced organizers (Ausubel, 1968; Dooling & Lachman, 1971; Bransford & Johnson, 1972, 1973) where the subject was or was not given information about textual material. In other words, activation of prior knowledge was studied given the same focal input. The first study below used this method to investigate age and media effects on children's listening comprehension. Another way to manipulate the relationship between what children know and incoming information is to assess or estimate normatively what children already know and vary the input according to some "semantic distance" scale. The second and third studies in this chapter were variations of this approach. In both related studies sentence comprehensibility was varied according to a criterion of probability of occurrence of an event described, (e.g., "the horse jumped the fence" vs. "the horse jumped the elephant") and comprehension was indexed with a reaction time measure.

1. The Influence of Contextual Organizing Materials on Children's Listening Comprehension. (Arnold & Brooks, 1976)

It has been well documented that contextual organizers can facilitate comprehension of connected discourse. Ausubel (1968) has proposed that this effect occurs because when new ideas (in the form of propositions) are encountered they need to be incorporated into pre-existing cognitive structures. He theorized that the process of anchoring ideas within such structures may be facilitated by presenting organizing clues. In a subsequent study, subjects read short essays with either relevant or irrelevant introductory paragraphs. Comprehension was facilitated for the essays preceded by relevant organizers. He believed that the relevant paragraphs selectively mobilized the most related of the learner's concepts, thus increasing familiarity and meaningfulness as well as providing subsuming concepts.

What constitutes sufficient organizational information, that is, information that will facilitate comprehension, has been studied by several researchers. Dooling and Lachman (1971) found that presentation of the theme of a metaphorical, complex paragraph facilitated retention. Bransford and his colleagues (Bransford & Johnson, 1972, 1973; Bransford & McCarrell, 1975) have demonstrated that knowledge of the topic, without knowledge of the particular context, may not be sufficient for the optimum comprehension of prose. In one study, Bransford and Johnson (1972) used pictorial pretask organizers for one group of subjects in which all of the elements of a syntactically complex story were depicted

in a noninteractional manner. The other group was shown the pictures arranged to give information concerning the interrelationships among the elements, a condition which greatly facilitated comprehension.

The Bransford studies illustrate that topical information alone does not facilitate an adult's comprehension of subsequent input as much as relational information. Since the utilization of relational information in sentences may be correlated with development and also be modality specific (Odom & Nesbitt, 1974), it is important to examine this aspect of the structure of prose with respect to children. In the present study second- and fifth-grade students were tested for their ability to use relational information given in two modes (pictorial or verbal) to facilitate comprehension of oral prose.

Method

Subjects

Subjects were sixteen second-grade and sixteen fifth-grade pupils attending the Demonstration School of George Peabody College for Teachers (now the University School of Nashville), Nashville, Tennessee.

Materials

The eight pre-recorded paragraphs to which the subjects listened were organizationally complex and concerned unusual situations for which subjects would not have the prerequisite semantic information. The passages did not simply describe the organizers but presented a set of events that could have happened within the given context. Each story consisted of 60 to 80 words, presented in approximately 45 sec. One of the stories was:

> Jimmy was hanging by his knees and his legs were beginning to ache, but he still hung on. The swan was flying very fast towards Jimmy's home. The wind was blowing through Jimmy's hair and jacket and he was getting cold. The other children were having a good time. Jimmy wished the trip were over. Lisa had fallen asleep on the white feather mattress and Joey was singing a song.

The pictorial organizers were simple line drawings. First the drawings of eight integrated pictures were made and copied. To make the nonintegrated pictures, the elements of each picture were cut out and randomly arranged on blank sheets of paper. Hence the pictorial organizers varied only on the spatial relationships between the elements. (Figures 1 and 2 show an example.) The verbal organizers varied as to the class of connective (verb or conjunction) used. For example, the integrated verbal organizer for the above story was "This story is about two boys and a girl riding a swan;" the equivalent nonintegrated verbal organizer was "This story is about two boys and a girl and a swan."

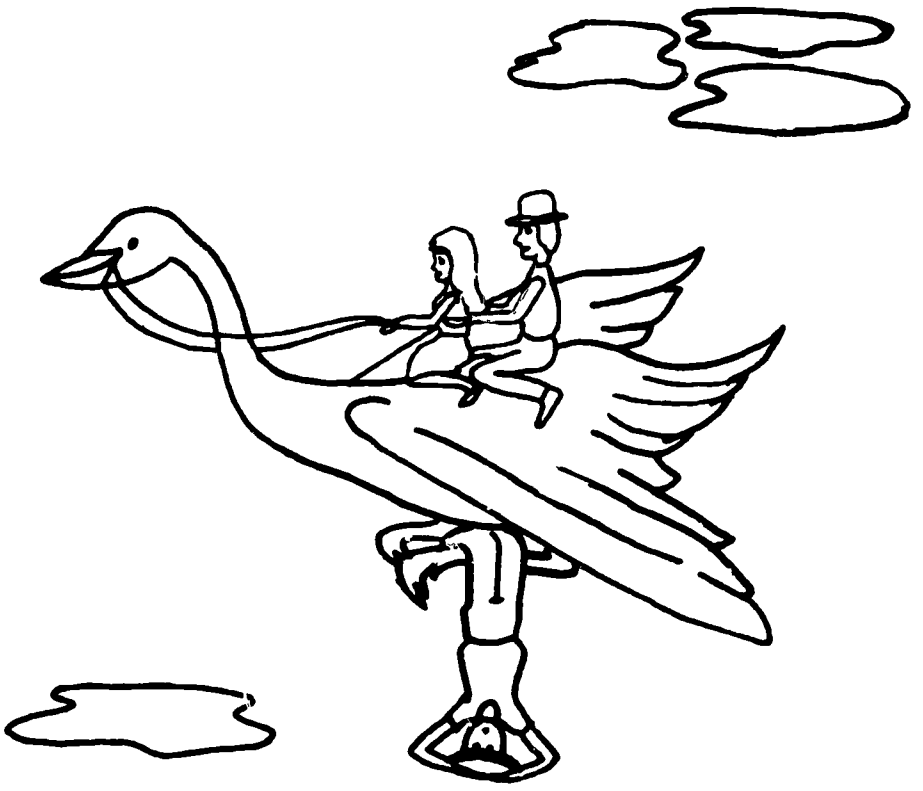


Fig. 1. Integrated pictorial organizer with relational context.

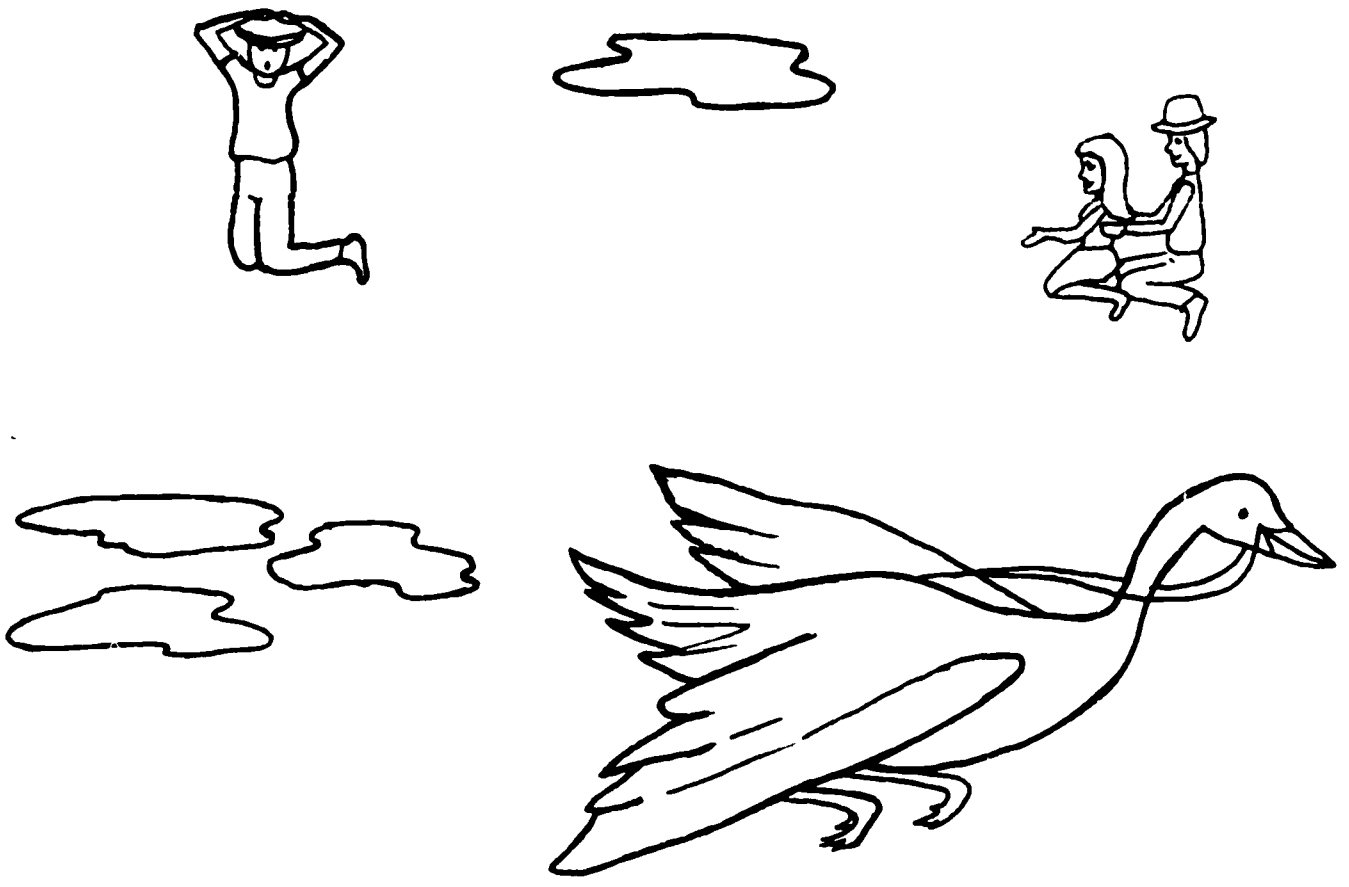


Fig. 2. Nonintegrated pictorial organizer without relational context.

Procedure

Subjects were seated next to a table upon which was the recording equipment; the experimenter sat directly in front of the subject.

Each subject heard eight stories, blocked by twos under each organizing condition (picture integrated, picture nonintegrated, verbal integrated, verbal nonintegrated). The order of the organizing conditions was randomized and the story content was counterbalanced so that the story about a girl riding a swan was heard by an equal number of subjects in each organizing condition. Before each paragraph was heard its organizer was presented. Bransford and Johnson (1972) found no facilitating effect of contextual materials presented after the paragraph, hence this condition was not employed. When presented with a pictorial organizer the subject was asked to name the objects seen in the picture to insure identification of the elements. The picture was removed before the story began. The verbal organizers were read to the subject by the experimenter; subjects were asked if they knew what all of the nouns were, again to insure familiarity. In no case did subjects express lack of knowledge about the nouns.

Immediately after the presentation of the organizer, the experimenter played the tape recorded story. At its conclusion, the experimenter turned on a second tape recorder and asked the subject, "What was the story about?" Subjects were encouraged to expand upon their statements. When the subjects had completed their responses, the experimenter asked, "Could you tell what was strange about this story?" Responses given to this question were included in the final analysis. Dependent measures used in comprehension experiments vary greatly and there is much disagreement over what constitutes an acceptable measure (Carroll, 1972). In this experiment explanatory responses and not factual, verbatim responses were solicited to allow a flexibility of analysis that would give a broader perspective to the effects of these experimental manipulations.

Results

The subjects' recorded responses were transcribed. Two adult judges, who were unfamiliar with the conditions of the study, then categorized each response into one of four categories (correct or incorrect verbatim responses and correct or incorrect inferential responses). A scorable response was defined as including both a subject and a predicate and was judged to be the expression of a single thought or proposition concerning the story. The sixteen correlations of the judges' categorizations for each variable (picture or verbal, integrated or nonintegrated) for each response type ranged from .54 to .83. Judges' scores were averaged for the analyses.

Responses were classified as correct recall if they were taken verbatim from the story (synonyms were scored as correct). Responses were categorized as incorrect recall statements when words that were

not synonymous replaced original words in otherwise verbatim responses. For example, if the response was "the boy was sitting on the car" instead of "the boy was sitting on the swan" the response would be recorded as incorrect recall.

Responses were recorded as correct inferences if they demonstrated an understanding of the organizational structure of the story or information capable of being logically derived from such information, but were not drawn verbatim from the content of the story or from the organizer. Responses were regarded as incorrect inferences if they reflected a failure to comprehend the intended structure of the story or were not logically derived from the story. For example, a response such as "the children were riding to Jimmy's house" was scored as a correct inference. A statement that "the children were holding on to Jimmy" was scored as an incorrect inference. Table 1 shows the mean number of responses for each category.

Analysis of Dependent Measures

Total responses. To determine whether subjects at both ages had the same number of responses under all conditions, an analysis of the total number of responses, regardless of category, was conducted. This and all other analyses used a 2 (Age) x 2 (Integration) x 2 (Verbal vs. Picture, or Mode) analysis of variance. There were no significant differences in the total responses under any condition.

Correct responses. The first index of comprehension analyzed was the degree to which subjects reproduced a story similar to that intended by the experimenter. For this purpose correct inference and correct recall scores were combined for each subject. The only significant effect in this analysis was Integration, F (1, 30) = 17.73, $p < .001$, with the subjects producing more correct inferences and recall statements in the integrated conditions than in the nonintegrated conditions.

Inferential responses. The responses that were rated as inferential were thought to reflect comprehension more strongly than the recall measures since to make an inference, information must not only be retained, but also be processed in a meaningful manner. The total number of inferences, regardless of correctness, was examined to see if any condition facilitated inferential output. The only significant effect was the interaction of Age, Mode, and Integration, F (1, 30) = 6.73, $p < .01$. This interaction reflected the second-graders' greater inferential production with pictorial than verbal organizers on integrated material only. The fifth graders, on the other hand, produced more inferential statements with the verbal organizers than the pictorial organizers under integrated conditions. There were no differences in Mode for either group under nonintegrated conditions.

Analysis were conducted on correct inferences, incorrect inferences, and the ratio of correct to total inferential output, all with similar

Table 1

Mean Number of Responses of Each Type of Organizer and Age*

	Grade 2			
	PI[a]	PNI[b]	VI[c]	VNI[d]
Total	14.72(3.49)	13.22(3.08)	13.12(3.32)	14.19(3.54)
Recall Total	8.34(2.94)	8.37(2.97)	7.69(3.09)	8.41(2.46)
Correct	6.69(3.20)	6.53(3.10)	6.12(3.33)	6.78(3.67)
Ratio	.76(.15)	.78(.07)	.70(.09)	.81(.10)
Inference Total	6.37(2.59)	4.72(2.13)	5.47(2.05)	5.72(2.23)
Correct	4.72(1.76)	2.28(1.72)	4.28(1.64)	2.66(1.48)
Ratio	.76(.08)	.48(.17)	.79(.12)	.47(.20)

	Grade 5			
	PI[a]	PNI[b]	VI[c]	VNI[d]
Total	15.56(3.37)	15.34(3.82)	15.25(5.22)	15.16(4.20)
Recall Total	10.09(2.71)	8.87(4.04)	9.28(3.22)	8.75(2.54)
Correct	9.69(2.70)	7.37(4.10)	8.09(3.53)	7.66(2.66)
Ratio	.95(.03)	.80(.09)	.84(.12)	.86(.14)
Inference Total	5.56(2.75)	6.34(2.21)	6.78(2.42)	5.91(2.33)
Correct	4.50(2.00)	3.78(2.50)	4.44(2.24)	2.28(1.56)
Ratio	.82(.18)	.59(.15)	.64(.20)	.37(.32)

[a] PI = Pictorial Organizer Integrated
[b] PNI = Pictorial Organizer Not Integrated
[c] VI = Verbal Organizer Integrated
[d] VNI = Verbal Organizer Not Integrated

*Standard deviations in parenthesis

results. The ratio of correct to total inferences, which condenses and clarifies these results, is reported. The Integration factor was significant, F (1, 30) = 57.56, $p < .001$, and the Pictorial Mode showed a higher proportion of inferences than the Verbal Mode, F (1, 30) = 5.26, $p < .02$. The interaction of Age and Mode was also significant, F (1, 30) = 8.77, $p < .001$. Fifth-grade students made significantly fewer correct inferences under a verbal condition than the second graders, t (15) = 1.99, $p < .05$, who were relatively stable across Mode. The fifth-graders'

tendency to make more correct inferences than the second graders using pictorial organizers was not significant, t (15) = 1.69, $.10 > p > .05$.

Discussion

The results replicate Bransford and Johnson (1972) in demonstrating that the nature of available contextual information can influence the ability to comprehend and recall prose. When a subject was alerted to existent or potential interactions by the integrated organizers, recall of the information was facilitated over conditions in which the subject knew the actors and objects but not their interaction. The multiple dependent measures proved helpful in showing that the interaction depicted by the organizers facilitated both verbatim recall and inferential responding. How relational information affects the ability to use information was not addressed; however, these data are consistent with Bransford and McCarrell's (1975) observation that relational information provides constraints that limit the possibilities within the story's structure.

An unexpected but interesting finding was that fifth graders made significantly more incorrect inferences than second graders when verbal organizers were used. Assuming that fifth graders have a more elaborate knowledge structure associated with story elements, perhaps the verbal condition allows these subjects to make more diverse "efforts after meaning" (Bartlett, 1932). Some of these inferences are incorrect, and may even interfere with the generation of correct hypotheses about story structure. This tendency among fifth graders is also reflected in the finding that, while second graders showed significantly fewer inferences under the nonintegrated condition than the integrated condition, no similar tendency was observed for fifth graders. These findings are consistent with Suchman's (1970) view that, as children grow older, they are more likely to build familiarity deliberately, rather than searching material for the meaning that is immediately available in it.

Both younger and older subjects were able to use effectively the information available in the pictures which displayed a relationship among the elements. While this may appear inconsistent with Reese's finding (1970) that preschool children had difficulty using integrated cues, his subjects were younger than the second graders of the present study. Several studies, e.g., Elkind, 1969, have shown that younger children extract less of the available information from pictures than older children, and the fifth-graders' slight tendency to make more correct inferences with pictorial organizers may be a reflection of this.

2. Comprehensibility and Reaction Time. (Iacobbo, Arnold, & Brooks)

Reading rate in skilled readers, who are no longer constrained by the struggle to recognize words, is nevertheless authomatically controlled by comprehensibility of material--a direct function of the organization and state of the reader's knowledge. As Barclay (1973) notes, sentence comprehension, like most communication situations, requires that the listener or reader construct semantic representations

of the objects and the relations between the objects, not representations of sentences per se. If this view is correct, comprehension consists of the subject's operating upon a statement until the relationships are understood in light of the subject's previous knowledge system. The more cognitive restructuring that is needed to do this, the more difficult comprehension is and the longer it should take.

In this study, reading comprehension time was examined as a function of the ability of the subject to recognize or realize how a particular relationship could take place. It is easy to understand "the horse jumped the fence" not only because it's something that is seen occasionally, but because the necessary action is within the obvious capability of both subject and object. Children were asked to determine whether the elements in a printed sentence and the elements in a picture depicted the same or different relationships. Their reaction times on relations containing information that was consistent with their knowledge of potential subject-object relationships as "the horse jumped the fence" were compared to those on low comprehensible sentences such as "the horse jumped the elephant" for which the relational information had little likelihood of being consistent with their experience with the objects.

Thirty-three students, whose scores on a reading achievement test were in the top or bottom third of a class of fifth-grade students, were subjects in this experiment. Each subject viewed 80 slides on which were sentences of either high or low comprehensibility, and pictures in which the elements were in the same relationship (same) or noninteractive presentation.

Results

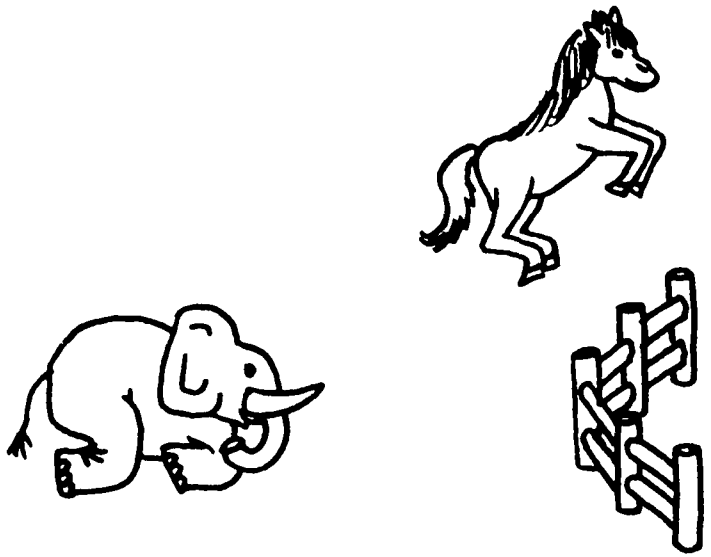
A 2 (Reading Ability) x 2 (Sentence Comprehensibility) x 2 (Same-Different Response) analysis of variance was used to analyze the response latencies. The main effects of Reading Ability, Sentence Frequency, and Response Type were significant in the expected directions ($p < .001$ for all effects) as was the interaction of Reading Ability x Response Type, and Sentence Frequency x Response Type, and the interaction of all three variables, Sentence Frequency, Reading Ability, and Response Type (all with $p < .02$). For all subjects, then, it took longer to identify relationships low in naturally occurring frequency, e.g., the picture of a horse jumping an elephant, than more familiar relationships, e.g., the picture of a horse jumping a fence. The time it takes to read and match sentences and pictures, then, is correlated with how much the sentences violate the child's relational presuppositions. The design of the study was such that we could separate sentence comprehension from picture comprehension only by comparing "different" responses (nos. 2 and 4 in Figure 3). In those conditions the picture was the same but the comprehensibility of the sentences was not. Both number of errors and verification time indicated that it was relatively more difficult to make a "different" response to a high comprehensible sentence than a low comprehensible sentence. Out of 20 possible correct choices per subject,

"Same"

Different

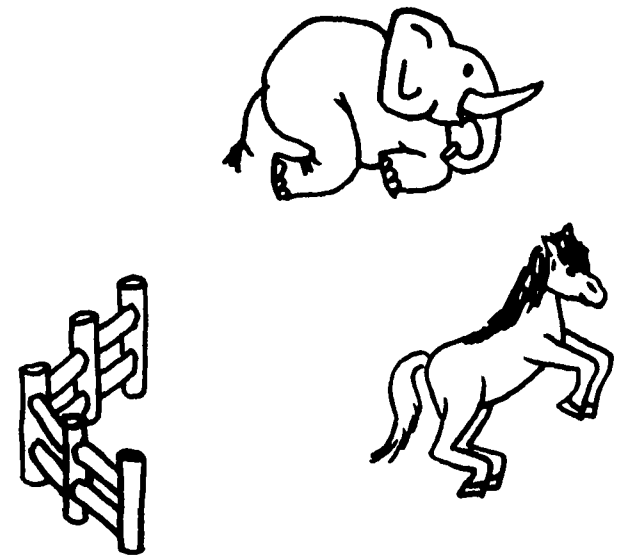
COMPREHENSIBILITY

High



Exp. II A horse can jump a fence
Exp. III A horse can jump vs. is jumping a fence

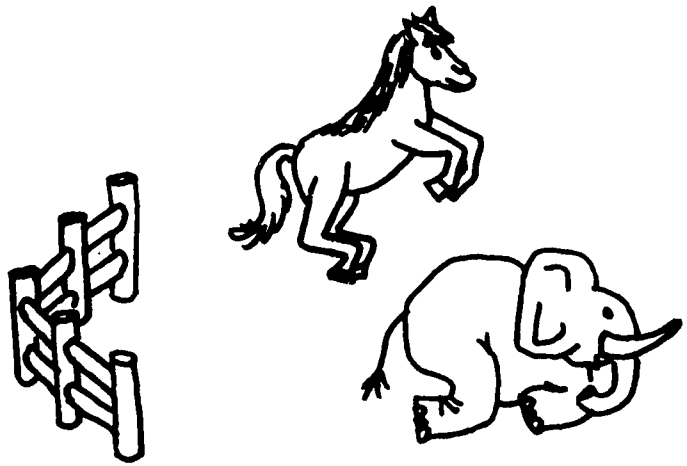
#1



Exp. II A horse can jump a fence
Exp. III A horse can jump vs. is jumping a fence

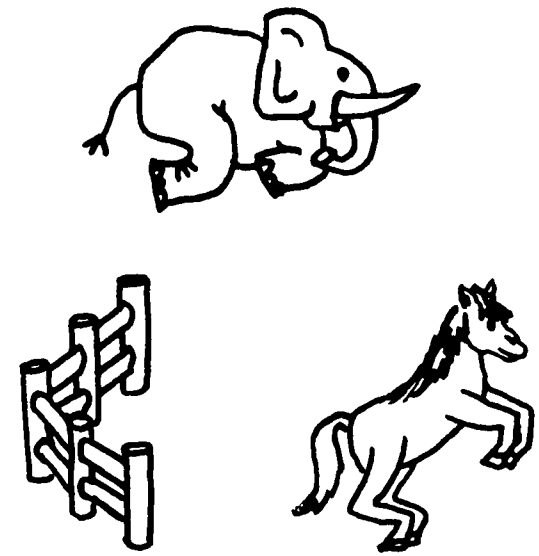
#2

Low



Exp. II A horse can jump an elephant
Exp. III A horse can jump vs. is jumping an elephant

#3



Exp. II A horse can jump an elephant
Exp. III A horse can jump vs. is jumping an elephant

#4

Fig. 3. Pictures used in Reaction Time Study.

mean number of errors was 2.2 and 0.3, respectively, the opposite of the predicted result.

We suspected that this unexpected result reflected the subjects' having a lenient definition of "different" with a high probability sentence and a strict criterion of "different" with a low probability sentence. The reader will recall from Figure 3 that the "different" pictures portrayed the objects in no particular activity. Thus, the objects (elephant and horse) can be "about to be" or "have just been" engaged in the activity. Subjects were likely to say "same" to picture #2 because it is easier to specify the antecedents and consequences of an event if it is consistent with relational presuppositions. In low comprehensible sentences, subjects cannot predict antecedent and consequent aspects of the event and are less likely to interpret a picture as congruent with the described event. This may be just another way of saying that sentences about possible events have more acceptable interpretations than sentences about unlikely events, or that artists would have more trouble deciding whether "olive green" was indeed "green" than army sergeants would. While this may be a good explanation for an unexpected result, we were not completely satisfied that relational presuppositions determined how fast a sentence was understood. The third experiment was designed to refine and expand the findings of this study.

3. Sentence vs. Picture Comprehensibility. (Arnold, Iacobbo, and Brooks)

I has been demonstrated (Willows, 1975) that poor readers have more difficulty reading words embedded in pictures than good readers hence, part of the previous study may reflect differences in abilities to process simultaneously presented sentences and pictures which were presented separately, in time, allowing us to examine the processing of text and pictures independently. It was expected again that the comprehensibility would affect the subjects' processing of sentences such that highly comprehensible sentences would be read more quickly than low comprehensibility sentences. Based on the results of the previous study, we also expected that sentence comprehensibility would affect the search for information in pictures. When there is a compatible relationship between two objects, one which could be assumed to match well with the subjects' knowledge system, it would be expected that it would be easier to obtain the information from the pictures. That is, one knows more specifically what to look for. Therefore, sentence comprehensibility should affect the strategies that the children employed while searching the pictures to see if they were "same" or "different."

Using different verb forms is one way to place differential restrictions on the decision rules subjects employ in verifying whether a picture is the same as the statement. Two verb forms were used--propositional, e.g., the horse can jump the fence, and indicative, e.g., the horse is jumping the fence. Propositional or "can" verbs should restrict picture searching less than "is" verbs and thus take longer to verify. "Can" allows for more possibilities, but "is" requires an extra decision, "Is there an ongoing action in the picture?" This extra decision activity may be peculiar to pictures because the viewer may have to

project the trajectory of the still objects to see if, indeed, the action is the one specified in the sentence. For example, an announcer's account of the televised football game might include the statement, "The players are now going onto the field." It would require little effort to verify that statement because the direction of movement relative to the field was immediately given. If the visual display was a still shot, the viewer would have to make inferences about the truth of the statement based on direction the players were facing, whether they were running, etc. It has also been reported (Smith, 1967) that good readers are more able to adjust their search for visual linguistic information to the requirements of the task. Poor readers, then, might adopt search strategies that were less sensitive to the constraints imposed by the sentences. This potential difference between good and poor readers was incorporated into the design of Experiment 3.

Method

Subjects were forty fifth-grade students, grouped by their teachers on the basis of group reading tests as being in the top or bottom third of their class in reading achievement. They viewed 80 sets of 2 slides, the first of which was a sentence of either high or low degree of constraint (a within factor) and stated in either a propositional or indicative verb form (a between factor). The second slide was a picture in which the objects were in the same relationship as stated in the sentence which required a same response or noninteractive (different) response. The sentences and pictures were those used in Experiment 2 and shown in Figure 3. Subjects were told to push a button when they read and understood the sentences. After the sentence was off of the screen, the experimenter asked the subject if he was ready. The experimenter then presented the picture slide. Subjects were to push one button, labeled "same," if the picture expressed the same information as the sentence. They were to press a button labeled "different" if the picture and sentence did not match.

Results

First, sentence reading latencies were subject to an analysis of variance. While the verb form (can or is) was not significant, the effects of both reading ability and constraint were significant ($p < .01$). Good readers processed the sentences faster than poor readers. Sentences high in relational constraint (high comprehensible) were read faster than those low in constraint (low comprehensible) by both groups.

An analysis of variance was then performed on the picture verification latencies. The analysis detects ways in which the sentences affected picture verification latencies. Again the effects of reading ability and degree of constraint were significant ($p < .03$). In addition, the interaction of response type ("same" vs. "different") and verb form were significant ($p < .01$). While there was no difference in the "different" responses in this interaction, the "same" responses, given

the indicative verb (is), took significantly longer than "same" responses given the verb can. Thus, it took significantly longer to verify that the horse is jumping the fence than to say that the picture agreed with the statement the horse can jump the fence.

Discussion

The finding that it took longer to read sentences which were difficult to understand probably reflects two aspects of reading: (a) a slowing down so that the objects mentioned in the text can be explored more carefully, and (b) a monitoring of one's own comprehension processes. In reading, unlike listening, a reader is at liberty to monitor his rate to correspond to his comprehension. This means that readers have to be aware of how well they are understanding the material, that is, whether there is, in Roger Brown's (1968) terms, that "click of comprehension." An outgrowth of the comprehension process includes, then, an awareness of whether one understands and some skills as to what to do about it if understanding is low. One of these skills is the slowing down of information intake. Our subjects, both good and poor readers, did this when the sentences were difficult to comprehend.

The results also demonstrated that children can obtain information more efficiently from pictures that are consistent with what they already know about the objects portrayed, i.e., that are consistent with their relational presuppositions. In general, more familiar situations provide more effective constraints upon possible interpretations of the picture, narrowing the search and thereby facilitating information pick-up.

This is true mainly when the response is one of "same." The "same" response is probably the usual one in the real world where seldom does a text not correspond in some way with ongoing activity. Probably the most frequent natural response in such rare cases is doubting one's hearing.

Some of the nonsignificant interactions in the analyses were informative. For example, the lack of interaction between "can" vs. "is" and frequency of relationship between the objects depicted suggests that comprehension operations may be independent of specific information required by the task, i.e., the readers' knowledge of the objects is equally helpful to them regardless of whether the text specifies capabilities ("can") or ongoing states "is."

One of the significant interactions was also informative. The interaction of response type ("same" vs. "different") and verb form ("can" vs. "is") suggests that the set created by the sentence does determine the decision rule by which information is evaluated. When propositional (can) verb is used the subject has only a generalized relationship, and can decide more readily on the basis of potentiality. Indicative (is) verbs require much more specific events to occur; this phenomenon is more true in static pictures than in natural scenes where ongoing events are

occurring. That the response type and verb form did not also interact with the constraints imposed by the frequency of object interaction may indicate that subjects accepted both levels of frequency as true statements for purposes of search through pictures.

Readers of both levels of ability seem to employ the same operations in processing pictures. It cannot be said, on the basis of this data, that poor readers are differentially able to utilize the constraint provided by linguistic context. It is more harmonious with the data to suggest that reading ability reflects general cognitive functioning which also affects the search for information in pictures.

Conclusions

Skills involved in the reading process, such as visual discrimination, word recognition, and visual verbal coordination have been taught by educators who are concerned with the development of reading ability. All of these skills are taught with the ultimate goal of allowing the child, or adult, to comprehend written discourse. However, while these skills are necessary for comprehension, they are not sufficient to allow it to occur. These studies reported here have demonstrated that comprehension, instead of being a separate, isolated skill, involves the relationship of the child's knowledge and the organization of that knowledge, as it relates to the material that is being read. That is, borrowing a term from Piaget, comprehension is a process involving assimilation of new information onto the child's previous knowledge.

When comprehension is recognized as being dependent upon the knowledge of the child, it becomes apparent that comprehension is more a process which can be facilitated rather than a skill which can be specifically taught. This facilitation can occur through directing attention (Gagne, 1969), presenting effective context (Arnold & Brooks, 1976) as well as providing reading materials that match the child's life experiences. Comprehension, unlike a reading skill, is not a goal to be accomplished but a process relative to the child's knowledge.

Pictures, also, must be comprehended and some are easier than others. There is a subtle but researchable relationship between the linguistic mode and the ongoing visual world. From the research reported in the paper, it is clear that the structure of text, in this case indicative vs. propositional, can influence the kind of information one seeks in the nonlinguistic world. Comprehension also proceeds in ways that are not influenced by differences in linguistic structure. It took longer for subjects to understand pictures about objects and relations that were unfamiliar to them. This is where good readers also excelled. Good text readers were also good picture readers. Perhaps their overall cognitive processes are more efficient at this age than those of poor readers, another suggestion that reading ability, like picture-reading ability, is an index not necessarily of a particular skill, but of general cognitive functioning.

CHAPTER 1 - CONCLUSIONS

The research reported in this chapter has been concerned with children's reading and listening comprehension as a match between what the comprehender already knows and incoming information. In the first study we demonstrated that activation of prior knowledge (via advanced organizers on thematic statements) facilitated memory for textual material. Modality of these organizers was important and interacted with age of the subject. Most importantly, however, was the structure of the organizer. Maximum facilitation occurred when it expressed the relationship between the topics in the text rather than simply naming them. This facilitation was not age related. In the second and third studies we demonstrated that the probability of this relationship determined speed of comprehension of the text. The more unlikely a relationship between two objects, the more difficult was the sentence to read and understand.

CHAPTER 2

THE INTEGRATION OF INFORMATION

Meaning is not contained in sentences but constructed by the reader or listener. Attributions of meaning are made relative to a given context or situation and are, therefore, idiosyncratic. In a sense, the definition of information as well as its form and content--its meaning--are determined by what implicit questions the person is asking of the environment. By implicit questions we mean distinctions that a person can or wants to make about a situation--winter instead of spring, outside instead of inside, sunny not cloudy, walking not riding, daytime not nighttime, etc. If incoming information somehow answers some of these questions or potential questions, then it will be understood or comprehended and the active comprehender seeks to know or is receptive to dimensions of information which will elaborate and differentiate aspects of a particular context. There are millions of contexts and almost as many categories of contexts. Such a multiplicity of contexts has prompted Gibson and Levin (1975) to chide educators who talk about reading as if it were a singular process, when, indeed, for the adult skilled reader it is a multi-faceted activity. Readers adapt their cognitive skills to read for a particular purpose; these purposes could include scientific reading (pp. 454-455), newspaper reading (pp. 455-456), novel reading (pp. 458-460), dictionary reading (pp. 460-462), and poetry reading (pp. 462-465), to name only a few.

So, the comprehender adapts the search for information to the demands--whether explicit or implicit--of the situation. On what basis, then, is old knowledge and incoming information integrated? If the foregoing statements are correct, the nature of the question asked determines the basis of the match. What are these questions that our knowledge system can ask about the environment? Some clues may be found in linguistic structures--who, what, where, which one, what kind, how many or how much, how, the nature of the relationship, etc. We examined children's bases for integrating incoming information in several ways. In the first three studies described (Paris & Carter; Paris & Mahoney; and Paris, Mahoney, & Buckhalt) we looked at integration of relationships portrayed pictorially and linguistically. In the subsequent studies we investigated how children infer additional information from sentences and stories (Paris & Lindauer, 1976; Paris & Upton, 1976).

A. Integration

There is much literature (Paris, 1973, 1975; Paris & Carter, 1973; Paris & Mahoney, 1974; Paris, Mahoney, & Buckhalt, 1974) to show that memory is directly related to what the person does to material upon initial encoding. In other words, the memory is not a photograph, but

a product of the interaction between the selective searching for particular kinds of information, its detection, or the operations one performs on it to make it work in the service of accommodation. Memory is, therefore, inaccurate in a sense; it is incomplete in some respects, too general in others. But this very inaccuracy can be almost reciprocally related to comprehension.[1]

1. Semantic and Constructive Aspects of Sentence Memory in Children. (Paris & Carter, 1973)

This study was initially conceived as an attempt to determine whether children demonstrate "constructive" memory. Constructive memory refers to the reader or listener's construction of a meaning for linguistic input. In this process, the reader or listener brings a diverse source of knowledge--internal and contextual--in the service of "making" a meaning. This meaning is subsequently incorporated into the listener's knowledge of the world. The alternative view which is held by a number of researchers in cognitive theory is called the "interpretive" approach and characterizes the reader or listener as relying mainly on the deep structure of the sentence for meaning. Experimenters in constructive memory usually present subjects with a variety of oral or written sentences which allow inferences to be drawn from them, e.g., "The dog is in the yard" + "The man is chasing the dog"-- Inference: "The man is in the yard." Subjects' knowledge of implied semantic relationships can be ascertained by whether they do indeed make such inferences. The ability to make such inferences testifies to the theory that people do use contextual information, i.e., surrounding sentences, in the act of interpreting a given sentence and that meaning is a composite construction of several sources of input.

Method

Subjects

Ten children from the second and 10 children from the fifth grade participated in this experiment. The children were randomly chosen as subjects within each grade with the provision that each group include five males and five females.

Task

Subjects were initially given a verbal acquisition list of sentences and later received a recognition test for those sentences. The acquisition list contained seven unrelated "stories." Each story was comprised of three simple active, declarative sentences; two premise statements and a filler sentence. As an example, the first story was:

(1) The bird is inside the cage.

---

[1] Memory accuracy is a very poor index of assimilation since it could mean either inadequate initial encoding or integration so complete that many of the specifics are lost.

(2) The cage is under the table.

(3) The bird is yellow.

All seven stories conformed to this paradigm which may be characterized as a (1) A-relation-B, (2) B-relation-C, inferential relationship between the premises.

The recognition test was composed of four different sentences for each story: A true premise sentence, a slightly altered false premise, a permissible A-relation-C true inference, and an invalid false inference where the relational term was incorrect. For example, the following four sentences were the test sentences for the first story.

(4) The bird is inside the cage.

(5) The cage is over the table.

(6) The bird is under the table.

(7) The bird is on top of the table.

Both types of true recognition sentences, (4) and (6), maintained semantic congruence with the original story while the false statements did not. However, the true inference (6) was never presented during acquisition. Within the recognition list, all four sentence types concerning the same story were presented contiguously. However, the order of the seven stories and the order of sentence types within stories were randomized initially and presented to all subjects in the same order. The first and tenth test sentences were true filler items and the total list length was therefore 30 sentences.

Procedure

Each child was tested individually in a mobile laboratory. Subjects were told that the experimenter was interested in how well children remember things and were explicitly instructed to remember the sentences in the stories because they would later be asked questions about them. During the acquisition list, each sentence was read aloud to the subjects. Immediately following acquisition, each subject participated in a five minute block-sorting task. The recognition test sentences were presented after the interpolated task with the instructions to say "Yes" if the exact same sentence was heard before in the stories and "No" if the same sentence had not been heard. During the recognition test, the experimenter obtained a three point scale of certainty of the response with a "1" indicating the child was "real sure," a "2" indicating "kind of sure," and a "3" indicating "not too sure."

Results

Recognition Errors

The errors on the recognition test were tabulated for the second and fifth graders for each sentence type and are shown in Figure 4. The pattern of errors is identical for both grade levels, only the magnitude of errors is different. Subjects consistently responded affirmatively that they had previously heard the true inference statements when in fact they had not. The error rates for the other sentences in comparison were relatively low. In the overall analysis of variance, Grade Level x Sex x Sentence Type x Truth, the high error rates on the true inferences were primarily responsible for three significant effects. The main effect of Sentence Type was significant, F (1, 16) = 49.61, $p < .001$, as was the main effect of Truth, F (1, 16) = 85.95, $p < .001$, as well as the Truth x Sentence Type interaction, F (1, 16) = 16.01, $p < .001$. The only other significant difference in this analysis was between Grades. The second graders made considerably more errors than the fifth graders, F (1, 16) = 6.13, $p < .025$. There was no difference due to Sex as a main effect or in any interaction. Similarly, there were no significant interactions with Grade because the error patterns for the younger and older subjects were congruent. It should also be mentioned that the correlations between IQ and errors on true inferences were low and insignificant.

The primary result was the strong tendency for children to "recognize" the semantically congruent true inferences as being identical to the sentences given during acquisition. This did not appear to be accidental or due to generally poor memory for the original sentences. In the first place, both true and false inference sentences contained the same A and C terms as the acquisition sentences and were of similar length and syntactic construction. The only difference between true and false inferences was the validity of the relational term, a subtle semantic, not syntactic difference. If the subjects confused the sentences or had memory for only some of the sentential information, one would not expect such large discrepancies in error rates between true and false inferences, t (19) = 10.0, $p < .001$. A second line of evidence against memory confusion is the fact that subjects were more likely to commit errors on true inferences of stories in which they correctly recognized the true premises. (The conditional probability of making an error on a true inference given that the true premise of the same story had been correctly recognized was .78.) This suggests that subjects were actually more likely to commit the inferential error when they correctly remembered the true premises and the information given in the acquisition story.

Certainty Judgments

The subjects' judgments of the certainty of their recognitions were strongly biased towards high assurance. The errors on true inferences were rated with the highest assurance of certainty 84.7 percent

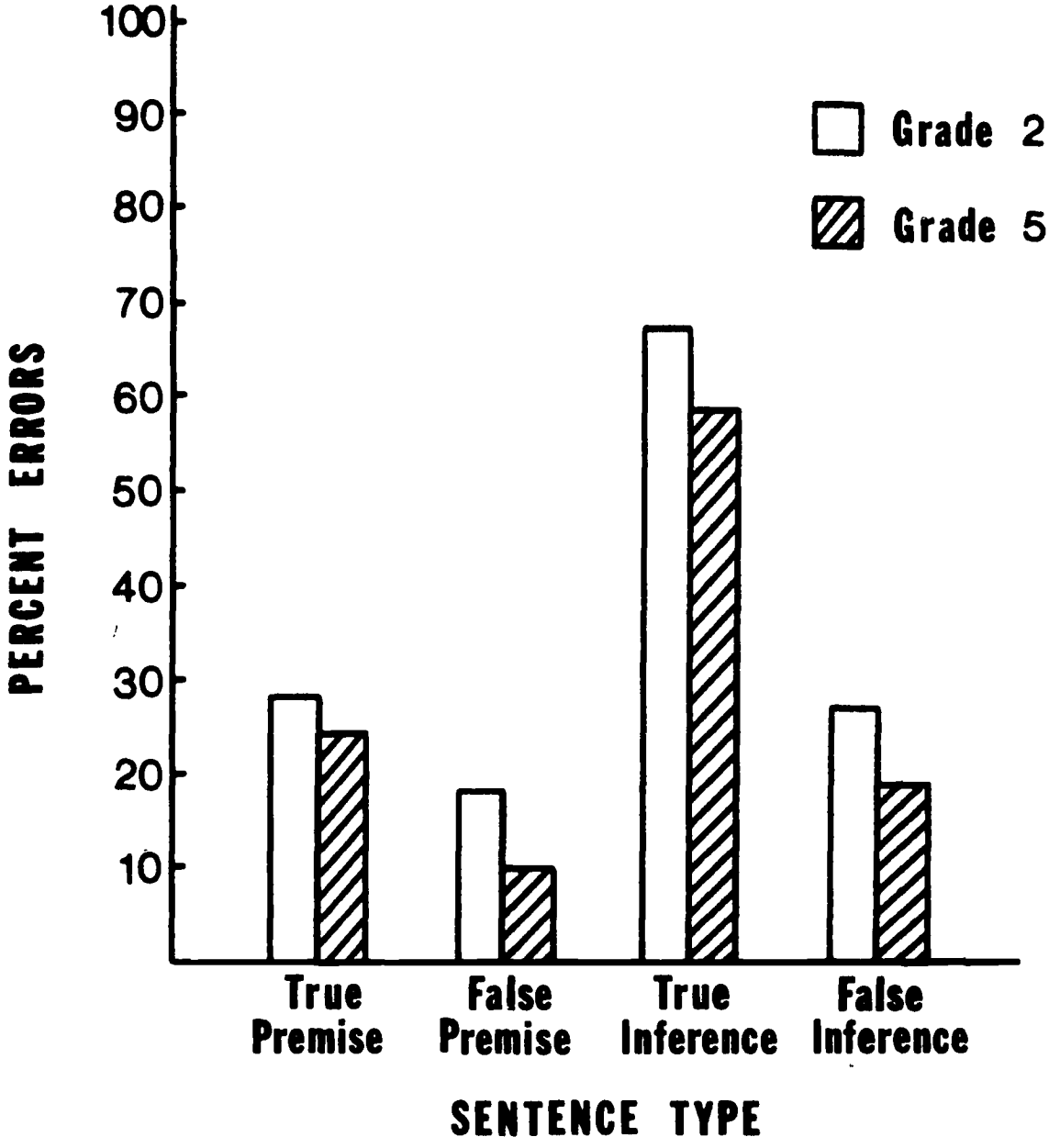


Fig. 4. Percent recognition errors.

of the time. This can be compared to subjects' certainty judgments on the other sentence types when an error was committed (51 percent). In general, subjects displayed considerably less assurance in their incorrect responses for other sentence types. Conversely, subjects were less sure of their correct recognition responses on true inferences than the other correct items. This evidence again suggests that the consistency of incorrect recognitions of true inferences was not due to subjects' poor memory for the information or uncertainty. Indeed, the inferential errors appear to be made with strong conviction when the original premise information is best retained.

Discussion

Within this study, subjects demonstrated the ability to acquire, construct, and retain semantic information implied within sentences. Subjects consistently "recognized" the nonpresented, semantically congruent true inferences as identical to premise sentences heard during acquisition. An active, semantic, constructive process seems to underlie the phenomena rather than a lexical confusion or underlying structure hypothesis. This does not imply that syntactic and lexical factors cannot be remembered or are unimportant. However, it does suggest that comprehension is an active, synthetic (cf., Neisser, 1966) process primarily dependent upon semantic information. It was observed that the younger and older subjects responded in a similar manner and only differed in the magnitude of their errors. The ability to apply the constructive process was evident at both grade levels and the differences may be due to performance variables or to familiarity with spatial relationships.

An implicit assumption of the constructive memory perspective was stated well by Bransford, Barclay, and Franks (1972), "People carry meanings, and linguistic inputs merely act as cues which people can use to recreate and modify their previous knowledge of the world" (p. 207). The emphasis is on active participation of the listener and the denial that meaning is immanent within words or sentences. There is a great similarity in this regard with Piaget's notions of assimilation and accommodation of cognitive structures and the representation of information in schemata. In both approaches memory is regarded as a constantly changing accumulation of knowledge. Implicit within this accommodating process is the proposition that what is retrieved from memory is not just some fractional component of what is stored. Perhaps the synthetic, organizational operations applied to the stored information and the consequent changes are critical and necessary for retention. This appears to be quite different from traditional perspectives in which it is often assumed that the entity called memory is functionally invariant, that what is retrieved is identical to what is stored, and that only the strategies of storage and retrieval change throughout development. Eventually, an adequate characterization must take into account the active, accommodating changes within schemata as well as the particular strategies used to assimilate the information.

2. Cognitive Integration in Children's Memory for Sentences and Pictures. (Paris & Mahoney, 1974)

Although most of the research concerned with the construction of semantic relationships during comprehension and memory has employed verbal material, there is no reason to suppose that this constructive capacity is simply a linguistic competence. There is ample evidence which shows that children's memory for pictorial material is a function of the relatedness of the pictured events. Recall for pictorial events is better when the stimulus elements are presented in meaningful, interactive, unitized contexts rather than in isolated form (Horowitz, Lampel, & Takanishi, 1969; Milgram, 1967; Rohwer, 1970). As with verbal material, encoding and retrieval of pictorial information are enhanced by virtue of the integrated relationship between events.

The purpose of the present study was to investigate further the cognitive integration abilities of children in their derivation and retention of meaning from pictures and sentences. We were primarily interested in determining whether children implicitly construct and integrate implied relationships among related sentences and pictures in memory or whether they interpret and store representations of individual pictures and sentences. The study compared children's comprehension of the same relationships presented verbally or pictorially and assessed the cross-modal transfer, e.g., pictorial acquisition items and verbal recognition items, a process expected if a general constructive comprehension strategy modulates the derivation of meaning. A recognition memory task was employed which involved a test list of sentences or pictures. Some of the items were identical with original sentences or pictures, and others involved structural and semantic transformations of the events. If children implicitly construct integrated representations of pictures and sentences, one would expect differentiation between correct and incorrect semantic relationships of objects. However, if sentences and pictures are processed and remembered individually, then subjects should discriminate between recognition items primarily on the basis of the presence or absence of objects in the new sentences and pictures.

Method

Subjects

Children from second-grade classes (mean CA = 96 months) and fourth-grade classes (mean CA = 123 months) from local public schools participated in this study. Three experimental groups of 12 subjects each were formed within each grade level.

Procedure

The task included an acquisition phase and recognition test phase designed to assess children's integration of relationships in sentences

and pictures. During acquisition, subjects were presented three sentences or three pictures for each story. The pictures and sentences of the acquisition task always represented the identical relationships in a series of two premise propositions and a filler item such as: (1) The box is to the right of the tree (premise), (2) The chair is on top of the box (premise), and (3) The tree is green and tall (filler). The pictures corresponding to these sentences were drawn in color on 5" x 8" cards. In addition to the three nouns mentioned in each story, the pictures included two irrelevant objects, e.g., a house and a cloud in the previous example, depicted in the identical shape and position for all pictures of a story. These objects were included to attenuate responding on the basis of sheer number of objects and were redundant in all recognition test pictures. The three relationships of concern here were the two assertions of the premises and the implied spatial location of the subject in the second premise, e.g., chair. There were six stories of this form presented during acquisition, but the first and last were nontest filler stories to attenuate primacy and recency effects. The middle four stories tested during the recognition phase portrayed the spatial relationships of right and left, above and below, higher and lower, and in front of and behind.

During the recognition phase, subjects were asked to judge whether test sentences and pictures were identical to those presented in acquisition. There were four different semantic recognition items for each story: a true premise identical to one of the acquisition premises, a false premise in which the relational term of the original premise was changed, a true inference derived from the relationships expressed in the acquisition premises, and a false inference which did not logically follow from the premise information. These four test items for the previous example are: (4) The box is to the right of the tree (true premise), (5) The box is to the left of the tree (false premise), (6) The chair is to the right of the tree (true inference), and (7) The chair is to the left of the tree (false inference). If sentences are retained as unitary word strings and pictures are retained as eidetic images, subjects should recognize (4) as the only sentence or picture identical to an acquisition item. On the other hand, if subjects integrate and retain the semantic relationships implied among sentences and pictures, one would expect true inferences such as (6) to be confused with acquisiton items because of the congruent implied relationships. The process of constructing implicit inferences was the operational index of integration in this study.

Several other propositionally similar recognition items were also included in the recognition test. The same semantic relationships of sentences (4)-(7) can be expressed with opposite relational terms. For example, sentence (4) can be rewritten as, "The tree is to the left of the box." Appropriate meaning-preserving recognition sentences corresponding to (4), (5), (6), and (7) were generated with juxtaposed subject and object nouns and opposite relational terms. These items were included in order to determine children's ability to abstract propositional meaning from semantically transformed sentences, a process previously demonstrated by adults (Bransford, Barclay, & Franks, 1972;

Kintsch & Monk, 1972). Thus, there were four original recognition items and four propositionally similar test sentences, resulting in eight recognition sentences for each story. Although the propositional similarity factor was irrelevant for recognition pictures, two additional items were included in the pictorial recognition phase. The true and false inferences corresponding to (6) and (7) were pictorially presented both with and without the relational objects, e.g., the box in the previous example, because of the ambiguity of these propositions in sentences. If children integrated the acquisition pictures into a single unitized scene, they should be more likely to confuse acquisition pictures and inferential pictures with the relational objects than without them, since the second acquisition picture always portrayed the two objects together, e.g., the chair was on top of the box. This prediction follows from a strategy of matching each test picture against an integrated schema derived from the acquisition pictures. The two inferential pictures without relational objects had less correspondence to the acquisition pictures because fewer of the premise and implied relationships were preserved.

Within each grade level, there were three experimental groups. One group was presented sentences during acquisition and recognition (verbal-verbal), one group saw pictures in both phases (picture-picture), and one group saw pictures during acquisition but was tested with sentences during recognition (picture-verbal). There were no verbal-picture groups because sentences such as (3) conveyed information which was true in the recognition pictures regardless of the relationships of other objects. The 18 acquisition pictures or sentences were presented in the same order to all subjects. The recognition items were presented in story blocks. The order of story blocks as well as the order of the six recognition pictures or eight recognition sentences within blocks was randomized initially and presented in the same order to all subjects.

Sentences were presented orally during acquisition, and subjects were required to repeat them correctly. The 5" x 8" color pictures were sequentially exposed to subjects for 10 sec. each. Following acquisition, subjects engaged in a 1-minute interpolated counting activity. Instructions prior to the recognition test stated that some of the pictures and sentences were the same as acquisition items and some different. The recognition items were prefaced with the question, "Did you hear this same exact sentence (or see this same exact picture) before?" Subjects in the picture-verbal condition were asked, "Did you see a picture which was exactly like this sentence?" Subjects' responses and three-point certainty judgments, i.e., "real sure," "sort of sure," or "not too sure," were recorded.

Results

Responses to Original Recognition Items

The percentages of positive recognitions, i.e., "yes" responses, to items such as (4), (5), (6), and (7) are shown in Table 2. For the

Table 2

Percentage "Yes" Responses on Original Recognition Items

Recognition Item	Group (by Grade) Verbal-Verbal 2	Verbal-Verbal 4	Picture-Verbal 2	Picture-Verbal 4	Picture-Picture 2	Picture-Picture 4
True Premise	72.9	66.7	85.4	79.2	83.3	87.5
False Premise	45.8	35.4	41.7	37.5	37.5	33.3
True Inference	72.9	62.5	62.5	75.0	89.6	66.7
False Inference	50.0	29.2	37.5	29.2	45.8	27.1

picture-picture groups, the scores for true and false inferences were derived from pictures which included the relational objects. If subjects remembered individual sentences and pictures in an ideal manner, one would expect 100 percent positive recognition responses for the true premises of Table 2 and 0 percent for all other cells, since these were all new test items. However, if subjects responded in terms of semantic consistency, as the constructive position predicts, one would expect many "yes" responses, i.e., errors, on true inferences. This in fact was obtained, and the percentages of positive recognition responses to true premises and inferences were similar across groups and grades. The positive recognition responses of Table 2 were analyzed in a five-factor analysis of variance, Grade x Group x Sex x Truth x Premise Inference. It was observed that second-grade subjects gave significantly more "yes" responses than fourth graders, F (1, 60) = 4.42, $p < .05$. The analysis also revealed significant main effects for Truth, F (1, 60) = 122.23, $p < .001$, and Premise Inference, F (1, 60) = 4.73, $p < .05$. It should be noted that the Truth effect was more than 20 times larger than the Premise-Inference effect. Although subjects could discriminate between the presence of the objects in the recognition test, i.e., premise-inference comparison, discrimination based on the meaning of the relationship, Truth, was much more effective. As shown in Table 2, second graders made considerably more "yes" responses to inferences in the picture-picture condition than fourth graders in both the picture-picture and verbal-verbal conditions, which resulted in a significant Grade x Group x Premise Inference interaction, F (2, 60) = 3.30, $p < .05$. These differences were significant in Tukey "honestly significant difference" (hsd) comparisons ($p < .05$. Performance

did not vary as a function of sex, although sex did enter into a significant four-way interaction, Grade x Group x Sex x Premise Inference, F (2, 60) = 5.80, $p < .01$.

The primary result was the strong tendency for children to recognize the semantically consistent true inferences as similar to the sentences and pictures given during acquisition. This does not appear to be accidental or due to generally poor memory for the original items, since both true and false inference items contained the same nouns and objects (pictorially or verbally) as did the acquisition items and were of similar complexity and syntactic construction. The only difference between true and false inference sentences was the validity of the relational term, a subtle semantic difference. Similarly, true and false inference pictures portrayed the identical objects in different positional arrangements. If subjects confused the sentences and pictures or remembered only some of the information, one would not expect such large discrepancies between true and false inferences.

Discussion

In the recognition memory task of this study, children had difficulty differentiating semantically consistent inferences from original sentences. The most plausible interpretation of this finding is that children implicit constructed semantic relationships among sentences and integrated the relationships among sentences and integrated the relationships into holistic schemata in memory. The construction and retention of implied information derived from sentences cannot be explained by a rote rehearsal strategy of sentence memory or a linguistic interpretation of the deep structure repres sentations. Even if the list of sentences is conceptualized as a single is conceptualized as a single conjoined set of deep structures, as Katz and Fodor (1963) suggested, the interpretive view of sentence memory cannot account for the retention of inferred information. Thus, this study corroborates the findings of Bransford, Barclay, and Franks, (1972) and Kintsch and Monk (1972) in that a linguistic structural representation is an insufficient characterization of the information which subjects abstract and retain from verbal input. This is not just a rejection of the formal competence model as a prescriptive performance device. Rather, the principles underlying language comprehension cannot be accounted for by the principles underlying a semantic interpretive component, and, therefore, the formal model should be broadened in scope to allow such correspondence. Whether an alternative position is framed in terms of case relationships (Fillmore, 1968), set-theoretic propositions relating to psychological indices (McCawley, 1968), holistic schemata (Bransford, et al., 1972), or underlying propositional meaning (Kintsch, 1972), an adequate psychological characterization of the derivation and retention of meaning must attend to the manner in which subject abstract semantic relationships among events from language.

The parameters underlying cognitive integration have not been made explicit, but in general it is crucial (a) that the material possess internal coherence or contextual relatedness and (b) that the material be sufficiently difficult to preclude effective learning or understanding

by rote memorization of individual items. These two conditions are usually tacitly satisfied in research that demonstrates schematization in memory. However, these two conditions are representative of everyday experience, and therefore, the demonstration of spontaneous integration in ccomprehension should not be regarded as a task-specific or artificial process. In fact, the critical nature of these two conditions for integration is apparent in research that demonstrates the facilitated memory which results from explicit provision of contextually organizing pictures, words, and sentences or which results from instructions to elaborate, embellish, image, and assimilate stimuli into existing schemata. These structural characteristics of the stimulus material and the cognitive contributions or operations of the comprehender determine the degree of integration evidenced on a particular task; yet the integrative process itself appears to be a basic operation in the child's effort toward understanding.

The present study extends previous research in several critical areas. First, this study demonstrates the reliability of the semantic integration phenomenon with a variety of spatial locative relationships in children's sentence memory (Paris & Carter, 1973). Children, as well as adults, are not only capable of deriving inferences from sentences but, more importantly, they appear spontaneously to construct and retain implied information in memory. In this regard, it should be noted that the slightly fewer "yes" responses on true inferences in Table 2 for fourth graders do not necessarily reflect less cognitive integration of the stories. The overall fewer integrative errors for older subjects are probably due to performance factors such as increased memory span for specific items and greater familiarity with listening and observing tasks. There is also a strong possibility that second graders were operating with a positive recognition response bias which inflated both error and correct response rates. This finding is not uncommon with young children in yes-no or true-false tasks.

The most important aspect of this study was the extension of the semantic integration paradigm to pictorial stimuli. Children did not store the pictures as static or eidetic copies, but, rather, if appears that subjects incorporated sequential visual relationships into unified representations. Although it is unclear where this integration occurred, e.g., encoding, storage, decoding, it appears to reflect Bruner's (1973) notion of the construction of behavior rather than the acquisition of responses and is not unlike Piaget's notion of assimilation to schemata. This, of course, does not deny that children can remember and recognize a list of unrelated pictures. However, when the pictures do preserve contextual relatedness, they are remembered as a holistic unit. This suggests that the images generated from the pictorial stimuli as well as the sentences were not retained individually and should not be regarded as a storehouse of images equivalent to derived meaning. Imagery in this task appears to provide cues which children can utilize in the construction and integration of a holistic situation.

Cognitive integration may be a general constructive process of comprehension which children spontaneously employ in order to derive contexual meaning from verbal and visual input. A consequence of this

process is that the retained information is, to some degree, relational in nature and embodies implied information not overtly expressed within individual words, sentences, or pictures. These hypotheses and the integration paradigm may afford a close approximation to children's listening, reading, and observational skills in everyday situations and may be a heuristic perspective from which to study cognitive development.

3. Facilitation of Semantic Integration in Sentence Memory of Retarded Children. (Paris, Mahoney, & Buckhalt, 1974).

The integration of information into thematically related units is usually an automatic process in the sense that the comprehender is not aware of the processes taking place. The comprehender seems to be searching for a basis for integrating information, an event or topic that needs to be clarified by incoming information. This integration can be enhanced experimentally by instructing subjects to employ special strategies, especially forming a mental picture of relationships described linguistically.

The present study was designed to determine if mildly retarded children share the constructive processes of comprehension that normal children have. In addition to assessing comprehension processes, this study also focused on determining whether the capability on retarded children to generate and construct semantic relationships could be enhanced. One of the consistent findings in the literature regarding the memory of mildly retarded children is their failure to generate appropriate organizational and elaborative relationships among words (Rohwer, 1970; Spitz, 1966). The effects of this failure to produce effective elaborative strategies can be ameliorated, however, with the explicit provision of interactive, sentential contexts for paired-associates such as, "The ROCK hit the BOTTLE" (Rohwer, 1970). In a similar vein, Taylor, Josberger, and Knowlton (1972) found that instructing retarded subjects to elaborate or image the words together facilitated recall. The underlying mechanisms responsible for these effects may be better initial comprehension of the material and more efficacious strategies of encoding information.

A specific purpose of the present study was to determine if imagery instructions would facilitate the organization and construction of semantic relationships for retarded children. Imagery was chosen as an intervention procedure for two reasons. First, imagery instructions have been used previously to enhance retarded children's learning and memory and the strategy appears both easy to teach and easy to learn. Second, semantic integration has been observed with pictorial stimuli as well as sentences, thereby implicating nonverbal, imaginal factors as potential mediators of the process (Paris & Mahoney, 1974). Thus, the present study assessed the ability of retarded children to construct semantic relationships and the efficacy of instructed imagery cues to promote comprehension and memory.

Method

Subjects

The subjects in this study were 40 children who were classified as EMR. The 20 older subjects had a CA of 142 months (range = 127 to 161 months) while the 20 younger subjects had a CA of 114 months (range = 89 to 126 months). The IQ scores of the older subjects ranged from 62 to 38 ($\overline{IQ}$ = 73). The scores for younger subjects ranged from 52 to 78 ($\overline{IQ}$ = 69). Each age group was randomly divided into experimental and control groups of ten subjects each which did not differ in terms of CA or IQ

Materials

Task 1 involved an acquisition phase and a recognition test. During acquisition, subjects were read four descriptive passages of the following form:

(1) John is chasing the dog.

(2) The dog is in the school yard.

(3) The dog is white.

The first two premises of each passage permitted the subjects to infer another spatial relationship such as, "John is in the school yard." The purpose of the recognition test was to determine if subjects could discriminate between semantically-consistent inferential statements and the original acquisition sentences. A linguistic interpretive position or a rote rehearsal strategy would predict that subjects would not recognize a true inference as an acquisition sentence while a constructive semantic position would predict such confusion.

Four different statements were incorporated in the recognition test: true premises which were identical to acquisition sentences, false premises which changed the subjects and objects of acquisition sentences, true inferential statements, and false inferences which distorted the relationship of the true inference. These four sentences types for the previous example are:

(4) John is chasing the dog. (True Premise)

(5) The dog is chasing John. (False Premise)

(6) John is in the school yard. (True Inference)

(7) John is outside the school yeard. (False Inference)

Procedure

Subjects were tested individually and the task was presented as a memory game. Each child was told he would hear several stories and that he should try to remember the sentences because the experimenter

would later ask questions about them. In the acquisition phase, four stories were read to subjects. During pre-test and acquisition, subjects imitated each sentence read by the experimenter.

The recognition test immediately followed acquisition. Subjects were instructed that some of the sentences were identical to the previous sentences and some were different. The first few recognition sentences were prefaced with the question, "Did you hear this same exact sentence before?", and subjects responded Yes or No.

Following Task 1, all subjects were presented with a second task which included four more similar acquisition passages with the same instructions. The experimental groups, however, received instructions concerning imagery. An example sentence was given and subjects were told to "make a picture of this sentence in your head." Task 2 followed immediately with periodic prompts to image given to subjects in both experimental groups. The order of the acquisition and randomized recognition sentences was the same in both tasks for all subjects.

Results

Performance on Task 1 served as a baseline assessment of retarded children's ability to integrate verbal information. It also allowed a pre-intervention comparison of the old and young experimental and control groups. The errors on the four recognition items constituted the data in a four-way analysis of variance with repeated measures, Age x Group x Premise-Inference x Truth. The Age and Group factors were nonsignificant as main effects and in all interactions indicating equivalent performance, of the four groups on Task 1. Collapsed across groups, the error rates were 18.8 percent on True Premises, 20.6 percent on False Premises, and 28.8 percent on False Inferences, while on True Inferences the average error rate was 50.0 percent. Thus, although the errors on true and false premises and false inferences were relatively low for all groups, the errors on true inferences were more frequent. The relatively high error rate on true-inference sentences was primarily responsible for a significant main effect of Premise Inference, F (1, 36) = 31.52, $p < .001$, a significant main effect of Truth, F (1, 36) = 9.75, $p < .001$, and the significant interaction of these two factors, F (1, 36) = 11.63, $p < .001$. A Tukey hsd analysis of the significant interaction suggests that the true-inference items accounted for this effect since there were significantly more errors on true inferences than either true premises, false premises, or false inferences ($p < .01$). The error rates on these three recognition items did not differ from one another. The finding that retarded children incorrectly recognized nonpresented true inferences as original acquistion sentences is consistent with research on adults and nonretarded children and supports the semantic integration approach to sentence memory.

A similar analysis of variance was performed on the data from Task 2. Again, the main effect of Premise-Inference was significant, (F (1, 36) = 25.47, $p < .001$, as was Truth, F (1, 36) = 11.16, $p < .001$, and the interaction, F (1, 36) = 81.60, $p < .001$. There were no significant

main effects of Age or Group in this analysis but none would be expected since improved performance would yield more errors on true inferences and fewer errors on the other recognition items for the experimental and older subjects. The Age x Premise-Inference x Truth interaction was significant, F (1, 36) = 4.83, $p < .05$, but a Tukey hsd analysis failed to demonstrate significant superiority of older subjects in any of the individual comparisons on the same recognition-sentence types. Although older subjects generally made more constructive errors on true inferences and fewer errors on other items than younger subjects, there were no significant age differences in Task 2.

The triple interaction of Group x Premise-Inference x Truth was also significant, F (1, 36) = 21.52, $p < .001$. As shown in Figure 5, the experimental groups made more true-inference errors but fewer errors on other recognition items than the control groups. A Tukey hsd probe for significance of this interaction revealed that for both the experimental and control groups, the number of errors in any of the other three categories ($p < .05$), while there were no differences among the other three recognition items. Furthermore, the pattern of errors for the experimental and control groups differed significantly in three of the four recognition categories. That is, the experimental groups made significantly more true-inference errors than did the control groups ($p < .01$), while the control groups were making a greater number of errors on the true premises ($p < .05$) and false inferences ($p < .01$). Thus, the imagery instructions promoted recognition of the semantic relationships expressed in the test sentences. In three of the four recognition categories the effects of the treatment were significant in the predicted direction, while for the false premises, the results were in the predicted direction but not significant.

Table 3 includes the mean number of errors for the experimental and control subjects on Task 1 and Task 2. The analysis of variance comparing the recognition scores on the two tasks revealed that there were significantly fewer errors on Task 2 than Task 1, F (1, 36) = 5.61, $p < .05$. A Newman-Keuls analysis of the significant Group x Task x Premise-Inference x Truth interaction, F (1, 36) = 7.19, $p < .01$, suggests that the differences between performance on the two tasks can be primarily attributed to fewer errors made by experimental subjects on true premises and false inferences in Task 2 than either the experimental or control groups in Task 1 ($p < .05$). There were no differences between the recognition scores between Task 1 and Task 2 for the control groups.

Discussion

The results of Task 1 clearly indicate that retarded children are capable of spontaneous semantic integration. The high error rate on true inferences indicates that subjects had difficulty differentiating between novel true-inference sentences and acquisition sentences. On the other hand, the relatively low error rates in the other three categories of recognition sentences suggests that subjects had little difficulty differentiating between acquisition sentences and recognition

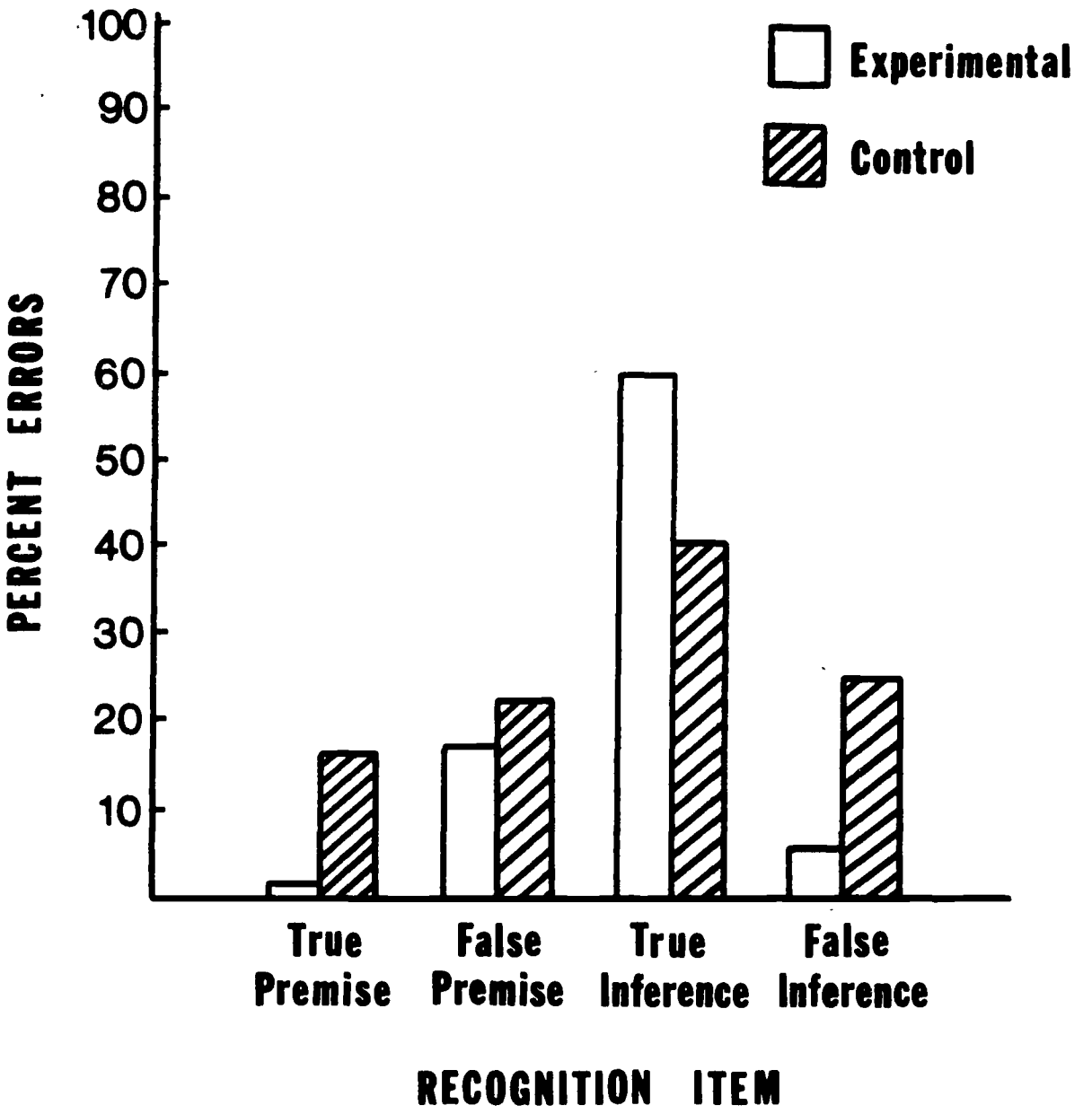


Fig. 5. Percent errors on recognition items of Task 2 for experimental and control groups.

Table 3

Percentages of Recognition Errors for Experimental and Control Groups on Task 1 and Task 2

Recognition Item	Task 1		Task 2	
	Experimental	Control	Experimental	Control
True Premise	16.25	21.25	1.50	16.25
False Premise	18.75	22.50	17.50	22.50
True Inference	51.25	48.75	60.00	41.25
False Inference	27.50	30.00	6.25	25.00

sentences in which the meaning was changed. The fact that they comprehended and remembered the semantic relationships expressed in the "stories" and not merely particular acquisition sentences is inconsistent with both the interpretive linguistic and rote rehearsal characterizations of memory. Of course, this does not imply that retarded children do not rehearse individual words and sentences or do not profit from syntactic cues of sentences. It does suggest, though, that EMR children are capable of abstracting semantic relationships in a manner qualitatively similar to nonretarded children and adults. Although this study does not allow developmental comparisons of relative degrees of semantic integration by retarded and nonretarded children, it does suggest that the comprehension and memory processes of retarded children are constructive in nature.

In Task 2 it was observed that imagery instructions can promote sentence comprehension and memory also, further, the imagery instructions appear to have promoted the construction of semantic relationships as evidenced by the greater number of true-inference errors made by the experimental groups relative to the controls. It appears that subjects' generation of images did not foster eidetic or copy images of events but rather facilitated the representational (Paivio, 1971) and operative (Piaget & Inhelder, 1969) aspects of images. The images provided additional cues to organize and encode the verbal information into wholistic descriptions of situations.

Although the effects of the imagery intervention were not large, instructions to image facilitated recognition in the predicted direction in every case. The experimental groups had more semantically consistent true-inference errors than the control groups but fewer errors on other recognition sentences. Considering the brief imagery manipulation, the finding of any gains in Task 2 may be surprising. The imagery effect should not be considered slight given these qualifications. With prolonged training on imagery and with more difficult material, the effects on comprehension and memory would be expected to be even larger. The

positive effects of even a brief intervention suggest that retarded children's comprehension and memory for verbal material can be promoted through training on effective organizational strategies such as imagery and elaboration. A great deal of research in mental retardation has exclusively emphasized memory as a storage system and has been concerned with demonstrating retarded and nonretarded differences in storage capacity. A reinterpretation of memory as primarily a consequence of comprehension shifts concern to possible comprehension differences between retarded and nonretarded people (Paris & Haywood, 1973). Much of the provocative research on organizational strategies of encoding indeed suggests that retarded children fail to generate spontaneously appropriate strategies (Rohwer, 1970; Taylor, Josberger, & Knowlton, 1972; Turnure & Walsh, 1971). Yet these children can utilize mediators such as imagery and elaboration when explicitly provided to them. The analysis of language comprehension difficulties of mentally retarded children as a failure to produce efficacious strategies of comprehension places strong emphasis on universal processes of cognitive development and de-emphasizes a deficit model. Finally, the methodology of semantic integration, or any similar paradigm evaluating comprehension of connected discourse through memory tasks, is regarded as valuable because of its closer approximation to school-related tasks and everyday experiences and hopefully will offer a valuable paradigm for educationally relevant research on mental retardation.

B. Children's Abilities to Utilize Implicit Information as Retrieval Cues

1. The Role of Inference in Children's Comprehension and Memory for Sentences. (Paris & Lindauer, 1976)

Part of the constructive process occurs as comprehenders add elements to incoming information to make that information more comprehensible. The elements are in answer to implicit questions about the material. One of these questions is undoubtedly "how" is the action implemented? Perhaps there is developmentally correlated increase in how an active relationship between subject and object is usually implemented. One of the things a child must learn is the normative appendages for activities (one usually throws with an arm, not a leg, conversely, kicking is the exclusive domain of the leg-foot areas) and the normative tools for activities /sewing (needle, thread, or machine); weaving (loom); sweeping (broom); digging (shovel for a person, but not a dog, earthworm, or construction crew/. Once this normative information is acquired it becomes part of the knowledge associated with a particular activity. Thus, when incoming information is comprehended, some of the comprehension is based on normative knowledge about how certain actions are carried out.

Children are continuously deriving and retaining these inferred relationships from prose. For example, it has been shown that children often infer presuppositions, consequences, means-ends relations, and affective states of characters in brief stories that are read to them (Paris, 1975; Stein & Glenn, Note 1). The ability to understand and remember inferences in prose appears to improve with age for children from six to 12 years old and may reflect more than an age-related increase in memory capacity. Paris (1975) showed that there was a high correlation between a child's ability to understand implied relationships within a story

and the long term retention of the main ideas of the story. Thus, comprehension of implied relationships may be an important operation for remembering semantic information.

Although children can draw inferences from words, sentences, and stories, it is unclear how and why this ability changes with age. One purpose of the present research was to provide a direct and simplified analysis of developmental changes in the inferential processing of sentences. This is necessary because past research has often confounded the developmental assessment of spontaneous inferential processing with methodological problems such as shifting response biases, free recall, and training. A second intent was to determine if there is an age-related increase in the functional utility of an inferential comprehension strategy for memory retrieval. A third purpose was to determine if young children could be made to draw inferences from sentences, in other words, to apply a strategy that they usually would not.

The paradigm for the following three experiments was similar. Each study involved the presentation of sentences to children to remember. The sentences were constructed to include an instrument commonly employed to accomplish the action of the verb. For example, one sentence was, "The workman dug a hole in the ground with a shovel." The word shovel corresponds to Fillmore's (1968) notion of instrumental case and is primarily constrained by the verb, although the sentence context also helps to define the appropriate instrument. The instrument of the sentence can be stated explicitly or it can be omitted and only implied by the sentence. If a subject ordinarily supplies missing, but implied, information to a sentence in order to understand its meaning, then he should derive the equivalent memory representation for sentences with either explicit or implicit instruments. Subsequently, the subject should be able to employ a retrieval cue such as the instrument to recall sentences with implicit or explicit instruments with equal facility. However, if young children do not spontaneously generate implied relationships such as appropriate instruments, then an instrument cue should be ineffective for retrieval unless it was stated directly in the sentence. This age by implicit-explicit cue factor interaction is the basic prediction in all of the studies.

Method

Subjects

Subjects in this experiment were 48 children; eight boys and eight girls from each of grades 1, 3, and 5. All children were Caucasian and attended regular classrooms in Indiana public schools. The mean ages of the groups were: grade 1, mean = 7 yrs. 1 mo., range = 6-6 to 7-10; grade 3, mean = 9 yrs. 0 mo., range = 8-7 to 9-8; grade 5, mean = 11 yrs. 3 mo., range = 10-8 to 12-0.

Materials

The eight sentences listed below were generated to either implicitly

or explicitly state the instrument used to accomplish the action of the verb.

1. The truckdriver stirred the coffee in his cup (with a spoon).
2. The workman dug a hole in the ground (with a shovel).
3. The teacher cut into the juicy steak (with a knife).
4. The soldier hit the ball (with a bat) for a homerun.
5. His mother baked a birthday cake (in the oven).
6. My father struck his finger instead of the nail (with a hammer).
7. Her friend swept the kitchen floor (with a broom).
8. Our neighbor unlocked the door (with a key).

Two lists were prepared so that each list contained four explicit and four implicit instrument sentences. The lists were balanced so that a given sentence occurred equally often with and without the instrumental phrase contained in parentheses. The two forms of the lists were distributed equally among boys and girls at each grade level. The order of sentences during presentation and recall was the same but randomized for every subject.

Procedure

Each subject was tested individually and was told that the task was a memory game. Then children were told that they would be given a word which was a clue to one of the sentences they had heard. The word did not have to be part of the sentence but it would help them remember. The first few cues were prefaced by "Which sentence does this word remind you of?" Each subject received four explicit and four implicit instrument prompts as retrieval cues.

A sentence was considered to be recalled correctly if the child remembered two out of three words in the subject-verb-object categories. Close synonyms were permitted in recall such as "Army man" for the word soldier. In addition, the child's recalled sentence had to preserve the meaning of the original sentence.

Results and Discussion

The percentages of correctly recalled sentences for each grade and cue condition are shown in Table 4. These data were subjected to a Grade x Cue Type repeated measures analysis of variance. Since there were no differences between lists or sexes in preliminary analyses, these factors were collapsed. The analysis revealed a significant Grade effect,

Table 4

Experiment 1: Percentage of Correctly Recalled Sentences as a Function of Cue and Grade

Retrieval Cue	Grade 1	3	5
Explicit Instrument	57.8	73.4	73.4
Implicit Instrument	31.3	48.4	65.6

F (2, 42) = 4.58, $p < .05$, which indicates that children in successive grades recalled more sentences. Newman-Keuls tests indicated that this difference was significant only for the grades 1 vs. 3 and 1 vs. 5 comparisons ($ps < .05$). There was also a significant Cue Type effect, F (1, 42) = 33.69, $p < .01$, and a significant Grade x Cue Type interaction, F (2, 42) = 3.28, $p < .05$. This interaction was predicted and indicates that although first and third graders recalled more sentences with explicit instrument prompts, the fifth graders recalled the implicitly and explicitly cued sentences equally well.

The older subjects appeared to have provided spontaneously the inferred relation of the instrument during encoding and were able to access the sentence because the implicit cue "made contact" with the subjects' representations of the sentence. One might argue that reconstructive processing occurred when directed at retrieval and that the association between the instrument and the sentence was formed only during recall. There are at least two arguments based on this interpretation which can be rejected readily. First, one might argue that the older subjects overlearned the list of sentences and merely checked through their memory list to find which sentence was most likely to occur with each implicit cue. This post-acquisition association hypothesis is ruled out by the nonceiling performance of older subjects on explicit sentences. We believe that the subject searches among the sentence representations in his memory during retrieval but instead of making associations ex post facto, he searches for those representations which are consistent with the relationships that he has constructed during encoding. The constraints on the search process are due to the constructed meaning generated by the child for each sentence. Of course, the child may retrieve and rehearse the sentence many times before the experimenter gives a cue and requests the child to recall the sentence. Each cycle of retrieval and encoding permits the child to recomprehend the sentence, to add and delete information, and to integrate the meaning derived from these operations. We have labeled these cyclical rehearsal processes recursive operations of comprehension (Paris & Lindauer, in press). Recursive operations are self-monitoring processes of comprehension that help to insure retention through continuous checking and updating of one's understanding. They also appear to be common sense characterizations of

memory which help to eliminate some of the artificial distinctions of encoding vs. retrieval, construction vs. reconstruction, and comprehension vs. memory by focusing on the continuous reciprocal relationships between the elements of these various dichotomies.

The second argument against a constructive encoding position is that the younger subjects did not know which instruments were implied in the sentences, i.e., implicit and explicit cues varied in familiarity or probability of leading to a correct inference for young children. We conducted a study to test this possibility. Twenty-two kindergarten children (CA = 5 yrs. 11 mos.) were individually presented each sentence without the instrument stated and asked to select the appropriate instrument from among four pictures. These instruments were common objects and the incorrect choices included plausible alternative instruments. Even kindergarten children chose the appropriate instruments on 97.7 percent of the picture-sentence matching trials.

Older subjects apparently generated implicit information during encoding of the sentences, incorporated these relationships into their memory representations, and subsequently utilized them to access the entire sentence's meaning. This is not merely a group data phenomenon. If we eliminate the three subjects in first grade who did not recall any sentences, we can compute the number of subjects in each group who recalled as many or more implicitly cued sentences as explicitly cued. The number of subjects meeting this criterion for grades 1, 3, and 5, are 3, 5, and 10 children, respectively, indicating that this effect is consistent within as well as between subjects in groups.

The materials of Experiment B_1 compared implicit and explicit cues on the same sentences. On the one hand, this seems the easiest way to investigate the constructive processes of comprehension and memory. However, one might object that this actually biases the children to do better with explicit cues since they nearly always occur at the end of the sentence and have a recency advantage. One might also argue that instruments are unusual and indirect aspects of a sentence and therefore not very good retrieval indices of a subject's memory for the sentence. Experiment B_2 was designed to compare the effectiveness of implied instrument prompts with more conventional explicit memory cues from sentences, namely, the explicit subject, verb, and object. Again, the prediction was that implicit cues (i.e., instruments) would be less effective for retrieval than explicit cues for young children but they would be equally effective for older children.

Method

Subjects

Sixteen children from each of the following grades, kindergarten, second, and fourth grade participated in this study. The ages of each group were: kindergarten, mean 5 yrs. 9 mos., range = 5-2 to 6-0; second grade, mean = 7 yrs. 10 mos., range = 7-2 to 9-2; and fourth

grade, mean = 9 yrs. 8 mos., range = 9-1 to 10-3.

Materials

The same eight sentences described in Experiment B_1 were employed in this study with all the instruments being implicit. Each sentence was cued during recall with either the explicit subject, verb, or object, or the implied instrument of the action. Four different lists were prepared so that each sentence appeared with each prompt type four times across subjects in a Latin squares design. The order of presentation and recall was the same but randomized for each subject.

Procedure

The procedure was identical to Experiment B_1.

Results and Discussion

The percentages of correctly recalled sentences are shown for each grade and cue condition in Table 5. The differences among subject, verb, and objects prompts were not consistent over grades nor

Table 5

Experiment 2: Percentage of Correctly Recalled Sentences as a Function of Cue and Grade

Retrieval Cue	Grade K	2	4
Subject	37.5	34.4	62.5
Verb	40.6	40.6	56.3
Object	37.5	50.0	65.6
Mean Total Explicit	38.5	41.7	61.5
Implicit Instrument	21.9	37.5	68.8

were the differences among these conditions statistically significant. The data were collapsed across the explicit cue types for analysis and are summarized accordingly in Table 5. In general, Table 5 replicates Table 1 with slightly lower percentages of recalled sentences by the younger subjects in Experiment B_2. We performed an analysis of variance, Grade x Cue Type (implicit-explicit), on these data and found only a significant Grade effect, F (2, 42) = 10.72, $p < .01$. Examination of the protocols revealed that among the sixteen subjects in each grade,

eleven children in the kindergarten group recalled none of the sentences cued by the implied instruments (as opposed to five kindergarten subjects who recalled no explicitly cued sentences). A nonparametric test was chosen to test for the age by cue type interaction. Rather than looking at just the number of implicitly cued sentences recalled by each subject, we calculated a score that took account of the increasingly good recall of older subjects. Each subject's data was rescored to yield a proportion; the number of correctly recalled implicitly cued sentences divided by the total number of recalled sentences. Because of the limitation imposed on this proportion (i.e., older children recalled more sentences thereby decreasing the proportion), we are actually biasing the analysis against our predicted interaction of age by cue type. We performed a Kruskal-Wallis nonparametric rankings test on these proportions and found that kindergarten subjects were significantly different from fourth graders ($p < .01$). This means that the younger subjects' total recall included a significantly lower proportion of implicitly cued sentences than the fourth graders. Again it appears that older children were able to use implicit relationships to access sentence memory and young children were not. Presumably, this reflects the failure during encoding to be aware of implied relationships which the kindergartners know but do not process.

The failure to generate additional information during encoding and the subsequent retrieval failure with implicit cues may be characteristic of a strategy production deficiency (Flavell, 1970). That is, young children fail to generate inferential operations which will facilitate sentence memory even though they are capable of using that information to mediate memory. Another way of describing this memory failure has been suggested by the "levels of processing" framework (Craik & Lockhart, 1972). Young children may not derive semantically complex relations, such as implied instruments, because they only process the sentences to a superficial or shallow level, perhaps because they are unaware of the normative aspects of the activity. One can ask, then, if young children can be made to process sentences to a deeper level and ameliorate their inefficient processing. This was the intent of Experiment B_3.

Method

Subjects

Ten children, five males and five females, from a first-grade public school class in Indiana participated in this study. The children's mean age was 7 yrs. 2 mos., range = 6-8 to 7-6.

Materials

A list of ten sentences was generated that permitted children to act out the described actions. Seven sentences from the previous list (except number 5) were included plus the following three sentences:

9. The man shot the robber in the leg (with a gun).

10. The girl scout lit the big campfire (with a match).

11. My cousin chopped the firewood (with an axe).

Procedure

The task was introduced as a memory game and the children were told that the sentences would be easier to remember if the children repeated them aloud and then acted out the actions described by the sentences. This forced the child to process the implied instrument with respect to themselves rather than a norm and also provided a readily observable response (as opposed to other cognitive instructions such as imagery). Interestingly enough, the children were virtually never wrong about their choice of instrument or appropriate action response. The few incorrect actions were not rectified although inaccurate sentence imitations were corrected as in the other studies.

Results and Discussion

The outcome was simple and dramatic. The children recalled a mean 71 percent of the ten sentence list. They recalled an average of 72 percent of the explicitly cued sentences and 70 percent of the implicitly cued sentences, a nonsignificant difference. The simple instructions to act out sentences forced children to generate personally relevant inferential relationships in order to understand the sentences and allowed them to utilize this information to facilitate recall. This procedure not only eliminated the previously found differences between implicitly and explicitly cued sentences, it also boosted recall for those children tremendously on a longer list of sentences.

General Discussion

These studies provide another demonstration that children "go beyond the information given" in their usual processes of sentence comprehension. The result of inferential and constructive processing is an informationally rich and semantically integrated memory representation. Intuitively, we know that people do not comprehend and remember sentences in isolation (cf., Bransford & Franks, 1972). The present study can be added to the growing body of experimental evidence that people spontaneously draw inferences (and include this information in memory) from questions (Loftus & Palmer, 1974), from previously given and contextually relevant information (Johnson, Bransford, & Solomon, 1973; Haviland & Clark, 1974; Paris & Mahoney, 1974), and from general knowledge (Bransford & McCarrell, 1975; Harris, 1974). The generated relationships are not extraneous bits of information; they serve as functional retrieval cues for access to information stored directly during encoding as well as for reconstruction of other potential relationships.

The effectiveness of various retrieval cues for memory permits one to infer the nature of the trace or representation of the event.

Presumably, only those cues that are part of the schema or memory presentation will be effective for retrieval (Barclay, Bransford, Franks, McCarrell, & Nitsch, 1974; Tulving & Watkins, 1975). On this basis, one would expect that the memory representation achieved with minimal inferential processing would contain less information, fewer relational associations, and fewer points of access. Young subjects in th studies appear to generate such "impoverished traces" because they do not construct implied relationships as a customary operation of encoding or did not have the implied relationship as objective, normative information. Their understanding and memory is consequently diminished.

Why didn't the young subjects infer instrumental relations which they knew? One explanation can be sought in the processing demands of the task as perceived by the children. Young children simply do not approach laboratory memory tasks with strategic plans. Their goal appears to be a monitoring task whereby the words in the sentence are repeated and "checked off" as a comprehensible sentence. Their task is accomplished at this point and the sentence is not rehearsed, monitored, or re-comprehended again. The goal of the child's behavior does not appear to involve strategies directed towards storing the experience for later retrieval (Brown, 1975; Kreutzer, Leonard & Flavell, 1975; Smirnov & Zinchenko, 1969).

Older subjects approach memory tasks, and perhaps artificial laboratory procedures and tasks in general, with a different set of intentions and metamemorial plans which permit the application of deliberate processing strategies. One can "rig" the task, as we did in Experiment B_3, so that the subject must process the implied relationships because they now become an inextricable part of the child's goal-oriented behavior. This procedure forces the child to do more than evaluate the sentence as a legitimate piece of information and do more than repeat the words. The child must recursively operate on the information in order to derive semantic relationships and to integrate explicit and implicit knowledge. These self-monitoring and recursive operations of comprehension may be the critical aspects of developmental changes in constructive processing (Flavell & Wellman, in press; Paris & Lindauer, in press). The operations may not have to be part of a conscious plan to remember. As long as the comprehension strategy is executed as part of the goal of the task and the information is elaborated and embellished, good memory usually results (Smirnov & Zinchenko, 1969). The developmental differences in these studies may be partly attributable to the older subjects' recognition of the value of inferential processes, their deliberate employment of such strategies, and the age-related changes in the perceived objectives of the task. Future research on children's inferential processes of memory should investigate developmental changes in comprehension of a range of semantic inferences, the role of metamemorial plans in age by strategy interactions, and "ecologically valid" tasks which permit ready extrapolation to children's everyday tasks and processing demands.

C. Children's Comprehension of Inferences in Prose

1. Children's Memory for Inferential Relationships in Prose. (Paris & Upton, 1976)

There is some evidence to show that children can integrate incoming information on the same bases as adults (Barclay & Reid, 1974; Paris & Carter, 1973; Paris & Mahoney, 1974; Trabasso, Riley & Wilson, 1975). It is important to ask, however, what the limits of this integration are; to seek a taxonomy of integrative bases. Any taxonomy of inferences is somewhat ad hoc because there is little theory or data available to help differentiate the various relationships. Part of the problem involves the lack of well-specified definitions of inferences and the semantic differentiation among inferences. Most inferences are probabilistic in nature and the likelihood of an inference being made or accepted varies greatly within a class of inferences as well as between inference types. The flexibility of language in the semantic expression of various inferences as well as between inferences mitigates against a rigid definition of types of inferences as unitary classes; however, the operations of the comprehender may afford some distinguishing characteristics of inferences. Inferential information in general differs from verbatim information because it requires the subject to construct additional relationships consistent with the context of the explicit statement. In this study, Experiment 1, the four inferences (as suggested by Glanzman & Pisoni, 1973) differed with regard to the breadth of the context on which they were based. The semantic entailment and implied instrument inferences were constrained primarily by single lexical items, nouns and verbs, respectively. Inferences of presupposition and consequence depended on sentential and intersentential relations to specify plausible temporal and causal sequences. Thus, the operation of effort or level of processing (cf., Bransford & McCarrell, 1975; Craik & Lockhart, 1972) differentiates the tasks of understanding implicit and explicit information and the additional variable of breadth of contextual constraint distinguishes what we have termed lexical and contextual inferences.

Our initial concern in this study was simply to determine age-related changes in children's memory for the implicit and explicit information in prose. Despite the large variations in difficulty and acceptability of inferences, we sought to determine if children of successive ages would improve their understanding of the same relationships that were exemplary of different linguistic inferences. We constructed paragraphs containing particular explicit and implied relationships, read them aloud to elementary school children, and assessed their understanding through directed questions.

Method

Subjects

The 72 participants in this study attended public elementary school in rural Indiana. Six males and six females were selected

randomly from each grade, "K" through fifth. The chronological ages were: Kindergarten, mean = 64.6 mos.; grade 1, mean = 82.5 mos.; grade 2, mean = 94.9 mos.; grade 3, mean = 106.8 mos.; grade 4, mean = 114.2 mos.; grade 5, mean = 125.4 mos.

Stimulus Materials

The materials consisted of six prose passages, each followed by a set of eight yes-no questions. The prose passages ranged from seven to nine sentences with 13 to 16 clauses and described such childhood topics as going to school, having a picnic, and raiding the cookie jar. An example passage is given below.

> Chris waited until he was alone in the house. The only sound he heard was his father chopping wood in the barn. Then he pushed the red chair over to the sink which was full of dishes. Standing on the edge of the sink, he could just barely reach the heavy jar. The jar was behind the sugar and he stretched until his fingers could lift the lid. Just as he reached inside, the door swung open and there stood his little sister.

Half of the questions for each story interrogated specific verbatim information and half questioned inferential relationships. The categories are described below.

Verbatim

1. Prenominal adjectives. Certain nouns in each story were modified by adjectival specification of color, quantity or other concrete, nonbinary attributes, e.g., the heavy jar, the red chair. The child's ability to retain this information was measured through a verbatim interrogation of the noun's attribute (Was the jar heavy?) or through a question which employed an incorrect adjective (Was the chair brown?).

2. Locative prepositions. Spatial relationships between two nouns were specified in the stories with locative prepositions, e.g., father in the barn, jar behind the sugar. These questions were also formed by interrogated transformations of the original sentences, e.g., Was Chris' father in the barn?, or with a question which contained a false preposition while maintaining the same syntactic order of the sentence constituents, e.g., Was the jar in front of the sugar?

3. Presuppositions. The events detailed in the story make it necessary or highly probable that a prior action would have occurred or state-of-being would have existed. For example, from the information that Chris waited until he was alone in the house and checked to ensure that his mother was not there, one can infer that Chris did not want his parents to know what he was doing, although this presupposition is not stated explicitly in the prose passage.

4. Consequences. The events detailed in the story make it necessary or highly probable that a subsequent action will occur or state-of-being will exist. From the information that Chris saw his little sister just as he reached inside the jar, one can infer that he was "caught in the act." Questions involving consequences of action, like presuppositions, were derived from information contained in several sentences rather than from single words.

5. Semantic entailments. Lexical elements in the stories can be conceptually subsumed within superordinate classes. Statements which are valid for the member element may also be valid for the class in general. Little sisters can be conceptually subsumed within the superordinate class of girls or children. While it would be valid to infer that a girl was standing in the door, the statement that a man was standing in the door would constitute a false semantic entailment.

6. Implied instruments. Tools, containers, vehicles, or other objects are conceptually necessitated by the function or operation of certain verbs, e.g., to chop. While the implied instrument is lexically based on the verb, to some extent, it is also contextually specified by the subject, the object and various modifiers. From the information that Chris' father was chopping wood in the barn, one can infer with high probability that the father was using an ax.

It was possible to make a general distinction between those inferential items which were generated from several phrases or sentences and thus contextually based, i.e., presuppositions and consequences, and those inferential items which were generated predominantly from a single word element and thus more lexically based, i.e., semantic entailments and implied instruments. The design was balanced to incorporate this distinction by including one true and one false question per story from the categories of verbatim adjective, verbatim preposition, contextual inference, and lexical inference. Furthermore, the position in the story of the information required to answer the question was balanced as closely as possible to preclude primacy or recency advantages to any category of questions.

Procedure

The experimental task was introduced as a memory game in which the experimenter would read six short stories, each followed by a set of yes-no questions. The subjects were instructed to listen carefully and try to remember as much as they could about the stories because they would be asked questions later. The same six stories and set of yes-no questions were administered to all subjects. The experimenter read each story; the duration of story presentations ranged from 30 to 45 sec.

Results and Discussion

The percent correct responses to questions are shown in Table 6 for each grade and each interrogated category. It is evident in the

Table 6

Percent Correct Answers to Questions in Experiment 1

Question Type	Grade "K"	1	2	3	4	5
Verbatim Information						
Adjectives	64.6	70.1	72.9	75.0	79.9	84.7
Prepositions	51.4	62.5	67.4	77.8	79.2	81.2
Contextual Inferences						
Presuppositions	62.5	76.4	73.6	76.4	84.7	88.9
Consequences	48.6	59.7	68.1	70.8	84.7	91.7
Lexical Inferences						
Semantic Entailments	66.7	73.6	84.7	83.3	93.1	90.3
Implied Instruments	69.4	70.8	77.8	84.7	88.9	87.5
Total	60.5	68.9	74.1	78.0	85.1	87.4

bottom row that performance improved monotonically across the successive grades and that older children comprehended and remembered a greater amount of information from the passages than younger children. It might be argued that these data confound shifting response biases on the two-choice task with correct understanding. Indeed, kindergarten subjects responded affirmatively to 72 percent of the questions while fifth graders responded affirmatively only 48 percent of the time. In order to eliminate response bias, ds were calculated from the group data (cf., Hochhaus, 1972). These values for responses to explicit and implicit information questions revealed better performance on inferential questions than verbatim questions and also indicated that the developmental improvement was robust with regard to response bias. Due to the small number of responses per subject, it was not possible to calculate individual subject ds for each type of question. The subsequent statistical analyses were performed on each child's number of correct answers.

The data presented in Table 6 were analyzed in a repeated measures analysis of variance with both subjects and stories treated as random

effects (cf., Clark, 1973). The design of the analysis was Grade (6) x Story (6) x Interrogated Category (3) x Subjects w/Grades (12). The various questions were grouped into three categories: verbatim adjectives and prepositions, lexical inferences, and contextual inferences for the following reasons. First, the operations necessary for comprehension and memory vary for each category. Second, the amount of information within the paragraph that serves as a basis for answering the question varies by category. Third, the task assesses understanding of only a few examples of each type of semantic relationship and comparisons between these few examples of generally defined relationships appears unsound. Fourth, the data revealed considerable variability among items and stories. The purpose of this study was not to investigate characteristics of individual items but rather to compare explicit and implicit information on a more general level. That is why the data were analyzed according to the three categories or levels of processing.

The monotonic improvement in performance across age levels resulted in a significant Grade effect, quasi-F (5, 84) = 9.47, $p < .01$. The Newman-Keuls Sequential Range test indicated that significant differences for successive grades occurred between kindergarten and grade 1 and between grade 3 and grade 4. Variability in the test materials was evidenced in the significant Story effect, F (5, 330) = 14.18, $p < .01$, and the Story x Interrogated Category interaction, F (10, 660) = 12.20, $p < .01$. It is this variability which necessitated the random effect analysis.

The differences among categories of questions, as well as the Grade x Category interaction were not significant in this conservative analysis. However, the steady developmental improvement for implicit and explicit information is an artifact of pooling across stories. The analysis of variance also revealed a significant interaction of Grade x Interrogated Category x Story, F (50, 660) = 1.94, $p < .01$ which indicates that the developmental improvement on different categories was obtained in various patterns on different stories. Figure 6 shows the three categories of questions, and their age-related performance changes, for the three most difficult stories and the three easiest stories (defined by overall error rates). The individual stories are consistent with the collapsed data in that the developmental slopes for contextual inferences are steeper than the slopes for lexical inferences or verbatim questions. The interaction is present on each story at different grades which might reasonably be expected given the variability of expression of a relationship. The point of interest is the consistent interaction between contextual inference and verbatim questions for the same stories.

In the span between kindergarten and fifth grade, children's understanding of different kinds of semantic relationships improved. Although this is important descriptive information it does not specify the processes underlying the age-related improvement. Something as vague as improved memory capacity might account for the changes. The Grade x Interrogated Category x Story interaction provides tenuous evidence

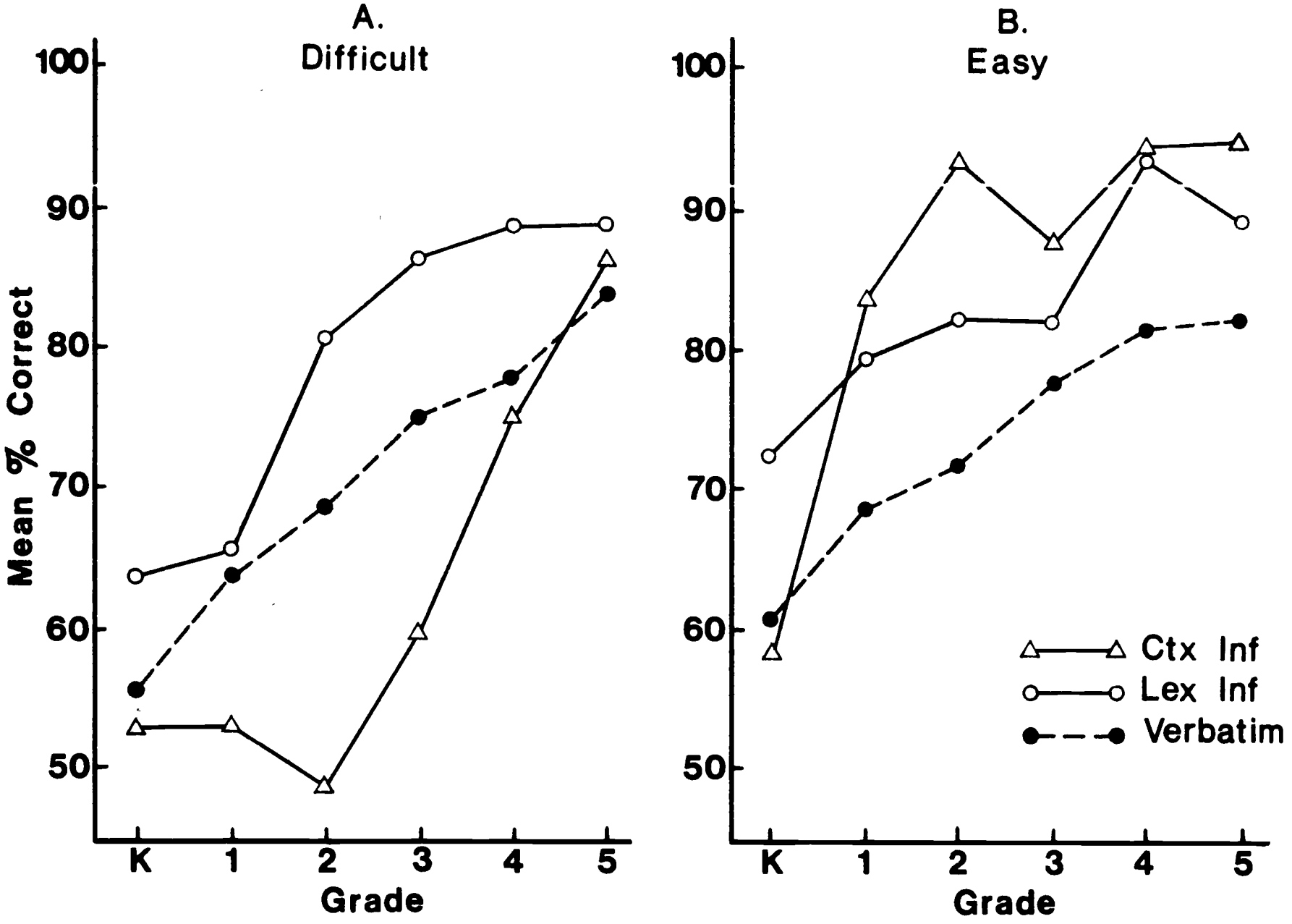


Fig. 6. Performance on question categories for easy and difficult stories.

that the knowledge required to understand and remember contextual inferences is qualitatively or quantitatively different than the knowledge required to answer other questions. If one could isolate the contribution of age-related increases in memory span, the changes in inferential reasoning with age could be identified and assessed. One method to partial out the effect of memory capacity is to perform an analysis of covariance with the performance on verbatim adjectives and prepositions as the covariate. This analysis requires at least two assumptions: (a) that responses to explicit information questions largely reflect a memory span or capacity for items and (b) that there is some equivalence between a chunk of explicit information and the chunk of explicit premise information upon which the inference is made. Acknowledging the weakness of these assumptions, we performed an analysis of covariance on the data to partial out the effects of memory improvement for explicit information. If contextual inference questions simply reflect developmental changes in memory capacity, the analysis of covariance should yield no developmental improvement. However, the covariance adjusted means for contextual inference questions did reveal significant developmental improvement, F (5, 65) = 3.42, $p < .01$. T-tests on the differences in adjusted means between kindergarten and grade 1 and grade 3 and grade 4 were significant at the .05 level. When lexical inference performance was adjusted according to performance on verbatim questions, the analysis of covariance detected no significant age-related improvement, F (5, 65) = 1.2.

This analysis suggests that the improved comprehension of contextual inferences with age may not be attributed solely to the increased memory capacity for explicit words which seems to underlie performance on verbatim and lexical inference questions. This is a tenuous inference but does suggest a plausible hypothesis that children's memory for prose relationships improves because of increasing capacity to remember individual words as well as the ability to construct inferential relationships which relate large segments of the passage to contextually valid sequences of action.

Experiment 2

In Experiment 1, children's comprehension and memory for implied information in prose improved across grades. The postulation that developmental improvement in the spontaneous application of inferential processes reflects more than increased memory capacity with age rests partially on the assumption that the verbatim items used as the covariate are a linear function of memory span. It is possible that the prenominal adjectives and prepositions were not perceived as salient bits of information by different aged children and that memory for these items reflects a different pattern than memory for the nouns and verbs involved in the inferential questions. Experiment 2 was designed to allow comparison of children's performance on questions of verbatim nouns and verbs with inferential information to test this possibility.

Experiment 2 was also designed to analyze the relationship between comprehension of implied information and children's memory for the meaning

of the paragraphs. Experiment 1 is consistent with the finding that elementary school-age children spontaneously construct inferential relationships which are integrated in their memory representations for the stories (Paris, 1975). These studies have demonstrated the constructive nature of children's understanding but have not shown the functional utility of these processes for long term memory. The present study employed a free recall task following the interrogated recall phase to assess children's memory for the ideas conveyed by the paragraph. The two tasks involved different retrieval requirements and the temporal intervals between presentation and test were different. The objective was to determine the correlation between children's initial comprehension of paragraph information in interrogated recall and their subsequent free recall of ideas derived from the passage.

Method

Subjects

Sixteen children from each of three grades, kindergarten, second, and fourth, participated in this study. Eight males and eight females were selected randomly from each grade. The chronological ages were: kindergarten, mean = 71.1 mos.; grade 2, mean = 96.8 mos.; and grade 4, mean = 120.8 mos.

Task

The easiest and most difficult stories, in overall error rate, from Experiment 1, were eliminated for brevity and the remaining four stories were presented orally to individual subjects. These stories were altered slightly to accommodate the new questions regarding verbatim nouns and verbs. The questions regarding each story were similar to those in Experiment 1 and often identical. There were four categories of explicit information questions: nouns, verbs, adjectives, and prepositions; and four categories of implicit relations: entailment, instrument, presupposition, and consequence. Types and orders of questions were counterbalanced and randomized as in the previous study.

Procedure

The procedure was identical to Experiment 1 except for a recall phase after the entire questioning task. Children were given a five-minute interpolated memory activity and then asked to recall as much of the stories as possible. Each story was identified by a title during the initial presentation and prompted before the recall phase, e.g., Tell me about the story of "Chris and the Cookie jar." Stories were recalled serially in the same order as the passage questions so that the time serially in the same order as the passage questions so that the time interval between first presentation and recall was approximately 20 min.

Results and Discussion

The results of the interrogated recall were similar to the previous study. As shown in Table 7, performance improved significantly with age

Table 7

Mean Percent Correct Responses by Question Category in Experiment 2

Category	Grade: Kindergarten	2	4
Adjectives and Prepositions	61.7	78.9	76.6
Nouns and Verbs	72.7	83.6	80.5
Contextual Inferences	60.2	78.1	80.5
Lexical Inferences	77.3	89.8	87.5

although the main difference was between the two youngest groups. The lack of improvement in the fourth-graders' performance may be traced to the wide age range of the subjects in that group and the inclusion of several relatively old children who may have had a history of school failure. The data were subjected to an analysis of variance, Grade (3) x Story (4) x Interrogated Category (4) x Subjects w/Grades (16), with both the story and subjects factors treated as random effects. This analysis revealed a significant Grade effect, quasi-F (2, 19) = 6.02, $p < .01$, which again indicated developmental improvement on all categories of questions. Newman-Keuls tests revealed the significant improvement on all categories of questions was confined to the differences between kindergarten and second-grade subjects ($p < .05$). As in Experiment 1, story variability resulted in significant effects of Story, F (3, 135) = 6.10, $p < .01$, Category x Story, F (9, 405) = 11.00, $p < .01$, and Grade x Category x Story, F (18, 405) = 1.71, $p < .05$. The grade and question category interaction varied according to individual stories but contextual inferences always revealed a greater developmental rate of change than verbatim questions.

The analysis of covariance allows the developmental trend for the verbatim covariate to be partialled out of the inferential categories. Contextual inferences showed significant age-related improvement when adjusted according to level of verbatim performance for adjectives and prepositions, F (2, 44) = 3.24, $p < .05$, while lexical inferences did

not reveal significant developmental changes. Similar patterns were obtained when verbatim nouns and verbs were used as the covariate with contextual inferences showing significant improvement, F (2, 44) = $p < .05$, while lexical inferences did not. The analyses of covariance again suggest that the developmental improvement on contextual inference questions may not be attributed to the identical processes responsible for developmental improvement on verbatim and lexical inference questions.

After the interpolated task, subjects were asked to recall as much of the story as possible. Recall data were scored for the number of idea units, roughly the equivalent of a clause or proposition, recalled per story which included verbatim recall, paraphrase, and inferences. Extraneous and erroneous elaborations were not included in the totals which showed that kindergarten subjects averaged 1.9 ideas/story, second graders--4.4, and fourth graders--9.3.

If understanding inferential relations in sentences is crucial to memory, there should be a strong relationship between initial comprehension and memory for the inferences and subsequent recall of the prose passage. We performed a step-wise multiple regression analysis to determine which category of questions predicted free recall performance best and the results are shown in Table 8. Over all grades and stories, grade accounted for 66 percent of the variance. Correctly responding to contextual inference questions was the next best predictor and both of these variables accounted for a significant amount of the variance ($p < .01$). Within grades the best predictor was always contextual inferences which was the only significant predictor for all grades. Thus, the best predictor of later recall was initial comprehension of the contextual inferences, presuppositions and consequences. Performance comparisons between grades indicated that contextual inferences were significantly better at successive grade levels ($p < .01$). Not only were contextual inferences the best predictor at each grade level but they were better and better predictors with increasing age of the children. This does not reflect the simple finding that older children recalled more of the original passages and also correctly answered contextual inference questions more often. The multiple regression analysis partialled out the successively better recall by older children and still revealed a significant correlation between recall and the ability to understand contextual inferences. Indeed, the functional utility of comprehending inferences in prose appears to increase with age and enhance recall.

Discussion

The primary finding of these studies is that the ability to comprehend and remember semantic inferences such as presuppositions and consequences improves between six and ten years of age. The developmental changes do not appear to result from changes in memory capacity alone, although both improve with age. A plausible interpretation of the developmental improvement in inferential abilities is that children change their strategies for monitoring comprehension during a story task. It

Table 8

Step-wise Multiple Regression Analysis: Percent Variance Accounted for by Each Predictor Variable Over and Above Preceding Variables

	Grade		
	Kindergarten	2	4
Rank Order of Predictors[a]	CTX-33.2*	CTX-46.2*	CTX-67.2*
	VAP-12.7	LEX-10.3	VNV- 2.9
	LEX- 2.6	VAP- 3.6	LEX- 1.5
	VNV- 0.4	VNV- 0.9	VAP- 0.0

*$p < .01$
[a]CTX = Contextual Inferences
LEX = Lexical Inferences
VAP = Verbatim Adjectives and Prepositions
VNV = Verbatim Nouns and Verbs

is a well-known fact that young children often fail to produce appropriate strategies for remembering (Flavell, 1970). When directed to use such strategies, they can remember as well as older children. Perhaps this same kind of production deficiency is evident when six and seven year olds listen to sentences or stories. They may not attempt spontaneously to interrelate information in the stories, draw potential inferences, or elaborate relationships to the same degree as older children and adults. One might characterize this as a specific strategy failure during comprehension or it may reflect a more general deficiency in the planfulness of young children. Six and seven year olds seldom engage in deliberate strategies or plans to encode and retrieve information. Their unawareness that good memory requires some comprehension strategy has been characterized as a lack of metamemorial plans and skills (Kreutzer, Leonard, & Flavell, 1975). Young children may not comprehend contextual inferences in prose easily because they may not engage strategies to "go beyond the information given" as they monitor discourse.

The present studies demonstrated a positive relationship between comprehension of inferences and memory for prose. Why is the ability to understand these general contextual inferences so critically related to total recall of a paragraph? One possible explanation concerns the time and energy expended in order to understand inferences. This may reflect Bartlett's (1932) notion of "effort after meaning" and is similar to the successively deeper levels of semantic analysis suggested by Craik and Lockhart (1972). Whether deliberate or automatic, attempts to infer

additional information appear to enhance comprehension of the original information. In addition to the cognitive effort, the derived memory representation may facilitate later recall. If a person constructs implied relationships and integrates them with original information, the derived memory representation may permit a temporally ordered, logical, sequential unit that can be stored parsimoniously and accessed readily. Although primacy and recency of the interrogated information was controlled for in the materials, presuppositions and consequences may serve as conceptual "pegs" for memory and thus serve as valuable retrieval cues from which the subject can reconstruct additional events. Experiment 2 also demonstrated that this functional relationship increases with age and that inferential comprehension is more critically related to retention of meaning from prose for older children. In the future, it may be possible to teach young children the effective use of inferential comprehension strategies and thereby promote memory in listening and reading tasks.

CONCLUSIONS

When one adopts an assimilation model of reading or listening comprehension, there are two immediate questions: "What is assimilated to what?" and "How is it accomplished?" We examined the first question rather briefly in three studies, one which provided subjects with the theme (basis) for assimilation and two which examined what subjects already possessed in the way of knowledge which could determine the ease of assimilation. The "how" of assimilatory processes consumed more pages of explication. Three studies were concerned with spatial relationships as bases for assimilation, one major project was concerned with activity (action) and its implementation as a basis for assimilation, and a third series of studies examined several other relationships between incoming information and previous knowledge. The "how" of assimilation or comprehension entails some active role on the part of the person. There are operations performed on information that embellish and elaborate the explicitly given relationships. Providing context and inferences are two operations that can facilitate comprehension and memory. These operations require "effort after meaning," a "deeper level of processing," or "a subjective, ego-centric response to the passage." The mature reader can supplement relationships within and among sentences easily in order to construct the meaning conveyed by the passage. Young children and beginning readers may need to be provided with techniques for elaborating the given information. However, it is the interaction between the reader's knowledge and the structure/content of prose which determines comprehension.

The structure and content of prose is determined by the author. The area most unresearched is the ability of the author to generate content that matches the cognitive abilities of the reader. To encourage integration, inference, elaboration, and other evidence of cognitive activity on the part of the reader is an art that we are trying to make a science. From the presente research, it is clear that children can and do act on incoming information in ways similar to adults. We found three potent interventions which facilitated these processes.

1. Common, familiar relationships are comprehended faster than uncommon or unfamiliar relationships. While this may sound like a trivial statement that simply reiterates common sense, the statement must be considered in the context of a given situation. Information is only comprehended or assimilated in light of disambiguating or elaborating an ongoing cognitive experience of the reader. This restriction probably means that the prose should be familiar or frequent (perhaps, expected) in that particular context or setting. The sentence "The horse jumped the elephant" is probably much more normal in a circus setting--animal act context than "The horse jumped the fence." Without benefit of specific context, however, normative contextual assumptions (or inferences) are in command of the comprehension process. While this discussion goes beyond the findings of the first few studies, it is not unwarranted speculation (Bransford & Nitsch, 1976).

2. Comprehension is aided if the reader acts on the information in the test. "Act" is a vague term and is used intentionally because there are many ways that one can "act" on material. There are developmental changes in the relative advantages of different kinds of acts. In one study, Paris and Lindauer (1976), found that if children acted out the action in a given sentence that it was remembered remarkably better than if it was not acted out. In another study, Paris, Mahoney, and Buckhalt found that instructions to image the sentences helped EMR subjects remember sentences considerably better. Paris and Lindauer (in press) state that "amalgamation, focusing, mapping, and inferring operations are all constructive transformations of the input which allow more complete comprehension," and later:

> devices such as chunking, rehearsal, imagery, elaboration, and use of context are different kinds of strategies that the child can apply to the event in order to understand it and relate the experience to an existing cognitive scheme. The enhanced retention that results from contextual provision, verbal elaboration of relationships, and interactive imagery attests to the value of these informationally expansive operations. All of these operations can be regarded as processing changes in the information before it is stored. Information that is presented concurrently (or serially in the case of discourse but within a small time span) undergoes constant monitoring and reorganization. The constructive process is like a recursive mapping of the event onto existing schemata.

Just as "reading" is not a unitary concept, "reading comprehension" is not a simple unitary concept. In our laboratory studies, we were interested first in understanding comprehension and then in facilitating it. It is a big, perhaps unwarranted leap from our laboratory studies where we examined single sentences or short paragraphs to the average reading situation (if there is such a thing). It is unlikely that the mature reader needs to image, act out, or otherwise deliberately act on the information in order to understand it or to remember it. Perhaps

these operations have become automatic or programmed (LaBerge & Samuels, 1974).

Information seeking and detection carried out in order to elaborate an ongoing experience are often spontaneous operations. When the abilities of the subject are limited or the structure of the passage is complex or ambiguous, these transformations must be deliberately invoked by subjects in order to comprehend the passage. Assimilation is enhanced by the cognitive effort and idiosyncratically constructed relationships. This reasoning brings us back to the third variable which can facilitate comprehension, thematic statements or advance organizers.

3. Readers benefit from being given a topic which further information will elaborate. This was the finding of the first study described in this report and has probably been one of the most consistent findings in the reading research literature. Our major contribution in this area was methodological and the finding that good and poor readers (children) seemed to benefit equally from having such information provided for them.

References

Arnold, D. J., & Brooks, P. H. Influence of contextual organizing material on children's listening comprehension. Journal of Educational Psychology, 1976, 68(6), 711-716.

Arnold, D., Brooks, P. H., & Iacobbo, M. The search for information in pictures. Paper presented at the meeting of the Society for Research in Child Development, Nashville, April 1976.

Ausubel, D. P. Educational psychology: A cognitive view. New York: Holt, Rinehart, & Winston, 1968.

Barclay, J. R. The role of comprehension in remembering sentences. Cognitive Psychology, 1973, 4, 229-254.

Barclay, J. R., Bransford, J. D., Franks, J. J., McCarrell, N. S., & Nitsch, K. Comprehension and semantic flexibility. Journal of Verbal Learning and Verbal Behavior, 1974, 13, 471-481.

Barclay, J. R., & Reid, M. Semantic integration in children's recall of discourse. Developmental Psychology, 1974, 10, 277-281.

Bartlett, F. C. Remembering: A study in experimental and social psychology. Cambridge, England: Cambridge University Press, 1932.

Bransford, J. D., Barclay, J. R., & Franks, J. J. Sentence memory: A constructive versus interpretive approach. Cognitive Psychology, 1972, 3, 193-209.

Bransford, J. D., & Franks, J. J. The abstraction of linguistic ideas: A review. Cognition: An International Journal of Psychology, 1973, 1, 211-249.

Bransford, J. D., & Johnson, M. K. Contextual prerequisites for understanding some investigations of comprehension and recall. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 717-726.

Bransford, J. D., & Johnson, M. K. Considerations of some problems of comprehension. In W. G. Chase (Ed.), Visual information processing. New York: Academic Press, 1973.

Bransford, J. D., & McCarrell, N. S. A sketch of a cognitive approach to comprehension. In W. Weimer & D. Palermo (Eds.), Cognition and the symbolic processes. Hillsdale, New Jersey: Erlbaum & Assoc., 1975.

Bransford, J. D., & Nitsch, K. E. Coming to understand things we could not previously understand. In J. F. Kavanaugh & W. P. Strange (Eds.), Implications at basic speech and language research for the school and clinic. Cambridge, Mass.: MIT Press, 1977, in press.

Brooks, P. H.. Arnold, D., & Iacobbo, M. Some cognitive aspects of reading comprehension. Peabody Journal of Education, 1977, in press.

Brown, A. L. The development of memory: Knowing, knowing about knowing and knowing how to know. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 10). New York: Wiley, 1975.

Brown, R. Words and things. New York: The Free Press, 1968.

Bruner, J. S. Organization of early skilled action. Child Development, 1973, 44, 1-11.

Carroll, J. B. Defining language comprehension: Some speculations. In J. B. Carroll & R. O. Freedle (Eds.), Language comprehension and the aquisition of knowledge. Washington, D. C.: V. H. Winston & Sons, 1972.

Clark, H. H. The language-as-fixed-effect fallacy: A critique of language statistics in psychological research. Journal of Verbal Learning and Verbal Behavior, 1973, 13, 335-359.

Cofer, C. Constructive processes in memory. American Scientist, 1973, 28(6), 537-543.

Craik, F. I. M., & Lockhart, R. S. Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 671-684.

Dooling, D. J., & Lachman, R. Effects of comprehension on retention of prose. Journal of Experimental Psychology, 1971, 88, 216-222.

Elkind, D. Developmental studies of figurative perception. In L. Lipsett & H. Reese (Eds.), Advances in child development and behavior (Vol. 4). New York: Academic Press, 1969.

Fillmore, C. J. The case for case. In E. Bach & R. T. Harms (Eds.), Universals in linguistic theory. New York: Holt, Rinehart, & Winston, 1968.

Flavell, J. H. Developmental studies of mediated memory. In H. W. Reese & L. P. Lipsitt (Eds.), Advances in child development and behavior (Vol. 5). New York: Academic Press, 1970.

Flavell, J. H., & Wellman, H. M. Metamemory. In R. V. Kail & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N. J.: Erlbaum & Assoc., in press.

Gagne, R. M. Context, isolation and interference effects on the retention of fact. Journal of Educational Psychology, 1969, 60, 408-414.

Gibson, E. J., & Levin, H. The psychology of reading. Cambridge, Mass.: The MIT Press, 1975.

Glanzman, D. L., & Pisoni, D. B. On verifying semantic inferences.

Unpublished manuscript, Indiana University, 1973.

Harris, R. J. Memory and comprehension of implications and inferences of complex sentences. Journal of Verbal Learning and Verbal Behavior, 1974, 13, 626-637.

Haviland, S. E., & Clark, H. H. What's new? Acquiring new information as a process in comprehension. Journal of Verbal Learning and Verbal Behavior, 1974, 13, 512-521.

Hochhaus, L. A table for the calculation of d' and β. Psychological Bulletin, 1972, 77, 375-376.

Horowitz, L. M., Lampel, A. K., & Takanishi, R. M. The child's memory for unitized scenes. Journal of Experimental Child Psychology, 1969, 8, 375-388.

Iacobbo, M., Brooks, P. H., & Arnold, D. Reading skills and real life experience as factors in sentence comprehension. Paper presented at the meeting of the Society for Research in Child Development, Nashville, April 1976.

Jenkins, J. J. Remember that old theory of memory? Well, forget it! American Psychologist, 1974, 29, 785-795.

Johnson, M. K., Bransford, J. D., & Solomon, S. K. Memory for tactic implications of sentences. Journal of Experimental Psychology, 1973, 98, 203-205.

Katz, J. J., & Fodor, J. S. The structure of semantic theory. Language, 1963, 39, 170-210.

Kintsch, W. Notes on the structure of semantic memory. In E. Tulving & W. Donaldson (Eds.), Organization of memory. New York: Academic Press, 1972.

Kreutzer, M. A., Leonard, C., & Flavell, J. H. An interview study of children's knowledge about memory. Monographs of the Society for Research in Child Development, 1975, 40(1, Serial No. 159).

LaBerge, D., & Samuels, S. J. Toward a theory of automatic information processing in reading. Cognitive Psychology, 1974, 6, 293-323.

Loftus, E. F., & Palmer, J. C. Reconstruction of automobile destruction: An example of the interaction between language and memory. Journal of Verbal Learning and Verbal Behavior, 1974, 13, 585-589.

McCawley, J. D. The role of semantics in a grammer. In E. Bach & R. T. Harms (Eds.), Universals in linguistic theory. New York: Holt, Rinehart, & Winston, 1968.

Milgram, N. A. Retention of mediation set in paired-associate learning of normal and retarded children. Journal of Experimental Child Psychology, 1967, 5, 341-349.

Neisser, U. Cognitive psychology. New York: Appleton-Century-Crofts, 1966.

Odom, P. B., & Nesbitt, N. H. Some processes in children's comprehension of linguistically and visually depicted relationships. Journal of Experimental Child Psychology, 1974, 17, 399-408.

Paris, S. Children's constructive memory. Paper presented at the meeting of the Society for Research in Child Development, Philadelphia, 1973.

Paris, S. G. Integration and inference in children's comprehension and memory. In F. Restle, R. Shiffrin, J. Castellan, H. Lindman & D. Pisoni (Eds.), Cognitive theory (Vol. 1). Hillsdale, N. J.: Erlbaum & Assoc., 1975.

Paris, S. G., & Carter, A. Y. Semantic and constructive aspects of sentence memory in children. Developmental Psychology, 1973, 9, 109-113.

Paris, S. G., & Haywood, H. C. Mental retardation as a learning disorder. In H. Grossman (Ed.), The Pediatric Clinics of North America. Philadelphia: W. B. Saunders Co., 1973.

Paris, S. G., & Lindauer, B. K. The role of inference in children's comprehension and memory for sentences. Cognitive Psychology, 1976, 8, 217-227.

Paris, S. G., & Lindauer, B. K. Constructive aspects of children's comprehension and memory. In R. V. Krail & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N. J.: Erlbaum & Assoc., 1977.

Paris, S. G., & Mahoney, G. J. Cognitive integration in children's memory for sentences and pictures. Child Development, 1974, 45, 633-642.

Paris, S. G., Mahoney, G. J., & Buckhalt, J. A. Facilitation of semantic integration in sentence memory of retarded children. American Journal of Mental Deficiency, 1974, 78, 714-720.

Paris, S. G., & Upton, L. R. Children's memory for inferential relationships in prose. Child Development, 1976, 47, 660-668.

Paivio, A. Imagery and language. In S. J. Segal (Ed.), Imagery: Current cognitive approaches. New York: Academic Press, 1971.

Piaget, J., & Inhelder, B. The psychology of the child. New York: Basic Books, 1969.

Potts, G. R. Information processing strategies used in the encoding of linear orderings. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 727-740.

Reese, H. Imagery and contextual meaning. Psychological Bulletin, 1970, 73(6), 404-414.

Rohwer, W. D., Jr. Mental elaboration and proficient learning. In J. P. Hill (Ed.), Minnesota Symposia on Child Psychology. Minneapolis: University of Minnesota Press, 1970.

Sachs, J. S. Recognition memory for syntactic and semantic aspects of connected discourse. Perception and Psychophysics, 1967, 2, 437-442.

Smirnov, A. A., & Zinchenko, P. I. Problems in the psychology of memory. In M. Cole and I. Maltzman (Eds.), A handbook of contemporary Soviet psychology. New York: Basic Books, 1969.

Smith, H. K. The responses of good and poor readers when asked to read for different purposes. Reading Research Quarterly, 1967, 3, 53-83

Spitz, H. H. The role of input organization in the learning and memory of mental retardates. In N. R. Ellis (Ed.), International Review of Research in Mental Retardation (Vol. 2). New York: Academic Press, 1966.

Stein, N. L., & Glenn, C. G. A developmental study of children's recall of story material. Paper presented at the meeting of the Society for Research in Child Development, Denver, 1975.

Suchman, J R. Motivation inherent in the pursuit of meaning: On the desire to inquire. In H. I. Day, D. E. Berlyne, & D. E. Hunt Eds.), Motivation. Montreal: Holt, Rinehart, & Winston, 1970.

Taylor, A. M., Josberger, M., & Knowlton, J. Q. Mental elaboration and learning in EMR children. American Journal of Mental Deficiency, 1972, 77, 69-76.

Trabasso, T., Riley, C. A., & Wilson, E. G. The representation of linear order and spatial strategies in reasoning: A developmental study. In R. Flamagne (Ed.), Psychological studies of logic and its development. Hillsdale, N. J.: Erlbaum & Assoc., 1975.

Tulving, E , & Watkins, M. J. Structure of memory traces. Psychological Review, 1975, 82, 261-275.

Turnure, J E., & Walsh, M. K. Effects of varied levels of verbal mediation on the learning and reversal of paired-associates by educable mentally retarded children. American Journal of Mental

Deficiency, 1971, 76, 60-67.

Willows, D. Influences of background pictures on children's decoding of words. Paper presented at the biennial meeting of the Society for Research in Child Development, Denver, 1975.

The following list represents publications and presented papers which were supported by NIE Grant No. NE-G-00-3-0089.

Arnold, D., Iacobbo, M., & Brooks, P. The search for information in pictures. Paper presented at the meeting of the Society for Research in Child Development, Nashville, April 1976.

Arnold, D. J., & Brooks, P. H. Influence of contextual organizing material or children's listening comprehension. Journal of Educational Psychology, 1976, 68(6), 711-716.

Brooks, P. H. The role of action lines in children's memory for pictures. Journal of Experimental Child Psychology, 1977, in press.

Brooks, P. H., & Arnold, D. J. Cognitive development in mental subnormality. In V. Hamilton & M. Vernon (Eds.), The development of cognitive processes. London: Academic Press, 1977. (Pp. 645-680)

Brooks, P. H., Arnold, D., & Iacobbo, M. Some cognitive aspects of reading comprehension. Peabody Journal of Education, 1977, in press.

Iacobbo, M., Arnold, D., & Brooks, P. Reading skills and real life experience as factors in sentence comprehension. Paper presented at the meeting of the Soceity for Research in Child Development, Nashville, April 1976.

Paris, S. G. Integration and inference in children's comprehension and memory. In F. Restle, R. Shiffrin, J. Castellan, H. Sindman, & D. Pisoni (Eds.), Cognitive theory (Vol. 1). Hillsdale, N. J.: Erlbaum & Assoc., 1975.

Paris, S. G., & Carter, A. Y. Semantic and constructive aspects of sentence memory in children. Developmental Psychology, 1973, 9, 109-113.

Paris, S. G., & Lindauer, B. K. The role of inference in children's comprehension and memory for sentences. Cognitive Psychology, 1976, 8, 217-227.

Paris, S. G., & Lindauer, B. K. Constructive aspects of children's comprehension and memory. In R. V. Krail & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N. J.: Erlbarum & Assoc., 1977.

Paris, S. G., & Mahoney, G. J. Cognitive integration in children's memory for sentences and pictures. Child Development, 1974, 45, 633-642.

Paris, S. G., Mahoney, G. J., & Buckhalt, J. A. Facilitation of semantic integration in sentence memory of retarded children. American Journal of Mental Deficiency, 1974, 78, 714-720.

Paris, S. G., & Upton, L. R. Children's memory for inferential relationships in prose. Child Development, 1976, 47, 660-668.