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AUTHOR Paris, Scott G.  
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ABSTRACT

This paper describes three studies designed to determine whether there are age-related differences in children's memory for implicit and explicit information in prose. In the first study, six experimental paragraphs were read individually to a total of 60 children in grades K-5. Each child was then asked four verbatim recall questions (specific adjectives and prepositions) and four inferential questions. The results indicated that the amount of both explicit and implicit information comprehended from the paragraphs increased with age. Due to a question about the saliency of adjectives and prepositions in sentences, the second study used verbatim recall questions with nouns and verbs. A total of 48 children in grades K, 2, and 4 participated in this study and were administered the same tasks as in the first study plus a delayed free recall task. The results showed specifically that the ability to draw and remember inferences improved with age. The third study used a cued recall paradigm to determine whether the spontaneity of inference drawing was related to age. A total of 48 children in grades 1, 3, and 5 heard action sentences with the instruments used stated explicitly in half of the sentences and only implied in the other half. They were then given a cued recall test which included the appropriate instrument nouns. Results suggested that children apply inferential operations more often and more effectively with increasing age. (JMB)

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## Developmental Changes in Constructive Memory Abilities

Scott G. Paris

Purdue University

Today, I want to discuss several studies concerning the role of inferential processing in children's memory.

Specifically, I will consider two questions:

1. Does the ability to spontaneously apply inferential processes to prose increase with age? and,
2. What is the relationship between sentence memory and inferential operations?

We know that the information that people understand from written and spoken language is not limited to a literal copy of the input string of words. Considerable research has demonstrated that adults remember the semantic relationships expressed by sentences better than the particular words or structures of the sentences (Bransford & Franks, 1971; Honeck, 1973; Kintsch & Monk, 1972; Potts, 1972; Sachs, 1967). The common theme among these studies is the emphasis on transformation of the input and distillation of the central ideas from prose. The strategies of deriving "gist" (Fislerbaum, 1966) may be abstractive (Zangwill, 1972) or constructive (Bartlett, 1932) but the important point is that the meaning derived from language is a consequent of the cognitive activities and semantic transformations applied by the comprehender.

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The inferential nature of comprehension is a focal tenet of the constructivist approach (Cofer, 1973; Jenkins, 1974), because it permits the person to "go beyond the information given" and understand implied relationships. When adults attend to prose, they typically attempt to interpret the new information with regard to pre-existing linguistic and nonlinguistic contexts (Bransford & McCarrell, 1974) and often integrate these relationships into holistic, situational memory representation (Barclay, 1973; Bransford, Barclay & Franks, 1972; Trabasso & Riley, in press). The inferred relationships are not just additional information which can be accessed but are often integrated semantic representations which appear to be constructed during encoding and assimilated to organized schemes in the Piagetian sense. Inferred semantic agents, locations, instruments, consequences of actions, and transitive linear orders have all been shown to be assimilated into the memory representations that adults have for the ideas of related sentences (Bransford & Franks, 1971; Johnson, Bransford & Solomon, 1972; Paris, Sorkin, & Pisoni, 1974; Potts, 1972).

Although several studies have demonstrated that children integrate implied information into their memory representations for sentences (Barclay & Reid, 1974; Paris & Carter, 1973; Trabasso, Riley & Wilson, in press), we still do not have evidence that the ability or propensity changes with age. These three studies employed different types of inferences, somewhat artificial stimulus materials, and vastly different paradigms, some of which may be inappropriate for developmental analyses (e.g., false-recognition paradigm).

Our first study (Paris & Upton, 1974) was an attempt to ameliorate these problems and determine if there are age-related differences in children's memory for implicit and explicit information in prose. We constructed paragraphs containing particular explicit and implicit

relationships, presented them orally to elementary grade-school children, and assessed their understanding through directed questions. We selected four different linguistic inferences to study. The first two we labelled contextual inferences because they required the amalgamation of information from several sentences. These were: presuppositions the pre-existing conditions necessary to make a sentence or paragraph true; and inferred consequences, the probable end result of a series of statements or conditions. The other two inferences were termed lexical inferences because the inferential relationship was dependent upon a single word. These included semantic entailment; a word is a subset of a larger class; and implied instruments, a verb implies a particular instrument to accomplish the action.

We constructed six paragraphs ranging from seven to nine sentences which permitted these inferences. (An example of a test paragraph and the questions are given in the handout.) The paragraphs were read to individual subjects, 12 each from Grades K through 5. Immediately after listening to a paragraph, subjects were asked eight Yes/No questions concerning the story. Four of these questions were the previously described inferences. We also asked four questions of verbatim information in order to prevent subjects from biasing their processing towards only inferential relationships and in order to provide a baseline comparison of explicit information retention. The verbatim items included pronominal adjectives such as big, new, and red and locative prepositions such as in, over, and under. The eight questions were balanced for verbatim and inferential items as well as truth-falsity within each category. The orders of paragraphs and questions were randomized for every subject.

We performed an analysis of variance (with both subjects and stories

treated as random effects) with the number of correct answers to each question by grade level. Performance significantly improved (quasi-F,  $p < .01$ ) monotonically across grades showing the sensitivity of this task to differences between children's comprehension and memory in successive grades. A response bias is often observed in young children and, indeed, our kindergarten subjects responded affirmatively to 72% of the questions while fifth-graders responded affirmatively only 48% of the time. A signal detection analysis takes response bias into account and we calculated  $d'$ 's for the data and found the same age-related improvement (shown in Figure 2).

Although inferences were answered correctly more often than factual questions, it should be noted that there was age-related improvement on the same items within all categories. We do not want to emphasize absolute comparisons among categories on this task, rather we want to ask if there is developmental improvement for the operations of inference and the spontaneous processing of implicit information above and beyond developmental increases in memory span.

In order to answer this question, we will assume that a correct answer to a verbatim question involves memory for a bit of information while a correct answer to an inferential question involves remembering the information plus performing an inferential operation. In essence, we can regard the developmental improvement on verbatim items as evidence for improvement in memory capacity and ask if the developmental effects for inferences merely parallel this curve or interact with it.

We partialled out the effects of memory improvement from the inferential operations by computing an analysis of covariance and covarying out the effects of verbatim items. When we did this, our adjusted scores, (shown in Figure 3), still revealed significant developmental

improvement in the inferential operations. The more difficult contextual inferences accounted for the majority of the improvement. This interaction appears to be independent of response bias as shown by the d's, and the greater comprehension and memory for contextual inferences with age appears to reflect more than increased memory span.

The results of this study suggest that children from six to eleven years of age increase the amount of both explicit and implicit information that they comprehend from paragraphs. Even when we take into account the variability due to paragraphs, items, and response bias, there is an increased proficiency with age of spontaneously performing inferential operations on linguistic material.

A few caveats are in order though. Certainly, comprehension and memory are related and developmental improvements in one should facilitate the other. We have tried to separate the effects in a statistical sense simply to show that children's comprehension of prose is dependent upon the operations applied to the material as well as the memory span for specific items. Also, this task assesses children's spontaneous comprehension processes and we do not wish to imply that young children cannot comprehend some of these linguistic inferences. They probably can when instructed to do so in simple tasks, but their normal comprehension strategies may not involve the implicit embellishment of information necessary for inferential comprehension and good memory.

It might be argued that our covariance analysis overemphasized the developmental improvement on inferences because adjectives and prepositions are less salient and important for the sentence meaning and therefore they were poorly remembered. We therefore revised our questions to include noun and verb categories, eliminated two stories, and ran the experiment again with 16 Ss from kindergarten, second and fourth

grade from a different school. In addition to the Ss' responses to the questions, we also required Ss to free recall the stories approximately 20 minutes later (after an interpolated task).

The results of the interrogated recall were similar to the previous study and performance improved with grade although the main difference was in the two youngest groups. There were no differences between inferential and verbatim questions in this study because the nouns and verbs were generally answered correctly more than adjectives and prepositions. However, our main concern was the analysis of covariance with nouns and verbs as the covariate. The adjusted mean % correct (after nouns and verbs effects are partialled out) showed significant developmental improvement for contextual inferences ( $p < .05$ ) and appears to reflect age-related improvement in inferencing operations.

After the interpolated task, subjects were asked to free recall as much of the story as possible. Their recall was scored for the number of idea units recalled per story which included verbatim recall, paraphrase, lexical inferences, and contextual 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. The inter-rater reliability on the scoring system, computed on individual stories according to the four categories described above, was  $r = .98$ .

We were interested in the relationship between children's performance during interrogated recall and later free recall. 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

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a step-wise multiple regression analysis to determine which category of questions best predicted free recall performance and the results are shown in Table 4. Over all grades and stories, grade accounted for 66% 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 inference, 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.

These two studies show that young children do draw and remember some inferences from prose but the ability improves with age. This appears to be a spontaneous aspect of comprehension which is applied more often and more effectively by older children in order to remember sentences. The relationship between making inferences during comprehension and subsequent good memory was correlational in the study. We wanted to find a more direct test of the developmentally emerging role of inferential operations as critical components of memory. We decided to investigate the problem with a cued recall paradigm.

The rationale behind this series of studies is that a memory cue will only be effective to the extent that it "makes contact with" a significant part of the memory representation for the sentence. If the cue is indirect and only implied by the original sentence, then it should not be effective unless the subject has already incorporated,

or can subsequently construct, the implied relation into his memory representation for the sentence. For example, if we present the sentence, "The workman dug a hole in the ground," the word shovel should be an effective memory cue only if the subject constructs the inferred instrumental relationship. Our first study simply compared the effectiveness of such instrumental cues, some explicitly stated in the sentences and some implicit. If young children do not spontaneously construct and supply inferred relations to a sentence, or are unable to do so, then one would predict a superiority of explicit cues for memory relative to implied cues. If older children do infer relations as they comprehend sentences, or during directed retrieval, then one would expect no differences between the cue types. We presented eight sentences, half with instruments explicitly stated and half implied to 16 Ss in each of grades 1, 3 and 5. The children repeated each sentence aloud after the experimenter throughout the 1st, participated in a 4 minute interpolated number-circling task, and were given a cued recall test with appropriate instrument nouns. The sentences were counterbalanced across Ss for implicit and explicit cues. The results are shown in Figure 5 and indicate a significant grade X cue-type interaction (as well as significant main effects for each factor). This interaction strongly suggests that children apply inferential operations more often and more effectively with increasing age.

There are also several controls which we ran. For instance, one could argue that the young Ss did not know the instruments that were appropriate for each sentence and therefore could not make the correct inference. We presented four pictures of common instruments with each test sentence to groups of kindergarten and first-grade children. Even the 6 year-old kindergarten Ss selected the appropriate instrument for

each sentence more than 95% of the time.

Another potential criticism is that the explicit instrument cue is an inappropriate comparison because it underestimates Ss knowledge of the sentences. We conducted another study which employed explicit subject, verb, and object retrieval cues and compared these to implicit instruments. These data are shown in Figure 6 and again reveal an age x cue type interaction such that young Ss do not access the sentences easily with implied cues and older Ss do.

The last experiment was concerned with facilitating children's memory. One might characterize the lack of inferential processing as a strategic "production deficiency" or a "shallow level" of processing. We decided to require Ss to act-out the sentences after they repeated them, because they necessarily would have to pretend to use the appropriate instrument. We constructed a ten-sentence list, five implied instruments and five explicitly stated, presented them to Ss with the action instructions, gave the usual four-minute interpolated task, and tested cued recall. Total recall for ten sentences was very good for the first-graders, 74%. A t-test revealed no difference between the number of sentences recalled with explicit cues and implied cues, 78% and 70% respectively.

In conclusion, these studies indicate that children often understand a great deal of implicit information in sentences and prose. The nature of their understanding, or operations of comprehension and memory, may be best characterized as constructive acts. These studies also suggest that the ability to spontaneously apply inferential processes to discourse increases with age from approximately six to eleven years (the age range studied in this research). Further, these processes are critically related to recall and the utility of constructed semantic encodings as retrieval cues increases with age. Hopefully, tasks such as

these have "ecological validity" and will enhance our understanding of the development of ordinary listening, reading, and comprehension skills.

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Scott G. Paris  
Purdue University

Figure 1

Linda was playing with her new doll in front of her big red house. Suddenly she heard a strange sound coming from under the porch. It was the flapping of wings. Linda wanted to help so much, but she did not know what to do. She ran inside the house and grabbed a shoe box from the closet. Then Linda looked inside her desk until she found eight sheets of yellow paper. She cut up the paper into little pieces and put them in the bottom of the box. Linda gently picked up the helpless creature and took it with her. Her teacher knew what to do.

Question type	Answer	
Adjective	Yes	1. Was Linda's doll new?
Adjective	No	2. Did Linda grab a match box?
Preposition	Yes	3. Was the strange sound coming from under the porch?
Preposition	No	4. Was Linda playing behind her house?
Presupposition	Yes	5. Did Linda like to take care of animals?
Consequence	No	6. Did Linda take what she found to the police station?
Entailment	No	7. Did Linda find a frog?
Instrument	Yes	8. Did Linda use a pair of scissors?

Figure 2:  $d'$ 's for Verbatim and Inferential Questions by Grades

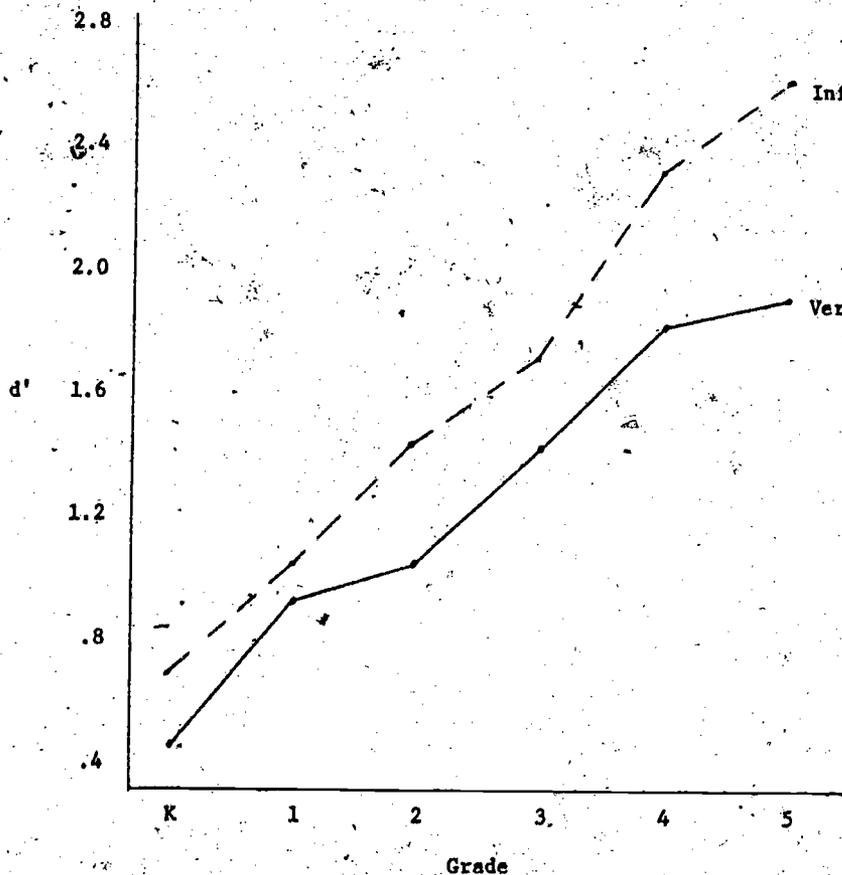


Figure 3: Adjusted Mean % Correct Responses for Contextual and Lexical Inferences (Verbatim items were the covariate)

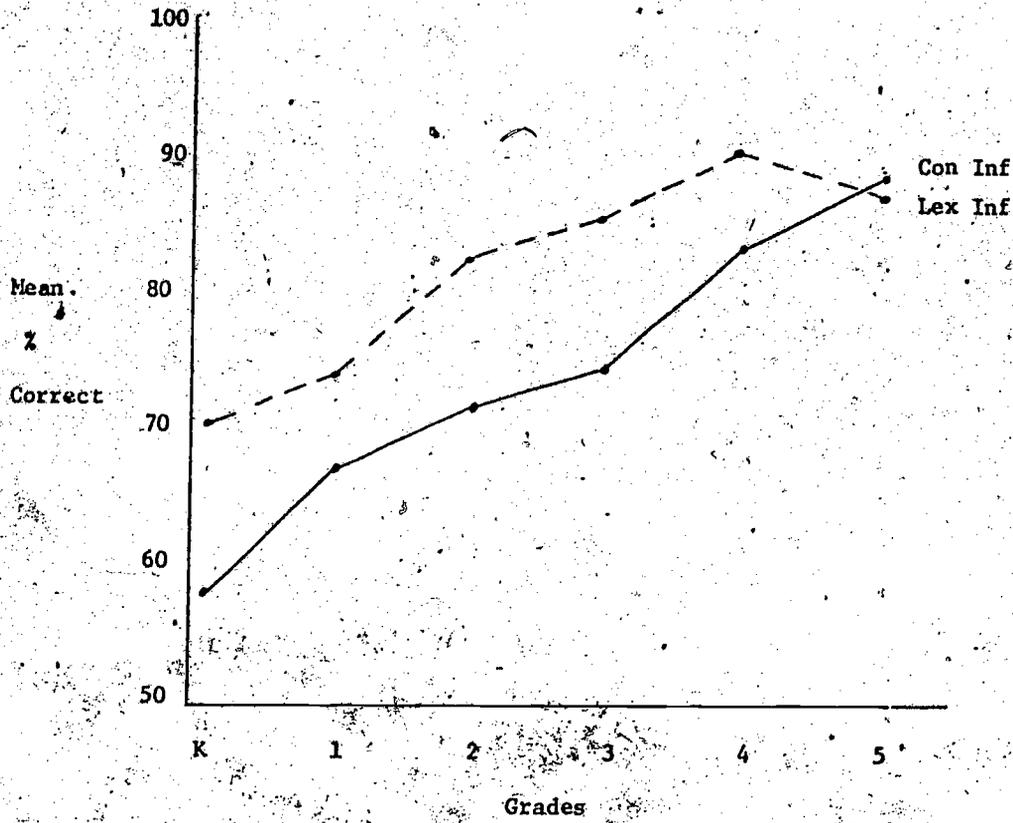


Table 1: Adjusted Mean % Correct Responses for Contextual and Lexical Inference Questions Exp. II (Verbatim nouns and verbs as covariate)

Questions	Grade			Quasi-Es
	K	2	4	
Contextual Inferences	60.6	77.8	80.4	p<.05
Lexical Inferences	78.3	89.1	87.3	p<.05

Table 2: Multiple Regression Analysis  
% Variance Accounted for by Each Predictor Variable

Rank Order of Predictors	Grade			Total
	K	2	4	
				Grade-65.8*
	CTX-33.2** ↔	CTX-46.2* ↔	CTX-67.2	CTX-10.3*
	VAP-12.7	LEX-10.3	VNV- 2.9	VAP- 0.3
	LEX- 2.6	VAP- 3.5	LEX- 1.5	LEX- 0.2
	VNV- 0.4	VNV- 0.9	VAP- 0.0	VNV- 0.2

\*p<.01  
\*\*p<.05

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Table 3  
Percent Correctly Recalled Sentences

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

Table 4  
Percent Correctly Recalled Sentences

Retrieval Cue	Grade		
	K	2	4
Explicit (S,V,O)	38.5	41.7	61.5
Implicit (I)	21.9	37.5	68.8