Constructive Aspects of Children's Reading Comprehension

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KAIL, ROBERT V., JR.; CHI, MICHELENE T. H.; INGRAM, ALBERT L.; and DANNER, FRED W. *Constructive Aspects of Children's Reading Comprehension.* CHILD DEVELOPMENT, 1977, **48,** 684–688. The focus of the present study concerned developmental and individual differences in children's ability to make inferences from prose. Children in grades 2 and 6 read several paragraphs, each consisting of 3 sentences. 2 sentences within each paragraph were premises from which an inference followed directly, while the third sentence was a filler, unrelated to the inference. Following the third sentence of each set, children read and answered 2 questions, 1 dealing with information contained in the premises, the other with information that could be inferred from the premises. Accuracy did not change with age and was greater than chance for both premise and inference information. Premise questions were answered faster than were inference questions, and true questions were answered faster than false questions. These effects did not interact wih age. Reading comprehension scores for 12-year-olds were related significantly to response times for both types of questions, even when reading speed was held constant.

Becoming a proficient reader involves the acquisition of a host of information-processing skills. A considerable amount of recent research has investigated the development of these component skills, in particular those concerning decoding of printed material. Substantially less attention has been paid to the development of skills necessary for comprehension, such as inference. Adults seem to make inferences from prose easily and regularly (Kintsch 1974); there is considerably less evidence concerning children's ability to do so. When 7–10-year-olds hear related sentences, such as, "The airplane flew over the city" and "The city was Chicago," later they are likely to say they had heard, "The airplane flew over Chicago" (Paris & Carter 1973). The latter sentence was not presented in fact but represents an inference derived from the two sentences that were presented. Surprisingly, skilled readers are not as likely as less skilled readers to report having heard sentences that are inferences (Waller 1976).

The purpose of the present research, like that of Paris and Carter (1973) and Waller (1976), was to investigate children's ability to make inferences from prose. Children from grades 2 and 6 read several paragraphs, each consisting of three sentences. Two sentences within each paragraph were premises from which an inference followed directly, while the third sentence was a filler sentence, unrelated to the inference. The manner in which inference making was measured differed from the previous studies. First, both Paris and Carter (1973) and Waller (1976) assessed inference making 5 min after the sentences had been presented by measuring the extent to which children falsely recognized novel sen-

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tences that were inferences from sentences heard previously. We assessed inference making directly by asking children two questions immediately after they had read the paragraph. One question dealt with information contained in the premises, the other with information that could be inferred from the premises. For example, given the sentences presented above, children would have been asked, "Did the airplane fly over Chicago?" Thus, we were not asking children whether they had actually heard that sentence, but whether it was semantically consistent with what they had heard. Second, latency of response for each question and reading time for the entire set of sentences were measured.

Thus, the present experiment was designed to provide data relevant to three questions: (1) Are there developmental changes in children's ability to make inferences during oral reading? (2) Are there developmental differences in the times required to answer premise and inference questions? (3) What are the relations between a psychometric measure of reading comprehension and response times on premise and inference questions?

Method

Materials.—Three types of paragraphs were constructed: (*a*) those that allowed transitive inferences to be made, (*b*) those that allowed contextual inferences to be made, and (*c*) untested, filler paragraphs which were included to conceal the structure of the other paragraphs. Each paragraph consisted of three sentences. In inferential paragraphs, two sentences were premises from which an inference followed directly. The third sentence was a filler sentence that provided additional information concerning the subject of one of the premises but was unrelated to the inference to be made. Filler sentences were included to make the relation between the two premise statements less obvious. Across paragraphs, filler sentences appeared as the second or third sentence with equal frequency.

Sentences in transitive inference paragraphs were of the type, A-relation-B, B-relation-C, thus allowing the inference, A-relation-C. One such story was the following:

> The bird is inside the cage. (Premise.)
> The cage is under the table. (Premise.)
> The bird is yellow. (Filler.)

Thus, children could infer: The bird is under the table. In paragraphs dealing with contextual inferences, an action was described in each premise; the inference could be derived by integrating these actions. For example:

> Mary was playing in a game. (Premise.)
> She was hit by a bat. (Premise.)
> Mary cried out in pain. (Filler.)

The inference here would be: Mary was playing baseball.

Eight instances of each type of paragraph were prepared, thus yielding a total of 24 paragraphs and 72 sentences. Four questions were constructed for each inferential paragraph. Two questions dealt with information contained in the premises, two with information that could be inferred from the premises. Yes was the correct answer for one of each type; no for the other. For example, the following four questions were prepared for the transitive inference paragraph described above:

Is the cage under the table? (True premise.)
Is the cage on top of the table? (False premise.)
Is the bird under the table? (True inference.)
Is the bird on top of the table? (False inference.)

Questions for which the correct answer was no were constructed by changing a critical verb or preposition. Thus, in the transitive inference example in which the cage was under the table, the false question asked if the cage was on top of the table. Questions for each paragraph were constructed so that they contained approximately the same number of words.

The 24 paragraphs were presented in a fixed order. Each type of paragraph appeared in every block of three paragraphs. Order within a block was random. Each paragraph was followed immediately by two questions: one premise and one inference. In each block of three paragraphs all four types of questions were asked once, in a random order. Across children the four types of questions for each story were presented the same number of times.

Apparatus.—Sentences and questions were mounted individually on slides and projected onto a blank wall approximately 1 m from the child. Sentences appeared as black letters on a white background; questions, white letters on a black background. Different background colors were used to start separate timers. Each presentation of a sentence activated a photocell, starting a Hunter timer, which stopped when the slide went off. When a question appeared, a second photocell and timer assembly was activated, which stopped when

the child pressed either response button mounted on a box placed on a desk where the child sat. Each of the response buttons was paired with yes and no for half of the children. Above the response buttons was a larger button used to advance the projector. Children pressed all buttons with the index finger of their preferred hand.

Procedure.—Children were told that the purpose of the experiment was to find out "some things about how children your age read." Children were told to read all sentences aloud and that periodically a question would appear to determine "how well you understand what happened in the story." They were to read the question aloud, then press the correct button. Instructions emphasized answering correctly as quickly as possible. Children practiced on a set of unrelated sentences and on two practice paragraphs until they clearly understood the task. The first sentence was presented by the experimenter; thereafter the child controlled rate of presentation of the 72 sentences and 32 questions. A short break occurred halfway through the series while the experimenter changed slide trays. The entire session lasted approximately 15–20 min.

Participants.—Thirty-two children, 16 second graders (median CA = 7-11) and 16 sixth graders (median CA = 12-1) from a school serving a middle-class community were tested individually. Approximately equal numbers of boys and girls were tested.

Results

Three aspects of the data are of particular interest: accuracy for the four types of questions, reaction times for correct responses, and the relation between reaction times and reading comprehension scores. Preliminary analyses revealed that performance was similar for boys and girls and for transitive and contextual inferences. Consequently, in all analyses reported here, data were summed across these variables.

Accuracy.—The mean number of correct responses for each of the four types of questions is presented in figure 1 for 7- and 12-year-olds. Children answered questions referring to premises more accurately than those referring to inferences, $F(1,30) = 15.48$, $p < .01$. This result is qualified, however, by a significant interaction between type of question and truth value, $F(1,30) = 26.86$, $p < .01$.

FIG. 1.—Number correct as a function of age for four types of questions.

Children were more accurate on true premises than on false premises, while the reverse held for inferences.

More important for the purposes of the experiment are two other findings. First, performance did not change with age, as the main effect of age and all interactions involving age were insignificant, F's < 1. Second, performance was greater than chance levels (i.e., four correct) on all four types of questions, t's$(15) \geq 4.11$, $p < .01$, for 7-year-olds, and t's$(15) \geq 4.18$, $p < .01$, for 12-year-olds. In other words, children at both age levels were quite able to answer questions that dealt with either information they had read or that could be inferred from what they had read.

Response times.—Four median response times were computed for each child, one based on response times on correct responses to each of the four types of questions. Overall, older children answered questions 1,073 msec faster than younger children. However, since children read questions aloud, and since the average reading time per sentence was much lower for 12-year-olds (3.04 sec) than 7-year-olds (4.39 sec), $t(30) = 5.60$, $p < .01$, it is likely that a major component of age differences in response time was reading time. Consequently, an analysis of covariance was computed for latencies, with age, type of question, and truth value as factors, and with reading time per sentence as the covariate.

As can be seen in figure 2, when reading time is covaried, 12-year-olds answered slightly, but not significantly, faster than 7-year-olds, $F(1,29) = 2.47$, $p > .10$. Children answered

FIG. 2.—Mean response time as a function of age for four types of questions, adjusted for reading speed.

premise questions more rapidly than inference questions, $F(1,30) = 31.29$, $p < .01$, and true questions more rapidly than false questions, $F(1,30) = 12.46$, $p < .01$. At both age levels, 15 of 16 children answered more rapidly on premise questions than on inference questions; 10 of 16 children answered more rapidly when the correct answer was yes. Thus, the group means reflect the performance of most children quite accurately.

In contrast to the main effects, all interactions were insignificant. It is particularly interesting that all interactions involving age were insignificant, F's < 1.32, for this would suggest that the time required to process inferences and negatives changes little between ages 7 and 12 years.

Relation between reading comprehension scores and response times.—Reading comprehension scores from the Iowa Test of Basic Skills were available for 15 of the 16 12-year-olds. Correlations between these scores and response latencies (summed across truth value) were $-.79$ and $-.60$ on premise and inference questions, respectively. Further, comprehension scores were related to response latencies ($p < .05$) even when the average reading time per sentence was partialed out: $-.64$ (premises) and $-.54$ (inferences). Thus, the question-answering and inference-making skills studied here would appear to be important components of reading proficiency as assessed by a standard achievement test.

Discussion

The important features of the results can be summarized quickly. First, neither accuracy nor response latency on the four types of questions varied with age. Second, processing times for both premise and inference questions related significantly to a measure of reading comprehension for 12-year-olds. Both of these findings deserve comment.

The absence of developmental differences in accuracy and latency clarifies the findings of Paris and Carter (1973), described in the introduction, in which recognition of sentences presented previously was tested. In that study, children in grades 2 and 5 falsely "recognized" approximately 60% of the sentences that had not been presented but that were semantically consistent with sentences presented. However, as Paris and Lindauer (in press) have noted, failure to find developmental differences in this context does not necessarily mean that inferential skills did not change with age. This is the case because improvement in memory skills with age would lead to a decline with age in false recognition of novel inferences, while improvement in inference making would lead to an increase in false recognition of inferences. A combination of both developmental changes might well produce an overall pattern of no developmental change. In contrast, with the procedures used in the present study, increased retention and inference making with age would both lead to increased accuracy of performance with age. Nevertheless, neither accuracy or speed of inference making changed developmentally in the present study. Thus, our results resolve some of the ambiguity surrounding Paris and Carter's (1973) conclusions.

The correlations between reading comprehension scores and processing times for premise and inference questions are of interest. With reading time partialed out, response time presumably includes the times necessary (*a*) to search working memory for information relevant to the question, and (*b*) to compare the retrieved information with the question. Thus, it would appear that higher scores on the measure of reading comprehension are associated with faster retrieval and comparison times in working memory. Such a conclusion is consistent with other recent evidence on the role of working memory in reading comprehension—capacity of working memory per se apparently is not critical; what does seem to be important is the ease with which an individual manipulates linguistic information

in working memory (e.g., Perfetti & Goldman 1976).

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