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Structural Components of Reading Time and Recall for Sentences in Narratives: Exploring Changes With Age and Reading Ability

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Multiple regression techniques were used to examine whether indexes of cognitive processes known to affect adults are also related to sentence reading times and recall of children. In a self-paced task, good and poor readers in Grades 5 and 7 read narratives presented one sentence at a time. For all readers, longer reading times were associated with indexes of microstructure processes (e.g., words, propositions). Poor readers in both grades differed from good readers in that shorter reading times were associated with macrostructure processes (e.g., causal relations), providing correlational evidence for a compensatory role in reading. Independent of reading skill, younger children differed from older children in that greater numbers of causal relations were associated with better sentence recall. The role that knowledge of causal relations may play in developmental change and individual differences in reading speed and recall is discussed.

In the context of information-processing models of reading, it is assumed that understanding texts involves the coordination of a number of component processes ranging from lexical access to the application of schemata for discourse types. Research with adults has begun to show how these various components jointly affect aspects of performance such as reading time and recall (e.g., Graesser, Hoffman, & Clark, 1980; Haberlandt & Graesser, 1985; Just & Carpenter, 1980; Vipond, 1980). However, researchers are only in the preliminary stages of examining how component processes jointly affect the performance of children (e.g., Aaronson & Ferres, 1984; 1986; Bentz, Baker, & Petros, 1987; Bentz & Petros, 1986; Bisanz, Das, Henderson, & Varnhagen, 1985).

The present study is an exploratory one. In this research, we used multiple regression techniques to examine whether indexes of component processes known to affect adults also affect the reading speed and recall of children. We examined the performance of good and poor readers in Grades 5 and 7 as they read and recalled well-formed, similarly structured narratives. Our primary goal was to determine whether indexes of component processes differentially affect the reading time and recall of sentences and whether these effects vary with age and reading skill. We hoped to identify qualitatively different patterns of performance on these measures, which related to developmental change and individual differences. Patterns of this type, identified in the context of the joint effects of component processes, would clearly warrant further study.

A distinguishing feature of this study is the comparison of the contributions of the multiple component processes to both reading time and recall. These two measures have predominated the field of reading research, with recall commonly used as an index of comprehension. However, seldom have reading time and recall been analyzed in a single study in a manner that allows direct comparisons (but see Carpenter & Just, 1981; Keenan, 1986).

In applying multiple regression techniques, (a) we assume that a given component process influences reading time or recall in a linear fashion (a potentially incorrect assumption); and (b) we recognize that the procedure, as we use it, will not uncover possible multiplicative relations between component processes that may affect performance (cf. Haberlandt & Graesser, 1985). An additional limitation is that we use structural properties of the text as indexes of a psychological process or clusters of component processes, a procedure that could be viewed as somewhat indirect. Similar to other investigators (e.g., Graesser, 1981; Graesser & Riha, 1984; Haberlandt & Graesser, 1985), however, we feel that the general approach of multiple regression analysis provides a useful step toward understanding the ways in which aspects of children's performance are affected by variables that reflect the joint action of component processes in reading.

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To interpret our regression analyses, we make some tentative assumptions about the nature of skilled reading in adults, as well as about the nature of developmental change and sources of individual differences in reading skill. We assume that the joint action of component processes in skilled adult readers is best characterized by a restricted interactive model (e.g., Perfetti, 1987). In such a model, text is comprehended on the basis of the information synthesized simultaneously from several knowledge sources (e.g., feature extraction, orthographic knowledge, syntactic knowledge, semantic knowledge, knowledge of discourse structure). As contrasted with a fully interactive model, however, this view acknowledges the possibility that interactions among knowledge sources may be constrained by modular systems. Modular systems are those that are fast, automatic, and informationally encapsulated (Fodor, 1983). For example, some investigators have provided evidence that word recognition may constitute such a system in fluent readers (e.g., Kintsch & Mross, 1985; Seidenberg, Waters, Sanders, & Langer, 1984). Other investigators have pursued the hypothesis that a flaw in a reader's word recognition module is the core problem in dyslexia (for a review, see Stanovich, 1989).

With respect to developmental change and individual differences, we assume, in accordance with Stanovich (e.g., 1980, 1986, 1989), that the various component processes in reading can operate in a compensatory manner for less skilled readers, whether they are young children or older readers with skill deficiencies. As Stanovich (1980) indicated, the compensatory hypothesis allows us to explore the possibility that, under certain conditions, "higher-level processes can actually compensate for deficiencies in lower-level processes" (p. 36). Stanovich (1980), for example, provided compelling evidence that poor readers use the information in sentence contexts to speed word recognition, whereas good readers exhibit rapid, context-free word recognition (see also Bruck, 1988). This effect is most evident when reading materials are within the range of poor readers' capability, with the relative ease of decoding rendering contextual information more readily available. Similarly, Adams and Higgins (1985) demonstrated that providing context improves decoding accuracy in poor and good readers in Grades 2–5.

With these assumptions serving as a basis for interpretation, regression analyses permitted us to explore similarities and differences in patterns of component processes that contribute uniformly or differentially to reading time among groups of children differing in grade and reading ability. Of importance in determining these patterns were the theoretically derived indexes of knowledge of causality and discourse structure (e.g., causal chains, story grammar categories) that we used. Previous research has shown that various types of poor readers have few difficulties with memory tasks that tap their knowledge of story structure. Difficulties arise instead on problem-solving tasks that require use of knowledge of causality to deal with the relational properties of stories (e.g., Fitzgerald, 1984; Rahman & Bisanz, 1986). Use of these theoretically derived measures provides the first opportunity, of which we are aware, to explore whether there is correlational evidence in an on-line sentence reading task consistent with compensatory processing at the level of knowledge about text structure or causality.

A weakness of previous studies in which multiple regression techniques were used to study reading time in children and adults is the nature of the indexes of higher level knowledge used (e.g., Bentz et al., 1987; Bentz & Petros, 1986; Graesser, 1981; Haberlandt & Graesser, 1985). Danks (1986) referred to the tenuous link between (a) some of the predictor variables in these studies and (b) theoretically motivated component processes as the construct validity problem. A similar problem is evident in the suggestive evidence provided by Jackson and Biemiller (1985) that precocious readers can effectively compensate for weak bottom-up skills with higher level knowledge. This conclusion was based on patterns of performance on separate tasks designed to assess the efficiency of component processes. Again, however, the evidence for use of higher level knowledge was measured quite grossly. Jackson and Biemiller suggested that further research directed toward identifying the higher level component processes that enable this compensation may lead to more effective remediation for some groups of poor readers (cf. Rahman & Bisanz, 1986).

Thus, beyond the initial goal of examining the differential effects of component processes on children's reading time and recall, a second, more specific goal of our work was to use theoretically motivated indexes of higher level knowledge and a single task that would allow us to examine the patterns of correlations among indexes of processes. We wanted to determine (a) whether there was evidence for higher level compensatory processing in the readers we studied and, if there was such evidence, (b) which higher level process or processes contributed to the effect. Later in this article we argue that evidence consistent with such processing is available in the finding that indexes of knowledge of text structure and especially of causality predict the sentence reading times of poor readers but not of good readers as they read passages within the range of their capability.

Component Processes Examined

On the basis of previous research, we selected variables that index eight components of reading as likely candidates to affect reading time, recall, or both. We refer to four of these as *microstructure components,* defined as variables that correspond to structural units or subprocesses hypothesized to be operative within sentences. Four of the components we selected are *macrostructure components,* defined as variables that index structural units or subprocesses that interrelate sentences and determine the cohesion of the passage as a whole.

Microstructure Components

Words. Although structural units smaller than the word (e.g., letters, syllables) can affect reading time (e.g., Graesser, 1981; Just & Carpenter, 1980), these variables are highly correlated with number of words per sentence. Given the importance of the word as a unit of processing in theories of skilled reading and given that word recognition processes have been implicated in reading difficulties (e.g., Just & Carpenter, 1980; Perfetti, 1985; Stanovich, 1986, 1989), one component we examined was the way in which the number of words per

sentence affected reading time and recall. We interpreted the slope of the word component as an index of the time it takes to access word units on the basis of letter, syllable, or whole word codes. Depending on the age and skill of the reader, the slope of the word component may also index changes in the nature of word encoding (e.g., Kraut & Smothergill, 1986) or the effects of other sources of knowledge activated by the sentence context (e.g., Stanovich, 1980). S. E. Taylor (1965) found that children in Grades 1 through 7 read from 80 to 195 words per minute. Using regression procedures to analyze reading time, Graesser et al. (1980) determined that the reading time for slow-reading adults ranged from 198 ms to 227 ms per word and that the reading time for fast-readers ranged from 114 ms to 135 ms per word depending on the task (see also Graesser & Riha, 1984).

Mean frequency of content words. The log frequency of content words in a sentence has been shown to affect the reading time of adults (Just & Carpenter, 1980). In Just and Carpenter's work, the Kucera and Francis (1967) norms were used, and a log transformation was used to adjust for the effects of frequent and infrequent words. Because the words we used in our study were all fairly frequent and because our subjects were children, we used the Thorndike and Lorge (1944) norms to derive the mean frequency of content words in a sentence. We included this measure to assess the effects of the average frequency of content words in a sentence independent of other factors that affect lexical access, such as those that may be indexed by number of words per sentence.

Propositions. Another component we examined was number of propositions per sentence. As did Graesser et al. (1980), we used Kintsch's (1974) propositional analysis (described in Turner & Greene, 1977). We took the slope of the proposition component to index processes associated with the assembly of propositions in working memory for each sentence (cf. Perfetti, 1985). Kintsch and Keenan (1973) reported that reading times for adults increase linearly with the number of propositions in passages. Subsequently, Keenan and Brown (1984) found that the reading times for average and good readers in Grades 3 and 5 also increased linearly with number of propositions. However, the materials in both of these studies consisted of either unrelated sentences or paragraphs, and the effects of other potentially important variables were not partialed out. Graesser et al. (1980) determined that the reading time for slow-reading adults ranged from 191 ms to 238 ms per proposition and that the reading time for fast readers ranged from 75 ms to 122 ms per proposition, depending on the task (for related findings see Graesser & Riha, 1984).

Syntax. Because there are known effects of clause boundaries on processing (e.g., Aaronson & Scarborough, 1976; Haberlandt & Graesser, 1985; Mitchell & Green, 1978), the fourth component we examined was the syntactic complexity of sentences. Linguistic analyses of syntactic complexity are generally imposed on the sentence as a whole, whereas psychological analyses generally attempt to capture the strategies that are used as sentences are read from left to right. Graesser et al.'s (1980) attempt to develop a psychological measure of syntactic predictability based on "augmented transition network" parsers was not notably successful in predicting the sentence reading times of adults (see also Graesser & Riha, 1984; Haberlandt & Graesser, 1985). In addition, an analysis of sentences into structural units as small as adjectival and adverbial clauses would produce units that are somewhat redundant with the propositional analysis we used. Because of the relatively large pauses known to occur at major clause boundaries, we used a structural unit—number of main and subordinate clauses per sentence—to operationalize this measure.

Macrostructure Components

New-argument nouns. The first macrostructure component examined was number of arguments in a sentence introduced into the passage for the first time. An argument is a noun referring to a character, object, location, or basic concept. It has been hypothesized that additional time and effort are needed to integrate these nouns with previous sentences in the text (e.g., Graesser et al., 1980). Therefore, we took the slope of this component as an index of the time it takes to integrate a new-argument noun with previous information in the passage. Keenan (1986) found that children in Grades 4 and 6 take longer to read passages with many different new-argument nouns than passages with few such nouns. Graesser et al. showed that the number of new-argument nouns is predictive of adults' reading time for sentences, although it does not differentiate the performance of slow and fast readers (for a discussion of related work, see Haberlandt, Graesser, Schneider, & Kiely, 1986).

Causal relations. Relational thinking is believed to be fundamental to story comprehension (e.g., Black & Bern, 1981; Stein & Glenn, 1979; Trabasso, Secco, & van den Broek, 1984; Trabasso, van den Broek, & Suh, 1989). According to this view, narratives make sense because readers use their naive theories of psychological and physical causality to connect statements in ways constrained by story settings. Trabasso and his colleagues (e.g., Trabasso et al., 1984, 1989; Trabasso & van den Broek, 1985; van den Broek, 1988) have developed procedures for analyzing narrative texts to identify explicit and implicit causal relations. These investigators (Trabasso et al., 1984; Trabasso & van den Broek, 1985) found that the recall of adults and children as young as first graders increased as a function of the number of causal relations connecting a unit of text with the rest of the text. The effect of causal relations on other dependent measures has also been examined. For example, van den Broek (1989) found that judgments of the importance to a story of a statement made by adults and children as young as third graders reflects, in part, the number of causal connections it has to other statements. Little is known, however, about whether or how causal relations affect sentence reading times. In addition, differences in sensitivity to causal relations as a function of reading ability have not been explored.

Causal chains. Analysis of causal relations in a narrative gives rise to an interconnected network of causally related events, states, and actions. A direct pathway through the narrative of these causally related sentences can be traced from the beginning to the end of the network. This pathway of causally connected states, events, and actions is called the causal chain. Narrative information located along the causal chain is considered central to the meaning of the narrative

(Omanson, 1982). Other information within the network, such as elaborations about why some actions were taken, is not located on causal chain; these sentences are called dead-end sentences because they do not provide essential story information (Trabasso et al., 1984). Trabasso and his colleagues (Trabasso & van den Broek, 1985; Trabasso et al., 1984) found that text information that falls on the causal chain is recalled better than dead-end information by children as young as first graders. As with measures of causal connectivity, causal chain analysis has not been extended to investigations of reading time for sentences, nor has it been used to examine reading ability as it relates to differences in narrative recall.

Story grammar categories. Finally, event, state, and action information can be characterized according to the role it plays in the narrative. Mandler and Johnson (1977) originally described these roles as story grammar categories (see also Stein & Glenn, 1979). A well-formed narrative generally contains information from categories that include setting, beginning event, reaction, goal, attempt, outcome, and ending. These categories have been shown to affect adults' reading times (e.g., Haberlandt, Berian, & Sandson, 1980) and the recall of children and adults (e.g., Mandler & Johnson, 1977; Omanson, 1982; Stein & Glenn, 1979; Trabasso & van den Broek, 1985).

As mentioned previously, the latter three macrostructure components described (causal relations, causal chains, and story grammar categories) have the advantage of being theoretically derived units of text with relatively clear and explicit criteria for identification. These components are excellent candidates to include in exploratory work because they have been found to make independent contributions to children's recall of narratives (Trabasso & van den Broek, 1985).

Method

Subjects

Subjects were 32 good readers (14 boys, 18 girls) and 17 poor readers (12 boys, 5 girls) from Grade 5 and 34 good readers (20 boys, 14 girls) and 29 poor readers (17 boys, 12 girls) from Grade 7. The study was conducted in the second year of a longitudinal project that monitored the performance of these readers on various tasks, including tasks to assess motivation (Harter, 1981), simultaneous and successive processing (Das, Kirby, & Jarman, 1979), and motor performance (M. J. Taylor, 1982). Poor readers were children attending resource rooms for part of the day to receive help with their reading during the first year of the study. Children who were neurologically impaired or having difficulty with English as a second language were omitted from the sample. Good readers were children judged by teachers to be reading at or above grade level.

Performance of these children on standardized reading tests obtained in the spring both 2 years and 1 year prior to our study and performance on IQ measures are shown in Table 1. These tests were administered by the school district. Also shown in Table 1 is performance on two tasks sometimes used in reading research to discriminate between good and poor readers: the Digit Span (Das, Kirby, & Jarman, 1979) and the Schonell Graded Reading Vocabulary Test (Schonell, 1963). These were administered in the year previous to our study as part of the longitudinal project and are included in this study to maximize the comparability of our samples to those in other research. Note that poor readers clearly differed from good readers on all measures of reading and at all times tested, even with the apparent migration of the mean performance score of poor readers toward the mean of good readers across 2 years of testing.

Unlike the other tests shown in Table 1, the Digit Span scores and the Schonell Graded Reading Vocabulary Test scores were directly comparable across grades because they involved administration of the same materials. Thus we conducted a separate two-way, unweighted means least squares analysis of variance on these scores, with grade and reading ability as factors. For the Digit Span, only grade approached significance, $p < .07$, $MS_e = 0.957$. For the Schonell Graded Reading Vocabulary Test, there was a significant effect of grade, $F(1, 108) = 90.73$, $p < .001$, $MS_e = 0.870$, with children in Grade 7 performing better than those in Grade 5. There was also a main effect of reading ability in the expected direction, $F(1, 108) = 60.85$, $p < .001$, $MS_e = 0.870$. Finally, there was a significant Grade × Ability interaction, $F(1, 108) = 6.04$, $p < .05$, $MS_e = 0.840$, such that the difference between good and poor readers was larger in Grade 7 than in Grade 5.

Materials

According to Mandler and Johnson's (1977) story grammar, we constructed seven two-episode narratives, each of which was 21

Table 1
Characteristics of the Children

Grade/ ability	Group *n*	Reading vocabulary[a] 2 years previous *M*	*n*	Reading vocabulary[a] 1 year previous *M*	*n*	Reading comprehension[a] 2 years previous *M*	*n*	Reading comprehension[a] 1 year previous *M*	*n*	IQ[b] PMA *M*	*n*	IQ[b] Lorge–Thorndike *M*	*n*	Other tasks Digit Span *M*	*n*	Other tasks Schonell *M*	*n*
Fifth grade																	
Poor	17	2.5	16	4.0	17	2.5	16	3.9	17	111.69	16	100.0	16	4.5	17	8.4	17
Good	32	4.0	32	4.6	31	4.5	32	4.8	31	111.25	27	107.2	29	4.7	32	9.3	32
Seventh grade																	
Poor	29	4.2	27	5.4	28	4.4	27	5.5	28	102.90	22	98.7	22	4.9	29	9.6	29
Good	34	6.5	32	7.4	32	6.3	32	7.1	32	109.60	23	106.4	33	5.4	33	11.5	33

Note. PMA = Primary Mental Abilities Test; Lorge–Thorndike = Lorge–Thorndike Intelligence Test/Cognitive Abilities Test; Digit Span = Digit Span used by Das, Kirby, and Jarman (1979); Schonell = Schonell Graded Reading Test. Reading vocabulary and comprehension scores were obtained 2 years and 1 year prior to the study, as indicated. Digit Span and Schonell scores were obtained 1 year prior to the study. For each measure, *n* indicates the number of test scores available.

[a] Reading scores are from the vocabulary and comprehension sections of the Canadian Test of Basic Skills.

[b] All students in the sample scored 85 or higher on some measure of IQ.

sentences long and contained sentences that conformed to the following formula: setting + setting + elaboration + 2(beginning event, elaboration, reaction, goal, attempt, elaboration, outcome, elaboration, ending). Stories were either original prose or modifications of folktales or stories. Whereas the stories were unfamiliar to the children, the types of problems and characters encountered should have been readily understandable. Four stories involved causally connected episodes, and three involved then-connected episodes. Using Kintsch's system (Kintsch, 1974; Turner & Greene, 1977), we determined that stories ranged in length from 93 to 125 propositions. Vocabulary was kept at a Grade 2 level (a) by asking Grade 2 students to read the stories and circle words they did not know, and (b) through consultation with teachers. A sample story is presented in the Appendix. (The other stories are available from the authors.)

Empirical validation of the distinction between central and elaborative sentences was obtained by asking 30 adults to rate each sentence for its importance to the story using a 5-point scale ranging from *very unimportant* (1) to *very important* (5). Sentences intended to be central to a given story category within the episodes received a mean rating of 4.05 and those intended to be elaborative received a rating of 2.74, $t(29) = 11.57$, $p < .001$.

To confirm episode boundaries, the adults were also asked, "If you were to divide this story into two parts, where would you do so?" The mean episode division occurred at Sentence 11.51, or between the elaboration of the outcome and the ending categories in the first episode. This division showed that the adults had no difficulty identifying episode boundaries.

Causal relations were identified and causal chain membership was determined according to the procedures detailed by Trabasso and Sperry (1985). Causal relations were identified through tests of causal necessity and sufficiency. Sentences were classified according to the number of causal relations that were identified. Reliability between two independent scorers in classification across the six narratives was 89%. Disagreements were generally of the nature of omission of a relation and were resolved through discussion. The causal relations analysis resulted in an interconnected network of causally related sentences, allowing for the determination of causal chain membership. Causal chain sentences were identified as those causes or consequences occurring along a direct path in the causal network from the opening to the closing sentences in the narratives. Dead-end sentences lacked causes or consequences and hence were not located along the pathway. An independent scorer performed the analysis; reliability with a second scorer across the six narratives was 92%.

Each sentence was then assigned a value for each of the eight components we examined. The mean and range of the values assigned were the following: (a) words (M = 10.9, range = 4 to 24); (b) frequency of content words (M = 896.4 per million, range = 658 to 1,000 per million); (c) propositions (M = 5, range = 2 to 14); (d) main and subordinate clauses (M = 1.4, range = 1 to 4); (e) new-argument nouns (M = 0.64; range = 0 to 4); and (f) causal relations (M = 2.3; range = 1 to 4). With respect to causal chains, sentences were also assigned a value of 1 or 0, depending on whether they were determined to be on or off the causal chain. Sentences were also assigned a series of values of 1 or 0, depending on their story grammar category (e.g., when a sentence was given a value of 1 as a setting, the other categories were given a value of 0). Thus, the story category component was actually represented by a set of variables in each regression analysis (see Discussion section).

In addition, on the basis of the consensus of two independent judges, one or two *core propositions* (usually predicates) were identified as best representing the meaning of each sentence. In scoring recall for the purposes of the regression analyses, presence of core propositions was the criterion for sentence recall. The overall reliability for two independent raters scoring all propositions for their presence or absence was 97%.

Procedure

Stories were presented one sentence at a time (40 characters per line) in appropriate uppercase and lowercase characters on a monitor run by an Apple II microprocessor. Tapping on a button that was mounted on a separate response board caused the removal of the sentence currently displayed and presentation of the next. Reading time per sentence was recorded by a Mountain Hardware clock timer. Data collection for this task always took place in the third and final session of the larger project. Subjects were tested individually and were seated in front of the monitor with the response board beneath their dominant hand. Children were instructed to read each story silently with the purpose of trying to retell it as closely as possible to the words they saw on the screen. They were told to read each sentence only once. The experimenter watched their eye movements to ensure that they did so. Reading was self-paced. Children first received a practice story and then a random sequence of 6 experimental stories drawn from a pool of 10 sequences. At the end of each story, subjects counted to 20 and then recalled the story into a tape recorder. Session length ranged from 35 to 60 min.

Results

The focus in the analyses that follow was to attempt to account for the variability in the reading times and in the recallability of the 126 sentences for each group of subjects.[1]

Simple Correlations

Table 2 includes the simple correlations of the predictor variables, except story grammar categories, with both the median reading time for each sentence for all four groups of subjects and the proportion of individuals in each group recalling each of the 126 sentences. Also included in Table 2 are the correlations among the predictor variables themselves. Words and propositions were related to both measures. Other predictors seem to fit a pattern such that microstructure components (e.g., clauses) appear to be more strongly related to reading time, and macrostructure components (e.g., causal relations, causal chains) appear to be more strongly related to recall.

Correlations between the seven story grammar categories and the other predictor variables, as well as correlations between these variables and reading time and recall for the four samples, revealed few significant relationships. The only

[1] According to a method used by many cognitive researchers who study reading (e.g., Graesser et al., 1980; Haberlandt et al., 1980; Just & Carpenter, 1980), we used regression procedures that involve collapsing data across subjects. To facilitate comparison with these regression analyses, we conducted an analysis of variance on the collapsed data in some cases to illustrate features of the data sets. It should be noted that because of the nonindependent performance measures associated with the set of sentences, the statistical tests conducted (and their associated significance probabilities) should be interpreted with caution. For example, Lorch and Myers (1990) have discussed how use of this method in regression analyses might result in inflated Type I error rates and estimates of the percentage of variance accounted for by predictor variables. In the present article, the only patterns in the data that are discussed are those that are clearly evident in more than one of the four separate regression analyses conducted for each dependent measure.

Table 2
Correlation Matrix for Reading Time and Recall with Seven Predictors

Predictor	Reading time				Recall				Predictor						
	Grade 5 readers		Grade 7 readers		Grade 5 readers		Grade 7 readers								
	Good	Poor	Good	Poor	Good	Poor	Good	Poor	CC	CR	NAN	C	P	MF	W
Causal chains (CC)	.12	.15	.15	.17	.38*	.31*	.37*	.39*	—						
Causal relations (CR)	.11	.08	.15	.08	.35*	.32*	.30*	.32*	.33*	—					
New argument nouns (NAN)	.22	.18	.26*	.17	.30*	.25*	.27*	.30*	−.09	.11	—				
Clauses (C)	.48*	.44*	.45*	.45*	.05	.04	.06	−.04	.08	−.02	−.05	—			
Propositions (P)	.83*	.83*	.82*	.82*	.27*	.25*	.30*	.22	.06	.13	.19	.40*	—		
Mean frequency (MF)	.18	.19	.16	.22	−.08	−.05	−.07	−.09	.15	−.01	.04	.29*	.22	—	
Words (W)	.89*	.90*	.89*	.89*	.33*	.28*	.35*	.27*	.20	.21	.24*	.45*	.85*	.25*	—

Note. For all correlations $df = 124$.
* $p < .01$.

correlations significant at the .01 level ($df = 124$) among the predictor variables were those between the setting category and number of new-argument nouns ($r = .46$), the beginning category and number of causal relations ($r = .28$), the ending category and number of causal relations ($r = -.23$), the reaction category and presence on the causal chain ($r = -.29$), and the goal category and presence on the causal chain ($r = .30$). In addition, the goal category correlated at the .01 level with recall for both good and poor readers in Grade 7 ($rs = -.25$). Because a number of the components are intercorrelated, a clearer picture of relationships with reading time and recall emerges from the regression analyses described next.

Reading Time

We conducted an unweighted means least squares analysis of variance on the median reading times for the 126 sentences, with grade and ability as factors. There was a significant effect of grade, $F(1, 500) = 27.10$, $p < .001$, $MS_e = 1.58$, with Grade 7 students reading faster than Grade 5 students. There was also an effect of reading ability, $F(1, 500) = 114.4$, $p < .001$, $MS_e = 1.58$, with good readers reading faster than poor readers.

We conducted a separate, data-determined stepwise regression on the median reading time per sentence for each group of subjects. In this procedure, the variable that showed the highest partial correlation with the dependent measure is selected for inclusion in the regression equation on each step of the analysis. Table 3 shows the variables that were significant predictors of reading time ($p < .05$) for each analysis in order of entry, as well as the nonsignificant predictors that were statistically significant for the other ability group in that grade. The order of entry, from words to propositions to indexes of higher level knowledge, is consistent with the canonical sequence of component processes in interactive models of skilled reading (cf. Rayner & Pollatsek, 1989).

Given an interactive framework, processes associated with word recognition would be those most frequently executed in reading a passage. In addition, participants' reading skills were still developing, so that word recognition was a resource-consuming process for them (e.g., Perfetti, 1985; Stanovich, 1980). Consequently, we expected the words variable to encompass most of the variance accounted for in sentence reading times. Variables indexing other component processes, such as causal relations, are no less essential to the act of passage comprehension but are hypothesized to occur less frequently. In addition, in current theories the effects of higher level processes on reading time are thought to be primarily, but perhaps not exclusively, associated with the sentence a person is currently reading. Given this context and the structural similarity of the passages we used, it is not surprising that the words variable does indeed account for most of the variance (see Table 3). Nevertheless, as shown in Table 3, other variables make a modest but unique contribution to the proportion of variance explained. In all cases, the constant made a significant contribution to the equation, indicating that variables other than the cognitive variables of interest accounted for a proportion of the variance.

Table 3
Significant Predictors of Reading Time in Order of Entry

Grade and ability level/ variable	Process type	Slope (ms)	R^2	F
Fifth-grade poor readers				
Words	Micro	355	.810	118.27**
Propositions	Micro	166	.826	9.11**
Causal relations	Macro	−247	.836	11.83**
Story category	Macro	−282[a]	.853	2.20*
Clauses	Micro	142	—	1.55
Fifth-grade good readers				
Words	Micro	195	.799	78.02**
Propositions	Micro	127	.817	11.91**
Clauses	Micro	175	.825	5.63*
Causal relations	Macro	−67	—	2.15
Story category	Macro	−28	—	1.05
Seventh-grade poor readers				
Words	Micro	287	.789	92.43**
Propositions	Micro	162	.807	10.36**
Causal relations	Macro	−153	.816	6.08*
Seventh-grade good readers				
Words	Micro	170	.793	89.56**
Propositions	Micro	94	.808	9.38**
Causal relations	Macro	−29	—	.57

Note. Single predictor variables contribute one degree of freedom to the F statistic; the story category set contributes six degrees of freedom. Degrees of freedom for the final step of the analyses for fifth-grade poor readers, fifth-grade good readers, seventh-grade poor readers, and seventh-grade good readers, respectively, were 9, 116; 3, 122; 3, 122; and 2, 123. Included in the table are nonsignificant predictors (indicated by dashes) that were statistically significant for the other ability group in that grade.
[a] The slope for setting is presented.
* $p < .05$. ** $p < .01$.

The trends are clear: Microstructure components, especially words and propositions, were predictive of the reading time of all types of readers; as indicated by the sign of the slopes, an increase in the number of these variables per sentence resulted in an increase in reading times. The regression analyses also provided information about the relative efficiency of these components for good and poor readers of different ages that were not evident from the simple correlations. If slope values are taken as indices of the number of milliseconds needed to process a single unit along these predictor variables, the rank order of efficiency is consistently one of good older readers, followed by good younger readers, poor older readers, and poor younger readers.

There was no variable that qualitatively differentiated between children in the two grades. However, poor readers in both grades were differentiated qualitatively from good readers in both grades in that macrostructure components predicted poor readers' reading times. As indicated by the sign of the slope, once significant microstructure components had been partialed out, more causal relations per sentence were associated with faster reading times for poor readers but not good readers. This relationship may have been masked in the simple correlations by the large, inverse effects of microstructure components on reading time.

Finally, there was an effect of story grammar category for Grade 5 poor readers. To determine whether the set of the story categories had an effect on reading time, we coded sentences as a set of dummy variables. The concept of dummy variable coding is to represent information about category membership in k groups by a series of $k - 1$ dichotomies. Thus, each sentence was assigned a value of 1 for the dummy variable representing its appropriate story grammar category and a value of 0 for each of the remaining dummy variables. Sentences representing the final "reference category" were coded as the absence of the other categories (see Cohen & Cohen, 1983). These variables were permitted to enter as a set into the regression equation.

We used a one-way analysis of covariance to determine the locus of the differences in reading times for story categories by Grade 5 poor readers. The significant predictors from the stepwise regression (words, propositions, and causal relations) were used as covariates, and the adjusted means for categories were examined. Mirroring the regression, there was a statistically significant effect of story category on reading time for these readers, $F(6, 116) = 2.20$, $p < .05$, $MS_e = 0.42$. Inspection of the pattern of adjusted means revealed that setting statements were read faster than statements representing other categories. There was only one significant pairwise comparison among these means, however. Using the Bryant–Paulson adaptation of the Tukey procedure (Kirk, 1982), we determined that setting statements ($M_{adj} = 4.93$ s) were read significantly faster than outcome statements ($M_{adj} = 5.58$ s), honestly significant difference (HSD) = .611, $p < .05$.

The most striking finding obtained from the regression analyses is that macrostructure components, especially greater numbers of causal relations, are related to faster sentence reading times for poor readers but not for good readers. As can be seen in Table 3, the slope and t values for these variables for good readers are small relative to those for poor readers. Furthermore, this pattern was replicated for poor

readers in two different grades. This macrostructure effect represents a qualitatively different pattern of performance between good and poor readers, occurring in the context of multiple component processes, which deserves further study.

Recall

To ensure that the recall data analyzed in this study were comparable to the recall data collected by previous researchers (e.g., Mandler & Johnson, 1977; Trabasso et al., 1984), the recall performance of good and poor readers in Grades 5 and 7 was analyzed with respect to theoretically derived features of text that have been examined in studies of developmental change or individual differences. In previous work, the focus typically has been the effect of a single feature on the pattern of recall. These effects have included the types of propositions recalled (predicates, modifiers, and connectives), the pattern of recall with respect to number of causal relations, the effect on recall of a sentence being on or off the causal chain, and the pattern of recall with respect to story grammar categories. In the present study, main effects of grade, reading ability, and type of text feature were significant in all cases. The patterns of effects with respect to text features were consistent with those obtained in previous research. (Details of these analyses can be obtained from the authors.)

To examine developmental and individual differences in recall as a function of combined components, we conducted a data-determined stepwise regression for each group of subjects on the proportion of individuals recalling each sentence ($n = 126$). Table 4 includes the variables that were significant predictors of recall ($p < .05$) for each analysis, in order of entry. Because a psychological intrepretation of the slope value would be difficult, we do not present slope values. Except for the slope associated with the story category of goal, the slopes associated with all predictors were positive.

As before, these results were obtained from analyses in which story categories were allowed to enter as a set of variables. Again, to isolate differences in recall as a function of story category, we performed a one-way analysis of covariance for each group, in which story category was a significant predictor of recall. In each case, we used significant predictors from the stepwise regression as covariates, and we examined the adjusted means for categories. Supporting the regression results, the overall story category effect was significant for each group: $F(6, 116) = 2.52$, $p < .05$, $MS_e = 0.06$, for Grade 5 good readers; $F(6, 117) = 3.78$, $p < .01$, $MS_e = 0.06$, for Grade 7 poor readers; and $F(6, 116) = 3.30$, $p < .01$, $MS_e = 0.06$, for Grade 7 good readers.

Inspection of the pattern of adjusted means revealed that goal statements were least well recalled. Reflecting this pattern, pairwise post hoc comparisons conducted with the Bryant–Paulson procedure revealed that a smaller proportion of Grade 5 good readers recalled goal statements ($M_{adj} = 0.27$) than statements representing the attempt ($M_{adj} = 0.54$), HSD = .260, $p < .05$, or the outcome ($M_{adj} = 0.61$), HSD = .256, $p < .05$. Grade 7 poor readers had poorer recall for goal statements ($M_{adj} = .19$) than for setting statements, ($M_{adj} = 0.54$), reaction statements ($M_{adj} = 0.55$), attempt statements ($M_{adj} = 0.55$), or outcome statements ($M_{adj} = 0.62$), HSDs > .265, $ps < .05$. Finally, a smaller proportion of Grade 7 good readers recalled the goal statements ($M_{adj} = 0.32$) than the beginning event statements ($M_{adj} = 0.60$), the reaction statements ($M_{adj} = 0.67$), the attempt statements ($M_{adj} = 0.61$) or the outcome statements ($M_{adj} = .70$), HSDs > .262, $ps < .05$. Although story category did not predict recall for Grade 5 poor readers, this group showed a similar pattern of poorer recall for goal statements than other statements.

Table 4
Significant Predictors of Recall in Order of Entry

Grade and ability level/ variable	Process type	R^2	F
Fifth-grade poor readers			
Causal relations	Macro	.104	5.11*
Causal chain	Macro	.150	8.98**
New argument nouns	Macro	.210	7.00**
Propositions	Micro	.237	4.33*
Fifth-grade good readers			
Causal chain	Macro	.146	24.01**
New argument nouns	Macro	.259	9.36**
Story category	Macro	.355	2.52*
Causal relations	Macro	.378	4.30*
Seventh-grade poor readers			
Causal chain	Macro	.154	42.29**
New argument nouns	Macro	.267	10.54**
Story category	Macro	.386	3.78**
Seventh-grade good readers			
Causal chain	Macro	.137	36.08**
New argument nouns	Macro	.233	7.97**
Story category	Macro	.356	3.30**
Propositions	Micro	.386	5.62*

Note. Single predictor variables contribute one degree of freedom to the F statistic; the story category set contributes six degrees of freedom. Degrees of freedom for the final step of the analyses for fifth-grade poor readers, fifth-grade good readers, seventh-grade good readers, and seventh-grade poor readers, respectively, were 4, 121; 9, 116; 8, 117; and 9, 116.
* $p < .05$. ** $p < .01$.

Again, the trends are clear. In contrast to reading time, for which microstructure components (words, propositions) were more predictive, macrostructure components (e.g., causal chain, new-argument nouns) were more predictive of recall in all groups. The only exception to this was the finding that propositions were predictive of Grade 5 poor readers' and Grade 7 good readers' recall. The simple correlations in Table 2 revealed significant correlations between all of the macrostructure components and recall for all groups. The regression results in Table 4 indicate which of the macrostructure components are most predictive of recall, once other related components are partialed out.

A pattern evident only in the regression analyses is that Grade 5 children differed qualitatively from Grade 7 children in that one additional macrostructure component, namely, number of causal relations, predicted recall. For comparison, the Fs to enter for this variable in the regression equation for children in Grade 7 were as follows, for poor and good readers, respectively: $F(1, 117) = 2.72$, $p = .10$, and $F(1, 116) = 1.41$, $p = .24$. Finally, no variable consistently differentiated between children of different reading ability.

Discussion

Of the numerous component processes that need to be coordinated in understanding narratives, some have a uniform effect across sentences and others operate differentially, rendering some sentences more difficult to read or remember than others. The regression analyses that were the focus of this study helped to isolate patterns of similarity and difference in reading times and memory among groups of children differing in age and reading ability. Potential implications of these patterns for theories of developmental change and individual differences are considered in the following paragraphs.

Reading Time

With respect to reading time, all groups were similar in that greater numbers of words and propositions in a sentence were related to slower reading speeds. These variables presumably index microprocesses such as lexical access and the assembly of propositions in working memory (cf. Perfetti, 1985). Reading times for words and propositions decreased as a function of increasing age and ability. Patterns, ratios of time to read words versus propositions, and speeds associated with component processes are within the ranges that could be expected given previous work with adult readers (Graesser et al., 1980). Although not directly comparable because different texts were used and different component processes were analyzed, the findings suggest, at the minimum, similarities between children at these ages and adults in processing words and propositions (cf. Keenan & Brown, 1984).

Macrostructure components were related to the reading times of poor readers only. Unlike microstructure variables, comparative findings of macrostructure components with adults are not available. Macrostructure variables are assumed to reflect processes involved in the construction of representations of the text as a whole. These representations could include both the text representation and the situation model (van Dijk & Kintsch, 1983). Story grammar category affected the sentence reading times of Grade 5 poor readers. More specifically, setting statements were read more quickly by these children than statements of some of the categories that followed, a pattern not evident in older and better readers.

Most striking, however, was the finding that greater numbers of causal relations were related to significantly faster sentence reading times by both groups of poor readers. In studies that focused exclusively on knowledge about the relational properties of stories, previous researchers (e.g., Fitzgerald, 1984; Rahman & Bisanz, 1986) found that poor readers were less effective than good readers in using their knowledge of causality to predict or identify a story's relational properties on untimed, problem-solving tasks. The present research highlights the importance of understanding differential use of this knowledge by good and poor readers. In this study, differences in performance related to this knowledge were obtained during the course of on-line text processing on indexes that reflect the joint effects of multiple component processes.

The negative slopes associated with causal relations provide correlational evidence of a possible compensatory function of macroprocesses in the reading process. As discussed in our introduction, Stanovich (1986, 1989) has developed a convincing case that poor readers use the information within a sentence context to speed up word recognition when they understand that context. In contrast, under similar conditions, good readers' word recognition is fast, automatic, and context free. This pattern occurs despite the fact that good readers actually demonstrate greater knowledge of the types of information that would facilitate context use on untimed "problem-solving" tasks. Leu, DeGroff, and Simons (1986) extended the interactive–compensatory hypothesis to describe poor readers' use of context in reading predictable texts. In Leu et al.'s study, the context provided by repetitive sentences and familiar words and syntactic patterns decreased reading times by poor readers. These types of text are viewed as opportunities for poor readers "to make inferences, draw conclusions, predict outcomes, and engage in other processes traditionally associated with comprehension instruction, opportunities that they seldom have because their attention is often occupied by word-recognition demands" (p. 352).

The narratives used in the present study were designed to be predictable in terms of cause-and-effect relations, as well as story structure. The predictability of these texts, and the fact that they could be decoded easily, may have provided poor readers with the opportunity to use their knowledge of causality and story structure as an aid to reading sentences in the same way that they use sentence contexts as an aid to reading individual words. If this is the case, then the present study provides evidence for compensatory processing at the level of the text as a whole.

Thus, similar to the work of Jackson and Biemiller (1985), the present research lends credence to the view that, under some conditions, readers may be able to use a top-down component to compensate for weak bottom-up skills. Evidence from the present study extends the range of correlational evidence for this effect to some types of poor readers and advances a candidate for the higher level component process that enables effective compensation, namely, the application of knowledge of causality. Interestingly, in the present study, evidence for compensatory processing was related to individual differences but not to developmental change.

Because our unit of analysis was sentence reading time, the results did not provide empirical clues as to how processes relevant to constructing representations of the meaning of sentences (e.g., lexical access, assembly of propositions in working memory, syntactic processing) may be affected by information presumably involved in constructing representations of the text in ways that might speed sentence reading time. Some of these processes (lexical access and syntactic processing) are hypothesized to be informationally encapsulated in the normal course of skilled reading (e.g., Ferreira & Henderson, 1990). Clearly, identifying the locus of these context effects and the boundary conditions of these effects with respect to age, reading ability, and difficulty of materials are tasks critical to determining the utility of concepts such as modularity in explaining developmental change and individual differences in reading skill.

Recall

Analyses of the recall data provided a different picture from that of the reading time data, with respect to age and skill. All groups were similar in that if a sentence fell on a causal chain or had more new-argument nouns, it was more readily recalled. Story category also affected the memorability of sentences for all but the youngest and poorest group of readers. The causal chain and story category variables presumably reflect macroprocesses associated with constructing a representation of a narrative as a series of causally linked events (Mandler & Johnson, 1977; Trabasso et al., 1984). The new-argument noun variable is thought to reflect a macroprocess that involves integrating new concepts with previous information in the text (Graesser et al., 1980). Consistent with previous studies (e.g., Mandler & Johnson, 1977), sentences that represented the goal category were less likely to be remembered than those representing other categories.

Again, however, the most striking difference pertained to sentence recall with respect to age and an index of one type of higher level knowledge. An additional variable, causal relations, was associated with differences in the recallability of sentences for children in Grade 5 but not in Grade 7. Thus, localized sentence-level relations in the text (causal relations), as well as more global relations contributing to story outcome (e.g., those falling on the causal chain), contributed to differential memorability for younger children; only global relations variables contributed to differential memorability for older children. Thus, the striking contrast of recall with reading time is that the recall effect is related to developmental change but not to individual differences in reading skill.

Within the Kintsch and van Dijk (1978) model, a major determinant of recall is the strategies that readers use to allocate their short-term memory resources during reading. Fletcher (Fletcher, 1986; Fletcher & Bloom, 1988) has shown that the performance of adults is best accounted for by strategies that are based on the plans and goals of characters. Presumably such information facilitates causal reasoning. Just as the evidence for compensatory processing declines with greater efficiency of lower level processes in word recognition, it may be that evidence for a relation between number of causal relations and sentence recall decreases as the short-term memory processes that are guided by higher level knowledge structures become more efficient. We speculate that this increased efficiency may be the result of opportunities that children have to acquire the higher level knowledge of the world that would facilitate causal reasoning through general learning experiences that occur in the course of everyday activities. It is possible that such experiences are relatively independent of the learning of specific skills, such as reading, which form part of the formal school curriculum (cf. Bisanz, 1989; Rahman & Bisanz, 1986). This explanation is highly speculative, but an account of this form is essential to explain the striking finding that the efficiency of sentence retrieval processes is more related to developmental change than to individual differences in reading skill.

Final Remarks

Both reading time and recall data point to the importance of understanding the role of knowledge of causal relations in developmental change and individual differences in reading speed and comprehension as measured by recall. An investigation of this type of knowledge and its differential effects on measures of performance can contribute to the growing body of work within the information-processing tradition that distinguishes the cognitive effects of learning skills in school from the cognitive consequences of the general learning experiences children have as they grow older (see also, Bisanz, 1989; Morrison, 1989; Varnhagen, 1989). For example, reading is taught in schools, and the relationship between higher level knowledge and reading speed observed in poor readers in this study is quite likely to be a product of the differential responses children have to specific learning experiences that occur in schools. In contrast, we speculate that the decline in the relationship between causal relations and recall observed as children grow older may be related to developmental changes or general learning experiences that occur in everyday activities.

Our research was exploratory. Whether the phenomena identified in this study will contribute to more effective programs of instruction depends on whether subsequent instructional research provides demonstrations that reading in a range of difficulty that enables higher level compensatory processing to occur will help some readers overcome slow, inefficient word codes. We suggest, however, that two extremely different types of readers might benefit from instructional programs designed to capitalize on any positive effects of such processing: the precocious, young child seeking encouragement and the reluctant, older reader in need of a challenge.

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Appendix

Sample Story: *The Tiger and the Children*

Setting:	Once a brother and a sister lived in a house near the woods.
Setting:	Each day they baked a cake for dinner and left it on the window to cool.
Elaboration:	The cakes smelled very sweet and good.

Episode 1

Beginning:	One day the tiger came by the house and smelled their cake.
Elaboration:	The sweet smell came to him on the morning air.
Reaction:	The tiger really like the smell.
Goal:	He wanted to have the cake himself.
Attempt:	So he walked up to the window and knocked the cake down with his paw.
Elaboration:	The cake crashed to the ground and broke into pieces.
Outcome:	Then the tiger sat below the window eating the cake.
Elaboration:	He smacked his lips and hummed as he ate.
Ending:	When the cake was gone, the tiger felt very good indeed.

Episode 2

Beginning:	The next day the tiger came back for a second cake.
Elaboration:	He sat near the house waiting for the cake to appear.
Reaction:	This made the children very mad.
Goal:	They wanted to get even with this tiger.
Attempt:	So they filled the centre of the cake with ants.
Elaboration:	Then they placed it upon the window like they did the day before.
Outcome:	When the tiger ate the cake he gave a cry of surprise.
Elaboration:	He began to roll on the ground and howl in anger.
Ending:	From that day on the tiger never came back to eat cakes.

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