Journal of Experimental Psychology:
Learning, Memory, and Cognition
1989, Vol. 15, No. 5, 815–823

0278-7393/89/$00.75

Reading Strategies of Fast and Slow Readers

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In three subject-paced experiments we evaluated reading patterns at the word, line, and sentence level for fast and slow readers. A moving-window method was used to collect word reading times for natural texts. At the word level, reading times of word N were influenced by features of word $N-1$ for fast readers but not for slow readers. The lag effect exhibited by fast readers indicates that they continue to process a word when it is no longer in view, thus limiting the notion of immediate processing. Contrary to our initial expectation that fast readers would process only a single new argument from a sentence, whereas slow readers would process several new arguments, we found that both reader groups adopted a many-argument strategy. However, fast and slow readers differed in terms of the text units (lines vs. sentences) defining the new-argument effects: Fast readers exhibited greater new-argument effects relative to lines, whereas slow readers exhibited greater new-argument effects relative to sentences. Specifically, slow readers integrated the new arguments primarily at the end of the sentence, whereas fast readers did so at line boundaries. These results are discussed in terms of a buffer-and-integrate model of reading comprehension.

Theories of reading comprehension are assumed to be general, like other cognitive theories. Every reader encodes words, accesses word meanings, interprets groups of words, integrates new information with prior information in the text, and extracts some abstract meaning from a text. For every reader these processes produce a cognitive load that is reflected in changes of the reading time. An infrequent word is more difficult to access in long-term memory (e.g., Carpenter & Just, 1983); a syntactically complex clause is relatively hard to interpret (e.g., Ford, 1983); a sentence with many new ideas is more difficult to integrate with the rest of the text (e.g., Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975); and in each of these cases the reading time is likely to increase (Haberlandt & Graesser, 1985; Just & Carpenter, 1987). Within this general picture, however, some provision must be made for different reader strategies, whether they are spontaneously adopted by a reader or induced by experimenter instructions (e.g., Aaronson & Scarborough, 1977, p. 289; van Dijk & Kintsch, 1983, p. 9).

In this report, we approached the issue of reader strategies by examining differences in reading profiles for fast and slow readers. The strategies were formulated within the framework of component processes of reading that we used in previous research (Haberlandt & Graesser, 1985; Haberlandt, Graesser, Schneider, & Kiely, 1986; see also Gernsbacher, 1985; Just & Carpenter, 1987). Processes at the word level, sentence level, text level, and other levels contribute concurrently to a text representation generated by the reader. Word-level processes include encoding operations that translate the physical features of a word into an abstract format and access operations that retrieve the word's meaning from memory. At the sentence-level the reader relates word concepts in terms of clauses and propositions. At the text-level he or she samples new arguments from successive parts of the text (e.g., Kintsch et al., 1975) and integrates them with the current text representation.

We focused on three specific strategy choices, one strategy at the word level and two text-level strategies, suggested by a review of the speed reading literature (e.g., Carver, 1973; Gibson & Levin, 1975, pp. 541–544). In speed reading courses, readers are trained in the use of certain "shortcuts" intended to increase their overall reading speed. We assumed that people participating in experiments would select some of these strategies spontaneously. At the word-level the strategy of interest was the grouping of adjacent words into chunks. Aspiring speed readers are instructed to do this; indeed they are told to "read" words in terms of groups, rather than as discrete units. Such grouping would presumably reduce the number of eye fixations, as well as facilitate their integration into higher level units.

The two text-level strategies concern the number of new-argument nouns sampled by the reader and the location of pauses to integrate the new arguments with text memory. Selecting a single new argument from a text unit, ideally the most important one, would save the reader from having to process many peripheral new arguments. The use of physical cues, including line and paragraph boundaries, is thought to provide readily identifiable locations for organizing the infor-

This research was supported in part by National Science Foundation Grant BNS-8410037 and by National Institute of Child Health and Human Development Grant 1 R15 HD23121-01.

We thank Diane Couture, Jennifer Hall, Judith Kiely, Scott Marshall, and Allen Nielsen for their assistance with this research. We also thank David Balota, Bob Crowder, Robert Lorch, Michael Masson, and Marilyn Smith for their suggestions in preparing this article.

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mation in a text unit. As a result, the rate of reading would speed up. This research examined three strategies although there are, of course, other reading shortcuts taught in speed reading courses (e.g., McLaughlin, 1969; Quattrini, 1985). Consider next the theoretical consequences of these strategies.

1. *Grouping of words and the lag effect.* According to eye-fixation research, readers have a rather limited *perceptual* span for information on either side of the fixation point (Rayner, 1975). In addition to the perceptual span, there is a *cognitive* span in which groups of words are organized into chunks. To the extent that words are buffered and grouped, there is some lag in word-level processing: The processing of the current word N is influenced by features of the previous word, word $N - 1$. Presumably, such a lag effect is more pronounced in fast than in slow readers because the former emphasize grouping strategies to a greater extent. There is ample evidence that the features of a word, both its length and its occurrence frequency, predict the word's reading time. A lag effect is detected when the reading times of word N are predicted to some extent by features of word $N - 1$. Depending on one's theoretical point of view, lagged processing can be considered either effective or ineffective. On the one hand, it could lead to better integration of the meanings of adjacent words. On the other hand, it could indicate that the reader requires some context in order to recognize word meanings (Perfetti, 1983). In contrast to both of these views, Just and Carpenter's (1987) immediacy assumption holds that only the current word is processed.

2. *Single-argument versus many-argument strategy.* This contrast concerns the amount of information selected from a text unit by fast versus slow readers. Because the reading time increases with each new argument processed, picking only a single new argument results in a savings of reading time. In previous research, we found for an average group of readers an increase of word reading times as a function of the cumulative number of new arguments in a sentence (Haberlandt et al., 1986). A slower reader presumably attempts to process every new-argument noun. As a result, his or her reading times should increase with the number of new arguments. On the other hand, if a relatively fast reader were to use a single-argument strategy, the reading time of a text unit should be independent of the number of new argument nouns. If, contrary to our expectation, fast readers adopted a many-argument strategy, we postulated that they would use different locations in order to integrate the new arguments with the text representation. This difference is addressed in the following section.

3. *Physical versus linguistic strategy.* This contrast is based on the buffer-and-integrate model of text-level integration (e.g., Haberlandt et al., 1986; Jarvella, 1979). According to the model, readers buffer new-argument nouns until they encounter specific locations, including sentence boundaries and line boundaries. Our data supported the model: The buffering process was reflected in an increase of word reading times as a function of the cumulative number of new-argument nouns prior to the boundaries. Integration at the boundaries was detected by a reading time increase as a function of the number of new-argument nouns in the preceding text unit (see also Aaronson & Scarborough, 1977; Haberlandt & Graesser, 1985).

A *physical* strategy was postulated for fast readers, whereas a *linguistic* strategy was assumed for slow readers. *Physical* strategy refers to processing of new arguments in terms of the physical lines, whereas *linguistic* strategy refers to processing in terms of such linguistic units as sentences. Because line boundaries occur in predictable locations, they are easy to detect. Fast readers were expected to take advantage of this fact and to use line boundaries for integration, in addition to the sentence boundaries. As a result, fast readers were expected to buffer the new arguments in terms of lines, whereas slow readers should buffer them in terms of sentences. The physical strategy is explicit in speed reading courses where readers are instructed to orient themselves in terms of physical cues including "edges of the print" or line boundaries (Gibson & Levin, 1975, p. 543). The linguistic strategy of pausing at the end of sentences is what we observed in our previous research with average readers.

These two strategies should not be considered in absolute terms. Rather, they express a relative emphasis on using physical and linguistic cues. Furthermore, the contrast between fast and slow readers may be modulated by another factor. If fast readers prefer lines as units of integration and if they hurry through the passage, one would expect a lagged integration effect. The effect should occur at the beginning of the line and should reflect the number of new arguments in the *previous* line. We observed such a lagged integration effect in pilot research. In the current study we sought to evaluate the notion of lagged integration processing more fully.

These three strategies should produce different reading patterns for fast and slow readers at specific locations in the text. We evaluated the hypotheses in a subject-paced word reading task in which natural full-length texts were read continuously by the subjects without interruption. We assessed the predicted pattern of reading times by performing multiple regression analyses on each person's reading times and analyses of variance (ANOVAS) on specific coefficients derived from those regression equations. The multiple regression analyses control statistically for a number of factors necessarily confounded in natural texts, for example, the number of new arguments per sentence and the serial position of the sentence in a passage. In order to limit the focus of this research, we chose not to explore various efficiency measures of reading (e.g., Jackson & McClelland, 1979) nor motivational factors implicated in reading speed. Usually readers trade off between retention accuracy and reading speed (e.g., Just & Carpenter, 1987; for exceptions see Jackson & McClelland, 1979; Lorch, Lorch, & Mogan, 1987).

In Experiments 1 and 2 we defined groups of fast and slow readers empirically according to the total reading time they chose to devote to the experimental passages. Fast and slow readers were selected from the extreme ends of the subject populations. In Experiment 3 we manipulated the readers' reading speed through experimenter instructions.

Experiments 1 and 2

We assessed the reading performance of fast and slow readers from two previous studies (Haberlandt & Graesser, 1985; Haberlandt et al., 1986). In these studies, subjects read passages under different task conditions by using the moving-window paradigm (cf. Just, Carpenter, & Woolley, 1982). Different task conditions were included for purposes of generality. Reading times and reading profiles of the 10 fastest and 10 slowest readers within each task condition were compared.

Method

Subjects. There were 116 subjects in Experiment 1 and 120 subjects in Experiment 2. All subjects were undergraduates at Trinity College who participated in the experiment in partial fulfillment of a course requirement.

Materials. In both experiments, subjects read 1 practice passage and 12 experimental passages. In Experiment 1, we used expository and narrative passages investigated by Graesser, Hoffman, and Clark (1980). These passages covered topics differing in rated familiarity and narrativity as established by independent norming groups using 7-point scales. The number of sentences per passage ranged from 16 to 30, with a mean of 19 sentences. The total number of sentences was 270. The number of words per sentence ranged from 9 to 23, with a mean of 12.5 words. Means and standard deviations of several other variables are displayed in Table 1. Reading times were analyzed for a total of 3,277 words.

Experiment 2 involved 12 expository passages on a variety of topics in medicine, sociology, astronomy, and other domains. As in Experiment 1, the passages were rated by independent judges in terms of their narrativity and familiarity. The number of sentences per passage ranged from 15 to 22, with a mean of 19. The number of words per sentence ranged from 3 to 28, with an average number of 14.5 words (see Table 1). Reading times were collected for a total of 3,298 words.

Apparatus. Stimulus presentation and reading time measurements were controlled by a PDP-11/34 computer in Experiment 1 and by an IBM-PC in Experiment 2. Words were presented on a video screen according to the moving-window method (e.g., Just et al., 1982). Except for the current word, the screen was filled with strings of dashes and spaces in the normal layout of the text. A reader proceeded through the text by pressing a key, thus exposing the current word. The reading time of a word was defined as the interval between successive key presses. This method produces longer reading times than the eye-fixation method and does not allow regressions of the eye to previous text. However, the reading time patterns from both methods are similar for the kind of reading effect examined here (e.g., Aaronson & Ferres, 1983; Altmann & Steedman, 1988; Ferreira & Clifton, 1986; Just et al., 1982; Taraban & McClelland, 1988).

Procedure. Experiment 1 included a comprehension condition and a recall condition. In both conditions each subject read one practice passage, followed by a unique random sequence of the experimental passages. Subjects were instructed to read each passage carefully. After reading a passage, subjects in the comprehension condition answered eight true–false questions. Recall subjects were instructed to recall the passage just read by speaking into a cassette recorder. In Experiment 2, a free-reading condition was conducted in addition to the two retention conditions. In the free-reading condition, subjects were asked to read each passage for comprehension only and were explicitly told that no retention test would follow. An experimental session lasted about 75 min in the recall condition, 50 min in the comprehension condition, and 40 min in the free-reading condition.

Table 1
Stimulus Variables for Passages in Experiments 1–3

Variable	Experiment 1 *M*	Experiment 1 *SD*	Experiments 2 & 3 *M*	Experiments 2 & 3 *SD*
Word level				
Word length	4.57	2.40	5.39	2.97
Log occurrence frequency	2.49	1.35	2.59	1.43
Text level				
Narrativity	4.32	2.04	3.84	0.55
Familiarity	3.68	0.90	2.83	0.87
No. of new arguments	1.72	1.34	2.66	1.64

Results and Discussion

In Experiment 1, word reading times averaged for all 58 subjects were 504 ms and 504 ms in the comprehension condition and in the recall condition, respectively. In the free-reading, comprehension, and recall conditions of Experiment 2, overall mean reading times were 463 ms, 446 ms, and 566 ms, respectively. In both experiments, readers from each task condition were ranked according to their mean reading time of all words.[1] Within each task condition, the 10 fastest and 10 slowest readers were identified. Table 2 provides descriptive information on reading times in the fast and slow reader groups from each experiment.

Retention performance was assessed by the d' measure in the comprehension groups and by the percentage of propositions correctly recalled in the recall groups. In Experiment 1, the mean d' score for the 58 readers in the comprehension group was 3.29. In the recall group, the mean recall score was 31.25. The corresponding values for Experiment 2 were 2.92 and 20.51. Table 3 provides the retention data separated for the fast and slow readers in each experiment. Slower readers exhibited better comprehension performance, in both experiments, $t(18) = 1.89$, $p < .10$, and $t(18) = 4.15$,[2] respectively. Similarly, slower readers exhibited a better level of recall, as measured by the percentage of propositions recalled, $t(18) = 3.42$, and $t(18) = 1.70$, $p < .11$, respectively. These results reflect the expected trade-off between reading speed and retention accuracy.

Good retention performance was also positively correlated with reading time for the entire sample of readers in each experiment. In Experiment 1, the correlation coefficients were $r(56) = .32$, and $r(56) = .46$, for the comprehension and recall conditions, respectively. The corresponding values for Experiment 2 were $r(38) = .58$ and $r(38) = .31$.

The remainder of this section examines the three processing hypotheses: the lag hypothesis, the single- versus many-argument hypothesis, and the physical versus linguistic strategy hypothesis. In each case we examined to what extent the two reader groups allocated their processing resources differently. The principal comparison between the reader groups consisted of a two-stage analysis involving multiple regressions on word reading times of individual subjects and subsequent ANOVAS on specific regression coefficients.

[1] Mean reading times of all words correlated highly with median reading times and the reading times of nonboundary words. The correlation coefficients were computed across all readers within each of the two conditions of Experiment 1 and within the three conditions of Experiment 2. There were 15 such correlations. All of the correlation coefficients exceeded $r = .66$, and 14 coefficients exceeded $r = .88$.

[2] The alpha level was set at .05 unless noted otherwise.

Table 2
Reading Times (in Milliseconds) of Fast and Slow Readers

Task	Experiment 1		Experiment 2		Experiment 3	
	Fast	Slow	Fast	Slow	Fast	Slow
Free reading						
M			307	635		
SD			82	313		
Comprehension						
M	347	723	309	595	317	434
SD	82	311	87	320	90	140
Recall						
M	311	744	369	769	403	590
SD	71	703	152	871	168	181

In the regressions, we computed regression coefficients for a set of word-level, sentence-level, text-level, and physical layout factors that are known to be reliable predictors of reading times[3] (Haberlandt & Graesser, 1985). The word-level variables included word length and the logarithm of the word frequency in the English language. The sentence-level variables included the sentence boundary and clausal boundary specifications. The text-level variables included empirical ratings of passage narrativity and familiarity, the amount of new information (as measured by the cumulative number of new arguments in a sentence or a line), and the sentence-serial position within the passage. There were four physical layout variables: beginning of line, end of line, beginning of screen, and end of screen.

Some of the predictor variables were measured on a continuous scale. The cumulative new-argument variable was one of the continuous variables. Words preceding the occurrence of the first new-argument noun within a sentence were coded as 0. The first new-argument noun in a sentence or line and subsequent words up to but excluding the second new-argument noun were coded as 1. The second new-argument noun received a 2 and so on. At the end of a sentence or a line, the cumulative new-argument count was reset to 0. Other predictor variables were binary, including the sentence boundary, the clause boundary, and the layout variables. Each of these variables was represented in a binary code. Thus, there was one variable for sentence-final words; these words were coded 1, while other words were coded 0. Similar variables were created for clause-final words and for words at the line boundaries (Graesser & Haberlandt, 1986; Haberlandt et al., 1986; Haberlandt & Graesser, 1985).

The set of these predictor variables was entered simultaneously into the multiple regression equation. The coefficients derived from the regressions included the standardized regression coefficient, or beta coefficient, and the R^2 coefficient. These coefficients were computed for the fastest and the slowest readers and were examined in analyses of variance like any other dependent variable. We used standardized regression coefficients rather than regression coefficients because the former reflect the relative contribution of a variable after all predictor variables have been equated for scale of measurement.

Word-level effects: Immediacy versus lag. If fast readers process adjacent words in a chunk, they should continue processing the previous word while the current word is exposed. We examined this lag hypothesis by computing for both experiments multiple regression analyses on the reading times of all words that were not located at sentence, line, or screen boundaries. The predictor variables were the length and logarithm of the occurrence frequency of the previous word, word $N - 1$. We did not include any other variables because the texts read by fast and slow readers were identical. The index for lagged processing was the variance in the reading times accounted for by the two predictor variables, expressed by R^2. In regressions on reading times separately averaged for fast and slow readers, there was a significant lag effect for fast readers in both experiments, $F(2, 2301) = 107.78$, and $F(2, 2291) = 32.28$. For slow readers, the effect was significant in Experiment 1, $F(2, 2301) = 3.42$, $p < .05$, and not significant in Experiment 2 ($F < 1$).

The comparison between fast and slow readers was based on similar regressions using reading times of individual readers as dependent variables. Table 4 lists R^2 values averaged separately for the fast and slow readers. The F values in the extreme right column were derived from ANOVAS on the R^2 values, with task and speed as between-subjects factors. In both experiments, fast readers demonstrated a significantly greater lag effect, which did not interact with task.

[3] For each experiment, we examined collinearity between the predictor variables. In each experiment, there were three cases of collinearity among 78 bivariate correlation coefficients for the 13 variables included here. Collinearity was judged to occur with a 5% overlap in the variance of two variables. The maximum case of collinearity involved word length and word frequency. These two variables, however, were shown to make independent contributions to the word reading time variance (see Haberlandt & Graesser, 1985).

Table 3
Retention Performance of Fast and Slow Readers

Task	Experiment 1		Experiment 2		Experiment 3	
	Fast	Slow	Fast	Slow	Fast	Slow
Comprehension (d')						
M	3.10	3.47	2.41	3.40	1.90	2.36
SD	0.50	0.36	0.59	0.46	0.57	0.54
Recall (%)						
M	28.20	38.95	18.99	24.86	25.49	27.99
SD	6.87	7.19	7.01	8.38	6.78	7.17

Table 4
Lag Effect: Variance in Reading Times of Word N Accounted for by Features of Word N − 1

Experiment	Free reading		Comprehension		Recall		F
	Fast	Slow	Fast	Slow	Fast	Slow	
Experiment 1	NA	NA	.017	.002	.019	.002	26.77
Experiment 2	.008	.001	.010	.002	.006	.002	18.04
Experiment 3	NA	NA	.014	.006	.008	.002	4.02

Note. NA = not applicable.

The lag effect exhibited by fast readers, although small in absolute terms, indicates that some of the processing of a word is carried over to the next word. This result adds to the set of "spill-over" effects observed in a variety of experiments on comprehension (e.g., Haberlandt & Bingham, 1978; McKoon & Ratcliff, 1980; Rayner & Pollatsek, 1987). Such spill-over effects limit the generality of Just and Carpenter's (e.g., 1987) immediacy hypothesis that the reading time of a word reflects only the processing load associated with that word. This analysis also illustrates the point that theoretical conclusions may be erroneous if they are based on reading times averaged across all readers (see Kliegl, Olson, & Davidson, 1982).

A single argument versus many arguments. The single-argument strategy postulated for fast readers was not supported in either experiment. In Experiments 1 and 2, there were significant new-argument effects for both fast and slow readers, indicating increases in reading times with new arguments for both groups of readers. The new-argument effects were established in simultaneous multiple regression analyses on reading times averaged separately for fast and slow readers in each experiment (all four $ps < .01$). The predictor variables used in these regressions included the word-level, sentence-level, text-level, and layout variables described earlier.

In order to compare the new-argument effects for fast versus slow readers, the following analyses were performed: Multiple regressions were computed on the reading times of all words read by individual fast and slow readers. The measure of new-argument processing was provided by the beta coefficient associated with the cumulative number of new arguments per sentence.

In Experiment 1, there was no significant difference in the new-argument processing of fast and slow readers, $M = .057$ and $M = .068$, respectively ($F < 1$). In Experiment 2, the new-argument effect was stronger in slow readers, but it was nevertheless significant for fast readers ($p < .01$). The parameters were $M = .023$ and $M = .043$ for fast and slow readers, respectively, $F = 6.61$, $MS_e = .001$. These data favored the many-argument strategy and disconfirmed the single-argument strategy for fast readers. On the other hand, there was at least a tendency for more new-argument processing in slow than in fast readers.

The many-argument strategy was observed in a global analysis based on the *entire* set of words read by a reader. The new-argument effect indicates that readers extract textual information in terms of new-argument nouns. By itself it does not reveal integration and buffering effects as postulated by the buffer-and-integrate model. In order to examine such effects, one must assess reading times at specific boundary and nonboundary locations. These analyses are reported in the following two sections.

Processing at line and sentence boundaries. Processing at line and sentence boundaries was evaluated in two steps. First, multiple regression analyses were computed on the reading times of individual subjects. In these regressions, the beginning-of-line and end-of-line codes were combined into a single line-boundary code.[4] Similarly, the beginning-of-sentence and end-of-sentence codes were combined into a single sentence-boundary code. Second, the beta coefficients for the line-boundary and sentence-boundary measures were submitted to an ANOVA, with speed and task as between-subjects factors and location as the within-subjects factor. The hypothesis that fast readers spend relatively more processing time at line boundaries and slow readers spend more time at sentence boundaries was supported by significant Location × Speed interactions, $F(1, 36) = 91.03$, $MS_e = .002$ for Experiment 1, and $F(1, 54) = 66.38$, $MS_e = .003$, for Experiment 2. The mean beta coefficients and standard errors (SE) that reflect this interaction are shown in Table 5.

The ANOVA also revealed significant main effects of location and of speed in both experiments. The location effect reflected longer overall processing at the sentence boundaries than at the line boundaries for the two experiments, $F(1, 36) = 45.62$, $MS_e = .002$, and $F(1, 54) = 93.11$, $MS_e = .003$, respectively. The speed effect resulted from longer overall processing by slow readers, $F(1, 36) = 12.14$, $MS_e = .003$, and $F(1, 54) = 37.03$, $MS_e = .008$, respectively. Finally, there was a significant Location × Task interaction in Experiment 2, $F(2, 54) = 8.35$, $MS_e = .003$. This interaction reflected increasing processing times at sentence boundaries and decreasing processing times at line boundaries as the task changed from free reading to comprehension to recall. The increase in the task demands from the free-reading to the recall condition apparently strengthened the linguistic sentence-boundary strategy relative to the physical line-oriented strategy (see Table 6).

The previous analyses have shown that fast readers tended to take a longer absolute time at line boundaries than the slow readers and that they took less time at sentence boundaries. The analyses on integration revealed that both reader

[4] Separate regression analyses revealed significant effects at line-initial, line-final, sentence-initial, and at sentence-final words in both reader groups.

Table 5
Processing at Line Versus Sentence Boundaries in Fast and Slow Readers

Location	Experiment 1		Experiment 2		Experiment 3	
	Fast	Slow	Fast	Slow	Fast	Slow
Line boundary						
M	.079	.029	.045	.029	.036	.024
SE	.008	.006	.005	.004	.008	.008
Sentence boundary						
M	.052	.187	.059	.196	.066	.114
SE	.011	.016	.011	.016	.012	.014

groups used line and sentence boundaries as opportunities for integrating new arguments but that the relative degree of boundary processing for lines and sentences differed. In the analyses, the reading times of the words at the beginning of lines and at the end of sentences were used as separate dependent variables. We compared the new-argument coefficients at these two locations for each reader. The new-argument coefficient at the end of the sentence was based on the number of new arguments in the current sentence. The new-argument coefficient at the beginning of the line was based on the new arguments in the previous line. The previous line was chosen to capture the lagged integration effect postulated earlier. In addition, sentence-serial position, passage narrativity, passage familiarity, word length, and word occurrence frequency were used as predictor variables. The mean beta coefficients for new-argument processing revealed by this analysis are tabulated in the top panel of Table 7.

The table shows the interaction between location and speed as predicted by the hypothesis that slow readers prefer the linguistic boundary strategy, whereas fast readers prefer the physical location strategy, albeit with a lag, in integrating the new information in a text. The Location × Speed interaction was significant in both experiments, $F(1, 36) = 21.12$, $MS_e = .002$, and $F(1, 54) = 8.14$, $MS_e = .002$. The fact that processing at the beginning of the line was predicted by the number of new arguments indicates that fast readers did not pause there merely because of a mechanical strategy, but apparently to execute the integration of new arguments.

Buffering for lines and sentences. Buffering was captured by the cumulative number of new arguments at nonboundary words relative to lines and to sentences. According to the buffering hypothesis, there should be an increase in the load of working memory with each added new argument. On the other hand, if integration were immediate for each new argument, there would be no residual load after each integration episode. The specific hypothesis was that slow readers buffer relative to sentence boundaries, whereas fast readers tend to buffer relative to line boundaries. We evaluated this prediction in Experiments 1 and 2 by computing two regressions for each reader. In one of the regressions, the cumulative number of new arguments was coded relative to sentences. In the other regression, it was coded per line. The remaining predictor variables were familiarity and narrativity of passage, sentence-serial position, word length, and word occurrence frequency. The set of reading times included nonboundary words, that is, words not placed at sentence, line, or clause boundaries.

The beta coefficients for new arguments of sentences versus lines were submitted to an ANOVA, with task and speed as between-subject factors and the text unit as within-subjects factor. The physical versus linguistic strategy was expected to produce an interaction between speed and text unit. The mean beta coefficients should be greater for lines than for sentences in fast readers, whereas in slow readers the beta coefficients should be greater for sentences than for lines. In both experiments the expected interaction involving text unit and reading speed was significant, $F(1, 36) = 14.32$, $MS_e = .001$, and $F(1, 54) = 7.54$, $MS_e = .001$, respectively. The mean beta coefficients reflecting the Text Unit × Speed interaction are shown in the bottom half of Table 7. (In Experiment 1, there was also a significant main effect for text unit, reflecting more overall buffering relative to sentences than to lines, $F[1, 36] = 9.47$, $MS_e = .001$. There was no such effect in Experiment 2.[5])

In sum, the physical strategy preferred by the faster readers led to more integration processing at the beginning of a line and to more buffering relative to lines. On the other hand, the linguistic strategy preferred by slower readers produced more integration processing at the end of sentences and more buffering relative to sentences rather than lines.

Table 6
Processing at Line Versus Sentence Boundaries as a Function of Task in Experiment 2

Location	Task		
	Free reading	Comprehension	Recall
Line boundary			
M	.046	.042	.023
SE	.006	.007	.005
Sentence boundary			
M	.092	.128	.162
SE	.021	.022	.023

[5] In Experiment 3, the new-argument buffering was more pronounced for lines than for sentences. Although the reason for this discrepancy is unclear, it does not affect the critical interaction between text unit and reading speed. This interaction exhibited the same pattern in all three experiments.

Table 7
New-Argument Integration and Buffering as a Function of Location and Speed

Location	Experiment 1 Fast	Experiment 1 Slow	Experiment 2 Fast	Experiment 2 Slow	Experiment 3 Fast	Experiment 3 Slow
			Integration			
Beginning of line						
M	.082	.008	.045	.030	.074	.022
SE	.018	.013	.009	.008	.010	.007
End of sentence						
M	.080	.108	.024	.057	.044	.070
SE	.022	.014	.011	.014	.011	.012
			Buffering			
Line						
M	.065	.038	.038	.034	.049	.042
SE	.010	.007	.007	.005	.005	.005
Sentence						
M	.061	.072	.024	.043	.031	.039
SE	.013	.007	.007	.006	.007	.005

Experiment 3

In Experiments 1 and 2, there was no experimenter control over the readers' reading speed, and reader groups were defined ex post facto. The purpose of Experiment 3 was to observe the lag hypothesis, the single-argument hypothesis, and the physical versus linguistic strategies under conditions of experimenter control. This was accomplished by instructing two groups of readers to maintain a specific reading goal: One group of readers was instructed to read "fast," whereas the other group was instructed to read "very carefully." Comparisons were made between groups to avoid any carry-over effects from repeated experimental sessions involving the same readers under different instructions.

Method

The subjects were 80 Trinity College students who were recruited from the Psychology Department's subject pool. The same passages and the same apparatus as in Experiment 2 were used for Experiment 3. There were two task conditions: a recall and a comprehension condition. These were handled as in Experiment 2, except that there were two groups of subjects within each condition: "fast" readers and "slow" readers. Instructions for both groups mentioned reading speed and the fact that there would be a subsequent retention test, but they differed in that fast readers were instructed to read "as fast as you can," whereas the slow readers were instructed to read "very carefully." After each of the 12 passages, readers received additional reminders to maintain their reading goal. The task and speed factors were crossed in a 2 × 2 between-subjects design, with 20 students randomly assigned to each condition.

Results

The instructions of reading "carefully" versus reading "fast" had the intended effect of separating the overall reading times of the two groups. In both task conditions, the faster group read faster than the slower group, $F(1, 76) = 20.96$, $MS_e = 22{,}099$ (see Table 2). The difference between fast and slow groups was less than in the two previous experiments, where fast and slow readers were selected from the top and bottom sections of the entire group. There was a main effect of task but no interaction involving task. Recall subjects exhibited longer reading times than comprehension subjects. The slow group retained significantly more information than the fast group in the comprehension condition, $t(18) = 2.60$, but there were no significant difference in the recall condition (see Table 3).

The three experimental hypotheses were evaluated as in Experiments 1 and 2 by multiple regressions computed on individual subjects' reading times and by subsequent ANOVAS on regression results. The overall pattern of results was replicated in Experiment 3, thus demonstrating their generality in an experimenter-controlled study. At the word level we observed lagged processing in fast readers but not in slow readers. There was also a greater tendency for the physical line-oriented strategy in fast than in slow readers. Additionally, as in the previous two experiments, both reader groups pursued a many-argument strategy. We now examine the hypotheses in detail.

The lag effect was indicated by R^2 coefficients computed in regressions on the reading times of word N; the length and the logarithm of the occurrence frequency of word $N - 1$ were used as predictor variables (Table 4). The lag effect was significant for fast readers, $F(2, 2291) = 10.28$, but not for slow readers, $F(2, 2291) = 2.56$, $p > .05$. In an ANOVA on R^2 coefficients computed from individual readers with speed and task as between-subjects factors we found a greater lag effect for fast readers, $F = 4.02$, $MS_e = .001$.

Both fast and slow readers exhibited the significant new-argument processing supported by the many-argument strategy ($p < .01$). The mean beta coefficients associated with the cumulative number of new arguments per sentence were .036 and .042 for fast and slow readers, respectively ($F < 1$).

As expected on the basis of the physical versus linguistic hypothesis, line-boundary processing was greater for fast readers than for slow readers, whereas sentence-boundary processing was greater for slow readers than for fast readers. This pattern of reading times produced a significant Location × Speed interaction in an ANOVA on beta coefficients computed in individual subject regressions, $F(1, 76) = 9.77$, $MS_e = .004$ (see rightmost panel of Table 5).

In Experiment 3, integration processing was greater at the beginning of lines for fast readers, but it was greater at the end of sentences for slow readers (Table 7). The different patterns of integration processing were revealed by a significant interaction of speed and location in an ANOVA on standardized new-argument coefficients, $F(1, 76) = 15.22$, $MS_e = .004$. The only other significant effect in this analysis involved the task manipulation, $F(1, 76) = 6.83$, $MS_e = .027$. The task effect resulted from greater new-argument processing in the comprehension condition than in the recall condition.

In Experiment 3, as in the previous two studies, fast and slow readers differed in terms of their buffering, as well as their integration strategy. Fast readers tended to buffer new arguments in terms of lines, whereas slow readers tended to buffer them in terms of sentences. This was revealed in a two-stage analysis consisting of a pair of regressions and a subsequent ANOVA on beta coefficients derived from those regressions. In one of the regressions, buffering relative to lines was assessed by coding the cumulative number of new arguments for lines. In the other regression, buffering for sentences was assessed. The line-oriented buffering of fast readers as compared with sentence-oriented buffering of slow readers yielded a significant interaction between text unit and reading speed, $F(1, 76) = 2.87$, $p < .10$, $MS_e = .001$. There was also a significant main effect for text unit, reflecting more buffering relative to lines than to sentences, $F(1, 76) = 5.89$, $MS_e = .001$. The mean beta coefficients for new-argument processing for lines and sentences were .046 and .035, respectively.

In sum, Experiment 3 confirmed the critical reading time patterns of fast and slow readers observed in Experiments 1 and 2. Unlike in Experiments 1 and 2, where reader groups were selected ex post facto, in Experiment 3 fast and slow reading time rates were induced by experimenter instructions. The importance of Experiment 3 lies in the fact that different reading strategies for fast and slow readers can be manipulated experimentally. In addition, it is interesting that the same reading differences between fast and slow readers were observed, whether the strategies were spontaneously adopted as in Experiments 1 and 2 or whether they were induced experimentally as in Experiment 3.

General Discussion

In three experiments, we observed certain commonalities as well as specific differences in the reading time patterns of fast and slow readers. At the word level, there was a lag effect in fast readers. Their reading times were influenced by attributes of the previous word, which was not the case in slow readers. At the level of intermediate text structures (e.g., sentences and lines), fast readers paused longer at physically defined locations such as the beginning of a line, whereas slow readers paused longer at linguistically defined locations such as sentence boundaries. Contrary to our expectation, however, fast and slow readers did not use different strategies of extracting new arguments from the text. Fast readers in all three experiments used the many-argument strategy rather than a single-argument strategy, as did the slow readers.

These results indicate that at least two of the "shortcuts" taught in speed reading courses have their basis in reading strategies adopted spontaneously by readers when they choose to read fast or when they are instructed to do so. The two shortcuts are the chunking of words and the line-oriented reading strategy. A consequence of the first strategy is the lag effect at the word level. We argued that this effect results from the fast readers' attempt to group adjacent words (Gibson & Levin, 1975). But consider an alternative account, namely, that a fast reader may not understand the meaning of a word immediately. In this case, the reader maintains the word briefly in working memory and continues to process it while the next word is already exposed. Both accounts predict the lag effect we observed in fast readers.

At the intermediate level of text, both reader groups exhibited integration and buffering behavior reported previously for an average group of readers (Haberlandt et al., 1986). However, fast and slow readers differed in terms of the text units they preferred for integration and buffering. Fast readers employed a physical line-oriented strategy, whereas slow readers used sentences as units for integration and buffering. We attribute this difference to the fact that lines and their boundaries can be spotted faster than sentences and sentence boundaries.

The line-oriented strategy of the faster readers poses an interesting theoretical problem. How is the information from a line of text mapped into semantic propositions? Major reading theories and empirical data emphasize processing in terms of clauses and propositions, rather than in terms of lines. Text representations in memory include propositions that express the semantic information of the text (e.g., Just & Carpenter, 1987; Kintsch et al., 1975). It is also known that reading comprehension improves when the physical layout of the text mirrors the linguistic and propositional structure of the text (Graf & Torrey, 1966). Of course, it is possible that readers do not encode all of the text's ideas in terms of propositions, especially when they read fast. They may either form propositions across sentences, or they may select only a subset of the arguments for propositional encoding. However, contrary to our initial prediction, readers do extract several new arguments from sentences, whether they read fast or slowly. The processing of new arguments appears to be an automatic operation that imposes a relatively small, but nevertheless detectable, cognitive load.

The present study also offers important methodological information. We specified three alternative theoretical differences between groups of readers, and we assessed these hypotheses in multiple regressions and subsequent ANOVAS computed on the regression coefficients of the two groups of readers. This analytical technique can be used to compare reading profiles of groups that are defined according to measures other than gross reading speed (see also Lorch et al., 1987). Thus, performance of reader groups can be contrasted according to different measures of reader efficiency (Jackson & McClelland, 1979). Similarly, specific reading strategies can be postulated for groups of readers that differ in reading ability, psychometric indexes, the span of working memory, and other cognitive attributes (e.g., Baddeley, Logie, Nimmo-Smith, & Brereton, 1985; Daneman & Carpenter, 1980; Palmer, MacLeod, Hunt, & Davidson, 1985). In any case, the present comparison of fast versus slow readers shows that the analysis of average data does not provide a full view of the reading process. For example, our study shows lag effects that were not detected in analyses of average reading times (Just & Carpenter, 1987; Haberlandt & Graesser, 1985). In this case, average data looked more like the data of slow readers than those of fast readers.

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Received March 25, 1986
Revision received January 13, 1989
Accepted February 2, 1989 ■