Reading Normal versus Rapid, Sequential Text Formats: Effects of Text Structure and Reading Ability

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Abstract

Subjects' comprehension of conventional presentations (pages) and rapid, serial visual presentations (RSVPs) of text were investigated. Paragraphs were presented with sentences in an intact order or in a scrambled order via a computer display at rates of 300 or 600 words-per-minute (WPM). Subjects were tested for recognition memory of verbatim sentences, true paraphrases, and false paraphrases of sentences in the paragraph. Generally, subjects' memory for meaning and surface information were better in 300 WPM conditions than in 600 WPM conditions, and they retained more paragraph meaning from coherent texts than from incoherent texts. Furthermore, subjects were separated into two groups based on their performance on a reading span test (Daneman & Carpenter, 1980). High- and low-span subjects differed in their reading efficiencies and processing strategies as reflected by the amount of meaning and surface information retained in memory and by an interaction between reading span and display mode. Low-span subjects retained significantly less paragraph meaning than high-span subjects with conventional presentations, and they did almost as well with RSVP. The findings thus suggest that individual differences exist for the RSVP reading and the technique could be useful for improving the reading abilities of less-skilled readers.

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Effects of Text Structure and Reading Ability

Reading has concerned psychologists and educators for a long time, not only because it reflects one of the most complex mental activities, but also because the ability to read well is critical for academic and job success. However, it is not obvious that the traditional reading method, executing a series of eye fixations and saccadic movements, is the optimal method of reading text (cf. Juola, Ward, & McNamara, 1982; Potter, Kroll, & Harris, 1980). In fact, researchers have noted that even for highly-skilled adult readers, reading comprehension can be a difficult task and there is room for improvement (e.g., Daneman & Carpenter, 1980; Juola et al., 1982). In recent years, the rapid proliferation of information has increased the need to read more efficiently. Consequently, psychologists have explored the possibility of developing methods that can increase efficiency of processing written information. One method that has achieved attention in the past several decades is the training of eye movements. The idea was that if readers could be trained to move their eyes more efficiently, they would automatically increase their spontaneous rate of reading for comprehension. However, researchers failed to find that such training was effective (for a review, see Tinker, 1965). More recently, psychologists have tried to use high-speed computers to develop text presentation methods that enable more efficient reading for comprehension. One such technique is the rapid, serial visual presentation (RSVP) method (as named by Forster, 1970). In RSVP conditions, not only are any inefficient motor components of normal reading eliminated by having the reader fixate a single location on a screen and letting mechanical or electronic devices present text segments successively to that location, but also the text segments presented and the time for which they are displayed can be experimentally controlled while guaranteeing exposure of all the text to the reader. Thus, the RSVP method has been considered as a possible candidate for an ideal text presentation method (Juola et al., 1980) and a powerful method to study reading and reading related processes (Healy, Oliver, & McNamara, Note 1; Juola et al., 1980; Masson, Note 2; Potter et al., 1980; Staller, 1982).

Researchers using the RSVP display format have found that the method facilitates performance in visual search (Lawrence, 1971), in sentence recall (Gilbert, 1959; Potter, Kroll, Yachzel, & Cohen, Note 3), and in reading for comprehension (Raygor, 1974). Other researchers have shown that the RSVP method apparently does not disrupt normal reading processes (Bouma & de Voogd, 1974; Forster, 1970; Juola et al., 1982; Potter et al., 1980). The literature does not support the idea that RSVP reading has a universal superiority over normal reading. Although the effects of inefficient eye movements on reading are eliminated in reading RSVP text, there seem to be other factors that limit the rate and effectiveness of RSVP reading. Potter et al. (1980) speculated that the performance decrements at high rates of RSVP reading could be the result of failure to consolidate information in memory or failure to establish detailed connections among ideas in the text. However, no investigations have explored directly the processes of integration and long-term retention in reading RSVP text. Thus, the present study was designed to investigate the integration process and memory in RSVP reading.

In the present experiment, texts were presented in RSVP conditions

approximately 12 characters at a time at rates of 300 and 600 WPM. The 12-letter segment size is chosen because it is the optimal segment size for presenting text in RSVP format (Juola, Ward, Chen, Cocklin, & Ikenaga, Note 4). Juola et al. (Note 4) used a variety of segment size and segment duration combinations to investigate the optimal means of presenting text in the RSVP format. Across a variety of presentation rates and text difficulties, comprehension was maximal for segments averaging about 12 character spaces in length. The 300 and 600 WPM presentation rates were chosen to compare RSVP and conventional reading at both normal and higher rates. To enable comparisons with normal reading situations, subjects were given equal amounts of time as in the RSVP presentations to read the texts using a conventional page display format.

In addition to text display mode and presentation rate, thematicity of the text was manipulated to examine subjects' integration processes. It is known that much of the cognitive activity that occurs in reading involves the integration of semantic information. Through integration processes, relationships among text segments are recognized or established, and individual pieces of information are organized into a general, coherent representation. Prior research has demonstrated that destroying text cohesiveness by scrambling the natural order of text segments influences the integration processes and decreases the efficiency of text processing (Kintsch, Mandel, & Kozminsky, 1977; Rosenberg & Lambert, 1974; Thorndyke, 1977). In the present study, thematicity was manipulated by the arrangement of sentences in the text. In one condition the sentences appeared in their normal order, and they were scrambled in the other condition. The idea is that scrambling the order of sentences in a paragraph destroys intraparagraph cohesiveness which serves to integrate the sentences into a general, coherent representation. Thus, differences in performance for paragraphs with sentences in an intact vs. a scrambled order would indicate whether normal integration processes have occurred in various text presentation modes and speeds. Furthermore, to assess possible effects of text structure and presentation modes on subjects' long-term retention, their comprehension performance was tested both immediately after each paragraph presentation and at the end of all presentations.

Finally, there are large individual differences among readers in how they process written information. Previous researchers have suggested that capacity to process and storage information plays a crucial role in reading comprehension (cf., Daneman & Carpenter, 1980; Just & Carpenter, 1980). For example, Daneman and Carpenter had subjects read aloud a series of sentences and then recall the final word of each sentence. The reading span (i.e., the number of final words correctly recalled) was found to be significantly correlated with three reading comprehension measures, including Verbal Scholastic Aptitude Test (SAT) scores and tests involving fact retrieval and pronominal reference. Just, Carpenter, and Woolley (1982) further speculated that the effectiveness of RSVP technique could depend on the individual's capacity to process and storage information in reading. Thus, the final concern of the present study was to investigate whether there is an aptitude by presentation format interaction.

In order to take into account the factor of individual differences in reading, the reading span test developed by Daneman and Carpenter (1980) was given to each subject at the first day of the experiment. This particular test was chosen because it was developed for college students and its

measurement correlated well with reading proficiency. On the second day, subjects were asked to read coherent and incoherent paragraphs presented in both conventional and RSVP formats with 300 and 600 WPM presentation rates. Text comprehension was measured by subjects' ability to discriminate statements that occurred in the text from statements that did not occur in the text.

In the 300 WPM conditions, one would be expected to find better comprehension performance for coherent paragraphs than for incoherent paragraphs as those found by previous researchers (e.g., Kintsch et al., 1977; Rosenberg & Lambert, 1974; Thorndyke, 1977). If the significant limitations of reading comprehension at higher rates of RSVP reading is in the integration process, one would expect to find no advantage of coherent paragraphs over incoherent paragraphs in the 600 WPM conditions, since higher reading rates presumably disrupts the normal integration process for coherent paragraphs. Therefore, a paragraph type by display rate interaction would be expected. If, on the other hand, the important determinant of reading comprehension at high rates of RSVP reading is the time required to stabilize material in memory, then, one would expect to find the advantage of coherent paragraphs over incoherent paragraphs in the 600 WPM conditions. In other words, the main effects of paragraph type and display rate but not the interaction between these two factors would be expected. Finally, the response pattern to sentence recognition tests in RSVP conditions was compared to that obtained in the conventional page conditions in order to get a more complete picture about possible processing differences between reading page vs. RSVP text, and to indicate what factors (beyond possible inefficient eye movements) limit the rate of normal reading.

Method

Subjects. Thirty-two native English-speaking undergraduates participated for research credit in an introductory psychology class at the University of Kansas. Twenty-four were females and eight were males. All subjects reported normal or corrected-to-normal vision.

Apparatus. The stimuli were presented on a Teleray cathode ray tube (CRT) terminal interfaced to a PDP 11/03 minicomputer with a real-time clock. The display materials were composed of illuminated white dots against a dark background with a potential 5 x 9 dot matrix available for each letter space. During the experiment the front of the CRT was placed approximately .7 meter from the subject's position so that a four-letter, lower-case word subtended a horizontal visual angle of about 1 degree. To reduce glare on the CRT screen the experiment was conducted in a semi-darkened room.

Materials. One hundred unrelated sentences (13-20 words in length) were used for the reading span test. Each sentence ended in a different word. Eighty-eight were constructed by Daneman and Carpenter (1980) and arranged to form five sets each of two, three, four, and five sentences, and three sets of six sentences. The remaining 12 sentences were constructed by the author to form two sets of six sentences.

Sixteen paragraphs (mean length = 181 words and mean difficulty level = 9-10th grade, according to the Dale-Chall Readability Formula, Dale & Chall, 1948) from the McCall-Crabbs reading test (1979) Books D, E, and F were used for the second day of the experiment. These paragraphs were used as coherent

paragraphs. The incoherent paragraphs were formed by scrambling the sentences of coherent paragraphs into a random order, with the constraint that no two consecutive sentences fell into the same sequence as originally.

For each of the 16 paragraphs, three sets of recognition statements with four statements of each type were constructed, which included true exact statements, true paraphrase statements, and false paraphrase statements. These sentences were formed by first decomposing a paragraph's text into idea units. The true exact statements were exact excerpts from text. The true paraphrase sentences were constructed by reforming the surface structure of exact excerpts but were consistent in meaning with the text. The false paraphrase sentences were formed by paraphrasing an idea unit so as to create a sentence that contradicted the original idea. Examples of a coherent paragraph, an incoherent paragraph, and three recognition sentences are shown in Table 1. The sentences from each set were randomly chosen to form two sets of sentence recognition tests, which were counterbalanced across subjects and conditions. Furthermore, care was taken in constructing the sentences to insure that on an a priori basis the sentences could not be discriminated as having or not having come from a given text. Prior to the experiment, 10 pilot subjects were asked to rate each sentence as a true exact sentence, true paraphrase sentence, or false paraphrase sentence without reading the original paragraphs. A statistical analysis of the percent judgments for each sentence type found no differences among the various types.

Insert Table 1 about here.

Procedure. The reading span test was given to each subject at the first day of the experiment. Unrelated sentences were presented on the CRT screen one at a time. Subjects were asked to read the sentence aloud at their own pace. As soon as the sentence was read, the sentence was replaced by another and the subject read the new sentence. The procedure was repeated until a string of stars signaled that a trial had ended and that the subject was to recall the last word of each of the sentences in the order in which they had occurred. Subjects were given two practice items at the two-sentence level before the test began. They were instructed to expect the number of sentences per set to increase during the course of the test. The span test contained five sets each of two, three, four, five, and six sentences. Subjects were presented increasingly longer sets of sentences until they failed all five sets at a particular level. Testing was terminated at that point. The level at which a subject was correct on three out of five sets was taken as a measure of the subject's reading span. However, if the subject was correct on only two out of the five, he or she was given a credit of .5.

On the second day of the experiment, subjects were asked to read coherent and incoherent paragraphs shown in both conventional and RSVP display formats. In the RSVP format, paragraphs were sectioned into segments approximately 12 characters in length. These segments were then sequentially displayed one at a time to a common central locus on the CRT screen. The first letter of each segment appeared in the same location. Sectioning was achieved by using a computer program that scanned the text for 12 characters and then found the nearest space. The text was segmented at that location, and the search for the next segment began. After each sentence the program inserted one segment comprised solely of spaces (i.e., a blank window). In the page format,

paragraphs were displayed in their entireties for equal amounts of time as in the RSVP format and then erased.

Within each display mode the paragraphs were presented such that the reading rates required to complete the texts were 300 or 600 WPM. In both page and RSVP formats, prior to the onset of each trial, a message "When ready, hit the carriage return" was presented. After the subject hit the return, he or she received an instruction to "Read Normally" or "Read Rapidly" shown on the CRT screen for 2 sec. The instruction informed the subject of the word-per-minute reading rate required for the upcoming display. The instruction was followed by a mask of overlapped Xs and Os for 1 sec. For the page conditions, the mask completely filled the CRT screen, whereas for the RSVP conditions the mask filled only the central location of the CRT screen at which the words were displayed. Following the mask, the text was displayed in either the RSVP or page format and then a second mask appeared. Following the second mask six recognition sentences were individually displayed on the CRT screen in a conventional format. Subjects were asked to read each text to the best of their abilities, and then to respond to each sentence. The subjects were to judge if each test sentence occurred in the previously read text. They made their responses by pressing the keys numbered 1-4 on the terminal keyboard. They used a "1" if they were confident that the sentence did not occur in the text, whereas a "4" was used to indicate that they were confident that the sentence occurred in the text. The "2" and "3" keys were used to indicate that their response was a guess.

Because of the difference between the masks for the conventional and RSVP display formats, these trial conditions were blocked; half the subjects received the conventional display condition first and half received the RSVP condition first. All other variates were counterbalanced or randomized. Across subjects, each paragraph occurred equally often in each experimental condition. The order of paragraph presentations within each display mode was randomized for each subject. Prior to the experimental sessions subjects were given a set of four practice trials to familiarize them with the experimental procedures and the characteristics of the computer displays.

At the end of the sentence recognition test for the final paragraph, an unexpected sentence recognition test was given. There were 16 additional sentence sets, and each included six sentence recognition trials. None of these sentences occurred in the immediate test sessions. Each sentence recognition set related to one of the previously presented paragraphs, and the order of these sets was matched to the order of the paragraphs. At the beginning of each set, a message "Questions for Paragraph #" (# was replaced by an appropriate number in the experiment) was presented and then the six recognition sentences appeared one at a time. The subject's task was to judge if each presented sentence occurred in that previously read paragraph as in the immediate tests.

Results

Each subject's mean rating response was computed for each cell of the design. Memory for meaning or gist of text was calculated by averaging the mean ratings for the true exact statements with those for the true paraphrase statements (both were consistent in meaning with the text), and substracting from this the mean rating of the false paraphrase statements. Memory for surface structure was defined as the difference between the mean ratings for

the true exact statements and true paraphrase statements (note that the only difference between these statements was whether or not their surface structure was consistent with that in the text). Using these transformed scores, separate analyses of variance (ANOVA) for repeated measures were performed to assess the effects of display mode (RSVP vs. page), presentation rate (300 vs. 600 WPM), paragraph type (coherent vs. incoherent) and time of test (immediate vs. delayed) on subjects' memories for surface structure and meaning.

The data of primary interest are subjects' memory for meaning. Table 2 presents the mean retention scores for meaning for each experimental condition. The repeated-measures ANOVA found significant main effects for presentation rate, $F(1,30)=29.71$, and for paragraph type, $F(1,30)=6.42$, both $ps<.02$. As shown in Table 2, memory for meaning was better in 300 WPM conditions than in 600 WPM conditions. Moreover, subjects retained more meaning information from coherent paragraphs than from incoherent paragraphs. However, there were no significant differences between RSVP and page conditions (mean meaning retention scores=.46 and .43, respectively) or between the immediate and delayed test sessions (mean meaning retention scores=.47 and .42, respectively). In addition, no significant interactions were found in the meaning retention scores analysis.

Insert Table 2 about here.

Table 3 presents the mean retention scores for surface information for each experimental condition. The ANOVA of subjects' memory for surface information found a significant difference between 300 and 600 WPM conditions, $F(1,31)=8.93$, $p<.005$. Similar to the meaning retention scores analysis, subjects' seem to retain more surface information in 300 WPM conditions than in 600 WPM conditions. However, unlike that meaning retention scores analysis, the effect of paragraph type was not significant. No other significant main effects or interactions were found in the surface information retention scores analysis.

Insert Table 3 about here.

On the first day of the experiment, each subject's individual reading skill was measured by the reading span task. The reading span reliably correlated with both the retention score for surface form and that for meaning; the correlations were $r(30)=.35$ and .37, respectively, both $ps<.05$. The reading span for the 32 subjects varied from 2 to 6 with a mean of 2.9 ($SD=.76$). Because reading span was significantly correlated with the memory scores for both surface form and meaning, it was used as a grouping variable in subsequent analyses to see if subjects' individual differences in reading skills interacted with the manipulated variables. Thus, subjects were divided into two groups of 16 each according to their performance in the reading span test.

In the meaning retention scores analysis, as expected, significant main effects were found for reading span, $F(1,30)=5.99$, for paragraph type, $F(1,30)=6.36$, and for presentation rate, $F(1,30)=30.68$, all $ps<.05$. The main

result was a significant interaction between reading span and display mode, $F(1,30)=8.34$, $p<.01$. As shown in Figure 1, the meaning retention scores for high-span subjects were better than that for low-span subjects in page presentation conditions, $t(30)=3.75$, $p<.001$, whereas no significant difference was found between these two groups in RSVP conditions, $t(30)=.76$. Apparently, high-span subjects are more skilled readers and process the conventional page presentation format efficiently, whereas low-span subjects are probably less-skilled readers in conventional page presentation conditions, however, RSVP condition helps them to read and comprehend more effectively. No other main effects or interactions were significant.

Insert Figure 1 about here.

In the surface information retention scores analysis, a significant main effect was found for presentation rate, $F(1,30)=8.66$, $p<.01$. There were no significant differences between high- and low-span subjects (mean surface information retention scores=.13 and .07, respectively). Moreover, the interaction between reading span and time of test was significant, $F(1,30)=4.79$, $p<.05$. As shown in Figure 2, memory scores for surface information were higher in the immediate test than that in delayed test for high-span subjects, $t(15)=2.10$, $p<.05$, whereas for low-span subjects, there was no significant difference between the memory scores for surface information in immediate and delayed tests. These results indicate that high-span subjects retained more surface information in the immediate test session than did low-span subjects, but surface information was lost rapidly and very little was retained in the delayed test session. For low-span subjects, it appears that very little surface information was retained even in the immediate test session, thus the time of test factor did not show any effect. No other effects were significant.

Insert Figure 2 about here.

Discussion

The finding of the present study is not consistent with the hypothesis that readers fail to complete normal integration processes at higher rates of reading. Subjects retained more meaning information from coherent paragraphs than from incoherent paragraphs in both 300 and 600 WPM conditions, and no interaction was found for the meaning retention measure between presentation rate and display format. Rather the results are more compatible with the idea that high-speed reading might disrupt a post-comprehension, memory consolidation stage of processing (Potter et al. 1980). Therefore, as reading rate increases, less processing resources could be devoted to stabilize the necessary intermediate and final products of reading processes.

The lack of a significant main effect of display format indicates that the differences between recognition of false paraphrases and the average ratings of true exact and true paraphrase statements were equivalent in RSVP and conventional reading conditions. Since the results failed to reject the null hypothesis, one might speculate that the possibility exists that the measures used in the present experiment were not sufficiently sensitive to

detect differences between the page presentation and RSVP. However, the results that RSVP reading results in levels of comprehension that are generally no worse than those obtained when reading text normally with eye movements has also been reported in previous research (e.g., Bouma & de Voogd, 1974; Juola et al., 1982; Potter et al., 1980; Raygor, 1974) with different measures such as multiple-choice comprehension questions and recall performance, thus the unsensitivity of dependent measures seems unlikely an adequate account of the findings. Furthermore, although the results of meaning retention measures showed a significant effect of paragraph type, this factor did not interact with display format. Therefore, the results seems to support Ward and Juola's (1982) speculation that general comprehension processes are similar for both normal and RSVP reading and are probably independent of a variety of visual display methods.

The present research also assessed the effects of display mode, presentation rate, paragraph type, and time of test on subjects' memory for a text's surface information. Subjects' memory for surface information was strongly affected only by presentation rate; subjects retained more surface information from texts at the slower reading rate. This result can be explained by assuming that at higher rates of reading, reader's processing resources are mainly devoted to meaning analysis, thus relatively less surface information will be processed and retained in memory. This effect is probably a general phenomenon of our processing system and is independent of the input format. It is, then, no surprise that no main effect of display mode or interaction involving display mode was found in the results. Furthermore, the manipulation of thematicity had no effect in subjects' retention of surface information. This result suggests that subjects employed similar comprehension processing strategies for both coherent and incoherent paragraphs. Thus, they did not pay more attention to surface information for incoherent paragraphs than for coherent paragraphs. A similar result has been reported by Mandler and Parker (1976) using pictorial material. They investigated subjects' memory for descriptive and spatial information in organized and disorganized complex pictures (e.g., a classroom scene) and found that subjects' memory of spatial information was better for organized than disorganized scenes. For memory of descriptive information, there was no difference between these two types of pictures. Once again, these results implied that general comprehension processes are probably independent of a wide variety of input methods and materials.

The final concern of the present study was to see if subjects' individual reading skills, as measured by the reading span tests (Daneman & Carpenter, 1980), would interact with the manipulated factors and particularly the factor of display mode as speculated by Just et al. (1982). As was expected, reading span reliably correlated with both meaning and surface information retention measures. This result is consistent with Daneman and Carpenter's (1980) finding that the reading span correlated well with reading proficiency. After taking into account the factor of subjects' reading span, two more results of interest were found. First, there was a significant interaction between reading span and display mode for meaning retention measures. In conventional reading conditions, low-span subjects retained less paragraph meaning than high-span subjects, whereas low-span subjects did almost as well as high-span subjects in the RSVP reading conditions. Other researchers have suggested that working memory capacity, especially in the trade-off between processing and storage, seems like a source of individual differences in reading comprehension (cf., Daneman & Carpenter, 1980; Lesgold & Perfetti,

1978). Their assumption is that readers execute similar reading processes for comprehension, but that they differ in the efficiency with which they are done. Therefore, the scores of reading span test presumably reflect subjects' efficiency of reading. Such efficiency differences imply that a high-span reader might have lighter demands on processing resources than a low-span reader, thus, more capacity is available for storing the necessary intermediate and final products of reading processes. Indeed, the results showed that high-span subjects retained more paragraph meaning than low-span subjects, and a similar but weaker result was found for surface information. Since, in RSVP reading, text segments are rapidly and automatically available, the reading task could then allow more processing resources to be devoted to comprehension analysis. Thus, it is no surprise to find that a capable but less-skilled low-span reader would be able to gain advantage from RSVP reading. However, a similar result was not found for high-span subjects. The result might be explained as that high-span readers are better able to maximize assimilation of information from the conventional reading method than are low-span readers. High-span readers' well practice techniques might be limited by other features of RSVP reading, such as the lack of control over what is seen and for how long, and thus are unable to use processing strategies that distribute attention over the text in ways that assist normal reading. Their performance for RSVP reading presumably was not as good as that for normal reading because of the less of control over attentional distribution. In fact, Patberg and Yonas (1978) have discussed the possibility that skilled reading may be disrupted to a greater degree than unskilled reading by task requiring modifications of well-practiced techniques. However, a more efficient system would also be expected to be more flexible and independent of input methods. It is, then, no surprise that even though high-span subjects' meaning retention scores in RSVP reading were not as good as that in page reading, however, the performance decrement was not significant. Finally, the interaction between reading span and display mode for meaning retention measures also indicates that although general comprehension processes seem to be similar for page and RSVP reading, they might require different processing strategies for processing information efficiently.

Finally, the results showed that high-span subjects were more sensitive to changes of surface information presented in recognition sentences in immediate tests than in delayed tests, whereas for low-span subjects there was no significant difference in memory between those two test sessions. Again, high-span subjects demonstrated that they are more efficient readers by showing that they not only retained more paragraph meaning than low-span subjects, but they also retained a certain amount of surface information from texts. However, this surface information was lost rapidly, and very little still remained in the delayed test session (for a similar result, see McKoon, 1977; Sachs, 1967). For low-span readers, their capacity to process and storage information in reading is relatively low as indicated by their reading span scores, thus presumably most of their processing resources are devoted to meaning analysis in reading. It is, then, no surprise that very little surface information was found even in the immediate test session for low-span subjects.

In summary, the results of the present study provide no support for the hypothesis that the limitation of rapid reading is the integration process that organizes ideas into a general coherent representation. Rather, at higher rates of reading, readers might have heavier demands on processing

resources than at normal reading speeds, thus, fewer resources would be available to stabilize ideas in memory. Furthermore, high- and low-span subjects differed in their reading efficiencies and processing strategies as reflected by the amount of information that can be retained in memory, the reading span and display format interaction for meaning retention measures, and the reading span and time of test interaction for surface information measures. The ability by format interaction confirmed the speculation of Just et al. (1982) indicates that individual differences might exist for the usefulness of the RSVP method of text presentation. Furthermore, since most previous researchers (Healy et al., Note 1; Juola et al., 1982; Masson, Note 2; Potter et al., 1980; Staller, 1982) failed to recognize the important individual differences in reading RSVP text, therefore, the results of the present study sound a necessary caution in studying RSVP as a new reading technique. Finally, the RSVP technique used in the present research has shown advantages over the conventional text presentation method for a group of less-skilled but capable readers. This result is interesting in the sense that it raises the possibility that RSVP could be useful for teaching of reading itself or for improving the reading skills of those needing remediation.

Reference Notes

1. Healy, A.F., Oliver, W.L., & McNamara, T. Detecting letters in continuous text: Effects of display size. Paper presented at the annual convention of the Psychonomic Society, Minneapolis, 1982.

2. Masson, M. Skimming and rapid sequential reading of text. Unpublished manuscript, University of Victoria, 1982.

3. Potter, M.C., Kroll, J.F., Yachzell, B., & Cohen, J. Pictures in sentences: Conceptual and lexical representations in language comprehension (Tech. Rep. No.8). ARPA Contract MDA 903-76-C-0441, July, 1978.

4. Juola, J.F., Ward, N., Chen, H.-C., Cocklin, T., & Ikenaga, C. Factors influencing readability of rapid-presented text segments. Unpublished manuscript, University of Kansas, 1982.

References

Bouma, H., & de Voogd, A.H. On the control of eye saccades in reading. Vision Research, 1974, 14, 273-284.

Dale, E., & Chall, J.S. A formula for predicting readability. Educational Research Bulletin (Ohio State University), 1948, 27, 11-20 and 37-54.

Daneman, M., & Carpenter, P.A. Individual difference in working memory and reading. Journal of Verbal Learning and Verbal Behavior, 1980, 19, 450-466.

Forster, K. Visual perception of rapidly presented word sequences of varying complexity. Perception & Psychophysics, 1970, 8, 215-221.

Gilbert, L.C. Saccadic movements as a factor in visual perception in reading. Journal of Educational Psychology, 1959, 50, 15-19.

Juola, J.F., Ward, N.J., & McNamara, T. Visual search and reading of rapid, serial presentations of letter strings, words, and text. Journal of Experimental Psychology: General, 1982, 111, 208-227.

Just, M.A., & Carpenter, P.A. A theory of reading: From eye fixations to comprehension. Psychological Review, 1980, 87, 329-354.

Just, M.A., Carpenter, P.A., & Woolley, J.D. Paradigms and processes in reading comprehension. Journal of Experimental Psychology: General, 1982, 111, 228-238.

Kintsch, W., Mandel, T., & Kozminsky, E. Summarizing scrambled stories. Memory & Cognition, 1977, 5, 547-552.

Lawrence, D. Two studies of visual search for word targets with controlled rates of presentation. Perception & Psychophysics, 1971, 10, 85-89.

Lesgold, A.M., & Perfetti, C.A. Interactive processes in reading comprehension. Discourse Processes, 1978, 1, 323-336.

Mandler, J.M., & Parker, R.E. Memory for descriptive and spatial information in complex pictures. Journal of Experimental Psychology: Human Learning and Memory, 1976, 2, 38-48.

McCall, W.A., & Schroeder, L.C. McCall-Crabbs Standard Test Lessons in Reading. New York: Teachers' College Press, 1979.

McKoon, G. Organization of information in text memory. Journal of Verbal Learning and Verbal Behavior, 1977, 16, 247-260.

Patberg, J.P., & Yonas, A. The effects of the reader's skill and the difficulty of the text on the perceptual span in reading. Journal of Experimental Psychology: Human Perception and Performance, 1978, 4, 545-552.

Potter, M.C., Kroll, J.F., & Harris, C. Comprehension and memory in rapid sequential reading. In R. Nickerson (Ed.), Attention and Performance

VIII, Hillsdale, N.J.:Erlbaum, 1980.

Raygor, R. An investigation of the relationship between eye movements and comprehension in fluent readers. Unpublished doctoral dissertation. University of Minnesota, 1974.

Rosenberg, S., & Lambert, W.E. Contextual constraints and the perception of speech. Journal of Experimental Psychology, 1974, 102, 178-180.

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

Staller, J.D. Word superiority in word detection. Perception & Psychophysics, 1982, 31, 237-242.

Thorndyke, P.W. Cognitive structures in comprehension and memory of narrative discourse. Cognitive Psychology, 1977, 9, 77-110.

Tinker, M.A. Bases for effective reading. Minneapolis: University of Minnesota Press, 1965.

Ward, N.J., & Juola, J.F. Reading with and without eye movements: Reply to Just, Carpenter, and Woolley. Journal of Experimental Psychology: General, 1982, 111, 239-241.

Footnotes

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Table 1

Examples of a coherent paragraph, an incoherent paragraph, and three recognition statements.

Coherent paragraph:

The discovery was entirely accidental. The two boys were searching for cattle that had strayed from the herd. The part of the plain over which they rode was separated from the inaccessible, and apparently useless, mesa by a turbulent stream. Jack had once seen a horse swim the river and disappear up the narrow box canyon of the mesa. Although the place had always been avoided by herders with cattle, the boys decided to cross and reconnoiter in search of the strays. They made their objective a high point that seemed to be the edge of the mesa. After an hour's climb they reached their lookout and beheld, in the cliffs above them, a city -- a sleeping city of stone! There, nestled in a great cavern, beautifully proportioned and symmetrically made, was a village of little tinted, flat-roofed houses. "Mirage" was their first thought. Then they realized that they were looking at the ruins of an ancient, extinct civilization. Preserved, in calm repose, were the homes of some of the forebears of our American Indians.

Table 1 (cotinued)

Incoherent paragraph:

The part of the plain over which they rode was separated from the inaccessible, and apparently useless, mesa by a turbulent stream. Then they realized that they were looking at the ruins of an ancient, extinct civilization. After an hour's climb they reached their lookout and beheld, in the cliffs above them, a city -- a sleeping city of stone! "Mirage" was their first thought. The two boys were searching for cattle that had strayed from the herd. Although the place had always been avoided by herders with cattle, the boys decided to cross and reconnoiter in search of the strays. There, nestled in a great cavern, beautifully proportioned and symmetrically made, was a village of little tinted, flat-roofed houses. Preserved, in calm repose, were the homes of some of the forebears of our American Indians. They made their objective a high point that seemed to be the edge of the mesa. The discovery was entirely accidental. Jack had once seen a horse swim the river and disappear up the narrow box canyon of the mesa.

True exact statement:

The place had always been avoided by herders.

True paraphrase statement:

After an hour's climb they reached the edge of the mesa.

False paraphrase statement:

The two boys were searching for a city of stone.

Table 2

Mean meaning retention scores and standard deviations (in Parentheses) as a function of display mode, paragraph type, time of test, and display rate.

	Display mode			
	Page		RSVP	
Display rate (WPM)	Coherent	Incoherent	Coherent	Incoherent
	Immediate test			
300	.74 (.71)	.51 (.68)	.71 (.71)	.51 (.74)
600	.36 (.47)	.27 (.55)	.36 (.64)	.26 (.51)
	Delayed test			
300	.64 (.68)	.46 (.65)	.57 (.76)	.59 (.71)
600	.25 (.51)	.20 (.42)	.39 (.68)	.25 (.57)

Table 3

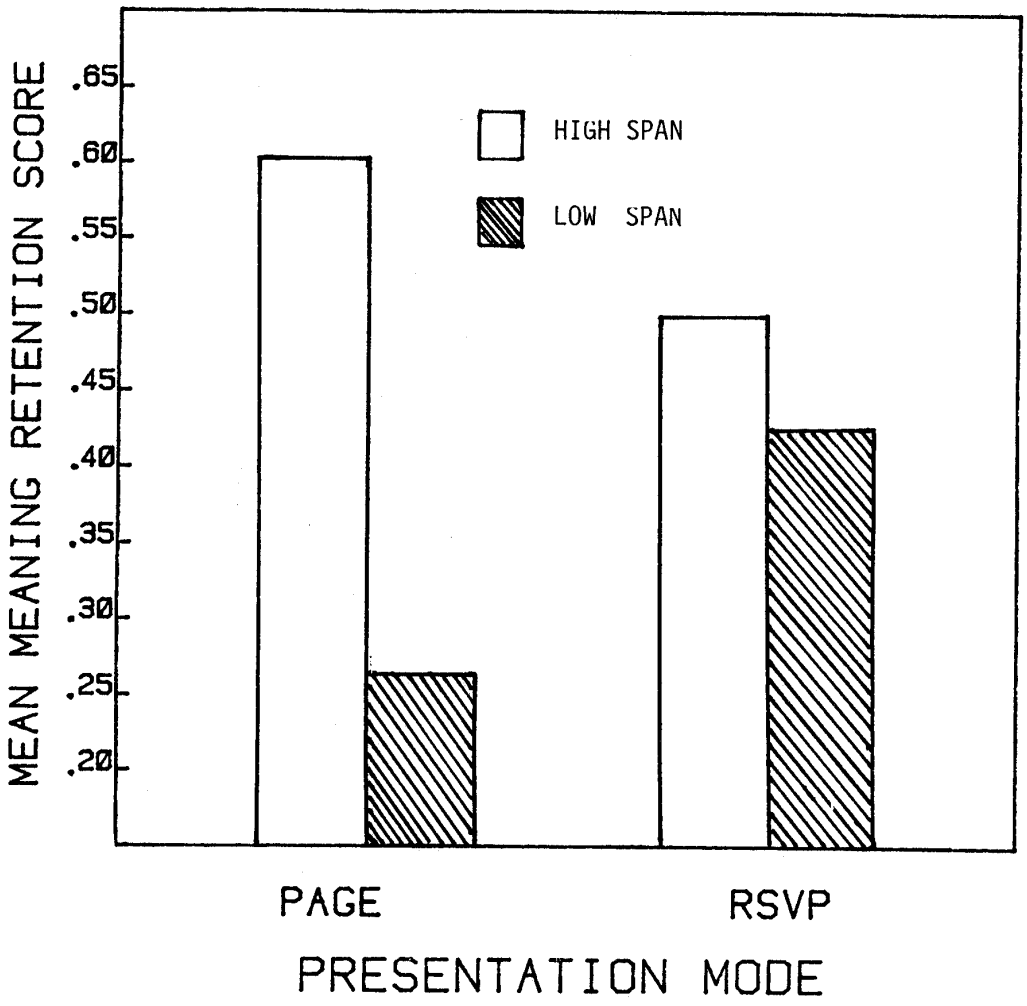
Mean surface information retention scores and standard deviations (in Parentheses) as a function of display mode, paragraph type, time of test, and display rate.

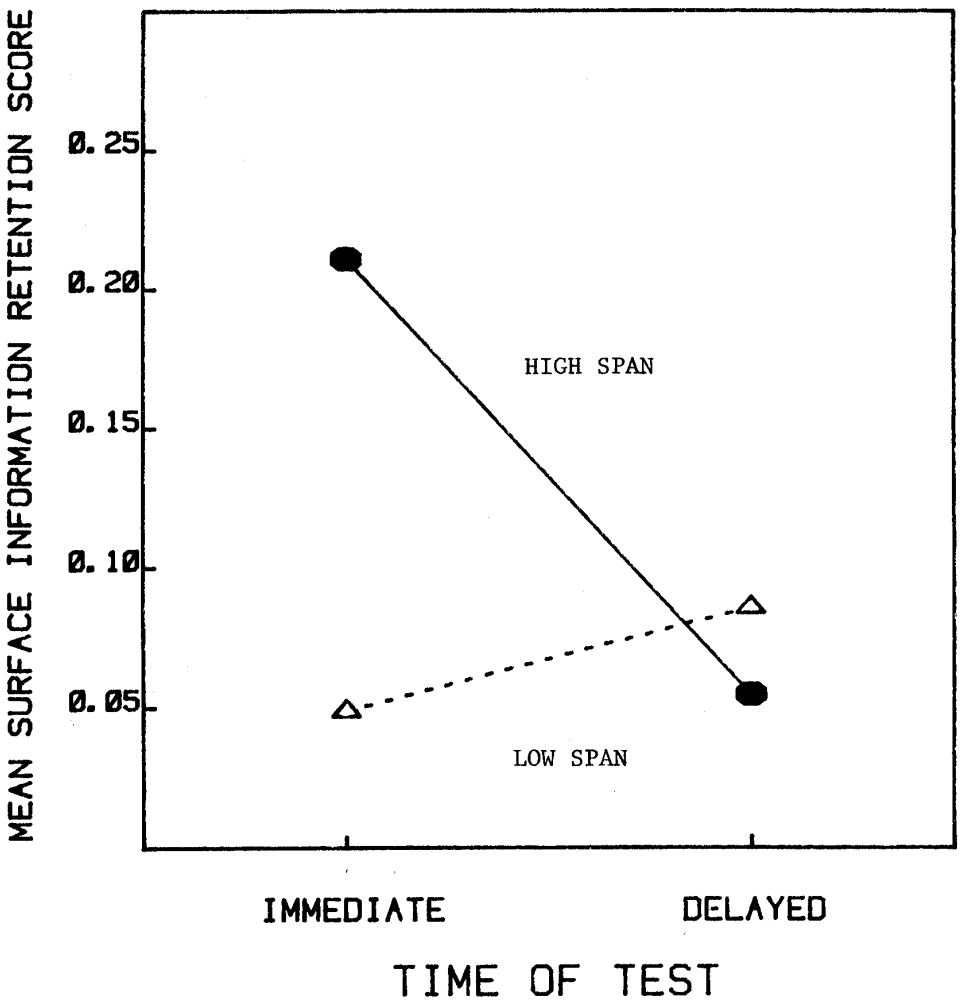
	Display mode			
	Page		RSVP	
Display rate (WPM)	Coherent	Incoherent	Coherent	Incoherent
	Immediate test			
300	.30 (.91)	.31 (.71)	.13 (.69)	.28 (.56)
600	.05 (.64)	-.02 (.69)	-.07 (.55)	.04 (.42)
	Delayed test			
300	.26 (.72)	-.03 (.61)	.21 (.69)	.04 (.61)
600	-.14 (.50)	.09 (.52)	.11 (.57)	.01 (.53)

Figure Captions

Figure 1. Mean meaning retention score as a function of presentation mode for high- and low-span subjects.

Figure 2. Mean surface information retention score as a function of time of test for high- and low-span subjects.


MEAN MEANING RETENTION SCORE
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
HIGH SPAN
LOW SPAN
PAGE
RSVP
PRESENTATION MODE


MEAN SURFACE INFORMATION RETENTION SCORE
0.25
0.20
0.15
0.10
0.05
HIGH SPAN
LOW SPAN
IMMEDIATE
DELAYED
TIME OF TEST