The Influence of Semantics and Syntax on What Readers Remember

CAROL S. ISAKSON AND JAN H. SPYRIDAKIS

Your English teachers told you to avoid passive voice, and now your computer grammar checkers also warn you to avoid passive voice. But sometimes when you revise a passive voice sentence, which flows smoothly, into an active voice sentence, you realize that your new sentence flows less smoothly. Do you ever wonder whether the reader is really going to understand the sentence better or remember more information because of your revision? And what about those debates you have with colleagues about where to place information you particularly want readers to remember? Do you place that information first or last in the passage? Do either or both locations really help the reader hang on to an idea?

When technical writers and editors compose or edit text, they continually make decisions that concern semantics—the meaning their words convey—and syntax—the way the words are arranged. However, writers and editors must often base these decisions on assumptions that have not been tested with technically oriented adult readers or technical documents, or perhaps not tested at all. Thus the actions writers and editors take may not in fact have the expected effects on readers' performance.

In this study, we set out to explore the accuracy of certain assumptions we all depend on by examining the relationship of specific semantic and syntactic text characteristics to what information readers recall. We also examine some characteristics of readers that influence their interpretation of text. Our hope is that this study will provide the groundwork for further investigation. Once we determine how individual variables or combinations of variables affect reader performance, as technical writers and editors we can maximize the effectiveness of our efforts by focusing on those variables that have the greatest impact on readers' recall of information.

In this article, we look at some previous research on reader performance, describe our study design, present and discuss our results, draw conclusions and address their implications, and finally suggest some directions for future study.

PREVIOUS RESEARCH

Previous research has examined numerous variables that influence reader performance. In general, the findings suggest that, even with well written text, readers' recall and comprehension is affected by their perceptions of the text, and the semantics and syntax of the text itself. We focused this exploratory study on variables that are most commonly believed to affect reader performance.

Readers' perception of text content

Research indicates that readers' familiarity with and interest in a passage's topic and the difficulty of the passage all affect reader performance. Many studies acknowledge the positive influence of readers' pre-existing knowledge or topic familiarity on text comprehension (Meyer 1984; Kintsch and van Dijk 1978; Gerbsbacher, Hargraves, and Beeman 1989; Kintsch, Welsch, Schmalhofer, and Zimny 1990). Prior knowledge in agreement with text content assists comprehension (Pearson, Hansen, and Gordon 1979). It also assists readers in selecting information to remember and in linking new information with old infor-

This article was originally published in the August 1999 issue of Technical communication (46, no. 3:366–381).
mation (Afflerbach 1990; Fincher-Kiefer, Post, Greene, and Voss 1988). One study, however, showed prior knowledge to have no effect (Recht and Leslie 1988).

Research also shows that readers' interest in text affects their performance: readers comprehend better and retain more information when they are interested in the topic of the passage (Baldwin, Peleg-Bruckner, and McClintock 1985; Asher 1980; Stevens 1980). Finally, text difficulty affects reader performance because more difficult information makes greater demands on working memory (Engle 1996). Text that readers rate as more difficult is read more slowly than less difficult text because readers have trouble decoding words, recalling meanings, and maintaining a large number of new concepts in working memory (Petros, Bentz, Hammes, and Zehr 1990).

Given our goal of examining the influence of text variables on recall, we wanted to minimize the impact of these reader perception variables; thus, we tried to use technical passages with information that would not be too familiar (to keep readers from relying on pre-existing knowledge), would be fairly interesting (to hold readers' attention), and would not be too difficult or too easy to read (to make reasonable demands on readers' working memory).

**Semantic characteristics**

In addition to readers' perceptions about the text, semantic characteristics also influence readers' performance. The term "semantics" refers to the study of how language conveys meaning. Using a broad definition of semantics, we investigated word features, the position of information in paragraphs and in documents as a whole, and idea importance.

Previous research on word features shows that high-frequency words (words that are used frequently in the English language), short words, and words with fewer syllables are much easier for readers to recognize and comprehend than their low-frequency or longer counterparts (Miller, Heise, and Lichten 1951; Zipf 1949; Hudson and Bergman 1985). In fact, high-frequency words tend to be shorter and contain fewer syllables.

In addition to these word characteristics, the location and importance of information influence what text content readers retain. Readers recall information better when it is presented first (primacy) or last (recency) in lists rather than in the middle of lists (Roediger and Crowder 1976; Baddeley and Hitch 1977; Glanzer and Cunitz 1966). A few studies have examined this issue in prose. One study found that recall of propositions in the text was significantly highest from first to last to middle propositions in two of eight passages (Freebody and Anderson 1986). Another prose study found only primacy effects (Frase 1969), and yet another study found both primacy and recency effects (Deese and Kaufman 1957). Finally, information of higher importance in the content structure of a passage is recalled best (McKoon 1977; Meyer 1985; Meyer and McConkie 1973; Kintsch 1977; Freebody and Anderson 1986; Petros, Bentz, Hammes, and Zehr 1990).

It may be that position and importance interact in some way. Meyer and McConkie (1973) and Kiers (1980) found that information was recalled better if it appeared early in the text but that this information was more important than other information in the text.

This semantic research suggests that we should analyze the relationship between word frequency and recall of the information conveyed. Further, we need to examine whether position and the importance of information affect what information readers recall.

**Syntactic characteristics**

Another type of text characteristic, syntax, also influences reader performance. "Syntax" refers to the way words are grammatically formed and ordered to form phrases, clauses, and sentences. Some syntactic structures are thought to affect reader performance, particularly verb voice and clause structures.

Studies of verb voice, in isolated sentences or in oral conditions, often support the popular belief that active voice ("John wrote the report") facilitates recall more than passive voice ("The report was written by John") (for example, Paul, Fischer, and Cohen 1988; Coleman 1965). However, the two studies that have reliably examined active and passive voice constructions in paragraphs show that recall of meaning is equivalent for both active and passive sentence structures (Blount and Johnson 1971; Rhodes 1997).

In addition to verb voice, clause structures—structures that contain a subject and a verb—affect comprehension and recall. Readers recall independent clauses ("He used the help system") faster than dependent clauses—clauses containing a subordinating conjunction ("Before he used the system, . . .") (Townsend, Ottaviano, and Bever 1979). In addition, readers show poorer comprehension of important information in dependent clauses than of important information in independent clauses (Creaghead and Donnelly 1982). Readers also make more comprehension errors...
Many studies have been performed with children, and with artificially constructed texts or isolated sentences without supporting context. With relative clauses—clauses that contain a relative pronoun such as who, that, or which—that are embedded in the middle of a sentence (“The report that John wrote won an award”) than with relative clauses that are at the end of a sentence (“The society gave an award to the report that John wrote”) (Creaghead and Donnelly 1982). Larkin and Burns (1977) similarly found decreased recall and comprehension of information in embedded relative clauses.

Combinations of effects
Finally, some studies show that semantic and syntactic properties do not operate in isolation. Two independent processors—semantic and syntactic—operate during sentence comprehension. Readers begin the syntactic analysis first, thus using sentence structure to begin understanding the content (Rayner, Carlson and Frazier 1983; Ferreira and Clifton 1986).

Implications of previous research
The studies we have discussed certainly increase our understanding of the influence of some reader and text characteristics on recall. But these studies have been conducted under conditions that make the results difficult to generalize to experienced readers of technical texts. Many studies have been performed with children, and with artificially constructed texts or isolated sentences without supporting context. Occasionally, research examining the effect of one variable has not sufficiently isolated that variable from other confounding variables, thereby making it difficult to interpret the results. And in some instances, different studies that have examined the same variable report contradictory findings. Unfortunately, such studies are what we must rely on until more research is conducted with technical documents and audiences.

With the intent of resolving some of these problems and finding some answers that would directly inform technical writers and editors, we conducted an exploratory study in which subjects read one of two well written texts and wrote down all they could recall. Their recall protocols were then analyzed to see whether the written drafts were then analyzed to see whether the variables discussed in this review of the research literature influenced what information subjects recalled. In the following section, we discuss the hypotheses for our study.

HYPOTHESES FOR THE STUDY
Based on the existing literature, we derived hypotheses regarding our readers’ perceptions about the content of the passages, and the relationship of the semantic and syntactic variables to recall.

Readers’ perception of the texts
Given the text selection procedures, we expected the two texts to be similar in familiarity, interest, and difficulty. We also expected the texts to be somewhat unfamiliar, interesting, and difficult. Based on these expectations, we predicted that the amount of information readers recalled and the amount of time participants required for reading and writing their recall protocols would be similar between the two texts.

Semantic variables
We expected that word frequency and recall would correlate—that is, that information contained in more frequent words would be recalled more frequently and vice versa.

Syntactic variables
We expected that more information would be recalled if it was:
- In the first or last sentences of paragraphs
- In the first or last paragraphs of the text
- More rather than less important

METHODS
A brief description of the participants, materials, and procedure that we used in this study will help in understanding the results and conclusions.

Participants
Thirty-nine engineering majors, who were native English speakers enrolled in introductory technical communication classes, participated in the experimental sessions. These students, generally freshmen and sophomores, are comfortable with technical information and are considered to be good readers. The mean of the SAT verbal scores for engineering majors was 561 versus 567 for arts and sciences majors (Gillmore 1997). In regular class
sessions, we invited native English-speaking students to sign up for an experiment that would provide information about how to improve document design. Students were told that they would be paid $10 USD for less than an hour’s work. Nineteen students read one text, and 20 read the other text.

For the development of materials, a separate group of 28 Engineering majors (juniors and seniors) in an advanced technical communication class participated.

Materials
The materials consisted of two texts and the tests.

Texts  In selecting the experimental passages, we first and foremost wanted to identify two texts that would be similar to each other so that we could replicate results across texts. We wanted scientific or technical passages with excerptable sections of about 1,200 words that would:

1. Be well written with regard to clarity of sentence and paragraph structure and organization as judged by the two researchers and three seniors in the Department of Technical Communication at the University of Washington
2. Contain a similar number of sentences, paragraphs, and sentences-per-paragraph
3. Contain a similar number of passive voice verbs
4. Have similar writing and rhetorical styles
5. Have a readability score between 14 and 17 on the Flesch grade level scale
6. Be somewhat difficult
7. Be somewhat interesting and unfamiliar

To ensure a consistent writing style in the two passages, we examined numerous technical articles and narrowed the selection to seven passages with descriptive rhetorical patterns (Meyer 1985) that met the first six criteria described above. To determine which passages met our criteria for interest and familiarity, we asked Engineering majors enrolled in an advanced technical communication class to rate 100 word abstracts about each passage for both characteristics. On the basis of their ratings, the articles with the two least familiar and most interesting topics were selected for the experimental materials.

The two passages were from Scientific American and met our initial criteria (see Table 1). One passage, referred to as Kuiper, describes the discovery of the Kuiper Belt of asteroidal material beyond the orbits of Pluto and Uranus (Luu and Jewitt 1996). The other passage, referred to as Sensors, describes how sensors in the exoskeletons of the legs of spiders, crabs, and cockroaches provide information to the muscles to enable these animals to walk (Zill and Seyfarth 1996). The excerpted portions contained about 1,330 words each.

Beyond meeting our initial selection criteria, the passages were similar in other syntactic characteristics. Table 2 shows the similarities in the number of clauses, individual clause types, prepositional phrases, and verbs.

So that we could measure recalled ideas against ideas in the texts, we quantified the information in each text by separating the texts into idea units (IUs), using a method initially developed by Johnson that we have refined (Spyridakis and Isakson 1998; Wenger and Spyridakis 1993; Spyridakis 1989). IUs are considered to be the smallest information units that readers may logi-
cally pause at to emphasize, to enhance meaning, or to take a breath; they are not based on text structure (Johnson 1972). To separate the texts into IUs, 26 students (13 per text) in an advanced technical communication class parsed (separated) all ideas that could be construed as IUs. The students were given the definition of IUs and a sample text with its parsed IUs to help them understand IU parsing. IUs were deemed to exist when a majority of students agreed on the parsing location. As an example of IUs in our study, note the following sentence, excerpted from the Sensors text, and its IU distribution.

Each of the three main arthropod groups—insects, arachnids and crustaceans—has its own version of a sense organ for detecting deformations or strains in its cuticle, or exoskeletal material.

<table>
<thead>
<tr>
<th>Type of IU</th>
<th>Kuiper</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>More Important</td>
<td>107</td>
<td>101</td>
</tr>
<tr>
<td>Less Important</td>
<td>61</td>
<td>68</td>
</tr>
<tr>
<td>Total</td>
<td>168</td>
<td>169</td>
</tr>
</tbody>
</table>

Next we determined the importance of the IUs by using a majority tally from the 26 students who, two weeks later, rated the importance of each IU in relation to the overall meaning of the passage. Reading the passage they had not parsed, they labeled more important IUs with the number 1 and less important IUs with the number 2. As Table 3 shows, the passages were very similar in the number of more versus less important IUs.

To analyze the word frequency in the texts, we obtained the frequency ratings of nouns by using a software program called the Oxford Psycholinguistic Database (Quinlan 1992) and, at times, the Kucera and Francis word frequency dictionary (1967), the same dictionary used by the Database. The dictionary is based on the frequency of words found in magazines and newspapers for the general reader, and is not an analysis of the frequency with which words appear in a given text. We averaged frequency ratings for all nouns in each IU to create one value for each IU.

Test packets The test packets included instructions, one of the two passages, a math problem distracter task, a text perception questionnaire, and two blank pages for recall protocols. The instructions told participants to read the passage and to not look back after they finished reading. The instructions also asked participants to record start and finish times for the reading and recall tasks, and to spend at least 20 minutes writing down all they could recall. The distracter task, 10 multiplication problems, helped erase participants’ immediate memory of the text they had read so that all the information they would write in their protocols would come from long term memory. The text perception questionnaire asked participants to rate the texts on familiarity, interestingness, and difficulty. All three questions used 4-point scales: the familiarity scale ranged from very unfamiliar to very familiar; the interestingness scale ranged from very uninteresting to very interesting; and the difficulty scale ranged from very difficult to very easy. The two test packets looked the same: the typefaces, page sizes, line spacing, and margins were identical in the two passages.

We used a recall test so that we could match information in the participants’ recall protocols to IUs in the original text. Recall is a necessary component of comprehension. For example, to understand the logic of the methods and the meaningfulness of the results of this study, you will need to recall some of the literature review.

Procedures All experimental sessions were held in classrooms outside the students’ regular class hours, with group size ranging from 5 to 16 participants. The two test packets were randomly distributed. Students were told that they were participating in an experiment that would involve reading a passage and taking a short test; the experiment would take less than an hour; and they would be paid $10 USD cash when they turned in their materials. Participants were told to read the passage as they would normally read and then complete the tests that followed without looking back at the passage.

To score the recall protocols, two trained raters (seniors in the Technical Communication Department) identified information in the recall protocols that matched the gist meaning of IUs in the original passages. Interrater reliability (agreement) was 93%. All disagreements were resolved in discussion with a third rater.

Data Analysis Results were analyzed using Microsoft Excel and SPSS (a statistical analysis program). Before analyzing the data and

<table>
<thead>
<tr>
<th>Table 3. Number of Idea Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of IU</td>
</tr>
<tr>
<td>More Important</td>
</tr>
<tr>
<td>Less Important</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
after consulting with a linguist, we combined IUs that contained only a portion of a clause into a single IU that would represent the whole clause and counted any recall of the original sub-IUs as recall of one IU. We did this because our IU parsing method, which was based more on semantic than syntactic analysis, had inflated the number of IUs containing clauses versus the actual number of clauses when the grammatical subjects, verbs, or compound subjects and verbs of single clauses were parsed into different IUs. Because this increase was disproportionate for the different types of clauses, it could have biased the results (giving more chance of recall for information from some clause types). Hence, given the combining of some IUs, the number of IUs was reduced to 118 in the Kuiper text and 145 in the Sensors text.

RESULTS AND DISCUSSION
We first review the results concerning readers’ perceptions of the texts and the overall text variables, and then the results concerning the analyses of the relationship of the semantic and syntactic variables to recall. We close this section with a discussion of the relationship between clause structures and idea importance. We discuss as significant only those results at an alpha level (p value) equal to or less than .05. In other words, the statistical test must show that there is at least a 95% probability that the results are due to the test materials, and only a 5% probability or less that the results are due to chance.

Readers’ perceptions of text content
We expected that the two passages would be similar in familiarity, interestingness, and difficulty; this expectation was confirmed by the nonsignificant Mann Whitney U tests (statistical tests that evaluate whether ordinal scaled responses of two groups differ). The lack of significant differences between these ratings for the two passages suggests that any differences in recall patterns between the two texts would not be caused by differences in familiarity, interestingness, or difficulty. Because the texts did not significantly differ on these variables, we combined the ratings of the two texts for further analysis of these variables.

Our expectation that the two passages would be somewhat unfamiliar was confirmed: 92% of the participants rated the passages as unfamiliar or very unfamiliar, the lower two points on the scale. These ratings suggest that readers could not rely on prior knowledge in writing their recall protocols. In addition, our expectation that the two passages would be somewhat difficult was confirmed: 100% of the participants rated the texts as difficult or easy, the middle two points on the scale. These ratings suggest that the reading situation was challenging enough to replicate real life encounters with technical information.

Our expectation that the passages would be somewhat interesting was not confirmed in that 77% of the participants found the passages “uninteresting” and 13% found the passages “very uninteresting,” the lower two points on the scale. We had assumed that participants would rate the texts a bit higher on interestingness because the students who pretested the five topics had rated the Kuiper and Sensors topics as quite interesting. We were surprised that the experimental and pretest groups differed in their views of interestingness because many of our previous studies had used a similar approach to identifying passages that would be interesting, and the pre-test subjects’ ratings were always very similar to the post-test subjects’ ratings (Spyridakis and Isakson 1998; Wenger and Spyridakis 1993; Spyridakis 1989).

Some researchers have found that when participants find texts somewhat interesting, overall recall is higher (Scott and McClintock 1985; Lane, Newman, and Bull 1988). Another study found that familiarity and interest positively correlate for adult readers, suggesting that our unfamiliar passages might have by default been uninteresting (Sadoski, Goetz, and Fritz 1993), though we have not found this to be the case in our previous work (Spyridakis and Isakson 1998; Wenger and Spyridakis 1993; Spyridakis 1989).

Overall semantic and syntactic results
We expected no difference in the number of IUs recalled between the two texts; a t test confirmed our expectation that the mean number of IUs recalled did not significantly differ (a t test determines whether two means differ). The mean number of IUs recalled from the Kuiper text was 25.25 (SD, or standard deviation, = 9.64); the mean number of IUs recalled from the Sensors text was 29.79 (SD = 9.70). The lack of a
significant difference between these means suggests that our initial text selection criteria were successful in identifying two similarly difficult texts, as the subjects themselves confirmed in the reader perception questionnaire.

However, we did find a significant difference between the mean reading times of the two texts ($t = 5.861, p = .021$), with the Kuiper text showing a mean of 11.67 minutes ($SD = 4.60$) and the Sensors text showing a mean of 9.67 minutes ($SD = 3.21$). The unexpected difference in reading time between the two texts was not reflected in the amount of information recalled or in the familiarity, interestingness, or difficulty results. Further, as expected, a $t$ test revealed no significant difference in writing time between the two texts, with the Kuiper text recall taking a mean of 20.05 minutes ($SD = 5.10$) and the Sensors text recall taking a mean of 22.44 minutes ($SD = 4.41$). The writing times, however, are very likely an artifact of participants being instructed to spend at least 20 minutes on the recall task.

**Semantic variables and recall**

In analyzing the semantic variables and recall, we considered the relationship of recalled IUs to the word frequency of the nouns, the location of information in paragraphs, the location of information in the whole passage, and the importance of the information.

**Word frequency** Our hypothesis that word frequency, as reflected by noun frequency, would correlate with IU recall was not confirmed, as revealed by a nonsignificant Pearson correlation (a Pearson correlation indicates the degree and direction of relationship between two variables). We have since realized that an analysis of word frequency in technical documents may be quite inaccurate when the ratings are based on a word frequency dictionary such as the Kucera Francis dictionary (1967) because it derives its ratings from lay publications. Unfortunately, there are no word frequency dictionaries that specifically base their ratings on a broad range of technical publications.

**Information location within paragraphs** To examine the hypotheses concerning the other semantic variables, we used Chi-square contingency table analyses (Chi-square analyses test whether a distribution of observed data matches an expected distribution). Table 4 (Kuiper text) and Table 5 (Sensors text) display the findings on the semantic variables. For ease of reference between our discussion and the tables, we have labeled the horizontal sections of the table with alphabet letters (A, B, and C). Chi-square analyses partially confirmed our hypotheses regarding location effects for sentences within paragraphs: significant differences occurred for the Kuiper text but not for the Sensors text. As shown in section A of Table 4 for the Kuiper text, the percentage of IUs recalled from the last sentences of paragraphs was significantly higher (28%) than the similar percentages of IUs recalled from first and middle sentences (21% and 19%, respectively). Thus, we see a large Chi square value of 18.92, large enough to be associated with a significant $p$ value of .0002, which means that there are only 2 chances in 10,000 that the results are due to chance.

### Table 4. Semantic Variables and Recall in the Kuiper Text

<table>
<thead>
<tr>
<th>Variable</th>
<th>% IUs Recalled</th>
<th>Not Recalled</th>
<th>Chi-square</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Paragraph</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First sentence</td>
<td>21</td>
<td>79</td>
<td>18.92</td>
<td>.0002</td>
</tr>
<tr>
<td>Middle sentences</td>
<td>19</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last sentence</td>
<td>28</td>
<td>73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Document</td>
<td></td>
<td></td>
<td>14.59</td>
<td>.0009</td>
</tr>
<tr>
<td>First paragraph</td>
<td>28</td>
<td>73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle paragraphs</td>
<td>20</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last paragraph</td>
<td>31</td>
<td>69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. IU Importance</td>
<td></td>
<td></td>
<td>93.22</td>
<td>.0000</td>
</tr>
<tr>
<td>More</td>
<td>29</td>
<td>71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less</td>
<td>12</td>
<td>88</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
However, as shown in section A of Table 5 for the Sensors text, the percentages of IUs recalled from the three sentence locations were very similar to each other (last = 20%, middle = 21%, first = 18%). Thus, we see a relatively small Chi square of 1.55 and a nonsignificant \( p \) value of .4379 (considerably higher than the \( p \) value of .05 that we originally set as our criterion for significance).

The differences between the results for the two passages led us to further examine the last sentences of paragraphs in the two texts. The two texts presented different types of information in the last sentences of paragraphs, and this difference may have biased the recall scoring. The Kuiper text frequently presented new and unique information at the end of paragraphs, while the Sensors text often repeated information at the end of paragraphs. With the standard recall scoring method, if IUs in the final sentence of a paragraph were unique and they were recalled, they would match only the IUs in the last sentence of that paragraph—a scenario that may describe the recall results with the Kuiper text. However, if recalled information corresponded to multiple IUs in the text, the recall raters had to choose the matching IU from among many IUs in the original text (when possible, the raters used the context of the recalled information in subjects’ recall protocols to select the IU match). Making such choices could reduce the likelihood of the recalled information being scored as a match to a specific IU in the last sentence—a scenario that may describe the recall results with the Sensors text. In other words, recall of information that was presented in many places in the text might very well be high for final sentences in paragraphs but our recall scoring method may not have identified this effect.

Information location in passages Chi-square analyses also partially confirmed the hypotheses regarding location effects for paragraphs within the two passages (section B of Tables 4 and 5). The analyses for both texts showed that location of information in first, last, or middle paragraphs significantly affected the probability of information being recalled (notice the \( p \) values are < .05), but the patterns among paragraphs differed. With the Kuiper text, recall was highest from last to first to middle paragraphs, yet with the Sensors text, recall was highest from first to middle to last paragraphs.

Note that the primary difference between the texts’ recall results seems to be in the last paragraphs, in that the final paragraph in the Kuiper text had the highest recall and the final paragraph in the Sensors text had the lowest recall. When we checked the content in the final paragraphs of the two texts, we found that the final paragraph of the Kuiper text introduced new, interesting information, while the final paragraph in the Sensors text continued to add fine detail about a preexisting idea that often triggered recall of preexisting information. With this type of information pattern in the texts, our recall scoring method would clearly match recalled information of new content in the last paragraph to IUs in the last paragraph, as occurred with the Kuiper text. But our scoring method would not necessarily match recalled

### Table 5. Semantic Variables and Recall in the Sensors Text

<table>
<thead>
<tr>
<th>Variable</th>
<th>% IUs Recalled</th>
<th>Not Recalled</th>
<th>Chi-square</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Paragraph</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First sentence</td>
<td>18</td>
<td>82</td>
<td>1.55</td>
<td>.4379</td>
</tr>
<tr>
<td>Middle sentences</td>
<td>21</td>
<td>79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last sentence</td>
<td>20</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Document</td>
<td></td>
<td></td>
<td>23.35</td>
<td>.0000</td>
</tr>
<tr>
<td>First paragraph</td>
<td>27</td>
<td>73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle paragraphs</td>
<td>20</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last paragraph</td>
<td>10</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. IU Importance</td>
<td></td>
<td></td>
<td>14.42</td>
<td>.0001</td>
</tr>
<tr>
<td>More</td>
<td>22</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less</td>
<td>16</td>
<td>84</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
information about information discussed in more than one location in the text to IUs in the final paragraph, as may have occurred with the Sensors text. Thus, while both passages clearly showed a primacy effect (higher recall for IUs in first paragraphs than in middle paragraphs) and the Kuiper text clearly showed a recency effect (higher recall for IUs in last paragraphs than in middle paragraphs), our recall scoring method may not have identified a recency effect in the Sensors text.

We also wanted to know whether information location related to information importance in terms of recall but could find no consistent patterns. For the Kuiper text, location and importance appeared to relate with the first and last paragraphs, which had the highest recall, in that 60% of the IUs in the first paragraph and 75% of the IUs in the last paragraph were more important. However, 60% of IUs in the middle paragraphs were also more important, and these paragraphs had the lowest recall. For the Sensors text, only 46% of the IUs in the first paragraph, which had the highest recall, were more important although 58% of the IUs in the middle paragraphs, which had the next highest recall, were more important; however, 91% of IUs in the last paragraph were also more important, and this paragraph had the lowest recall. We found no consistent relationship for location and importance as some earlier researchers have claimed (Meyer and McConkie 1973; Kieras 1980). Hence, we believe that the location effects for recall from paragraphs in documents are due to location alone.

Our overall results for primacy and recency effects for recall of information differ in terms of the location of sentences in paragraphs versus the location of paragraphs in passages. Primacy effects occurred for location of paragraphs in documents for both texts, a scenario we expected given earlier research (Freebody and Anderson 1986; Frase 1969). However, no primacy effects occurred for recall of information in the first sentences of paragraphs, an effect that very little research has examined. We found recency effects for location of sentences in paragraphs, and location of paragraphs in documents for only one text, but we believe that recency effects may have existed for the other document but may not have been detected with our scoring method. It is unfortunate that so little research has examined these issues, yet our results consistently show higher recall for information in the first paragraph of passages than for information in middle paragraphs, and suggest that information in the last sentence of paragraphs and the last paragraph of documents may be recalled better than information in sentences in the middle of paragraphs and paragraphs in the middle of documents.

**Information importance** As hypothesized and confirmed by Chi-square analyses for both texts, a significantly higher percentage of more important IUs was recalled than less important IUs (see section C in Tables 4 and 5), a result that is supported abundantly in the literature (McKoon 1977; Meyer 1985; Kintsch 1977; Freebody and Anderson 1986; Petros, Bentz, Hammes, and Zehr 1990). We return to the issue of idea importance in the section on interaction of idea importance and clause structure after we discuss the results concerning the syntactic variables.

**Syntactic variables and recall** In analyzing the syntactic variables and recall, we considered the relationship of recalled IUs to verb voice and clause structures.

**Verb voice** Although we hypothesized that proportionately more IUs would be recalled if they contained active instead of passive voice verbs, we were unable to assess the variable of verb voice because of the disproportionately low number of passive voice verbs (the Kuiper text passage contained 7 passive and 110 active voice verbs, and the Sensors text passage contained 14 passive and 117 active voice verbs). Given the descriptive nature of the two passages and the fact that they were excerpted from *Scientific American*, we should have realized earlier on that by including “well-written articles” in our selection criteria we were less likely to select articles that contained many passive voice verbs.

**Clause structures** As hypothesized for both texts, IUs containing clauses had a significantly higher percentage of recall than IUs containing other structures as revealed through Chi-square tests. Tables 6 (Kuiper text) and 7 (Sensors text) display the findings on the syntactic variables. In the first row of both tables, notice that the $p$ values are $\leq .05$ and thus indicate significant differences between clauses and other structures in both texts.

As further hypothesized, in the Kuiper text, IUs containing independent clauses had a significantly higher percentage of recall than IUs containing dependent clauses, relative clauses, and other structures, results obtained from Chi-square tests. The Sensors text had a similar pattern except the recall percentage of IUs containing independent clauses versus the recall percentage of IUs containing rel-
ative clauses did not significantly differ in the Chi-square analyses. Further, IUs containing relative clauses had a significantly higher percentage of recall than IUs containing dependent clauses and other structures.

These differences between the two texts with regard to the recall of relative clauses led us to examine the number of embedded relative clauses in the middle of sentences versus unembedded relative clauses in the two texts. With the Kuiper text, 61% of the 18 relative clauses are embedded, and only 39% are unembedded and appear at the end of sentences. The poor recall of ideas in embedded relative clauses for the Kuiper text aligns with results of Larkin and Burns (1977) regarding embedded relative clauses. However, with the Sensors text, only 19% of the 16 relative clauses are embedded and 81% are unembedded and appear at the end of sentences. Apparently in the Sensors text, the unembedded relative clauses led to better recall of IUs containing relative clauses. These unembedded relative clauses apparently benefited from their position at the end of the sentences; however, we are uncertain as to whether the high recall was due to the location of the relative clause or the location of the information itself at the end of the sentence.

**Interaction of idea importance and clause structure**

To examine the interaction of idea importance and clause structures (hence, the interaction of semantics and syntax), we evaluated idea importance and clause structure together in a Chi-square analysis for each text. In both texts, the results were significant. For the Kuiper text, the Chi-

---

**TABLE 6. SYNTACTIC VARIABLES AND RECALL IN THE KUIPER TEXT**

<table>
<thead>
<tr>
<th>Variable</th>
<th>% IUs Recalled</th>
<th>Not Recalled</th>
<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clauses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clause</td>
<td>24</td>
<td>76</td>
<td>9.00</td>
<td>.0026</td>
</tr>
<tr>
<td>Other</td>
<td>19</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clause Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ind. Cl. (ICl)</td>
<td>28</td>
<td>72</td>
<td>34.82</td>
<td>.0000</td>
</tr>
<tr>
<td>Dep. Cl. (DCl)</td>
<td>16</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rel. Cl. (RCl)</td>
<td>17</td>
<td>83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>19</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ICl &gt; DCl, RCl, &amp; other*</td>
<td></td>
</tr>
</tbody>
</table>

* The “greater than” sign (>) signifies which structures have significantly higher recall than other structures.

---

**TABLE 7. SYNTACTIC VARIABLES AND RECALL IN THE SENSORS TEXT**

<table>
<thead>
<tr>
<th>Variable</th>
<th>% IUs Recalled</th>
<th>Not Recalled</th>
<th>Chi-square</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clauses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clause</td>
<td>23</td>
<td>77</td>
<td>35.86</td>
<td>.0000</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
<td>87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clause Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ind. Cl. (ICl)</td>
<td>24</td>
<td>76</td>
<td>53.36</td>
<td>.0000</td>
</tr>
<tr>
<td>Dep. Cl. (DCl)</td>
<td>15</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rel. Cl. (RCl)</td>
<td>28</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
<td>87</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RCl &gt; DCl &amp; other*</td>
<td></td>
</tr>
</tbody>
</table>

* The “greater than” sign (>) signifies which structures have significantly higher recall than other structures.
square was 81.93 ($p < .0000$), and for the Sensors text the Chi-square was 22.48 ($p < .0000$). We then constructed histograms comparing idea importance to individual clause types. IU importance had a more pronounced effect in the Kuiper text than in the Sensors text (see Figures 1 and 2). Semantics and syntax strongly interact in the Kuiper text. In fact, IU importance played a major role in the recall pattern in which, regardless of clause structure, readers recalled a higher percentage of more important IUs than of less important IUs. However, in the Sensors text, the interaction of semantics and syntax is less clear. IU importance had a relatively small positive effect on independent and dependent clauses, a negligible effect on relative clauses, and a counterintuitive negative effect on other structures.

It is interesting to note the percentage of IUs that contained independent clauses or portions of them and were also rated as more important: 79% for the Kuiper text and 89% for the Sensors text. Our raters who identified information importance and the authors of the texts must have honored this relationship of important information and independent clauses at some intuitive level. It would be fascinating to know whether writers consciously or subconsciously place important information in independent clauses, as apparently is the case with our two texts. We suspect this may be a chicken-and-egg conundrum.

However, the strong pattern of a higher percentage of IUs that were both more important and contained independent clauses occurred only in the Kuiper text. More documents need to be tested to confirm whether authors, raters, and readers perceive the relationship of information importance and clause structures in the same way.

The results for the semantic and syntactic variables—and the interaction of idea importance and clause structures—suggest some interesting conclusions.

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS
From the study described here, writers and editors can recognize some basic principles of reading and gather some guidance about what composition and revision decisions will influence the information their readers will recall. Readers’ perceptions of text will always interact with text characteristics. Readers who are familiar with and interested in a topic will read a text more easily than readers who are less familiar with and interested in a topic. Although writers cannot literally change who their readers are, they should certainly use every opportunity to increase their readers’ topic familiarity and interest by providing background information, using analogies and metaphors, adding illustrations, and so on. There is considerable literature regarding techniques that teachers use to increase students’ familiarity with and interest in texts, but this literature is beyond the scope of this study.

Our study also confirms that readers recall information they perceive to be more important more frequently than information they perceive to be less important. While writers and editors may not have much influence over their readers’ familiarity with and interest in a topic, or the importance of the information to their readers, they can influence the informa-
tion their readers retain through their semantic and syntactic style decisions. This study suggests that, to help readers recall certain information, writers should place that information in:

- Clauses
  - Independent clauses
  - Relative clauses at the end of the sentence (if using relative clauses)
  - The first paragraph of a document
  - The last paragraph of a document and the last sentence of a paragraph (this suggestion is based on the results of only one of the two texts studied)

To examine the advice about the importance of clauses and independent clauses to readers, let's look at a few examples. For the following sentence from the Sensors text, recall was much higher for information in the independent clause (“Each of the three arthropod groups has its own version of a sense organ”) than for information in the final phrases (“for detecting deformations or strains in its cuticle or exoskeletal material”).

*Each of the three arthropod groups has its own version of a sense organ for detecting deformations or strains in its cuticle or exoskeletal material.*

Yet we could shift the emphasis and very likely influence the reader to recall the information about detecting deformations or strains by placing that information in the independent clause (“Each of the three arthropod groups detects deformations or strains in its cuticle or exoskeletal material”) and moving the information about versions of sense organs into a phrase (“using its own version of a sense organ”).

*Each of the three arthropod groups detects deformations or strains in its cuticle or exoskeletal material using its own version of a sense organ.*

A more complex example shows how a writer can move the information contained in independent clauses as well as change the position of relative clauses and influence what information readers will recall. The original sentence below contains two independent clauses (“Japan was . . . Japan took . . .”) and two embedded relative clauses (“that experienced . . . that allowed . . .”). The reader is more apt to recall information from both independent clauses than any other information in the sentence. Because the relative clauses are embedded, the information in the clauses is not being emphasized any more than the information in other structures.

> Japan was one of many societies that experienced pressure from Western nations, but Japan took a positive stance that allowed it to regain its national sense of identity as its government weakened.

The writer could shift the reader’s focus to a single main idea by changing one of the independent clauses into another type of structure. The revision below does this by changing the first independent clause (“Japan was . . .”) into an introductory phrase (“One of many . . .”), thus leaving only one independent clause (“Japan took . . .”) that the writer highlights for the reader to remember; thus, the reader will be most likely to recall the information in this one independent clause over other information in the sentence because the relative clauses are still embedded.

> One of many societies that experienced pressure from Western nations, Japan took a positive stance that allowed it to regain its national sense of identity as its government weakened.

The writer can increase the likelihood of the reader recalling information in a relative clause by moving it to the end of the sentence. That is exactly what the next revision does: the last relative clause (“that allowed . . .”) has been moved to the end of the sentence. Of course, the reader is still also quite likely to recall the information in the independent clause (“Japan took . . .”).

> One of many societies that experienced pressure from Western nations, Japan took a positive stance as its government weakened that allowed it to regain its national sense of identity.

One could continue to revise this sentence in many other ways, but writers should realize that their often subconscious decisions regarding the types of structures that they use to present information can affect what information their readers recall. The best marriage of structure and meaning occurs when the information that writers want readers to retain is placed in the type of structures that readers are most likely to recall.

Beyond matching structure and meaning, writers should consider the overall location of information in paragraphs and passages. The fact that readers exhibit
In taking a first step at looking at multiple semantic and syntactic variables in one study, the current study does advance our field’s knowledge about what variables influence the information that readers recall.

We fully recognize that the exploratory nature of this research forced us to limit the number of semantic and syntactic variables examined in this initial study. One goal was to develop a workable methodology and identify applicable findings, while bringing some kind of order to an initial study. Additionally, we wanted findings that would go beyond much of the existing research that has examined isolated variables in researcher-constructed sentences or paragraphs. Thus, by using naturally occurring, somewhat long passages, we were entering more difficult territory. And this territory became even more complex when we used more than one passage in an attempt to replicate results between passages. However, both the use of naturally occurring text and multiple texts increases the generalizability of the results to real world text scenarios, and that strength is worth the additional complexity.

To further technical communicators’ understanding of the issues addressed in this experiment, we have some suggestions for future research. Certainly a greater number of passages and a variety of rhetorical structures should be examined. And additional semantic and syntactic variables should be examined—for example, an examination of primacy or recency effects within sentences, and of the location of old versus new information. Finally, different recall and scoring methods should be investigated, which might in turn lead to other ways to analyze the data.

In taking a first step at looking at multiple semantic and syntactic variables in one study, the current study does advance our field’s knowledge about what variables influence the information that readers recall. The results begin to point out how technical communicators can facilitate their readers’ recall of information by the stylistic decisions they make.

**ACKNOWLEDGMENT**

We want to thank the Society for Technical Communication for funding a grant that supported the research reported here. We also want to thank Donna Faiferlick and Cathy Manning, students in the Department of Technical Communication at the University of Washington, for their help in preparing materials and tabulating results.

**REFERENCES**


**POSTSCRIPT**

This article reports the results of a study concerning the influence of semantics and syntax on the information that readers recall. The study, made possible through a grant from the Society for Technical Communication, sought to make sense of some text-based and reader-based factors that contribute to the information that readers encode and
can thus retrieve from long-term memory.

Given the complicated nature of such research and the advent of new media, researchers have continued to examine how readers’ processing of specific semantic and syntactic text features interacts with readers’ attitudes and knowledge sets in print and online text. Although some prefer to characterize the reading process as top-down versus bottom-up, or reader-based versus text-based, it is in fact the interaction of the reader and the text that makes constructing audience-appropriate messages such a rewarding challenge. This article continues to be relevant today as authors and editors seek to determine what text and reader characteristics have the greatest influence on readers’ understanding of text.

**CAROL ISAKSON** is a PhD student in educational psychology at the University of Washington. Her research interests concern cognitive processing of print and online technical documents. She is a member of Sigma Tau Chi, the STC student honorary society. Contact information: cisakson@u.washington.edu

**JAN H. SPYRIDAKIS** is a professor in the Department of Technical Communication at the University of Washington. She teaches courses on style in writing, research methodology, and international and advanced technical communication. Her research focuses on the refinement of research methods, and on the effect of document and screen design variables on comprehension and usability. She has received teaching and publication awards, and is a fellow of the Society for Technical Communication. In addition to her university work, she consults with organizations and companies regarding their communication needs. Contact information: jansp@u.washington.edu